A UNITED STATES
DEPARTMENT OF
COMMERCE
PUBLICATION

NBS SPECIAL PUBLICATION 305

SUPPLEMENT 1

Publications of the National Bureau of Standards 1968-1969

U.S.
EPARTMENT
OF
COMMERCE
National
Bureau
of
Standards

UNITED STATES DEPARTMENT OF COMMERCE
MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

Publications of the National Bureau of Standards 1968-1969

(A Compilation of Abstracts and Key Word and Author Indexes)

Betty L. Oberholtzer

U.S. National Bureau of Standards, Special Publication 305 Supplement 1

To Accompany National Bureau of Standards Circular 460, its Supplement, Miscellaneous
Publication 240, its Supplement, and Special Publication 305

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Preface

This supplement to NBS Special Publication 305 presents the complete citations and abstracts, along with author/key word indexes, for all NBS publications issued during 1968–69, plus a number of earlier publications not previously listed. Included is a new series established in 1968, the Federal Information Processing Standards (FIPS) Publications, as well as full citation information on the papers that make up the proceedings of "state-of-the-art" conferences. These conferences, sponsored and cosponsored by NBS, cover areas of international and national scientific and technological interest.

Like its predecessor, this supplement was prepared using the computer-assisted photocomposition and publication system at NBS. This type of computer application, generally called electronic printing, enables us to extract and typeset authors and key words for indexing without additional keyboarding. Large and continuing amounts of scientific information are thus made available to create a data bank for retrieval and updating. The complex and specialized nature of the Bureau's subject matter, the increasing volume of its work, the necessity for accuracy, and the need for prompt publication of results have all spurred the Bureau's research into the feasibility and application of electronic printing. This publication, and the increasing number of similarly prepared NBS publications, represents significant progress in realizing this aspect of the computer's potential in photocomposition.

New aids incorporated into this supplement should increase its usefulness. An edge index on the outer back cover provides ready reference to the NBS series citations and to other areas of interest as noted in the table of contents.

Of the many NBS personnel involved in this ongoing effort, special contributions have been made by Betty Oberholtzer, Rubin Wagner, Rebecca Morehouse, and Robert Thompson. The NBS units particularly involved are the Data Systems Design Group of the NBS Office of Standard Reference Data, and the Computer-Assisted Printing Section of the NBS Office of Technical Information and Publications.

W. R. Tilley, Chief
Office of Technical Information
and Publications

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1. NBS PERIODICAL AND NONPERIODICAL PUBLICATIONS

1.1. NBS PUBLICATION PROGRAM

For many years, the National Bureau of Standards formal publication program has provided a principal and effective means of communicating the results of the Bureau's research, development, and service activities to the scientific and technical community. Publications thus constitute a major end product of the Bureau's efforts, totalling about 1,000 items per year. These take the form of the Bureau's four periodicals, its nine nonperiodical publications, and articles in the journals of professional organizations and technological associations.

This book, Publications of the National Bureau of Standards, lists those publications representing the results of the Bureau's inhouse programs; these publications, plus the Clearinghouse publications and services, are as follows:

1.2. JOURNAL OF RESEARCH

The *Journal of Research* reports research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. The *Journal* also presents review articles by recognized authorities and compilations of information on subjects closely related to the Bureau's technical program. The *Journal of Research* is issued in three separate sections as follows:

A. Physics and Chemistry

This section presents papers of interest primarily to scientists working in these fields. It covers a broad range of physical and chemical research, with major emphasis on standards of physical measurements, fundamental constants and properties of matter. Issued six times a year.

Editor: C. W. Beckett
Associate Editor: D. D. Wagman

B. Mathematical Sciences

This section presents studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems are covered, together with short numerical tables. Issued quarterly.

Editor: M. Newman
Associate Editors: F. W. Olver and J. R. Edmonds

C. Engineering and Instrumentation

This section reports results of interest chiefly to the engineer and the applied scientist. It includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It also covers some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly.

Editor: M. Greenspan
Associate Editors: G. F. Montgomery, R. V. Smith, and A. F. Schmidt

1.3. TECHNICAL NEWS BULLETIN

Reports results of Bureau's programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—engineers, chemists, physicists, research managers, product-development managers, and company executives. Readers use the *TNB* to learn of new developments with practical applications, to fill in background, to get ideas for further investigations, and for information on NBS services and publications. Issued monthly.

1.4. NONPERIODICALS

Nine categories of nonperiodical publications, as described below, are listed in this catalog:

MONOGRAPHS—major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

HANDBOOKS—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

SPECIAL PUBLICATIONS—provides material of a particular nature and quality. Includes proceedings of high-level national and international conferences sponsored by NBS, precision measurement and calibration volumes, NBS Research Highlights, and other special publications appropriate to this grouping. This series had previously been designated Miscellaneous Publications.

APPLIED MATHEMATICS SERIES—mathematical tables, manuals, and studies.

NATIONAL STANDARD REFERENCE DATA SERIES—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a world-wide program coordinated by NBS.

BUILDING SCIENCE SERIES—research results, test methods, and performance criteria of building materials, components, systems, and structures.

TECHNICAL NOTES—designed to supplement the Bureau's regular publications program. Communications and reports of data of limited or transitory interest. Often serve as final reports on work sponsored at NBS by other Government agencies.

PRODUCT STANDARDS—developed cooperatively with interested Government and industry groups, and used voluntarily. The term *Product Standards* is now being used to identify all new standards as well as all revisions of existing standards. Existing standards will continue to be referred to as *Commercial Standards or Simplified Practice Recommendations* until such time as they are revised.

FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS—publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding (1) uniform Federal information processing standards resulting from provisions of Public Law 89-306 (the Brooks Bill), and (2) data elements and codes standards in data systems developed under the provisions of Bureau of the Budget Circular No. A–86. FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

1.5. PAPERS PUBLISHED BY OTHERS

Many significant contributions by NBS authors are published in other journals. Up-to-date listings of these articles are carried regularly in the Technical News Bulletin, as well as in each section of the Journal of Research, along with selected abstracts.

1.6. CLEARINGHOUSE SERVICES[1]

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write: Clearinghouse, U.S. Department of Commerce, Springfield, Virginia 22151.

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[1] Effective September 2, 1970 the Clearinghouse for Federal Scientific and Technical Information was transferred from the National Bureau of Standards to the National Technical Information Service, U.S. Department of Commerce.

2. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

2.1. PURCHASE PROCEDURES

The publications of the Bureau are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at the prices listed in this publication. You may also order through the U.S. Department of Commerce Field Office nearest you (see page 497 for list of Field Offices of the U.S. Department of Commerce). Nonperiodicals (only) may also be ordered through the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia 22151.[2]

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[2] See footnote 1 above.

This section includes price lists of available publications, plus instructions on how to acquire reprints of articles by NBS authors, and how to get out-of-print material.

How to Make Remittances. Remittances for publications for which individual sales or subscription prices are shown should be mailed to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, by coupon, postal money order, express money order, or check. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order or draft on an American bank.*

The letter symbol, publication number, and full title of the publication must be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication.

For the convenience of the general public, coupons in the denomination of five cents may be purchased from the Superintendent of Documents. These may be exchanged for Government publications sold by the Superintendent's office. Address order to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of $25 or more are accepted against which orders may be placed without making individual remittances or first obtaining quotations. Order blanks are furnished for this purpose. After the order has been processed, the order itself is returned, showing the publications supplied, explanations regarding those not sent, the amount of charge, and the balance on deposit.

No charge is made for postage on documents sent to points in United States and possessions, or to Canada, Mexico, Newfoundland (including Labrador), and certain Central and South American countries. To other countries the regular rate of postage is charged, and remittances must cover such postage. In computing foreign postage, add one-fourth of the price of the publication.

This Supplement to Special Publication 305 of the National Bureau of Standards lists the publications of the Bureau issued between January 1968 and December 1969. It includes an abstract of each publication (plus some earlier papers omitted from Special Publication 305), key-word and author indexes; and general information and instructions about NBS publications.

Miscellaneous Publication 240 (covering the period July 1, 1957 through June 30, 1960) and its supplement (covering the period July 1, 1960 through June 30, 1966), and Special Publication 305 (covering the period July 1966 through December 1967), remain in effect. Two earlier lists, Circular 460 (Publications of the National Bureau of Standards, 1901 to June 1947) and its supplement (Supplementary List of Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957) are also still in effect.

The catalogs of NBS publications are more completely described in section 2.3.

2.2. ANNOUNCEMENTS OF NBS PUBLICATIONS

The Bureau itself does not maintain a free individual mailing list for announcing its new publications. However, the Government agencies mentioned below regularly issue the following official announcements dealing wholly or in part with new NBS publications of interest in the journals' respective fields.

Technical News Bulletin. Issued monthly by the National Bureau of Standards. In addition to publishing technical news of the Bureau, the Bulletin announces all new publications by members of the staff, including those appearing in other journals. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, $3.00; $4.00 foreign. Single copies, 15 cents each.

Monthly Catalog of United States Government Publications. Issued monthly by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, with consolidated annual index, $7.00; $8.75 foreign.

Price Lists. These consist of lists of publications prepared by the Superintendent of Documents on special subjects. Single copies sent on request without charge provided you state the subject matter field in which you desire information. For a complete list and order form for subject price lists, request a copy of **How to Keep in Touch with United States Government Publications** from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

List of Selected Government Publications. Issued semimonthly by the Superintendent of Documents. Each list is arranged alphabetically by subjects, with annotations and prices. May be obtained free from that office.

Business Service Check List. Weekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards Publications, as well as those of other offices of the Department of Commerce. Available from the Superintendent of Documents. Annual subscription, $2.50; $4.00 foreign.

2.3. CATALOGS OF NBS PUBLICATIONS

Previous catalogs, plus this publication, constitute a complete list of the titles of the Bureau's publications through December 31, 1969, including brief abstracts of the material published in the NBS publication series. This publication also contains abstracts of papers published recently in outside media. Where the price is given, the catalog is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Otherwise, it may be consulted in a library which maintains sets of National Bureau of Standards publications.

Circular 24, 7th edition: Publications of the Bureau of Standards 1901 to 1925. 271 pages, including brief abstracts and subject index	(*)
Circular 24 Supplement: Supplementary list of publications of the Bureau of Standards, July 1, 1925 to December 31, 1931. 214 pages, including brief abstracts and subject index	(*)
Circular 24 Supplement: Supplementary list of publications of the National Bureau of Standards, January 1, 1932 to December 31, 1941. 386 pages, including brief abstracts. The subject and author indexes cover the period 1901 to December 31, 1941	(*)
Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947. 375 pages, including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947	$1.25
Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes	$1.50
Miscellaneous Publication 240: Publications of the National Bureau of Standards July 1, 1957 to June 30, 1960. Includes Titles of Papers Published in Outside Journals 1950 to 1959. 391 pages, including subject and author indexes	$2.25
Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages, including subject and author indexes	$4.00
Special Publication 305: Publications of the National Bureau of Standards published by NBS, July 1966 through December 1967; published by others, 1966-1967. 223 pages, including subject and author indexes	$2.00
Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages, including subject and author indexes	$4.50

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* Out of print.

2.4. DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries. The libraries listed in Appendix A are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

2.5. FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

Department of Commerce Field Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access, at the local level, to the Department's reports, publications, statistical statements, surveys, as well as to the specialized and experienced staff in charge. Each Field Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase locally a wide range of Government publications. The reference library maintained by each Field Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

2.6. AVAILABILITY OF NBS PUBLICATIONS

A. PERIODICAL SUBSCRIPTION RATES

Periodical	Domestic [1]	Foreign [2]
Journal of Research of the National Bureau of Standards:		
Section A. Physics and Chemistry, issued six times a year, paper covers (4)	9.50	11.75
Bound volume (1 volume per year), blue buckram	(3)	(3)
Section B. Mathematical Sciences, issued quarterly, paper covers (4)	5.00	6.25
Bound volume (1 volume per year), green buckram (4)	(3)	(3)
Section C. Engineering and Instrumentation, issued quarterly, paper covers	5.00	6.25
Bound volume (1 volume per year), salmon buckram (4)	(3)	(3)
Technical News Bulletin, 12 monthly issues (4)	3.00	4.00

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[1] United States and its possessions, Canada, Mexico, Newfoundland (including Labrador), and certain Central and South American countries.

[2] Foreign price includes the cost of the publication and postage.

[3] Prices of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

[4] These monthly periodicals may be obtained on a 1-, 2-, or 3-year subscription basis (although at no reduction in rates).

B. NONPERIODICAL PRICE LISTS

The following lists give the numbers and prices of all NBS publications issued from 1901 through December 31, 1969 which may be purchased from Federal Government sources. Order publications from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce Field Office nearest you.

When an item refers to "see —" the publication has been superseded by the one referenced, and the price opposite the number is the sales price for the superseding publication. If "OP" is listed instead of a price, the superseding publication is *out of print.* (See Out-of-Print Material, page XXI.)

Nonperiodicals (but not periodicals) may also be ordered through the Clearinghouse for Federal Scientific and Technical Information. (See section 1.6.)

CIRCULARS

No.	Price	No.	Price	No.	Price
3 see C547, Sec. 1, in part	OP	101 see C447	OP	415 see Mono. 47	$0.30
8 see Mono. 90	$0.25	131 see C385	OP	428 see C533	2.50
9 see C602	OP	138 see C385	OP	433	1.50
10 see C425	OP	139 see C390	OP	434 see C602	OP
12 see C440	OP	154 see H71	*	435 see H71	*
16 see C555	OP	239 see C363	OP	438	*
17 see Mono. 47	.30	257 see C365	OP	450 see C579	*
25 see M260	.45	280 see C406	OP	454 (PB192338)	**
29 see C60	OP	294 see C407	OP	456 see Mono. 47	.30
31 see H100	.50	300 see C418	OP	460	1.25
32 see C405	OP	319 see C378	OP	460 Suppl	1.50
35 see M183	OP	322 see C360	OP	462 see Mono. 80, in part	2.75
40 see C381	OP	328 see Mono. 15	OP	464	*
44 see C440	OP	330 see C362	OP	465 see H90	.40
47 see M233	OP	332 see Mono. 15	OP	466 see H71	*
49 see H8	OP	339 see C363	OP	467 Vol. I	5.50
51 see C432	OP	371 see C378	OP	467 Vol. II	4.00
52 see C387	OP	375 see C457	OP	467 Vol. III	3.00
54 see H3 & H4	OP	380 see C418	OP	470	.30
57 see C410	*	383 see C424	OP	474 see C576	*
61 see H29	OP	390 see H71	*	477 see C555	OP
62 see C424	OP	392 see C432	OP	478 see Mono. 104	.35
65 see C417	OP	396 see C418	OP	482 see C509	OP
75 see C397	OP	398 see M260	$0.45	485 see C592	OP
76 see C346	OP	399 see C406	OP	488 Sect. 1 & 2	1.25
82 see C361	OP	400 see C426	OP	488 Sect. 3, 4, & 5	1.50
83 see C333	OP	402	.05	495 see Mono. 88	.35
95 see C426	OP	410	*	499	*
100 see C592	OP	413 see C426	OP	500 Pt. I see TN270-3	1.25
		414 see H71	*		

*See page XX for additional information.
**Now available from the Clearinghouse, order by PB number for $3.00.

CIRCULARS—Continued

No.	Price
500 Pt. II see TN270-3	$1.25
506 see C576	*
508 see C561	OP
510 (PB192339)	***
510 Suppl. 1 (PB192340)	**
510 Suppl. 2 (PB192341)	**
518 See Mono. 70, Vol. I in part Vol. II in part	2.00 3.00
533	2.50
536	$0.20
537 see NSRDS-NBS 10	.40
539 Vol. 1 to 10 are now PB178902 through PB178911	**
542 (PB188806)	**
552 see M260	.45
553	2.00
556 (PB172004)	**
559 see H71	*
563 & 563 Suppl. 1, see M274	.50
564	*
567 see M271	$1.25
571 (PB175659)	**
572 see Mono. 15	OP
576	*
577 & 577 Suppl.	*
579 (PB168350)	*
580 see M251	OP
582	3.25
592 see Mono. 106	1.25
593	.45
596 (PB172059)	**
600 see Mono. 90	.25
601	.30

*See page XX for additional information.
**Now available from the Clearinghouse, order by PB number for $3.00.
***Now available from the Clearinghouse, order by PB number for $10.00.

MONOGRAPHS

No.	Price
2 (PB187752)	*
3 Vol. I	$6.00
3 Vol. II	6.00
4 (PB174987)	*
8 (PB186237)	*
10	.20
11	.20
12	1.50
13 (PB172156)	*
14	.15
17	.65
18 see Mono. 88	.35
20	2.75
22	2.00
23 (PB183992)	*
24	.20
25 Sect. 1 (PB178429)	*
25 Sect. 2 (PB178430)	*
25 Sect. 3 (PB178431)	*
25 Sect. 4	.55
25 Sect. 5	.55
25 Sect. 6	.60
25 Sect. 7	1.50
26	.20
27 Suppl. incl. in Suppl. 2	$0.35
27 Suppl. 2	.35
28 see BSS17	.40
29 (PB172178)	*
30 (PB193908)	*
31	.35
32 Suppl. to Parts I & II	.30
33	.55
34 Vol. 2	2.00
35	.60
35 Suppl. 1	.65
36	.30
38	.70
40	.50
41 (PB191728)	*
42	.75
43 Vol. I	6.50
43 Vol. II	6.25
44	.15
45 (PB186433)	*
46 (PB176590)	*
47	$0.30
49	2.75
50 see M278	.55
& M278 Suppl.	.30
51	.30
52	1.00
54	.25
55	.20
56	.30
57 see M274	.50
58 (PB193909)	*
59	1.75
60	.25
61	4.00
62	.15
63	.35
64	.15
65	.15
66	.35
67 (PB186426)	*
68	.25
69	.30
70 Vol. I (PB168072)	*
70 Vol. II (PB189714)	*

*Now available from the Clearinghouse, order by PB member for $3.00.

MONOGRAPHS—Continued

No.	Price	No.	Price	No.	Price
70 Vol. III	$4.25	86	$0.35	103	$0.20
70 Vol. IV	5.50	87	.40		
70 Vol. V	4.75	88	.35	104	.35
71	2.00			105	2.25
72 (PB186427)	*	89 (AD700466)	**	106	1.25
73 (PB186432)	*	90	.25	107	1.75
		91	2.25	108	.45
74	.30	92	2.75		
75	.40	93	.75	109	.55
76	.20			110	.30
77* (PB180646)	**	94	.75	111	2.00
78	.20	95	.45	112	.35
		96	1.25		
79	.35	97	.25		
80	2.75	98	.55		
81	3.25				
82 (PB189659)	**	99	.70		
83	.55	100	4.50		
		101	2.75		
85	.70	102	.25		

*Consolidated supplement to BMS144 and supersedes supplements 1 & 2 of BMS144.
**Now available from the Clearinghouse, order by PB or AD number for $3.00.

APPLIED MATHEMATICS SERIES

No.	Price	No.	Price	No.	Price
1 see AMS25	$0.45	23 (PB175967)	*	42 (PB175819)	*
2	.15	24 (PB175816)	*	43 (PB176127)	*
5	.50			44 (AD695954)	*
6	2.25	25	$0.45	45	$0.55
8	.30	26 (PB178415)	*		
				46 (PB186429)	*
9	1.75	27	4.00	47	.45
10	2.00	28 (AD695952)	*	48 (PB176119)	*
11	.70	29 (AD695953)	*	49	.50
12 (PB184887)	*	30 (PB175817)	*	50 (PB176520)	*
13	.40	31	4.75	51	4.50
		32	2.25	53 (PB186430)	*
		33 (PB175818)	*	54	.30
14	5.50	34	2.00	55	6.50
		35	2.00	56 (PB190608)	*
17	2.00	36	4.00	57	.35
19 (PB175815)	*			58	.40
20	1.75	40 (PB186428)	*	59	3.25
21 (PB178392)	*			60	.60
22 (PB192337)	*	41 (PB176521)	*	61	.70

*Now available at the Clearinghouse, order by PB or AD number for $3.00.

BUILDING MATERIALS AND STRUCTURES REPORTS

No.	Price	No.	Price	No.	Price
17 See BMS144	OP	19 see BMS116	OP	144 & Suppl. 1 & 2, see Mono. 77 (PB180647)	*
17 Suppl. 1 & 2, see Mono. 77 (PB180647)	*	64 (PB177986)	*	151 (PB177987)	*
		66	$0.60		

*Now available at the Clearinghouse, order by PB number for $3.00.

MISCELLANEOUS PUBLICATIONS

No.	Price	No.	Price	No.	Price
3 see M232	$0.50	171 see M187	*	260–13	$0.40
39 see M234	.10	172 see M243	OP	260–14	.30
54 see BH5	OP	174 see M211	$0.20	260–15	.20
64 see M247	.40	179	*	262–1	.60
65 see M178	OP	187	*	262–2	4.25
78 see M82	OP	203 see M243	OP	265	3.00
85 see H29	OP	211	.20	266	3.75
89 see H28, Part I	2.00	214 see M286	2.25	267	2.00
H28, Part II	.75	230 see M288	2.00	268 (6.25 for 100)	.10
H28, Part III	.60	232	.50	269	2.75
H28, Suppl	.70	233 see M286	2.25	271	1.25
90 see M187	*	234	.10	273	2.50
92 see H46	*	236 see SP236	.25	274	.50
93 see M160	OP	240	2.25	275	5.25
94 see M163	OP	240 Suppl.	4.00	276	2.00
95 see H13	OP	241 see M260	.45	277 see SP322	.75
100 see CS8–61	.40	247	.40	277 Suppl. 1, see SP322	.75
111 see M155	OP	250 see SP250	1.75	278 see SP320	1.25
114 (PB192894)	*	253 (6.25 per 100)	.10	278 Suppl	.30
121 see M233	OP	257	1.75	279	.65
125 see M187	*	258	1.25	280	1.50
126 see M183	OP	259	.05	281	2.00
130 see M178	OP	260 see SP260	.50	283	.60
134 see M160	OP	260–1	.30	284	1.25
141 see H28, Part I	2.00	260–2	.35	285	1.75
H28, Part II	.75	260–5	.25	286	2.25
H28, Part III	.60	260–6	.45	287	2.50
H28, Suppl	.70	260–7	.60	288	2.00
143 see M146	OP	260–8	.55	289	.50
144 see M154	OP	260–9	.15	290	1.00
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Circular 499, Nuclear Data. The publication of nuclear data is being continued in a new journal entitled *Nuclear Data*, published by Academic Press, 111 Fifth Avenue, New York, N.Y. 10003.

Circular 564, Tables of Thermal Properties of Gases. A reprinted edition is available from Pergamon Press of London and New York, at $20.00. Microfische of this Circular is available from Cryogenic Data Center, National Bureau of Standards, Boulder, Colorado 80302 for $4.50.

Circular 576, Automotive Antifreezes. For information on this subject consult American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons. These have been superseded by NASA Special Publication 3012, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, at $3.00 hardcopy and $.65 microfische Number N65-12506.

Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, has issued a publication on this subject. Available from them as A58.1-1955, at $2.50.

Miscellaneous Publication 187, Directory of Commercial and College Laboratories. A new Directory of College and Commercial Testing Laboratories is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, at $1.50.

Handbook 46, Code for Protection Against Lightning. A United States of America Standards Institute Code for Protection Against Lightning (NFPA No. 78-1969) is available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, at $1.25.

Handbook 49, Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. Reprints of this Handbook can be purchased as NCRP Report 9 at $1.00 from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 58, Radioactive Waste Disposal in the Ocean. Reprints of this Handbook can be purchased as NCRP Report 16 at $1.00 from ICRU Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 59, Permissible Dose from External Sources of Ionizing Radiations. Reprints of this Handbook can be purchased as NCRP Report 17 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 63, Protection Against Neutron Radiation up to 30 MeV. Reprints of this Handbook can be purchased as NCRP Report 20 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes. Reprints of this Handbook can be purchased as NCRP Report 21 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 71, Specifications for Dry Cells and Batteries. For more information on this Handbook, write to American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

Handbook 74, Building Code Requirements for Reinforced Masonry. The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018 has issued a publication on this subject. Available from them as ACI318–631, at $2.75.

Handbook 76, Medical X-ray Protection Up to Three Million Volts. For more information on this Handbook, write to NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 84, Radiation Quantities and Units, has been superseded by ICRU Report 11 at $1.00 per copy from ICRU Publications, Post Office Box 4869, Washington, D.C. 20008.

Handbook 89, Methods of Evaluating Radiological Equipment and Materials. Reprints of this Handbook can be purchased as ICRU Report 10F at $1.25 per copy from ICRU Publications, Post Office Box 4869, Washington, D.C. 20008.

Handbook 97, Shielding for High-Energy Electron Accelerator Installations. Reprints of this Handbook can be purchased as NCRP Report 31 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 102, ASTM Metric Practice Guide. American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, has issued a publication as Document E380-70, at $1.50.

3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS[1]

3.1. PAPERS FROM THE NBS JOURNAL OF RESEARCH, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 72A, JANUARY–DECEMBER 1968

January-February 1968

Reactions of uranium with the platinide elements. I. The uranium-ruthenium system, J. J. Park, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 1-10 (Jan.-Feb. 1968).

> Key words: Intermetallic compounds; phase diagram; ruthenium; solubility; uranium.

The phase diagram of the uranium-ruthenium system was constructed from data obtained by thermal analysis, metallographic examination, and x-ray diffraction. The system is characterized by five intermetallic compounds: U_2Ru, formed peritectically near 937 °C; "URu," melting congruently near 1158 °C; U_3Ru_4, formed peritectically near 1163 °C; U_3Ru_5, formed peritectically near 1182 °C; and URu_3, formed peritectically at about 1850 °C. "URu" has a solid-state transition at about 795 °C. One eutectic occurs near 886 °C and 18.5 atomic percent (a/o) ruthenium; and a second at about 1148 °C and 49 a/o ruthenium. The maximum solid solubilities are about 7.5 a/o ruthenium in uranium and near 1.3 a/o uranium in ruthenium. Ruthenium lowers the gamma-uranium transformation to near 691 °C and the beta-transformation to near 625 °C.

Reactions of uranium and the platininde elements. II. The uranium-rhodium system, J. J. Park, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 11-17 (Jan.-Feb. 1968).

> Key words: Intermetallic compounds; phase diagram; rhodium; solubility; uranium.

The phase diagram of the uranium-rhodium system was constructed from data obtained by thermal analysis, metallographic examination, and x-ray diffraction. The system is characterized by four intermetallic compounds: U_4Rh_3, formed peritectically near 1155 °C and having a solid state transformation at about 720 °C; U_3Rh_4, formed peritectically near 1450 °C; U_3Rh_5, formed peritectically near 1550 °C; and URh_3, melting congruently at about 1700 °C. One eutectic occurs near 865 °C and 24.5 atomic percent (a/o) rhodium, and a second near 1393 °C and 87 a/o rhodium. The maximum solid solubility of rhodium in uranium is approximately 8 a/o, and of uranium in rhodium is approximately 3 a/o.

Reactions of uranium and the platinide elements. III. The uranium-iridium system, J. J. Park and L. R. Mullen, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 19-25 (Jan.-Feb. 1968).

> Key words: Intermetallic compounds; iridium; phase diagram; solubility; uranium.

The phase diagram of the uranium-iridium system was constructed from data obtained by thermal analysis, metallographic examination, and x-ray diffraction. The system is characterized by five intermetallic compounds: U_3Ir, formed peritectically near 945 °C and decomposing eutectoidally near 758 °C; U_3Ir_2, formed peritectically near 1121 °C; UIr, melting congruently at about 1470 °C; UIr_2, formed peritectically above 1850 °C; and UIr_3, having a congruent melting point above 1950 °C. U_3Ir_2 has a solid state transition near 898 °C. One eutectic occurs at 914 °C at about 15 atom percent (a/o) iridium between uranium and U_3Ir; a second occurs between UIr and UIr_2 near 1450 °C; and a third occurs between UIr_3 and iridium at about 1950 °C. The solid solubility of iridium in gamma-uranium is about 5.5 a/o and of uranium in iridium is under 3 a/o. Iridium lowers the gamma-beta uranium transformation to about 681 °C and the beta-alpha transformation to about 565 °C.

Phase relations between palladium oxide and the rare earth sesquioxides in air, C. L. McDaniel and S. J. Schneider, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 27-37 (Jan.-Feb. 1968).

> Key words: Dissociation; equilibrium; Ln_2O_3:PdO compounds; Ln_2O_3-PdO systems; phase relations.

The equilibrium phase relations were determined in an air environment between PdO and each of the following: La_2O_3, Nd_2O_3, Sm_2O_3, Eu_2O_3, Gd_2O_3, Dy_2O_3, Ho_2O_3, Y_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, and Lu_2O_3. In air PdO dissociates to Pd metal at 800 °C. The dissociation of PdO is apparently a reversible process. The Nd_2O_3-PdO and Sm_2O_3-PdO systems were studied in detail inasmuch as they typified several of the Ln_2O_3-PdO systems. Three compounds, $2Nd_2O_3 \cdot PdO$, metastable $Nd_2O_3 \cdot PdO$, $Nd_2O_3 \cdot 2PdO$ occur in the Nd_2O_3-PdO system. The 2:1, 1:1, and 1:2 compounds, of unknown symmetry, dissociate or decompose at 1135, 860, and 1085 °C, respectively. The 2:1 compound dissociates to the solid phases, Nd_2O_3 and Pd. No further reactions occur between Nd_2O_3 and Pd up to 1300 °C. Three compounds, 2:1, metastable 1:1, and 1:2 occur in the Sm_2O_3-PdO and Eu_2O_3-PdO systems. Two compounds, 2:1 and 1:2 occur in the La_2O_3-PdO system. Other compounds detected were the 1:1 and 1:2 in the Gd_2O_3-PdO system and the metastable 1:1 in the Dy_2O_3-PdO system. Each of these compounds subsequently dissociated upon heating. No apparent reaction occurred between PdO and either Ho_2O_3, Y_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, or Lu_2O_3.

Preparation and purification of some oxidation products of perylene, A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 39-47 (Jan.-Feb. 1968).

> Key words: Absorption spectra; air pollutants; anthraquinone-1,5-dicarboxylic acid; dihydroxyperylenequinones; infrared; perylene; perylenequinones; photo-oxidation products of perylene; polycyclic aromatic hydrocarbons; thin-layer chromatograms; ultraviolet; visible absorption spectra; 4-oxo-4*H*-benz[*de*]anthracene-7,8-dicarboxylic anhydride.

Reliable procedures are given for the purification of perylene, and for the preparation and purification of 3,10-perylenequinone, 1,12-perylenequinone, 2,11-dihydroxy-3,10-perylenequinone, 4,9-dihydroxy-3,10-perylenequinone, 4-oxo-4*H*-benz[*de*]-anthracene-7,8-dicarboxylic anhydride, phenanthrene 1,8,-9,10-tetracarboxylic dianhydride, and anthraquinone-1,5-dicarboxylic acid. Data on the physical properties of 3,9-perylenequinone are also reported.

Electron spin resonance spectra of polymer radicals in aqueous solution, R. E. Florin, F. Sicilio, and L. A. Wall, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 49-73 (Jan.-Feb. 1968).

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[1] The various NBS publications series are grouped under subheadings within this section. The several volumes of the Journal of Research are presented consecutively within their appropriate subheadings. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.

Key words: Abstraction; dextran; dextrin; free radicals; hydroxyl; polyacrylic; polyethylene imine; polyethylene oxide; polymer degradation; polymethacrylic acid; polypropylene oxide; polyvinyl alcohol; starch.

Mixing of aqueous polymer solutions containing Ti^{3+} and H_2O_2 in a rapid flow mixer produced radicals by abstraction, $OH + RH \rightarrow R\cdot + H_2O$, which were observed by electron spin resonance. Oscillation of segments was sufficient to narrow the lines to 0.5 – 2.0 g. Polymers and radicals identified with more or less certainty were polyacrylic acid, $\sim CH(CO_2H)\dot{C}HCH(CO_2H)\sim$, polymethacrylic acid, $\sim C(CH_3)(CO_2H)\dot{C}HC(CH_3)(CO_2H)\sim$, polyvinyl alcohol, $\sim CHOH\dot{C}HCHOH\sim$, and one indefinite, polyethylene imine, $\sim CH_2\dot{N}CH_2\sim$ or $\sim CH_2\dot{N}OCH_2\sim$, polyethylene oxide, $\sim CH_2O\dot{C}HCH_2O\sim$. Radicals from polypropylene oxide, dextran, dextrin, soluble starch, and the disaccharide maltose were unidentified; the last three were strikingly similar.

Products of secondary C – C scission were not observed with certainty. It is presumed that such reactions are slow compared to the time-scale of the experiment, 10 msec. However, some evidence exists for a very rapid $\beta-OH$ loss in carbohydrate radicals and a slow C – O scission in polyethylene oxide radicals. A large number of related small molecule radicals were investigated, and hyperfine splittings and g-values are reported.

A mass spectrometric study of the BeO-BeF$_2$ system of high temperatures, J. Efimenko, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 75-80 (Jan.-Feb. 1968).

Key words: Beryllium difluoride; beryllium oxide; high temperatures; mass spectrometry; reaction enthalpy; sublimation enthalpy.

Mass spectrometric studies were made at high temperatures of the vapors over $BeF_2(s)$ and $BeO(s)$ individually and of their mixture. The sublimation enthalpy, $\Delta H_0^\circ = 55.56 \pm 0.43$ kcal/mol, where 1 kcal equals 4184 J, was obtained for BeF_2 by the use of a log I^+T versus $1/T$ plot. A complex molecule appeared in the BeF_2-BeO system at high temperatures which, on the basis of its m/e position, corresponded to Be_2OF_2. For the reaction, $BeO(s)+BeF_2(g)=Be_2OF_2(g)$, a second law treatment of the data gave an enthalpy value, $\Delta H_0^\circ=41.56\pm1.8$ kcal/mol. The data, combined with free energy functions, resulted in a mean reaction enthalpy, $\Delta H_0^\circ=42.6$ kcal/mol. The heat of formation for $Be_2OF_2(g)$, $\Delta H_0^\circ=-288.3$ kcal/mol, was computed using the reaction enthalpy based on the second law.

Laser induced Raman spectra of some tungstates and molybdates, R. K. Khanna, W. S. Brower, B. R. Guscott, and E. R. Lippincott, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 81-84 (Jan.-Feb. 1968).

Key words: Molybdates; Raman spectra; tungstates.

The Raman spectra of single crystals of $CaWO_4$, $CaMoO_4$, $PbWO_4$, and $PbMoO_4$ have been recorded using a He-Ne laser ($\lambda = 6328$ Å) and an Argon ion laser ($\lambda = 4880$ Å) as the exciting radiation sources. The polarization data have enabled us to classify unambiguously the observed fundamentals into the Raman active species of the point group C_{4h} to which these crystals belong. The comparison of the spectra of these crystals in the low frequency region has also enabled us to make a rough classification of the bands into the rotational and the translational lattice vibrations.

Valence-only correlation in LiH and BeH$^+$, W. A. Sanders and M. Krauss, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 85-90 (Jan.-Feb. 1968).

Key words: BeH^+; correlation energy; dissociation energy; LiH; molecular orbital; potential energy curve.

The pseudonatural orbital procedure has been applied to the calculation of the potential energy curve of LiH and the dissociation energy of BeH^+. Only the two-electron bonding pair is correlated and estimates of σ and π type correlation are obtained. The results for LiH are in good agreement with the most accurate previously published calculations. Comparison with experimental results for LiH indicates that the calculated dissociation energies are accurate to about 0.15 to 0.2 eV.

Thermalization by elastic collisions: positronium in a rare gas moderator, W. C. Sauder, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 91-93 (Jan.-Feb. 1968).

Key words: Elastic collisions; positronium; thermalization.

The energy decay of particles moving through a moderating medium is discussed for the case in which only elastic collisions occur between these incoming particles and the moderator atoms; the random thermal motion of the moderator atoms is taken into account. It is shown that if the cross section is independent of particle velocity the equation for the energy decay emerges in a rather simple form involving the hyperbolic cotangent. Finally, the theoretical development is applied to estimating the thermalization time of positronium in rare gas moderators, and is shown to agree with the limited experimental results presently available.

Density fluctuations in fluids having an internal degree of freedom, R. D. Mountain, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 1, 95-100 (Jan.-Feb. 1968).

Key words: Brillouin scattering; density fluctuations in liquids; Rayleigh scattering; spectral distribution of scattered light; structural relaxation; thermal relaxation; volume viscosity.

The frequency spectrum of density fluctuations is calculated for a fluid whose molecules possess an internal degree of freedom which is weakly coupled to the translational degree of freedom of the fluid. Irreversible thermodynamics is used to obtain an equation of motion for the internal degree of freedom. This equation plus the linearized hydrodynamic equations are solved for the frequency spectrum of density fluctuations. The results are compared with a similar calculation involving a frequency dependent volume viscosity. The results are identical for structural relaxation but there is a difference for thermal relaxation. The origin of the difference is discussed and the magnitude of the difference is examined for CCl_4 and for CS_2.

March-April 1968

Constant pressure flame calorimetry with fluorine. II. The heat of formation of oxygen difluoride, R. C. King and G. T. Armstrong, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 113-131 (Mar.-Apr. 1968).

Key words: Bond energy (O – F); flame calorimetry; flow calorimetry; fluorine; heat of formation; heat of reaction; hydrogen fluoride (aqueous); oxygen; oxygen difluoride; reaction calorimetry; water.

The heats of the following reactions were measured directly in an electrically calibrated flame calorimeter operated at one atm pressure and 303 °K.

$$OF_2(g) + 2H_2(g) + 99H_2O(l) \rightarrow 2[HF \cdot 50H_2O](l)$$

$$F_2(g) + H_2(g) + 100H_2O(l) \rightarrow 2[HF \cdot 50H_2O](l)$$

$$\tfrac{1}{2}O_2(g) + H_2(g) \rightarrow H_2O(l)$$

The reactants and products were analyzed for each of the reactions. From these heats we calculated the corresponding heats of formation, as follows:

$OF_2(g)\Delta H^\circ_{f298.15} = +24.52 \pm 1.59$ kJ mol^{-1} ($+5.86 \pm 0.38$ kcal mol^{-1})

$HF \cdot 50H_2O(1)\Delta H^\circ_{f298.15} = -320.83 \pm 0.38$ kJ mol^{-1} (-76.68 ± 0.09 kcal mol^{-1})

$H_2O(1)\Delta H^\circ_{f298.15} = -285.85 \pm 0.33$ kJ mol^{-1} (-68.32 ± 0.08 kcal mol^{-1})

The uncertainties indicated are the estimates of the overall experimental errors. The value of the average O – F bond energy in OF_2 was calculated to be 191.29 kJ mol^{-1} (45.72 kcal mol^{-1}).

The heat of formation of boron carbide, E. S. Domalski and G. T. Armstrong, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 133-139 (Mar.-Apr. 1968).

Key words: Bomb calorimeter; boron carbide; boron trifluoride; carbon tetrafluoride; heat of combustion; heat of formation; polytetrafluoroethylene.

The standard heat of combustion in fluorine of a boron carbide sample having the composition $B_{4.222}C$ was determined from the heats of combustion of polytetrafluoroethylene and of boron carbide-polytetrafluoroethylene mixtures. The energy of the combustion reaction was measured in an isothermal-jacket bomb calorimeter. From the experimental data, we calculate −17.1 kcal mol^{-1} for the heat of formation of boron carbide. By combining all probable errors, we estimate our overall experimental uncertainty to be 2.7 kcal mol^{-1}. The value for the heat of formation of boron carbide is for the phase represented by the formula $B_{4.222}C$.

Solubility of tris(hydroxymethyl)aminomethane in water-methanol solvent mixtures and medium effects in the dissociation of the protonated base, P. Schindler, R. A. Robinson, and R. G. Bates, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 141-148 (Mar.-Apr. 1968).

Key words: Dissociation constant; medium effect; methanol-water solvents; solubility; tris(hydroxymethyl)aminomethane.

The dissociation constant of the protonated form of tris(hydroxymethyl)aminomethane has been measured at 25 °C in water-methanol solvents containing 30, 50, 70, and 90 wt percent methanol by means of potentiometric titrations. The solubility of tris(hydroxymethyl)aminomethane at 15, 25, and 35 °C in water-methanol solvents containing from 0 to 100 percent methanol has been determined. The results are discussed in terms of free energies of transfer and "medium effects" for hydrochloric acid, tris(hydroxymethyl)aminomethane, and tris(hydroxymethyl)aminomethane hydrochloride.

Calibration of the nickel dimethylglyoxime spectral shift at pressures to 20 kilobars for use in spectroscopic pressure measurement, H. W. Davies, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 149-153 (Mar.-Apr. 1968).

Key words: Absorption spectra; diamond-anvil cell; high pressure measurement; nickel dimethylglyoxime.

A method for incorporating solid nickel dimethylglyoxime in a liquid enclosed by a gasket in the diamond-anvil high pressure cell is described. A calibration curve relating the spectral shift of the nickel dimethylglyoxime visible absorption band to the known freezing pressures of 14 liquids has been obtained. The equation for the calibration line is $\Delta\bar{\nu} = -158.9\ P + 1.82\ P^2$ where P is expressed in kilobars. The 90 percent confidence band about the calibration curve has been computed, and the curve has been used to determine the room-temperature freezing pressures of acetone and methylcyclohexane.

Second virial coefficient of He^4 in the temperature range from 2 to 20 °K, M. E. Boyd, S. Y. Larsen, and H. Plumb, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 155-156 (Mar.-Apr. 1968).

Key words: He^4; low temperature; second virial.

We present preliminary values for the second virial coefficient of He^4 in the temperature range from 2 to 20 °K. They were derived from recent sound velocity measurements in the gas made by Plumb and Cataland using an ultrasonic interferometer.

Diffusion rates in inorganic nuclear materials, A. L. Dragoo, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 157-173 (Mar.-Apr. 1968).

Key words: Chemical interdiffusion; grain-boundary diffusion; intrinsic diffusion; lattice diffusion; self-diffusion; tracer diffusion.

The tracer diffusion coefficient, the self-diffusion coefficient, the intrinsic diffusion coefficient and the interdiffusion coefficient are briefly described. Grain boundary and lattice (volume) diffusion are contrasted. The frequency factors (D_0) and activation energies (Q) are tabulated for diffusion in the borides, carbides, and oxides of Be, Hf, Mo, Nb, Ta, Th, Ti, and Zr and for diffusion of C, N, and O in these metals. The purity of the solvent media, the preparation and properties of the samples, the method, the type of diffusion coefficient measured and the temperature range are also specified.

Effect of oxide additions on the polymorphism of tantalum pentoxide (system Ta_2O_5-TiO_2), J. L. Waring and R. S. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 175-186 (Mar.-Apr. 1968).

Key words: Phase equilibria; polymorphism; tantalum pentoxide; titanium dioxide.

The phase equilibrium relationships of the TiO_2-Ta_2O_5 system were determined in air. An equimolar compound, $TiTa_2O_7$, was found to melt congruently at about 1662 °C and have a monoclinic unit cell $a = 20.297$ Å, $b = 3.804$ Å, $c = 11.831$ Å, $\beta = 120°14'$, apparently isostructural with $TiNb_2O_7$. In addition, two other compounds are postulated to occur at about TiO_2:$49Ta_2O_5$ and TiO_2:$7Ta_2O_5$ and to dissociate at about 1230 and 1190 °C, respectively. TiO_2 apparently accepts a maximum of 9 mole percent Ta_2O_5 in solid solution at 1630 °C. Two eutectics occur in the system at 54 mole percent Ta_2O_5 and 1650 °C and 31 mole percent Ta_2O_5 and 1630 °C.

The high temperature form of Ta_2O_5 is apparently triclinic at room temperature with $a = 3.801$ Å, $b = 3.785$ Å, $c = 35.74$ Å, $\alpha = 90°54.4'$, $\beta = 90°11.5'$, and $\gamma = 89°59.9'$. A metastable transition occurs at 320 °C to a monoclinic form which inverts to tetragonal at 920 °C with $a = 3.81$ Å, $c = 36.09$ Å. Several intermediate morphotropic phases are found with up to 9 mole percent TiO_2 in solid solution.

Effect of statistical counting errors on wavelength criteria for x-ray spectra, J. S. Thomsen and F. Y. Yap, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 187-205 (Mar.-Apr. 1968).

Key words: Lattice constants; peak intensity; physical constants; spectral line profiles; statistical error analysis; x-ray line shapes; x-ray spectra; x-ray wavelength criteria.

Various features of the spectral profile of an x-ray line can be measured with an uncertainty which is only a small fraction of the observed line width. With recent improvements in measurement techniques, statistical errors due to the random fluctuations of the intensities in counter recordings may become significant. The present study considers the effect of such errors on several features of the line profile which could be used for definition of its wavelength. These may be broadly classified into three groups, viz, the peak, the centroid, and the median. In the present analysis the statistical errors associated with these features are compared theoretically, with the assumption of negligible error in angular measurement. Certain systematic errors are also briefly examined. The effects of truncation range, asymmetry, and background intensity are considered, as well as possible optimization of the data-taking procedure.

In general, σ, the standard deviation of the wavelength, is given by $\sigma/W=F/(I_pT)^{1/2}$, where W is the full width at half-maximum intensity, I_p the peak intensity, T the total counting time, and F a dimensionless factor of the order of unity. Thus F may be regarded as a factor of merit for comparing the various cases, a low value of F being desirable. When the form of the line profile is known a priori, it is usually best to make use of this knowledge; e.g., a Lorentzian can be thus fitted with $F \approx 0.8$ for any of the three wavelength features. Using optimized truncation ranges and including the error in locating end points, one obtains approximately this same F for the centroid or median even without prior knowledge of the profile. In the latter case the value of F for the peak usually ranges from about 1.6 to 2.1. However, the peak is less subject to certain systematic errors and is preferable from the viewpoint of simplicity and historical precedent. It is recommended that use of the peak be continued at present; further study of the problem from the viewpoint of atomic energy level interpretation would be desirable.

Thermodynamic properties of ammonia as an ideal gas, L. Haar, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 2, 207-216 (Mar.-Apr. 1968).

Key words: Ammonia; ideal gas; thermodynamic functions.

Thermodynamic functions for ammonia as an ideal gas at one atmosphere pressure have been evaluated. The contribution of the highly anharmonic out-of-plane vibrational mode, including its large coupling with rotation and its coupling with the other vibrational modes, is considered in detail. Tables of $C_P{}^\circ/R$, $(H^\circ - E_0^\circ)/RT$, $(E_0{}^\circ - G^\circ)/RT$, and S°/R have been calculated at closely spaced intervals from 50 to 5000 °K within an overall uncertainty of less than 0.1 percent at 1000 °K.

May-June 1968

Jump rates for point defects in special positions held by a trapping center of noncubic symmetry, H. S. Peiser and J. B. Wachtman, Jr., *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 231-237 (May-June 1968).

Key words: Crystal symmetry; equivalent sites; jump rates; point defects; relaxation; trapping center.

In a previous paper [J. Phys. Chem. Solids **27,** 975 (1966)] the authors have discussed symmetry conditions for equivalence of jump rates operative in point-defect motion between crystallographically equivalent general sites neighboring a trapping center. The treatment is here extended to equivalent special sites to show that the total number of inequivalent jump rates can be expressed as $(N_t/N_d)-q_e-1$ where N_t and N_d are the orders of the symmetry groups of the trap and defect respectively and where q_e is the number of independently effective pairs of nonself-inverse symmetry operators (paired with their inverses) all in the symmetry group of the trap. The number q_e can be obtained by counting any nonself-inverse operator pair, an element of which, when multiplied by an element of the defect symmetry, equals neither its own inverse nor an element of a pair previously counted.

For thermally activated relaxation processes expressions apply for maximum and minimum numbers of jump frequencies involved in complete and partial relaxation processes. For complete relaxation the maximum number is the number of prime factors in the ratio of the order of the symmetry group of the trap to that of the defect group. The minimum number is the minimum number of generators that will raise the defect position symmetry to that of the trap.

The thermodynamics of the ternary system; water-potassium chloride-calcium chloride at 25 °C, R. A. Robinson and A. K. Covington, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 239-245 (May-June 1968).

Key words: Activity coefficient; calcium chloride; isopiestic measurements; mixed salt solutions; osmotic coefficients; potassium chloride; vapor pressure.

Isopiestic vapor pressure measurements have been made on the system: water-potassium chloride-calcium chloride at 25 °C. The osmotic coefficients of the mixed salt solutions and the activity coefficients of each salt in the presence of the other have been evaluated.

Force field for SiF_4, I. W. Levin and S. Abramowitz, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 247-249 (May-June 1968).

Key words: Band contour; Coriolis constant; force field; infrared; isotopic shift; low temperature; SiF_4.

The force field of SiF_4 has been determined using both Coriolis coupling constants obtained from an investigation of the band contour of ν_3 at 195 °K and isotopic shifts. The force fields are equally well determined using both methods and are in agreement.

Blemish formation in processed microfilm, C. I. Pope, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 251-259 (May-June 1968).

Key words: Archival record film; blemishes due to aging; colloidal silver; microfilm; microfilm storage cartons; permanent record film; peroxides.

Oxidizing and reducing agents generated by paper cartons during storage may react with the image silver to form blemishes. The type of fixing bath, concentration of chlorine in the wash water, washing time and composition of the storage cartons can be factors that accelerate or retard the attack of the peroxide on the image silver. Microfilm washed after fixation in distilled water or chlorine-free tap water formed blemishes when exposed to peroxide paper. A trace of silver chloride in the image silver of processed microfilm augmented the formation of the natural type blemishes when exposed to peroxide paper, but high concentrations of residual silver chloride inhibited blemish formation. During storage, some storage cartons evolved formaldehyde, formic acid, and ammonia which created a chemical environment favorable for blemish formation in microfilm in the presence of peroxide. A correlation was found between the incidence of blemishes and the brand of paper storage cartons. A procedure was developed for testing processed microfilm to determine its susceptibility to blemish formation. According to the present theory, peroxide reacts with the silver in the image, forming colloidal silver which imparts a yellowish or reddish color to the blemishes.

Absolute isotopic abundance ratios of common, equal-atom and radiogenic lead isotopic standards, E. J. Catanzaro, T. J. Murphy, W. R. Shields, and E. L. Garner, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 261-267 (May-June 1968).

Key words: Absolute ratios; abundance; isotopic standards; lead.

Absolute values have been obtained for the isotopic abundance ratios of common, equal-atom, and radiogenic lead isotopic standards using solid-sample mass spectrometry. Samples of known ^{208}Pb/^{206}Pb ratio, prepared from nearly pure separated ^{206}Pb and ^{208}Pb solutions, were used to calibrate the mass spectrometers.

Rate of nickel in Al-10 percent Si composites containing nickel-coated sapphire whiskers, H. Yakowitz, W. D. Jenkins, and H. Hahn, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 3, 269-272 (May-June 1968).

Key words: Al-10 percent Si alloy; electron probe microanalyzer; fiber composites; matrix-whisker bonding; Ni coated sapphire whiskers; optical metallography; sapphire whiskers.

The role of nickel in regard to whisker-matrix bonding in a composite of nickel-coated sapphire whiskers inserted into a matrix of aluminum-10 percent silicon alloy by means of liquid phase hot-pressing was investigated. The study was carried out with the aid of optical and electron microscopy, electron probe microanalysis, and microhardness measurements. Results show that most of the nickel is distributed within the matrix alloy.

Some of the nickel apparently interacts with the matrix and forms $NiAl_3$. The presence of $NiAl_3$ in this form increases the average hardness of the composite but apparently does not contribute significantly to strengthening of the alloy. Occasionally, clusters or clumps of nickel-rich material which also contains aluminum are found at or very near whisker-matrix interfaces. It is concluded that if any bonding of the nickel to the sapphire occurred, it was in these regions. Finally, a heat treatment to improve nickel to sapphire bonding and hence bonding of the entire composite is suggested.

July-August 1968

Mass spectrometric study of photoionization. X. Hydrogen chloride and methyl halides, M. Krauss, J. A. Walker, and V. H. Dibeler, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 4, 281-293 (July-Aug. 1968).

Key words: Dissociation energies; HCl; ionization; mass spectrometry; methyl halides; vacuum ultraviolet spectroscopy.

Photoionization efficiency curves are obtained for hydrogen chloride and several methyl halides, both ordinary and deuterated, from ionization threshold to 600 Å. Discussion is given on electronic structure of ions, autoionizing Rydberg states, and line-shape behavior. Ionization energies, heats of formation of ions, and bond dissociation energies are tabulated without regard to distribution of energy in internal modes, in relative kinetic energy, or other possible modes.

The fourth and fifth spectra of vanadium (V IV and V V), L. Iglesias, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 4, 295-308 (July-Aug. 1968).

Key words: Atomic spectra, V IV and V V; classified lines, V IV and V V spectra; spectra V IV and V V; terms, V IV and V V spectra; vanadium, the fourth and fifth spectra of.

The V IV spectrum has been extended by using as light sources a condensed spark and a hollow cathode discharge. With the new data, the experimental interpretation of levels of the $3d^2$, $3d\ 4d$, $3d\ 5s$, $3d\ 5p$, $3d\ 4f$, $3d\ 5d$ and $3d\ 6s$ configurations has been completed with the exception of three levels of the $3d\ 4f$ and $3d\ 5d$ configurations. Four levels of the $3d\ 5g$ electron configuration have also been found. These levels account for 340 of the 360 lines assigned to V IV in the region 675 Å – 5940 Å.

Three members of the $3d\ ns$ series give an ionization potential of 376730 ± 40 cm^{-1} = 46.70 volts.

The $4d\ ^2$D term of V V has also been located in the course of this work. With the aid of the new observations between 675 Å and 2200 Å the value of some levels already known has been improved.

Variation of absorptance-curve shape with changes in pigment concentration, G. L. Howett, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 4, 309-340 (July-Aug. 1968).

Key words: Absorption; adaptation; Beer's law; chromatic adaptation; color vision; concentration; cones; curve shape; high luminance; metameric matches; pigment; photopigment; vision.

A complete quantitative analysis is presented of changes in the shape of the spectral absorptance curve of any Beer's-law pigment solution (or other Bouguer's-law material) as concentration of the pigment, or thickness of the solution layer, is varied. The relative absorptance curve, normalized to unit maximum, is taken as defining the shape of the absolute absorptance curve, and the index of shape change is taken to be the difference between the normalized curves. All concentration changes from infinite decrease to infinite increase are covered, with some extreme cases requiring limit methods. Formulas and graphs are given for determining, as a function of concentration change and peak absolute absorptance of the original curve, where along the curve the shape change is greatest, and how large the maximum change is. Implications for color vision theory are discussed and it is shown that the assumption of low peak absorptances ($<10\%$) for the visual photopigments accounts for the constancy of the color-matching functions for moderate luminances, but not, in itself, for the breakdown of matches at high luminances; while the assumption of high peak absorptances ($\approx 80\%$), although it contradicts recent microspectrophotometric measurements, seems to account for both phenomena.

Periodic acid, a novel oxidant of polycyclic, aromatic hydrocarbons, A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.)),* **72A** (Phys. and Chem.), No. 4, 341-350 (July-Aug. 1968).

Key words: Aprotic solvents; aromatic hydrocarbons; malonic acid; periodic acid; pyrene radical; quinones; reaction mechanism; sodium metaperiodate.

Certain polycyclic, aromatic hydrocarbons can be oxidized with periodic acid in aprotic solvents containing a small proportion of water. A unique, two-fold character of response to periodic acid by these hydrocarbons has been found: (1) production of a coupling reaction through a radical intermediate [conversion of pyrene into 1,1′-bipyrene, and fluorene into 1,2-bis(2,2′-biphenylylene)ethylene] or (2) conversion into quinones by a two-equivalent oxidation mechanism that does not involve a radical intermediate [acenaphthene, anthracene, anthrone, benz[*a*]anthracene, naphthacene, naphthalene, and phenanthrene]. Little or no reaction was observed when oxidation was attempted with sodium metaperiodate instead of periodic acid.

Electron-spin resonance revealed no radical intermediate in the oxidation of malonic acid with either periodic acid or sodium periodate.

A galvanic cell with a low emf-temperature coefficient, G. N. Roberts and W. J. Hamer, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 4, 351-354 (July-Aug. 1968).

Key words: Cell with low temperature coefficient; double salt; galvanic cells; standard cells.

This paper presents data on a modified cadmium sulfate saturated standard cell of the Vosburgh type in which a tertiary amalgam containing 11.2 percent bismuth and 8.4 percent cadmium is used as anode and the double salt, $CdSO_4 \cdot Na_2SO_4 \cdot 2H_2O$ is added to the usual $CdSO_4$ electrolyte in an amount more than sufficient to saturate the solution with the double salt. Crystals of $CdSO_4 \cdot Na_2SO_4 \cdot 2H_2O$ are placed over the surface of both electrodes. The emf of the cell, as a function of temperature, is given by

$$E \text{ (in volts)} =. 1.018243 + 3.0956 \times 10^{-5} t - 8.559 \times 10^{-7} t^2 + 1.3534 \times 10^{-8} t^3.$$

At 25 °C the cell has an emf-temperature coefficient of +13.5 $\mu V/°C$ while the conventional saturated cadmium sulfate cell has a dE/dT of $-49.4\ \mu V/°C$. Data on the emf-temperature hysteresis of the cell on cooling and on heating are also given in graphical form. Data on the changes in Gibbs energy, enthalpy, entropy, and heat capacity for the cell reaction are given for the temperature range of 5 to 40 °C.

Synthesis of cerite, J. Ito, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 4, 355-358 (July-Aug. 1968).

> Key words: Ca, Mg phosphate; hydrothermal synthesis; inorganic synthesis; mineral chemistry; rare-earth silicate; x-ray powder analysis.

Some compounds isostructural with cerite have been synthesized hydrothermally at temperatures from 500 to 720 °C. The compositional range for cerite, and its phase relation to the silicate apatites are established in terms of ionic radii of rare-earth and divalent ions. The proposed formula for cerite on the basis of isomorphism with whitlockite, $Ca_3(PO_4)_2$, is discussed. A solid-solution series between $Ca_9P_6O_{24} - Ca_7Mg_2P_6O_{24}$ (whitlockite — Mg-whitlockite) has been established.

Tables of collision integrals for the (m,6) potential function for 10 values of m, M. Klein and F. J. Smith, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 4, 359-424 (July-Aug. 1968).

> Key words: Collision integrals; diffusion; potential; thermal conductivity; thermal diffusion; transport properties; viscosity.

Tables of collision integrals are presented for the (m,6) potential function for 87 reduced temperatures for each of 10 values of m. The exponents m used were $m = 9$, 12, 15, 18, 21, 24, 30, 40, 50, and 75. Comparisons are made with five other calculations for the case $m = 12$. The accuracy of the calculation appears to be at least several parts in 10,000.

Spectrum of relaxation times in GeO_2 glass, A. Napolitano and P. B. Macedo, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 4, 425-433 (July-Aug. 1968).

> Key words: Activation energy; annealing; germania glass; index of refraction; relaxation times; thermal expansion; two relaxation model; viscosity.

Index-of-refraction versus time isotherms have been established for germania glass. Using the crossover technique with air-quenched samples and applying the two relaxation time model previously reported for borosilicate glass, it was found that the width of the spectrum of relaxation times for germania glass was temperature dependent. Upon analyzing this in terms of a distribution of activation energies, the results showed that, similarly to B_2O_3, activation energies smaller than the activation energy present in the Arrhenius region appear at low temperatures.

Extensive viscosity measurements by the fiber elongation method were made from 10^{11} to 6×10^{14} poises. From this data a lower and more precise value of the activation energy ($E\eta =$ 72.3 kcal/mol) was obtained in the annealing range.

Resumé of values of the Faraday, W. J. Hamer, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 4, 435-439 (July-Aug. 1968).

> Key words: Coulometers; Faraday; inclusions in silver coulometers; values of Faraday.

A resumé is given of the determinations of the value of the Faraday. Values obtained by silver deposition, iodide oxidation, oxalate oxidation, the omegatron, and silver dissolution are reviewed. All values are converted to the unified ^{12}C international scale of atomic weights using the international atomic weights of 1967. Values of the Faraday are given in terms of both the NBS (legal) and absolute units of electrical measure. In the latter the new value for the acceleration due to gravity is used in computing the absolute value of electric current. On this basis and using the atomic weight of silver determined by Shields, Craig, and Dibeler, and converting to the ^{12}C scale, the value of the Faraday is 96,486.9 ± 1.6 absolute coulombs per gram-equivalent which differs by only 1 part per million from the value recommended by the National Academy of Sciences—National Research Council. If the atomic weight of silver recommended in 1967 by the International Atomic Weight Commission is used, the Faraday on the new gravity value is 96,486.5 ± 1.6 absolute coulombs per gram-equivalent which differs by 5 parts per million from that recommended by the National Academy of Sciences—National Research Council. No change in the value of the Faraday adopted by the NAS—NRC Committee is recommended.

September-October 1968

Studies in bomb calorimetry. A new determination of the energy of combustion of benzoic acid in terms of electrical units, K. L. Churney and G. Armstrong, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 5, 453-465 (Sept.-Oct. 1968).

> Key words: Benzoic acid, heat of combustion; bomb calorimetry, procedures and errors; bomb-calorimeter; electrical calibration; Dickinson calorimeter; heat of combustion.

The heat of combustion of NBS Standard Sample 39i of benzoic acid under standard bomb conditions has been determined in terms of electrical units. A value of $-26{,}434.0$ J g^{-1} was obtained. The total uncertainty in our determination is estimated to be ±3.3 J g^{-1}. The uncertainty due to random errors was 1.7 J g^{-1} and is based on the appropriate factors for the Student t distribution at the 95 percent confidence limits for eleven determinations of the energy equivalent of the calorimeter and six determinations of the heat of combustion of benzoic acid. The principal systematic error, neglect of surface temperature correction for our calorimeter, has been assigned a value of ±2.6 J g^{-1} until more reliable estimates of the correction can be made. Particular emphasis was placed on improving the precision of a calorimetric measurement over those previously obtained in this laboratory by the use of more sensitive auxiliary measuring equipment and more accurate procedures to evaluate the corrected temperature rise.

Effect of low pressures on the room temperature transitions of polytetrafluoroethylene, G. M. Martin and R. K. Eby, *J. Res. Nat. Bur. Stand. (U.S.)*, **72A** (Phys. and Chem.), No. 5, 467-470 (Sept.-Oct. 1968).

> Key words: Dilatometry; enthalpy; entropy; helical molecule; low pressure; phase diagram; polytetrafluoroethylene; transitions; triple point.

Between approximately 20 and 30 °C at atmospheric pressure, polytetrafluoroethylene exhibits a phase (denoted as IV), which has not been observed in P-V-T measurements at pressures above 10^8 Nm^{-2} (1 Kilobar). Data are presented to resolve this phase in the temperature range 0 to 50 °C and the pressure range 0 to 0.686×10^8 Nm^{-2}. The II-IV (20 °C) transition pressure increases with temperature according to the equation $P = (-820$

$+ 26.9t + 0.68t^2) \times 10^5$ and the IV-I (30 °C) transition according to the equation $P = (-91 - 57.8t + 1.99t^2) \times 10^5$ suggesting a possible triple point near 2.6×10^8 Nm^{-2} and 54 °C. However, the IV-I transition probably cannot be resolved by volume measurements at pressures above 2×10^8 Nm^{-2} because its volume of transition is small and the two transitions overlap. The enthalpies of the transitions are calculated for different pressures and some thermodynamic properties of phase IV are determined indirectly. It is shown that, if the effect of volume change is subtracted, random reversals of the hand of the helical conformation of the molecule can account for appreciable fractions of the enthalpy and corresponding entropy change for the combined transitions at atmospheric pressure.

Electrostatic potentials and their spatial derivatives about point defects in ionic crystals, H. S. Bennett, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 471-475 (Sept.-Oct. 1968).

Key words: CaF_2; classical ionic lattice theory; electrostatic potential; lattice distortion; NaCl; point defect.

The electrostatic potential which arises from a lattice array of point ions is computed in terms of a Taylor's series expansion for small distances from a lattice site. This expansion gives the change in electrostatic energy when an ion moves in the background of a perfect point ion lattice potential. The Taylor's series coefficients for terms up to fourth order in the ion displacement are evaluated for the NaCl and CaF_2 lattice structures.

Electric fields produced by a charge density in ionic crystals, H. S. Bennett, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 475-478 (Sept.-Oct. 1968).

Key words: CaF_2; dipole shell coefficient; electric fields; NaCl; polarization; spatially extended defects.

Spatially extended defects such as the *F* center give rise to an effective defect charge density which may produce important polarizations in the crystal. The electric field in the crystal depends upon these induced dipoles. Lattice summations for the contribution to the electric field which arises from ionic shells centered about the defect are evaluated for the NaCl and CaF_2 lattice structures.

Mass spectrometric study of the photoionization of some fluorocarbons and trifluoromethyl halides, C. J. Noutary, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 479-485 (Sept.-Oct. 1968).

Key words: CF_4; C_2F_6; C_3F_8; C_4F_{10}; CF_3H; CF_3Cl; CF_3Br; CF_3I; heats of formation; ionization energies; mass spectrometric; photoionization; vacuum ultraviolet.

The photoionization curves and the threshold energies for the molecule and several abundant fragment ions of CF_4, C_2F_6, C_3F_8, C_4F_{10}, CF_3H, CF_3Cl, CF_3Br, and CF_3I have been measured. The threshold energies are correlated and the ionic heats of formation and some bond dissociation energies are calculated. It is apparent that the values obtained for the CF_3^+ ions are not the adiabatic ones, but include large amounts of excess energy. This excess is the lowest for the CF_3^+ from CF_3I for which an explanation is suggested. Assuming that the excess is not zero for the last compound we obtain the following upper limits: $\Delta Hf_0^\circ(CF_3)^+ \leqslant +365.3$ kJ mol^{-1} = +87.3 kcal mol^{-1}; $I(CF_3)^+ \leqslant 8.62$ eV; $I(C_2F_5)^+ \leqslant 8.72$ eV; $I(C_3F_7)^+ \leqslant 8.70$ eV; $I(C_4F_9)^+ \leqslant 8.68$ eV. From the mean value $D(C_p - C_p) = 402 \pm 2$ kJ mol^{-1} = 96.0 ± 0.5 kcal mol^{-1} the bond dissociation energies $D(C_p - C_s) = 363 \pm 3$ kJ mol^{-1} = 86.8 ± 0.8 kcal mol^{-1} and $D(C_s - C_s) = 337 \pm 4$ kJ mol^{-1} = 80.6 ± 1.0 kcal mol^{-1} and $D(C_p - F) = 525$ kJ mol^{-1} = 125.7 kcal mol^{-1} are calculated.

Infrared matrix spectra of lithium fluoride, S. Abramowitz and N. Acquista, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 487-493 (Sept.-Oct. 1968).

Key words: Force field; infrared; lithium fluoride dimer; low temperature; matrix; vibrational assignment.

Evidence for a linear dimer Li_2F_2 has been obtained by extending the spectral measurements for matrix isolated lithium fluoride into the far infrared region. The vapors from solid ^6LiF, ^7LiF, and $^6LiF/^7LiF$ mixtures were deposited in argon matrices at liquid hydrogen temperatures. Vibrational assignments were made on the basis of the following linear species: $^6Li_2F_2$, $^7Li_2F_2$, $^{6,7}Li_2F_2$ and $^{7,6}Li_2F_2$. Although the specific geometry of the dimer could not be determined, a normal coordinate analysis supported the spectral interpretation of a linear structure ($C_{\infty v}$).

Electronic transition moment integrals for first ionization of CO and the A − X transition in CO⁺. Some limitations on the use of the *r*-centroid approximation, P. H. Krupenie and W. Benesch, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 495-503 (Sept.-Oct. 1968).

Key words: CO; CO^+; electronic transition moment integrals; Franck-Condon factors; Franck-Condon principle; transition probabilities.

Integrals necessary for the determination of transition moment matrix elements from experimental data have been evaluated numerically by use of vibrational wave functions derived from RKR potentials. A power series expansion for the electronic transition moment has been assumed. The significant quantities which can be related to an arbitrary center of expansion are vibrational overlap integrals and quantities of the form $\int \psi_{v} r^{n} \psi_{v''} dr$. Experimental band intensities and relative populations for vibrational levels of the initial electronic state are needed to determine the expansion coefficients. Transition moment integrals have been calculated for first ionization from the ground electronic state of CO and for the $A^2\Pi_i - X^2\Sigma^+$ transition of CO^+. Comparison of these integrals with previous calculations based on Morse functions has shown them to be rather sensitive to the wave-functions [potentials] used. Characteristics generally attributed to the *r*-centroid and related integrals are examined, and some limitations on the use of the *r*-centroid approximation are discussed, following a review of assumptions made in the use of that approximation.

The configurations $3d^n4p$ in doubly ionized atoms of the iron group, C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 505-520 (Sept.-Oct. 1968).

Key words: βQ and T corrections; configurations $3d^n4p$; energy levels; interaction parameters; iron group; third spectra.

Experimental levels of the configurations $3d^n4p$ in the third spectra of the iron group were compared with corresponding calculated values. Besides the electrostatic and spin-orbit interactions the $\alpha L(L + 1)$, βQ and T corrections were considered in the individual and general treatments. The insertion of the parameters β and T improved the results by about 25 percent. The root-mean-square (rms) error on fitting 581 experimental levels by means of 21 free interaction parameters was 138 cm^{-1}. Altogether 912 energy levels were predicted.

Electron impact excitation of hydrogen Lyman-α radiation, R. L. Long, Jr., D. M. Cox, and S. J. Smith, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 5, 521-535 (Sept.-Oct. 1968).

Key words: Atomic hydrogen; beams; electron impact excitation; experimental; high vacuum; Lyman-α.

An experimental investigation of electron impact excitation of the 2*p* state of atomic hydrogen is described. A beam of electrons was passed through a chopped beam of hydrogen atoms in a high vacuum apparatus. The modulated flux of Lyman-α photons emitted in the radiative decay of the $2p$ state was taken as a measurement of the excitation probability resulting from direct excitation plus indirect excitation resulting from cascading. The region surrounding the intersection of the two beams was electrically and magnetically shielded to prevent quenching of metastable $2s$ atoms and thereby to ensure that the observed Lyman-α flux resulted from decay of the short-lived $2p$ state. The experimental results are consistent with those obtained by Fite, Stebbings, and Brackmann [1959], and confirm the existence of a large discrepancy between theoretical and experimental results in the electron energy range below 50 eV.

November-December 1968

Interaction energy surfaces for Li(2^2S) and Li(2^2P) with H_2, M. Krauss, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 553-557 (Nov.-Dec. 1968).

Key words: Charge-transfer; energy surface; energy transfer; Hartree-Fock; $H_2(X^1\Sigma_g^+)$; Li(2^2P); Li(2^2S); resonance state.

Interaction energy surfaces for the interaction of Li(2^2S) and Li(2^2P) with H_2 are calculated using approximate Hartree-Fock trial functions. The crossing of energy curves is observed for C_{2v} conformations if the H_2 internuclear distance is sufficiently large. No crossing is observed for colinear collisions for any H_2 distance.

The wave function of the strongly attractive state involved in the crossing is related to the metastable negative-ion states that are postulated to account for resonant electron-molecule scattering. Such a charge-transfer state can only be bound for C_{2v} conformations for the H_2 molecule. The likelihood and geometry of the crossing complexes for other molecules interacting with alkalis is discussed in terms of the formation of these resonance charge-transfer states.

Energy levels and classified lines in the first spectrum of technetium (Tc I), W. R. Bozman, C. H. Corliss, and J. L. Tech. *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 559-608 (Nov.-Dec. 1968).

Key words: Atomic spectra; energy levels, Tc I; spectrum of technetium; technetium.

Progress in the classification of Tc I lines is reported. About 2200 of the known Tc I lines between 2154 and 8918 Å are now classified as transitions between 108 even and 147 odd energy levels. Tables of levels and classified lines are given.

The first spectrum of tungsten (W I), D. D. Laun and C. H. Corliss, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.). No. 6, 609-755 (Nov.-Dec. 1968).

Key words: Atomic spectra; energy levels; spectroscopy; spectrum of tungsten; tungsten; wavelengths.

The first spectrum of tungsten (W I) has been observed in the region between 2000 Å and 10500 Å. Of the 6800 spectral lines reported here, about 5500 have been classified as transitions between 91 even and 365 odd levels.

Theoretical interpretation of the even levels in the first spectrum of tungsten, Y. Shadmi and E. Caspi, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 757-760 (Nov.-Dec. 1968).

Key words: Atomic spectrum, W I; energy levels, W I; spectrum of tungsten; tungsten; W I.

The calculated even levels of W I up to the height of about 40,000 cm^{-1}, which is the height of the ground level of the d^6 configuration, are reported. Fifty-seven observed levels are fitted to them, with a mean error of 100 cm^{-1}. *L-S* coupling and configuration assignments are usually meaningless because of a between 108 even and 147 odd energy levels. very strong spin-orbit interaction and configuration interaction. For every level, the largest squared *L-S* coupling components of its eigenvector are reported, as well as observed and calculated *g*-values.

Stable carbon isotope ratio measurements with a gas density meter, S. P. Wasik and W. Tsang, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 761-764 (Nov.-Dec. 1968).

Key words: Carbon-13; carbon dioxide; ethyl acetate; gas chromatography; gas density meter; isotope ratios.

A method is presented for measuring C^{13}/C^{12} isotope ratio of organic compounds by burning the material in a stream of normal CO_2, separating the combustion products by gas chromatography and sequentially measuring the density of the enriched CO_2 peak with a gas density meter. Data are presented for the analysis of enriched ethyl acetate from 15 to 1 percent enrichment. The method is applicable for other stable isotope analysis.

The single crystal spectrum of hexakis(imidazole)nickel(II)nitrate, C. W. Reimann, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 765-768 (Nov.-Dec. 1968).

Key words: Crystal spectrum; hexakis(imidazole)nickel(II)nitrate; octahedral nickel(II); spin-forbidden bands.

The crystal spectrum of hexakis(imidazole)nickel(II)nitrate from 7000 cm^{-1} to 30,000 cm^{-1} at liquid nitrogen temperature has been measured. Three spin-allowed and three spin-forbidden bands in this spectrum were assigned on the basis of octahedral ligand field symmetry. These assignments are compared with those made in several related materials. Important differences and similarities in spectral detail and their bearing on assignments in other strong field nickel(II) complexes, are discussed.

Crystalline alpha and beta forms of 3-*O*-α-D-glucopyranosyl-D-arabinopyranose, H. S. Isbell, H. L. Frush, and J. D. Moyer, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 769-771 (Nov.-Dec. 1968).

Key words: Anomeric sugars; calcium maltobionate; maltose-*1*-^{14}C; mutarotation of 3-*O*-α-D-glucopyranosyl-D-arabinopyranose; Ruff degradation of; sugars; 3-*O*-α-D-glucopyranosyl-D-arabinopyranose.

Crystalline 3-*O*-α-D-glucopyranosyl-α-D-arabinopyranose monohydrate, mp 120 to 121 °C, and 3-*O*-α-D-glucopyranosyl-β-D-arabinopyranose, mp 155 to 157 °C, were prepared from a sirup obtained by the Ruff degradation of calcium maltobionate. For the *alpha* monohydrate, $[\alpha]_D{}^{20} = +\ 16.7 \times 10^{-0.024t} - 9.6 \times 10^{-0.098t} + 46.6$, and for the anhydrous *beta* form, $[\alpha]_D^{20} = -25.6 \times 10^{-0.025t} - 9.4 \times 10^{-0.097t} + 49.2$. The structure of the sugar was established by converting it into maltose.

Treatment of the *alpha* form with pyridine-acetic anhydride gave a heptaacetate, mp 127 to 128 °C, $[\alpha]_D^{20}\ +62.4°$ (*c* 2.5, chloroform). The *beta* form gave a heptaacetate, mp 194.5 – 195.5 °C, $[\alpha]_D^{20} + 13.4°$ (*c* 2.5, chloroform).

Preparation and solubility of hydroxyapatite, E. C. Moreno, T. M. Gregory, and W. E. Brown, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72A** (Phys. and Chem.), No. 6, 773-782 (Nov.-Dec. 1968).

Key words: Apatite; hydroxyapatite; calcium phosphates; solubility; solubility isotherms; solubility product.

Two portions of a synthetic hydroxyapatite (HA), $Ca_5OH(PO_4)_3$, fully characterized by x-ray, infrared, petrographic, and chemical analyses, were heated at 1,000 °C in air and steam atmospheres, respectively. Solubility isotherms for these two samples in the system $Ca(OH)_2$-H_3PO_4-H_2O were determined in the pH range 5 to 7 by equilibrating the solids with dilute H_3PO_4 solutions. Both samples of HA dissolved stoichiometrically. The activity products $(Ca^{++})^5(OH^-)(PO_4^{\equiv})^3$ and their standard errors—obtained by a least squares adjustment of the measurements (Ca and P concentrations and pH of the saturated solutions) subject to the conditions of electroneutrality, constancy of the activity product, and stoichiometric dissolution—were $3.7_3 \pm 0.5 \times 10^{-58}$ for the steam-heated HA and $2.5_1 \pm 0.4 \times 10^{-55}$ for the air-heated HA. Allowance was made in the calculations for the presence of the ion pairs $[CaHPO_4]^0$ and $[CaH_2PO_4]^+$. The higher solubility product for the air-heated HA is ascribed either to a change in the heat of formation brought about by partial dehydration or to a state of fine subdivision resulting from a disproportionation reaction. The solubility product constants were used to calculate the points of intersection (i.e., singular points) of the two HA solubility isotherms with the isotherms of $CaHPO_4 \cdot 2H_2O$ and $CaHPO_4$; it was found that the pH's of the singular points for the air-heated HA were a full unit higher than those of the steam-heated preparation. Conditions are described for the precipitation of HA crystals suitable for solubility measurements.

High temperature dehydroxylation of apatitic phosphates, T. Negas and R. S. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **72A** (Phys. and Chem.), No. 6, 783-787 (Nov.-Dec. 1968).

Key words: Apatite; dehydroxylation; high temperature; phosphates; x-ray diffraction.

$Sr_{10}P_6O_{24}(OH)_2$, (Hex. a = 9.765 Å, c = 7.280 Å), and $Ba_{10}P_6O_{24}(OH)_2$, (Hex. a = 10.177 Å, c = 7.731 Å), undergo cell parameter contractions at elevated temperatures in air. These can be correlated with progressive dehydroxylation, although neither can be completely dehydrated. $Pb_{10}P_6O_{24}(OH)_2$, (Hex. a = 9.878 Å, c = 7.432 Å), also does not completely dehydrate in air.

A new apatite-like strontium phosphate, (Hex. a = 9.872 Å, c = 7.199 Å), was prepared at elevated temperatures in vacuum.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 73A, JANUARY-DECEMBER 1969

January-February 1969

Specific heats of oxygen at coexistence, R. D. Goodwin and L. A. Weber, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 1-13 (Jan.-Feb. 1969).

> Key words: Coexistence; experimental; heat capacity; liquid phase; oxygen; saturated liquid; specific heat.

Specific heats of saturated liquid, along the coexistence path, are useful for computing thermodynamic properties throughout the compressed liquid phase. We report 86 experimental heat capacities of oxygen for the two-phase system, liquid plus vapor, from the triple-point to near the critical-point and corresponding derived values for the liquid phase. These results are represented by a formula which can be integrated for heat absorbed and for entropy. The changes in value of internal energy, enthalpy, and entropy of the saturated liquid are tabulated from the triple-point to the critical-point.

Specific heats C_v of fluid oxygen from the triple point to 300 K at pressures to 350 atmospheres, R. D. Goodwin and L. A. Weber, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 15-24 (Jan.-Feb. 1969).

> Key words: Compressed liquid; heat capacities; liquid; oxygen; specific heats; thermodynamic properties.

Experimental specific heats at constant volume for oxygen in single phase domains are reported from the triple point to 300 K at pressures to 350 atmospheres. An empirical equation with seven constants describes these specific heats over the entire domain of ρ-T coordinates to within the experimental accuracy of 1 to 2 percent. Values for the terminal slopes of *PVT* isochores at the coexistence boundary, $(\partial P/\partial T)_v$, are derived for the liquid.

Thermodynamic properties of fluid oxygen at temperatures to 250 K and pressures to 350 atmospheres on isochores at 1.3 to 3.0 times critical density, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 25-36 (Jan.-Feb. 1969).

> Key words: Compressed liquid; enthalpy; entropy; internal energy; oxygen; saturated liquid; thermodynamic properties.

The starting point for these calculations is liquid oxygen at the triple point. An analytical formula is used for specific heats of saturated liquid along the coexistence path to obtain internal energies and entropies of the saturated liquid. With these initial values, the calculations next are made as a function of temperature along isochores, using an "equation of state" for the specific heats $C_v(\rho, T)$ in the single-phase domain. Enthalpies are obtained by adding Pv to the internal energies. Results are tabulated at uniform densities and temperatures. Based on uncertainties of one percent in the specific heat data, the uncertainty of thermal properties also is taken to be 1 percent.

Two new standards for the pH scale, B. R. Staples and R. G. Bates, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 37-41 (Jan.-Feb. 1969).

> Key words: Acidity; carbonate; citrate; emf; hydrogen electrode; pH; standards for pH.

Two new primary standards for the NBS pH scale, supplementing the five already available, are proposed. The new reference solutions are the 0.05 molal solution of potassium dihydrogen citrate and a mixture of sodium bicarbonate and sodium carbonate, each 0.025 molal. The citrate solution has a pH of 3.776 at 25 °C and is more stable under certain conditions than either the tartrate or phthalate standards. The carbonate solution has a pH of 10.012 at 25 °C. It therefore extends the NBS pH scale above its present upper limit of 9.180 at this temperature. Reference values pH(S), based on emf measurements of cells with hydrogen electrodes and silver-silver chloride electrodes, have been assigned to these two standard solutions at 11 temperatures from 0 to 50 °C.

Calculation of diffusion coefficients in ternary systems from diaphragm cell experiments, P. R. Patel, E. C. Moreno, and T. M. Gregory, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 43-49 (Jan.-Feb. 1969).

> Key words: Diaphragm cell; diffusion coefficients; least squares calculation; ternary system.

Using a generalized least square procedure, a method is developed to estimate diffusion coefficients, D_{ij}, from concentration measurements made in a set of experiments of varying duration but with the same initial conditions. The method requires neither approximations nor restrictions in the flow equations. The D_{ij} and their errors are calculated simultaneously with the adjustment of the weighted observables—concentrations of the two solute components and time. A procedure is described to insure convergence in a given experimental set. The effect of the duration of the longest experiment, and errors in the observables on the estimated values of D_{ij} and their errors, are investigated. Application of the method to available data yielded values for D_{ij} in agreement with those previously calculated by more involved procedures.

Calculated line strengths for the transition array $(3d^3 + 3d^24s) = 3d^24p$ in Ti II, H. Mendlowitz, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 51-64 (Jan.-Feb. 1969).

> Key words: Calculated line strengths; configuration interaction; intermediate coupling; Ti II; $3d^3$, $3d^24s$, $3d^24p$ configurations; transition array.

The transition array for the transitions between the configurations $(3d^3+3d^24s)$ and $3d^24p$ in Ti II are presented here. The relative line strengths have been calculated in the intermediate coupling scheme, taking into account interaction between configurations. The relative phase and magnitude of the radial transition integrals $(s-p)$ and $(d-p)$ for the jumping electron in the *LS* coupling have been determined empirically.

Morphological stability of a cylinder, S. R. Coriell and S. C. Hardy, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 65-68 (Jan.-Feb. 1969).

> Key words: Cylinder; ice; interface kinetics; morphological stability; solute diffusion; surface tension.

The stability of the shape of a solid cylinder crystallizing in a supercooled liquid is treated. The effects of solute diffusion, slightly anisotropic surface tension and interface kinetics are included. The resulting stability equations are applied to the specific case of ice cylinders.

Distorted tetrahedra in strontium copper åkermanite, J. Ito and H. S. Peiser, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 69-74 (Jan.-Feb. 1969).

Key words: Åkermanite; crystal chemistry; crystal growth; cupric silicate; flux growth; ion polyhedron distortion; melilite; Mössbauer spectroscopy; silicate gels; silicate synthesis; x-ray powder data.

New analogs of åkermanite: $Sr_2CuSi_2O_7$ and $Sr_2CdSi_2O_7$ as well as many previously synthesized analogs were obtained by a simple technique consisting of heating in air of precipitated gels of the right composition. X-ray data revealed an anomaly of the Cu^{2+} and (to a lesser extent) Fe^{2+} åkermanites which is explained by a simple geometric argument in terms of a small ($\sim 3°$) angular distortion of the oxygen tetrahedron surrounding the smaller divalent cation. This interpretation is consistent with previous theoretical discussions and Mössbauer data on the iron analog prepared for this study. Single crystals of cobalt åkermanites can be grown from a sodium tungstate flux.

Tritium-labeled compounds XII. Note on the synthesis of D-glucose-2-*t* and D-mannose-2-6, H. S. Isbell, H. L. Frush, C. W. R. Wade, and A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 75-77 (Jan.-Feb. 1969).

Key words: D-Gluconic-*2-t* acid, synthesis of; D-Glucose-*2-t,* synthesis and radioanalysis of; D-Mannonic-*2-t* acid, synthesis of; D-Mannose-*2-t,* synthesis and analysis of; Sodium 2-*keto*-D-gluconate, reduction with lithium borohydride-*t*; sugars, tritium-labeled; tritium-labeled compounds, D-mannose-2-*t* and D-glucose-2-*t*.

D-Glucose-*2-t* and D-mannose-*2-t* have been synthesized from sodium 2-*keto*-D-gluconate (sodium D-*arabino*-hexulosonate). Reduction of the salt with lithium borohydride-*t* produced the epimeric, 2-labeled aldonic acids in almost equal proportions. The acids, separated by carrier techniques, were lactonized, and the lactones were reduced with sodium amalgam to the corresponding sugars. The specificity of the labeling was established by converting each sugar into D-*arabino*-hexulose phenylosazone and determining that the osazone was substantially tritium-free.

A survey of blemishes on processed microfilm, C. S. McCamy, S. R. Wiley, and J. A. Speckman, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 1, 79-97 (Jan.-Feb. 1969).

Key words: Aging blemishes; archival records; blemishes; microfilm blemishes; microscopic spots; redox blemishes.

As part of an investigation of the formation of six types of redox blemishes on microfilm, 7411 rolls of microfilmed records in 36 Federal Government agencies were microscopically inspected by 34 inspectors trained by the National Archives and the National Bureau of Standards. About 350,000 observations were statistically analyzed. Careful photographic processing, adequate washing, careful handling, cool and dry storage in inert containers, and adequate ventilation, are among the conditions that have been found beneficial in preventing blemish formation. Data are compiled in an appendix.

March-April 1969

Color representation of electron microprobe area-scan images by a color separation process, H. Yakowitz and K. F. J. Heinrich, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 113-123 (Mar.-Apr. 1969).

Key words: Color photography; metallography; petrography; photomicrography; scanning electron microprobe; x-ray microscopy.

Composite color photographs were prepared using x-ray area scanned images from the electron probe microanalyzer. Three-color composites are completely interpretable in terms of the primary color (red, green or blue) chosen to represent each element. The color pictures were obtained by preparing conventional black-and-white scanning images which were then used as color-separation-positives, with appropriate filters, to make color prints. Methods for preparing and interpreting color composites are considered. Specifically, color mixing, proper choice of filters to match film characteristics, exposure criteria, and choice for each partial image are discussed in detail. Finally, typical applications drawn from the fields of metallurgy, mineralogy, and biology are shown to illustrate the principles described. With the use of Polaroid film this procedure is quite convenient.

Configurations $3d^n4p$ in singly ionized atoms of the iron group, C. Roth, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 125-157 (Mar.-Apr. 1969).

Key words: Configurations $3d^n4p$; β and T corrections; energy levels; interaction parameters; iron group; second spectra.

Experimental levels of the configuration $3d^n4p$ in the second spectra of the iron group were compared with corresponding calculated values. Besides the electrostatic and spin-orbit interactions the α, β and T corrections were considered in the individual and general treatments. The insertion of the parameters β and T improved the results by about 21 percent. The rms error on fitting 703 levels by means of 21 free interaction parameters was 231 cm^{-1}. Altogether 912 energy levels were predicted.

Configurations $3d^n4p+3d^{n-1}4s4p$ in Sc II, Ti II, and V II, C. Roth, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 159-171 (Mar.-Apr. 1969).

Key words: Configurations $3d^n4p$ + $3d^{n-1}4s4p$; energy levels; interaction between configurations; iron group; second spectra.

Experimental levels of the configurations $3d^n4p$ + $3d^{n-1}4s4p$ for Sc II, Ti II, and V II were compared with corresponding calculated values. Electrostatic, spin-orbit interactions, as well as the α, β and T corrections, whenever possible, were considered for $3d^n4p$ and $3d^{n-1}4s4p$. The electrostatic interaction between the configurations $3d^n4p$ and $3d^{n-1}4s4p$ was included explicitly. The rms errors for Sc II, Ti II and V II were 4.6, 75 and 66 cm^{-1}, respectively.

Effective interactions in the even configurations of the third spectra of the iron group, Y. Shadmi, E. Caspi, and J. Oreg, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 173-189 (Mar.-Apr. 1969).

Key words: Atomic theory; iron group; third spectra.

Four hundred eighty-three levels belonging to the configurations $3d^n + 3d^{n-1}4s$ of all third spectra of the iron group were calculated, and 334 observed levels were fitted to them. In addition to the usually used approximation, we first introduced a complete set of two-body and three-body effective-interaction parameters between $3d$ electrons. Using only two-body effective interactions, we obtained a rms error of 175 cm^{-1}; while the addition of three-body effective interactions reduced the rms error to 46 cm^{-1}. When a parameter representing three-body effective interaction between $3d$ and $4s$ electrons was also introduced, the rms error was reduced to 38 cm^{-1}.

Test of a kinetics scheme: emission in $H(^2S)+NO(^2\Pi)$, M. Krauss, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 191-193 (Mar.-Apr. 1969).

Key words: Hartree-Fock; $HNO(^1A', ^3A'', ^1A')$; interaction energy; ionic state; radiative recombination; reaction barrier.

The mechanism to explain the afterglow in the collision of $H(^2S)$ and $NO(^2\Pi)$ is critically examined by calculating part of the energy surface of the $^3A''$ state. It is found that the long range interaction energies are consistently repulsive even though at shorter distances attractive ionic interactions dominate. It is concluded that the essential feature of the Clyne and Thrush mechanism is missing; intimate interaction of H(^{2}S) and NO($^2\Pi$) is not possible at room temperature along the $^3A''$ surface. This study was undertaken to provide an example where a theoretical calculation is required to critically test a kinetics mechanism.

A nuclear magnetic resonance and relaxation study of dimethoxyborane, T. C. Farrar and T. Tsang, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 195-199 (Mar.-Apr. 1969).

Key words: Boron-10; boron-11; dimethoxyborane; proton: pulsed nuclear magnetic resonance; scalar and quadrupolar coupling constants and relaxation effects.

Proton and boron-11 c.w. nuclear magnetic resonances have been studied in solid $H^{11}B(OCD_3)_2$ and $H^{10}B(OCD_3)_2$. For ^{11}B, only the $-1/2 \rightarrow 1/2$ transition, broadened by second order quadrupolar effects and by proton dipolar interaction can be seen; from the spectrum at several rf frequencies, the quadrupolar coupling constant $|e^2qQ/h|$ was found to be 3.0 ± 0.2 MHz (± always refers to rms errors). In $H^{10}B(OCD_3)_2$, the proton line shapes at 53 and 10 MHz are considerably different; this may be interpreted as due to changes in the directions of ^{10}B nuclear quantization. Nuclear magnetic relaxation studies have been made in the liquid phase. From the ^{10}B and ^{11}B relaxation times, the activation energy for molecular reorientation was found to be 8.7 ± 0.4 kJ/mol (2.1 ± 0.1 kcal/mol). Consistent values for $|e^2qQ/h|$ were obtained from relaxation measurements in liquid phase and from c.w. spectra in solid phase. The temperature dependence of proton relaxation times deviates significantly from the activation energy model at higher temperatures, where spin-rotation interactions may be important. Proton transverse relaxation times (T_2) have also been measured and are consistent with the Allerhand-Thiele theory.

The effects of low energy irradiation on organometallics. Organometal halides of group IVA, F. E. Brinckman, G. F. Kokoszka, and N. K. Adams, Jr., *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 201-206 (Mar.-Apr. 1969).

Key words: EPR; free radicals; germanium; irradiation; low-temperature reaction; organometallic compounds; silicon; tin.

A group of selected group IVA halides of the type $(CH_3)_nMCl_{4-n}$, where $n = 0$, 1, 3 and M = Si, Ge, Sn have been subjected to low-energy irradiation (254 and 370 nm) in the condensed phase at -196 °C. This survey also examined related compounds including $HSiCl_3$, $CH_2ClSiCl_3$, CH_3SiF_3, CH_3SiHCl_2 as well as cocondensed mixtures. It is demonstrated by EPR spectroscopy that these conditions suffice to cleave M–C bonds. By following spectral changes during or following irradiation, as a function of time, it is demonstrated that both primary and secondary reactions occur. Some general features of the spectra are discussed and certain conclusions are projected to additional studies on low temperature reactions in 1:1 cocondensed mixtures of organometal halides. Some preliminary supporting evidence from mass spectrometric observations is discussed.

Measurements of gaseous diffusion coefficients by a gas chromatographic technique, S. P. Wasik and K. E. McCulloh, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 207-211 (Mar.-Apr. 1969).

Key words: Argon; diffusion coefficient; gas chromatography; helium; krypton; nitrogen; oxygen.

A method is presented for measuring gaseous diffusion coefficients using a gas chromatographic technique. Diffusion coefficients were measured for the systems: argon, krypton, oxygen, and nitrogen diffusing into helium at temperatures from 77 to 400 K.

Phase relations in the Ru-Ir-O$_2$ system in air, C. L. McDaniel and S. J. Schneider, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 213-219 (Mar.-Apr. 1969).

Key words: Dissociation; oxidation; phase relations; Ru-Ir-O$_2$ system; RuO$_2$-IrO$_2$ system; solid solution.

The equilibrium phase relations were determined in an air environment for the system Ru-Ir-O$_2$. In air Ru oxidizes at moderate temperatures, to form RuO$_2$, which in turn dissociates at 1405 °C. Similarly Ir oxidizes to form IrO$_2$ and dissociates at 1020 °C. The dissociation of RuO$_2$ and IrO$_2$ are reversible processes. A ternary equilibrium phase diagram was constructed indicating selected oxygen reaction lines and isotherms. A binary representation of the Ru-Ir-O$_2$ system in air is given. Up to 1020 °C, RuO$_2$ reacts with IrO$_2$ to form a complete solid solution series having the rutile-type structure. At 1345 °C three solid phases, rutile$_{ss}$, Ru$_{ss}$, and Ir$_{ss}$, exist in equilibrium for compositions between approximately 2 and 45 mole percent IrO$_2$. Above 1405 °C dissociation is complete for all compositions and the phase relations are represented by the Ru-Ir system. At 1500 °C solid solution of Ru and Ir occurs with the addition of up to 45 mole percent Ir and up to 44 mole percent Ru, respectively.

Heats of reaction of natural rubber with sulfur, N. Bekkedahl and J. J. Weeks, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 221-231 (Mar.-Apr. 1969).

Key words: Aneroid calorimeter; calorimeter; heat measurements; heat of vulcanization; rubber; rubber-sulfur reaction; volume change on vulcanization; vulcanization.

An adiabatic copper calorimeter was used to determine the heats of vulcanization of pale crepe natural rubber with sulfur for mixtures varying in composition from 0 to 32 percent added sulfur. The side reaction that produces hydrogen sulfide was avoided by using reaction temperatures near 155 °C. Heats of reaction at 25 °C and at 155 °C are reported. The enthalpy change at 25 °C for compounds containing up to about 18 percent sulfur is given in joules per gram of vulcanizate by the equation, $\Delta H_{25} = -21.1 \cdot S$ with a standard deviation of 11 J/g. Here S is the percentage of combined sulfur. Above 18 percent sulfur the heat of reaction at 25 °C remains approximately constant at 380 ± 8 J/g. A comparison is made between the heat of vulcanization and the volume change on vulcanization, both as functions of combined sulfur, by making use of data in the literature.

A table of rotational constants of symmetric top molecules giving rise to microwave spectra, M. S. Lojko and Y. Beers, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 233-239 (Mar.-Apr. 1969).

Key words: Asymmetric, linear, and symmetric top molecules; "B" rotational constants; formaldehyde; microwave spectra; spectral lines; water.

This paper lists, in order of increasing value, the "B" rotational constants of most of the linear and symmetric top molecules which have been observed by microwave spectroscopy. Also are listed the microwave spectral lines which have been observed for the asymmetric tops water and formaldehyde. These data are useful for making a quick selection of a molecule which has a spectral line close to some previously selected frequency.

Energy levels, wave functions, dipole and quadrupole transitions of Fe^{+++} ions in sapphire, J. Lewiner and P. H. E. Meijer, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 2, 241-268 (Mar.-Apr. 1969).

Key words: Energy levels of Fe^{+++} in Al_2O_3; iron doped Al_2O_3; magneto elastic tensor; paramagnetic resonance; quadrupole transitions; spin hamiltonian; transition probabilities; ultrasonic (paramagnetic) resonance; ultrasonic transition probabilities; wave functions of Fe^{+++}.

A computation is made of energy levels, wave functions and transition probabilities of the Fe^{3+} ion in Al_2O_3. The crystal field parameters used were those determined by Symmons and Bogle at 4 K. The magnetic field direction is described by the angles θ and φ indicating the directions with respect to and around the c axis of the crystal. The values of θ go from 0 to $\pi/2$ with $\pi/12$ intervals, the angles φ are 0 and $2\pi/3$ corresponding to the two nonequivalent sites of the crystal. The transition probabilities are given for dipole radiation in three polarization directions and for ultrasonic work the six components of the quadrupole transitions were computed.

May–June 1969

New even levels and classified lines in the first spectrum of tungsten (W I), C. H. Corliss, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 3, 277-279 (May-June 1969).

Key words: Atomic energy levels in W I; classified lines of W I; spectrum, W I; tungsten, first spectrum; W I.

Ten new even levels, which classify 161 previously unclassified lines, have been found in the first spectrum of tungsten. Nine of these fit levels in the $(5d+6s)^6$ mixture of configurations calculated theoretically by Shadmi and Caspi.

The heat of combustion of beryllium in fluorine, K. L. Churney and G. T. Armstrong, *J. Res. Nat. Bur. Stand.* (*U. S.*), **73A** (Phys. and Chem.), No. 3, 281-297 (May-June 1969).

Key words: Analysis of methane-hydrogen mixtures; beryllium fluoride; beryllium metal; combustion calorimetry; fluorine; heat of formation; molecular-sieve gas analysis; polytetrafluoroethylene.

An experimental determination of the energies of combustion in fluorine of polytetrafluoroethylene film and powder and of mixtures of beryllium with polytetrafluoroethylene gives for reaction (1) $\Delta H^\circ_{25^\circ C} = -1022.22$ kJ mol^{-1} (-244.32 kcal mol^{-1}) with an overall precision of 0.96 kJ mol^{-1} (0.23 kcal mol^{-1}) at the 95 percent confidence limits. The total uncertainty is estimated not to exceed ± 3.2 kJ mol^{-1} (± 0.8 kcal mol^{-1}). The measurements on polytetrafluoroethylene give for reaction (2a) and reaction (2b) $\Delta H^\circ_{25^\circ C} = -10369.7$ and -10392.4 Jg^{-1}, respectively. Overall precisions expressed at the 95 percent confidence limits are 3.3 and 6.0 Jg^{-1}, respectively.

$$Be(c) + F_2(g) = BeF_2(\text{amorphous}) \qquad (1)$$

$$C_2F_4(\text{polymer powder}) + 2F_2(g) = 2CF_4(g) \qquad (2a)$$

$$C_2F_4(\text{polymer film}) + 2F_2(g) = 2CF_4(g) \qquad (2b)$$

Be_2C and Be metal were observed in a small carbonaceous residue from the combustion of the beryllium-polytetrafluoroethylene mixtures. Methods of analysis for these substances were developed. Gases resulting from the solution of the solid residues in aqueous KOH were analyzed for H_2 and CH_4 by differential absorption in molecular sieves at low temperatures.

Deuterium isotope effect on the dissociation of weak acids in water and deuterium oxide, R. A. Robinson, M. Paabo, and R. G. Bates, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 3, 299-308 (May-June 1969).

Key words: Acidic dissociation; acidity; deuterium isotope effect; dissociation constants; heavy water; isotope effect pK values.

The dissociation constants of *o*-nitroanilinium ion, *m*-nitroanilinium ion, and 4-chloro-2,6-dinitrophenol in deuterium oxide at 25 °C have been determined by a spectrophotometric method, and an emf method has been used to obtain $(pK_1 + pK_2)/2$ for citric acid in deuterium oxide. In addition, data for the dissociation constants of other weak acids in ordinary and heavy water have been critically examined with a view to clarifying the relationship between the deuterium isotope effect and the intrinsic strength of the acid. The difference ΔpK between the pK value in deuterium oxide and that in water varies linearly with pK above $pK = 7$. Two stronger inorganic acids (sulfuric and phosphoric) also appear to lie on an extension of this same line. On the contrary, a considerable group of organic acids with pK less than 7 have values of Δpk that are more or less constant near $\Delta pK = 0.55$. It appears, therefore, that the isotope effect is more complex than has heretofore been assumed.

Vortex motions in ideal Bose superfluid, M. J. Cooper, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73A** (Phys. and Chem.), No. 3, 309-312 (May-June 1969).

Key words: Coherent Bose gas; superfluid; vortices.

A general nonlinear field equation is derived for the macroscopic order parameter of an ideal coherent Bose gas. It is shown that this noninteracting system can support stable quantized vortex-like motions within the superfluid phase. It is suggested that this coherent phase of the ideal Bose gas describes the dominant physical features of real superfluid liquid helium.

Franck-Condon factors for the ionization of H_2O and D_2O, R. Botter and H. M. Rosenstock, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 3, 313-319 (May-June 1969).

Key words: D_2O; Franck-Condon principle; geometry; H_2O; ion; photoionization; photoelectron spectroscopy.

Franck-Condon factors have been calculated for vertical transitions of H_2O and D_2O involving both bond length and angle changes. It is shown that even in the harmonic oscillator approximation different Franck-Condon factors are obtained for positive and negative angle changes. The results are used to obtain the geometry of the ion ground state. Satisfactory agreement is obtained for the isotope effect on the vibrational transition probabilities. The effects of anharmonicity are discussed semiquantitatively.

Topological features of hot carrier induced anisotropic breakdown on silicon diode surfaces, G. G. Harman, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 3, 321-331 (May-June 1969).

Key words: Anisotropy; crystallographic orientation; hot carriers; semiconductor breakdown; silicon diodes.

Both Gunn and Morozov have reported breakdown paths (tracking) on the surface of germanium under hot carrier conditions. Many silicon and gallium arsenide device failures appear to have been caused by similar breakdown tracks extending between contacts or across junctions. In the present work on silicon, extremely anisotropic tracking has been observed on the surface of long, thin, forward biased, $n^+ - p - p^+$, silicon diodes. The tracks propagate only in $\langle 100\rangle$ crystallographic directions, independent of the applied field orientation, the temperature, or the crystal growth direction. For example, on a sample with a $\{100\}$ surface plane, having the field oriented along a $\langle 110\rangle$ direction, the tracks propagate along $\langle 100\rangle$ directions which are 45° away from the applied field. Tracks on $\{100\}$-plane, disk shaped diodes, propagate radially from the center (positive biased) ohmic contact region and mark off the $\langle 100\rangle$ directions within 2°. Tracking requires both high current densities ($\sim 5 \times 10^3$ A/cm^2) and high fields ($\sim$ 15 kV/cm), and occurs most readily on the p-region of 10 Ω cm, $n^+ - p - p^+$, ⟨100⟩ oriented diodes. Diodes with $n^+ - n - p^+$ structures having n-regions ~ 1 Ω cm, and $n^+ - n - n^+$, structures of ~ 1 Ω cm will also track, but require much higher fields and the ⟨100⟩ tracking orientation is not clearly defined. Tracking does not occur on diodes having the field oriented along a ⟨111⟩ direction.

Two basic types of tracks are observed. The first resembles a series of tiny explosion craters ($\sim 10 \mu$ m diam). The second appears to be continuous in nature, even though it is extended by each applied pulse. These tracks may be several micrometers wide and deep.

It is also shown that hot-minority-carrier sample explosions are anisotropic and not, as generally assumed, caused by thermal breakdown. Typically a {110}⟨111⟩ oriented $n^+ - p - p^+$ sample requires 4 to 6 times more impulse energy to explode than a {100}⟨100⟩ oriented sample.

The third spectrum of praseodymium (Pr III) in the vacuum ultraviolet, J. Sugar, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 3, 333-381 (May-June 1969).

Key words: Energy levels; interaction parameters; praseodymium; third spectrum; vacuum ultraviolet; wavelengths.

Measurements of the spectrum of doubly ionized praseodymium from 821 to 2103 Å are given. One hundred fifty-three energy levels deduced from these wavelengths and an earlier line-list of longer wavelengths are presented. These levels are identified with the configurations $4f^26s$, $4f^27s$, $4f^28s$, $4f^26p$, $4f^26d$, $4f^25f$, $5d^24f$, and $4f5d6s$ and are given term designations. Radial energy integrals belonging to these configurations are parametrically deduced from the known levels.

A value of 21.625 eV (174420 cm^{-1}) for the ionization energy of Pr III, with an estimated uncertainty of 0.016 eV (130 cm^{-1}), is derived from the $4f^2ns$ series ($n = 6, 7, 8$).

July-August 1969

Classical path methods in line broadening. I. The classical path approximation, E. W. Smith, C. R. Vidal, and J. Cooper, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 4, 389-404 (July-Aug. 1969).

Key words: Classical path methods; line broadening theory.

The classical path approximation is reviewed in a manner which permits definitive statements concerning its region of validity.

Classical path methods in line broadening. II. Application to the Lyman series of hydrogen, E. W. Smith, C. R. Vidal, and J. Cooper, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 4, 405-420 (July-Aug. 1969).

Key words: Classical path; impact theory; line broadening theory; one-electron theory.

The use of the classical path approximation in line broadening theory is illustrated in a development of the familiar impact and one-electron theories. The one-electron theory which is presented is an improved version of the usual one-electron theory; this improved version of the theory provides a consistent description of a line profile from the halfwidth to the quasi-static wings. The validity criteria for the impact and one-electron theories are discussed in detail and a comparison of the theories is made with a view toward the development of a more general theory containing elements of both. To avoid unnecessary mathematical complications and to provide a more transparent comparison of the theories, the Stark broadening of the Lyman series in hydrogen is used as a specific example.

The second virial coefficient for the realistic pair potential, H. W. Woolley, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 4, 421-423 (July-Aug. 1969).

Key words: Hypergeometric series; London interaction; pair potential function; realistic potential; second virial coefficient; spherical potential.

An analytical formulation for the second virial coefficient is given for a spherically symmetric potential function of a simple form which has been called a realistic pair potential. This potential, given as an inverse relationship with r as a function of U, is capable of being much softer than a Lennard-Jones in the extreme of close approach. Differing forms of the result are given, including an expression by means of the generalized hypergeometric series. The result is also expressed in terms of the second virial coefficient for the (12, 6) potential.

Synthesis of barium ferrates in oxygen, T. Negas and R. S. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 4, 425-430 (July-Aug. 1969).

Key words: Ferrates; hexagonal barium ferrate; perovskite; phase equilibria; tetravalent iron.

Phase relations in the system $BaO-Fe_2O_3-$"FeO_2" at 1 atm (1 atm $= 1.013 \times 10^5$ N/m^2) oxygen and between 800 to 1050 °C are shown in the vicinity (high Ba portion) of the 1:1 cation-cation ratio composition. A hexagonal $BaTiO_3$-like phase, $BaFeO_{3-x}$($a = 5.676$ Å, $c = 13.934$ Å), exists below 960 °C. A perovskite-like phase $BaFeO_{3-x'}$ occurs between 960 and 1050 °C. Single-phase tetragonal perovskite can be obtained at room temperature by quenching compositions with Ba-Fe ratios of 67:66 ($a = 3.985$ Å, $c = 4.005$ Å, 1000 °C) and 27:26 ($a = 3.988$ Å, $c = 4.003$ Å, 1000 °C) from above 960 °C. At the 17:16 ratio, single phase cubic perovskite (a = 3.994 Å, 1000 °C), can be synthesized. Influence of temperature, additions of barium, and use of Pt-containers on phase relations are discussed.

The system SrO – "chromium oxide" in air and oxygen, T. Negas and R. S. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 4, 431-442 (July-Aug. 1969).

Key words: Chromium oxide; phase equilibria; strontium chromates; strontium-"chromium oxide" system, $SrCrO_4$, $Sr_3Cr_2O_8$.

Phase relations in the system SrO – "chromium oxide" were determined in air and 1 atm O_2 (1 atm $= 1.013 \times 10^5$ N/m^2) and are shown as isobaric projections on the $SrO-Cr_2O_3$ pseudobinary. At both oxygen pressures, the system consists of three joins in the $SrO-Cr_2O_3$-oxygen ternary, (1) $SrO-Sr_3Cr_2O_8$, (2) $Sr_3Cr_2O_8-SrCrO_4$, and (3) $SrCrO_4-Cr_2O_3$. The former is binary from 1065 °C to liquidus temperatures in air and includes a eutectic near 79 mol percent SrO (in terms of $SrO-Cr_2O_3$ starting materials). $Sr_3Cr_2O_8$ melts congruently at 1453 °C. Below 1065 °C in air, phase relations are complicated by reactions with atmospheric water vapor resulting in the formation of $Sr_{10}Cr_6O_{24}(OH)_2$ which decomposes to SrO and $Sr_3Cr_2O_8$ above 1065 °C. In air, below 775 °C, $Sr_3Cr_2O_8$ reacts with water vapor and oxygen to form $Sr_{10}Cr_6O_{24}(OH)_2$ and $SrCrO_4$. Water vapor reactions are restricted in 1 atm O_2. The $Sr_3Cr_2O_8-SrCrO_4$ join contains a binary eutectic between 69-70 mol percent SrO but liquidus relations are ternary below 69 (air) and 68 (oxygen) mol percent SrO, as reduction of Cr^{6+} occurs. Likewise, the $SrCrO_4-Cr_2O_3$ join is not binary at solidus and liquidus temperatures. In air, $SrCrO_4$ melts at 1251 °C to Cr_2O_3 plus liquid with release of oxygen. In oxygen, the compound melts at 1283 °C with evolution of oxygen.

September-October 1969

Conversion of existing calorimetrically determined thermodynamic properties to the basis of the International Practical Temperature Scale of 1968, T. B. Douglas. *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 451-470 (Sept.-Oct. 1969).

Key words: Existing property tables; IPTS−48; IPTS−68; practical-scale differences; temperature-scale conversion; thermodynamic properties.

Formulas are derived for converting the relative enthalpy, heat capacity, entropy, and Gibbs energy from the basis of one practical temperature scale to the basis of another, when these properties on either scale have been derived from calorimetric measurements of enthalpy as though that scale were the thermodynamic one. These formulas are directly applicable for converting certain other properties as well. The conversion relates the values of the property at the same numerical temperature on both scales. The formulas, given as exact infinite series, are applicable to widely differing scales, one of which may vary linearly with a temperature-measuring quantity such as electrical resistance. However, great simplification is well within most calorimetric accuracy when the conversion is from the International Practical Temperature Scale of 1948 to the corresponding scale of 1968, which has recently replaced it, provided the heat capacity is not changing abnormally rapidly, as in a transition region. For convenient application to conversion between these two scales, relatively simple numerical equations are derived giving the differences between the two scales at temperatures from 90 K to 10,000 K. The problem of avoiding the introduction of discontinuities with temperature in converted tables, arising from the existing discontinuities in the temperature derivative of the differences between the two scales, is discussed.

Measured enthalpy and derived thermodynamic properties of alpha beryllium nitride, Be_3N_2, from 273 to 1200 K, T. B. Douglas and W. H. Payne, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem), No. 5, 471-477 (Sept.-Oct. 1969).

Key words: Beryllium nitride; drop calorimetry; enthalpy data; light-element compounds; refractory crystals; thermodynamic properties.

The relative enthalpy of a sample of alpha beryllium nitride, Be_3N_2, of 95 percent purity was precisely measured over the temperature range 273 to 1173 K using a drop calorimetric method. Corrections were applied for the impurities, and the resulting heat capacity—temperature function was required to join smoothly that from recent precise NBS adiabatic calorimetry which covered the range 20 to 315 K. The enthalpy, heat capacity, entropy, and Gibbs free-energy function were computed from empirical functions of temperature and tabulated from 273 to 1200 K.

Measured enthalpy and derived thermodynamic properties of solid and liquid lithium tetrafluoroberyllate, Li_2BeF_4, from 273 to 900 K, T. B. Douglas and W. H. Payne, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 479-485 (Sept.-Oct. 1969).

Key words: Drop calorimetry; enthalpy data; lithium beryllium fluoride; lithium tetrafluoroberyllate; premelting; thermodynamic properties.

The enthalpy of a sample of lithium tetrafluoroberyllate, Li_2BeF_4, of 98.6 percent purity was measured relative to 273 K at eleven temperatures from 323 to 873 K. Corrections were applied for the impurities and for extensive premelting below the melting point (745 K). The enthalpy and heat capacity, and the entropy and Gibbs free-energy function relative to the undetermined value of $S^\circ_{298.15}$, were computed from empirical functions of temperature derived from the data, and are tabulated from 273 to 900 K.

Nonanalytic vapor pressure equation with data for nitrogen and oxygen, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 487-491 (Sept.-Oct. 1969).

Key words: Critical point; equation; formula; liquid; nitrogen; nonanalytic; oxygen; vapor pressure.

The specific heat of a two phase liquid-vapor system at constant volume apparently increases without limit at temperatures approaching the critical point, suggesting (via a thermodynamic relation) that the vapor pressure derivative d^2P/dT^2 may behave similarly. This nonanalytic behavior at the critical point is used in the present vapor pressure formula to gain simplicity and accuracy, as seen by use of data for nitrogen and oxygen.

Some precise measurements of the vapor pressure of water in the range from 25 to 100 °C, H. F. Stimson, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 493-496 (Sept.-Oct. 1969).

Key words: Manometer; precision manometer; pressure; *p-t* relation; *p-t* relation of water; standard resistance thermometers; temperature; vapor pressure; vapor pressure of water; water.

The vapor pressure of water was measured at seven temperatures in the range from 25 to 100 °C using the boiler and precision manometer with which standard resistance thermometers were calibrated at the NBS in the 1940's. A table gives measured values of pressure, adjusted to even degrees, and indicates estimates of the standard deviations of pressure and of the corresponding temperatures. Except for the measurement at 25 °C, the values of pressure were consistent within one part in 50 000. The temperature measurements had an estimated standard deviation of 0.000 40 degree.

The configurations $(3d+4s)^n\,4p$ in neutral atoms of calcium, scandium, and titanium, C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 497-510 (Sept.-Oct. 1969).

Key words: Configurations $(3d+4s)^n4p$; energy levels; first spectra; *g*-factors; interactions between configurations; iron group.

Experimental levels of the configurations $(3d+4s)^n4p$ for neutral atoms of calcium, scandium, and titanium were compared with corresponding calculated values. The rms errors in the calculated values for Ca I, Sc I, and Ti I were 23, 126, 126 cm^{-1}, respectively.

Absolute isotopic abundance ratio and atomic weight of terrestrial rubidium, E. J. Catanzaro, T. J. Murphy, E. L. Garner, and W. R. Shields, *J. Res. Nat. Bur. Stand. (U.S.),* **73A** (Phys. and Chem.), No. 5, 511-516 (Sept.-Oct. 1969).

Key words: Absolute ratio; atomic weight; isotopic abundances; rubidium.

An absolute value has been obtained for the isotopic abundance ratio of terrestrial rubidium, using solid-sample thermal ionization mass spectrometry. Samples of known isotopic composition, prepared from nearly isotopically pure separated rubidium isotopes, were used to calibrate the mass spectrometers. The resulting absolute $^{85}Rb/^{87}Rb$ ratio is 2.59265 ± 0.00170 which yields atom percents of: $^{85}Rb = 72.1654 \pm 0.0132$ and $^{87}Rb = 27.8346 \pm 0.0132$. The atomic weight calculated from this isotopic composition is 85.46776 ± 0.00026. The indicated uncertainties are overall limits of error based on 95 percent confidence limits for the mean and allowances for the effects of known sources of possible systematic error.

Fundamental aspects of dislocation theory: A conference report with abstracts, J. A. Simmons, R. deWit, and R. Bullough, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 5, 517-552 (Sept.-Oct. 1969).

Key words: Abstracts; conference; dislocations; fundamental aspects; theory.

A brief description of the Conference "Fundamental Aspects of Dislocation Theory" held at NBS, April 21-25, 1969, is given. This is followed by the abstracts of the papers, which will be published in 1970 in the hardbound Proceedings.

November-December 1969

Scaling analysis of thermodynamic properties in the critical region of fluids, M. Vicentini-Missoni, J. M. H. Levelt Sengers, and M. S. Green, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 563-583 (Nov.-Dec. 1969).

Key words: CO_2; chemical potential; critical point parameters; critical region; fluids; He^4; scaling laws; specific heat; thermodynamic properties; vapor pressure; xenon.

A review of the scaled equation of state proposed for the critical region of fluids and magnets is given using the language appropriate for fluids. The experimental evidence for the validity of the basic hypothesis underlying this equation of state is discussed in detail. Experimental data in the critical regions of CO_2, Xe, and He^4 are then analyzed using a closed-form expression for the chemical potential as a function of density and temperature, based on scaling ideas. Agreement between the proposed equation and the experimental data is found for the three substances. The results of the scaling of $\Delta\mu$, $\Delta\rho$, t data are shown not to be in contradiction with the analysis, also based on scaling ideas, of independent experimental measurements of both specific heat and vapor pressure.

Formulation of a nonanalytic equation of state for parahydrogen, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 585-591 (Nov.-Dec. 1969).

Key words: Critical point; equation of state; hydrogen; parahydrogen; specific heats; thermodynamic properties.

A method is described for building an equation of state which gives an infinite specific heat C_r at the critical point approached from the one-phase domain. Interpolated *PVT* data are used on isochores up to 100 K at densities to the liquid triple point. In addition to an accurate representation of these data, the equation gives specific heats which agree well with experimental data along near-critical isochores.

Dynamical model for Brillouin scattering near the critical point of a fluid, R. D. Mountain, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 593-598 (Nov.-Dec. 1969).

Key words: Brillouin scattering; critical opalescence; critical phenomena; density fluctuations in fluids; light scattering; volume viscosity.

A dynamical model for density fluctuations in a one-component fluid near the critical point is proposed and compared with existing measurements in carbon dioxide. The model is described by a set of linearized hydrodynamic equations modified to include a nonlocal pressure density relationship and to include relaxation in the volume viscosity. Parameters for the model are found which are consistent with bulk measurements. With these parameters the model reproduces, within experimental uncertainty, the observed Brillouin spectrum of critical opalescence in CO_2. The low frequency volume viscosity is found to diverge as the $-1/3$ power of $T-T_c$. An additional modification of the hydrodynamic equations, a frequency dependent thermal conductivity, is considered, but no definite conclusions can be reached as the Brillouin line-width data lack sufficient precision.

Odd configurations in singly-ionized copper, C. Roth. *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 599-609 (Nov.-Dec. 1969).

Key words: Copper; energy levels; interaction between configurations; odd configurations; parameters; second spectra.

Experimental levels of the configurations $3d^94p$, $3d^95p$. $3d^96p$, $3d^84s4p$, $3d^94f$, and $3d^95f$ of Cu II were compared with corresponding calculated values. The electrostatic interactions between the configuration $3d^84s4p$ and the configurations $3d^94p$, $3d^95p$, and $3d^96p$ were considered explicitly. It was shown that the configurations $3d^94f$ and $3d^95f$ of Cu II do not interact strongly with other configurations.

Capillary depressions for nearly planar menisci, M. C. I. Siu, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 611-613 (Nov.-Dec. 1969).

Key words: Bessel functions; calculus of variations; capillary depression; Laplace's equation; meniscus; meniscus height; nearly planar meniscus.

It is demonstrated analytically that the capillary depression C of a nearly planar meniscus is linearly related to its meniscus height h by the relationship $C=h/[1-I_0(r/a)]$. Here $a^2=\gamma/\rho g$, ρ and γ are the density and surface tension of the liquid respectively, g. the acceleration due to gravity. r is the radius of the capillary tube at the liquid-solid-gas interface, and $I_0(z)$ is the modified Bessel function of the first kind and zero order.

Phase transformation in barium tetraborate, C. R. Robbins and E. M. Levin, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 615-620 (Nov.-Dec. 1969).

Key words: BaB_8O_{13}; heats of transformation; orthorhombic form; polymorphism; tetragonal form.

Orthorhombic BaB_8O_{13} ($a=8.550$, $b=17.352$, $c=13.211$ Å, $D=2.927$ g/cm³ at 25 °C) transforms reversibly at 700 °C to a high-temperature tetragonal form ($a=8.629$, $c=13.252$ Å, $D=2.906$ g/cm³) stable from 700 °C to the congruent melting point (889 °C) of the compound. The transition is rapid and probably displacive in character. At the transformation point cell constants change discontinuously, doubling of the b axis is lost and cell contents are reduced from $Z=8$ to $Z=4$. Doubling of the b axis reappears with cooling to the transformation temperature and volume strain is relieved by formation of multiple twins or domains. The latent heat of transformation is 2100 J/mol (0.50 kcal/mol) and $dT/dP=-0.0363$ K/bar.

Crystallography and preparation of some $ABCl_3$ compounds, H. F. McMurdie, J. de Groot, M. Morris, and H. E. Swanson, *J. Res. Nat. Bur. Stand. (U.S.)*, **73A** (Phys. and Chem.), No. 6, 621-626 (Nov.-Dec. 1969).

Key words: Chlorides, crystal structures; double chlorides; lattice constants; melting point; perovskites; polymorphism; x-ray diffraction.

Compounds of the composition $ABCl_3$, in which A is K, Rb, NH_4, or Cs and where B is a divalent element, have been reviewed. Ten new compounds were prepared on which there was little or no previous crystallographic information. Refined unit cell parameters were obtained on these and on fifteen other compounds in this group. A general review of the structural information on this group is presented in tables, and a comprehensive list of references is included.

3.2. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICAL SCIENCES, VOLUME 72B, JANUARY-DECEMBER 1968

January-March 1968

Means and the minimization of errors, M. Aissen, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 1-4 (Jan.-Mar. 1968).

Key words: Arithmetic mean; geometric mean; harmonic mean; means; relative error.

Let $0 < a < b$. How should a number p be chosen so that the maximum 'relative error' obtained, by replacing a number x varying in the closed interval $[a, b]$, by p, is a minimum? For a large number of 'relative errors,' p must be chosen as the geometric mean of a and b.

On Taylor's theorem, O. Shisha, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 5 (Jan.-Mar. 1968).

Key words: Iterated integrals; remainders; Taylor series.

A simple way of looking at and proving Taylor's theorem.

Principal submatrices III: linear inequalities, R. C. Thompson, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 7-22 (Jan.-Mar. 1968).

Key words: Cauchy inequalities; Hermitian matrices; interlacing theorems; matrices; matrix inequalities; matrix theory; principal submatrices.

Let H be an $n \times n$ Hermitian matrix with eigenvalues $\lambda_1 \leqslant \lambda_2 \leqslant \ldots \leqslant \lambda_n$. Let $H(i|i)$ denote the principle submatrix of H obtained by deleting row i from H. Let $\xi_{i1} \leqslant \xi_{i2} \leqslant \ldots \leqslant \xi_{i,n-1}$ be the eigenvalues of $H(i|i)$. The famous Cauchy inequalities assert that $\xi_{i1}, \ldots, \xi_{i,n-1}$ interlace $\lambda_1, \ldots, \lambda_n$. It was recently proved by the present author that, for each fixed j, the arithmetic mean $n^{-1} \sum_{i=1}^{n} \xi_{ij}$ of the ξ_{ij} lies between $(1-\theta)\lambda_j + \theta\lambda_{j+1}$ and $\theta\lambda_j + (1-\theta)\lambda_{j+1}$, where $\theta = 1/n$. In the present paper the cases of equality in these inequalities for the arithmetic mean of the ξ_{ij} are discussed.

The diophantine equation $P(x, y) = (xy + d)z$, C. F. Osgood, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 23-28 (Jan.-Mar. 1968).

Key words: Algebraic equations; diophantine equations; integers; three variables.

Under certain conditions the algebraic equation $P(x, y) = (xy + d)z$, where $P(x, y)$ is a polynomial in x and y with integral coefficients and d is an integer, is shown to have an infinite number of distinct solutions with x, y, and z each an integer.

A note on the G**-transformation,** H. L. Gray and T. A. Atchison, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 29-31 (Jan.-Mar. 1968).

Key words: Improper integrals; nonlinear transformation.

Recent literature concerning the use of nonlinear transformations to evaluate numerically certain improper integrals of the first kind has shown that difficulties are encountered if the integrand f is such that

$$\lim_{t \to \infty} \frac{f(t+k)}{f(t)} = 1.$$

This note introduces a new nonlinear transformation which is in some cases quite useful when the above limit is one. A simple example is given to illustrate the use of this transformation.

The distribution of the sample correlation coefficient with one variable fixed, D. Hogben, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 33-35 (Jan.-Mar. 1968).

Key words: Analysis of variance; calibration; correlation coefficient; degrees of freedom; distribution; fixed variable; noncentral beta variable; noncentrality; Q variate.

For the usual straight-line model, in which the independent variable takes on a fixed, known set of values, it is shown that the sample correlation coefficient is distributed as Q with $(n-2)$ degrees of freedom and noncentrality $\theta = (\beta/\sigma) \vee \Sigma(x_i - \bar{x})^2$. The Q variate has been defined and studied elsewhere by Hogben et al. It is noted that the square of the correlation coefficient is distributed as a noncentral beta variable.

Solutions of the time-dependent Klein-Gordon and Dirac equations for a uniform electric field, V. W. Myers, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 37-42 (Jan.-Mar. 1968).

Key words: Dirac and Klein-Gordon equations; time-dependent solutions; uniform electric field.

The time-dependent Klein-Gordon and Dirac equations are solved for the motion of a charged particle in a classical uniform electrostatic field of infinite extent. The elementary solutions have a position dependence of the form $e^{i\mathbf{k}\cdot\mathbf{r}}$ with the component of k in the field direction varying linearly with time.

Analysis of a market split model, J. M. McLynn, A. J. Goldman, P. R. Meyers, and R. H. Watkins, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 43-60 (Jan.-Mar. 1968).

Key words: Demand; elasticity; mathematical economics; partial differential equations.

A mathematical analysis is given for a class of models describing how a "market" (i.e., some subset of the consuming public) might divide its patronage among p competing products $(p > 1)$. The analysis is confined to the question of how the respective shares of market change with respect to changes in the variables describing the competing products. The split fractions which define the share of market are assumed to be functions of the choice-influencing attributes of *all* the competing products. The elasticities of the split fractions with respect to these attributes are assumed to be functions only of the split fractions themselves. Some functional forms (including the linear case) leading to self-consistent models are analyzed and their solutions derived.

Citation searching and bibliographic coupling with remote on-line computer access, F. L. Alt and R. A. Kirsch, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 61-78 (Jan.-Mar. 1968).

Key words: Bibliographies; citations; computer; information retrieval; remote consoles; timesharing.

Experiments were performed on a remote, multiple access computer to retrieve bibliographic items based on citation data. The citations were from some 25,000 physics papers. Estimates were made of the relevance of bibliographies derived from such citations. Some extrapolations are made to future systems with remote multiple access capability.

Simple analytic expressions for the total Born approximation cross section for pair production in a coulomb field, L. C. Maximon, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 1, 79-88 (Jan.-Mar. 1968).

> Key words: Born approximation; coulomb field; moderate energy cross section; pair production; Racah cross section; total photon cross section.

The total Born approximation cross section for pair production in a coulomb field given originally by Racah is used to derive two simple and rapidly convergent analytic expansions for this cross section, one valid for high energies, k, of the incident photon, the other for energies near the threshold. For $k > 4mc^2$ the fractional error involved in using the first four terms in the high energy expansion is $< 4.4 \times 10^{-5}$. For $k < 4mc^2$ the fractional error committed in using the first five terms of the low energy expansion is $< 1.1 \times 10^{-4}$. The leading terms in these expansions are the well known high energy and low energy limits of this cross section, respectively.

April-June 1968

The probability of an equilibrium point, K. Goldberg, A. J. Goldman, and M. Newman, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 93-101 (Apr.-June 1968).

> Key words: Equilibrium; probability; theory of games.

A formula is derived for the probability that a "random" m-by-n two-person noncooperative game has an equilibrium-point solution in pure strategies. The limit of this probability as $m, n \rightarrow \infty$ is shown to be $1-1/e$. The probability is tabulated for $m, n \leqslant 10$.

On spaces and maps of generalized inverses, J. Z. Hearon and J. W. Evans, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 103-107 (Apr.-June 1968).

> Key words: Generalized inverse; linear algebra; matrix.

Several classes of generalized inverses of a given $m \times n$ matrix are considered. A collection of continuous maps is given, each of which maps a class of generalized inverses onto a stronger class and the elements of the stronger class are the fixed points of the map. For the case of EPr matrices one of these maps is studied in more detail. The various classes of generalized inverses are characterized as subspaces of the space of all $n \times m$ matrices.

Differentiable generalized inverses, J. Z. Hearon and J. W. Evans, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 109-113 (Apr.-June 1968).

> Key words: Differentiable generalized inverse; generalized inverse; matrix.

Necessary and sufficient conditions are given for a differentiable matrix to have a differentiable generalized inverse. It is shown that when these conditions are met there exist, for several classes of generalized inverses, a differentiable generalized inverse which coincides with a prescribed generalized inverse on a particular subset. The relations betweeen the derivative of a matrix and that of a differentiable generalized inverse are given.

Principal submatrices V: some results concerning principal submatrices of arbitrary matrices, R. C. Thompson, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 115-125 (Apr.-June 1968).

> Key words: Eigenvalues; matrix; principal submatrices; rank; symmetric matrix.

This paper studies: (i) interlacing properties for the real eigenvalues of matrices; (ii) symmetric matrices with many equal principal minors; (iii) the determinantal characterization of the rank of a matrix.

Mathematical basis for the plasma kinetic equations (BBGKY), J. J. Sopka, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 127-133 (Apr.-June 1968).

> Key words: BBGKY hierarchy equations; probabilistic basis for kinetic equations.

The general family of kinetic equations, which in plasma kinetics are called the BBGKY equations, are obtained rigorously from basic probabilistic considerations in order to exhibit explicity the conditions or assumptions under which they obtain.

On the diffusion of an ion sheet in Poiseuille flow, S. Jarvis, Jr., *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 135-143 (Apr.-June 1968).

> Key words: Diffusion; ion flow tubes.

A nonuniform sheet of ions generated at time $t = 0$ diffuses in a cylindrical ion diffusion tube containing a nonreacting neutral species flowing with parabolic velocity distribution. Calculation of the on-axis ion density at a point z downstream as a function of time t is reduced to a single numerical integration for each (z, t) involving some functions which have been computed once for all. An example is given showing the effect of the velocity distribution compared with a uniform flow with the same flow rate. The results appear to be corroborated by experiment.

A class of thickness-minimal graphs, A. M. Hobbs and J. W. Grossman, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 2, 145-153 (Apr.-June 1968).

> Key words: Bipartite graphs; graph theory; mathematics; planar graphs; thickness of graphs; t-minimal graphs.

The thickness of a graph G is the minimum number of planar subgraphs whose union is G. A t-minimal graph is a graph of thickness t which contains no proper subgraph of thickness t. In this paper, we show that the complete bipartite graph on two sets each containing $4t-5$ vertices is t-minimal for all $t \geqslant 2$. We also show that if the complete graph on 16 vertices has thickness 4, it is 4-minimal.

July-September 1968

Interaction in multidimensional contingency tables: an information theoretic approach, H. H. Ku and S. Kullback, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 3, 159-199 (July-Sept. 1968).

> Key words: Contingency tables; estimation of cell frequencies from marginals; generalized independence; hypothesis testing; information theory; interaction; second-order interaction.

The problem of interaction in multidimensional contingency tables is investigated from the viewpoint of information theory as developed by Kullback. The hypothesis of no rth-order interaction is defined in the sense of an hypothesis of "generalized" independence of classifications with fixed rth order marginal restraints. For a three-way table, with given cell probabilities π_{ijk}, the minimum discrimination information for a contingency table with marginals $p_{ij\cdot}$, $p_{\cdot jk}$, and $p_{i\cdot k}$ is given by the set of cell probabilities $p^*_{ijk} = a_{ij}b_{jk}c_{ik}\pi_{ijk}$ where a_{ij}, b_{jk}, and c_{ik} are functions of the given marginal probabilities, that is, $\ln(p^*_{ijk}/\pi_{ijk}) = \ln a_{ij} + \ln b_{jk} + \ln c_{ik}$, representing no second-order interaction. The minimum discrimination information statistic, asymptotically distributed as χ^2 with appropriate degrees of freedom is

$$2\Sigma_{ijk}x_{ijk} \ln x_{ijk} - 2\Sigma_{ijk}x_{ijk} \ln x^*_{ijk} \geqslant 0$$

where x_{ijk} are the observed cell frequencies and x^*_{ijk} are the "no interaction" cell frequencies uniquely determined by a simple convergent iteration process of the marginals on π_{ijk}. For lower order marginal restraints the usual independence hypotheses are generated when π_{ijk} are taken to be the cell probabilities under uniform distribution. It is shown that the set p^*_{ijk} satisfies definitions of no second order interaction in a $2 \times 2 \times 2$ table given by Bartlett and no interaction in a $r \times s \times t$ table by Roy and Kastenbaum, and is also related to that given by Good. Results of application to the analysis of some "classical" three-dimensional contingency tables are given, together with full details for two four-dimensional examples.

On the coupling of longitudinal and transverse waves in a linear three-element viscoelastic string subjected to transverse impact, J. C. Smith and J. T. Fong, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 3, 201-214 (July-Sept. 1968).

Key words: Characteristics; finite-difference equations; linear viscoelasticity; partial differential equations; transverse impact; wave propagation; waves in strings.

The problem of wave propagation in a simple viscoelastic string subjected to constant velocity transverse impact is reexamined. An error in an earlier solution by Smith (*J. Res. NBS* **70B,** 257 (1966)) is corrected and an alternate numerical scheme based on the method of characteristics but using an implicit formulation of finite-difference equations is presented. The constitutive equation used is that of a linear viscoelastic model consisting of a spring and Maxwell element in parallel. Results of an illustrative calculation are discussed.

Allocating service periods to minimize delay time, W. A. Horn, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 3, 215-227 (July-Sept. 1968).

Key words: Allocation; queueing theory; scheduling; switching theory; traffic flow; transportation theory.

Consider a facility which must divide its services, during the time interval $[0, T]$, among N streams of arrivals. The problem treated is that of finding a pattern of service which minimizes total delay to the members of the streams, taking into account the "dead time" which begins each service period. For each stream, it is required that final queue size equal initial size, and that the queue be empty sometime in $[0, T]$. Conditions for feasibility of solutions are given in the case where the instantaneous service rates are bounded above by known constants. In the event that all streams have constant arrival rates and are to be served the same number of times, an optimal service pattern is derived using a recent result of R. Rangarajan and R. M. Oliver.

The second orthogonality conditions in the theory of proper and improper rotations. I. Derivation of the conditions and their main consequences, H. Gelman, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 3, 229-237 (July-Sept. 1968).

Key words: Matrices; orthogonal transformations; rotation.

A new set of orthogonality conditions is derived for real three-by-three orthogonal matrices which describe transformations in Euclidean three-dimensional space. The principal consequences of these conditions are obtained. These are: (1) the existence and construction of the intrinsic vector of the transformation, (2) an equation connecting the trace of a transformation matrix with that of its square, which, for rotations, can be solved to give the well-known trace formula analytically, (3) a simple formula for the determinant of a transformation matrix directly in terms of the relative handedness of the two coordinate systems connected by the transformation, (4) the secular equation for a transformation matrix.

Thickness and connectivity in graphs, A. M. Hobbs and J. W. Grossman, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 3, 239-244 (July-Sept. 1968).

Key words: Conjectures; connectivity; cut-set; graph theory; mathematics; minimality; thickness of graphs.

A graph G has *thickness* t if and only if t is the smallest number of planar subgraphs of G whose union is G. A *thickness-minimal,* or *t-minimal,* graph is a graph of thickness t with no proper subgraph of thickness t. In this paper we show that, for every t, a cut set in a t-minimal graph can have no fewer than t edges. This theorem suggests that the connectivity of a t-minimal graph is bounded from below by t. We disprove this suggestion for every $t > 2$ by constructing a graph which contains a 2-connected t-minimal graph. Two theorems extend this result and develop additional properties of the construction method. In addition, we show that the connectivity of a graph of thickness t is at most $6t - 1$ and that the thickness of K_{22} is 4. Finally, we make four conjectures about graphs of thickness t.

October-December 1968

Principal submatrices VII: further results concerning matrices with equal principal minors, R. C. Thompson, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 4, 249-252 (Oct.-Dec. 1968).

Key words: Matrix; principal submatrices; rank; symmetric matrix.

This paper characterizes real symmetric matrices A such that all $t \times t$ principal minors are equal and all $t \times t$ nonprincipal minors are of fixed sign, for two consecutive values of t less than rank A. It also characterizes matrices A (over an arbitrary field) in which all $t \times t$ principal minors are equal and all nonprincipal $t \times t$ minors are equal, for one fixed value of t less than rank A.

On the multipliers of the Dedekind modular function, J. Lehner, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 4, 253-261 (Oct.-Dec. 1968).

Key words: Cancellation; commutator subgroup; modular group; multiplier; word.

The Dedekind modular function is defined by $\eta(\tau)= e^{\pi i \tau/12} \prod_{1}^{\infty} (1-e^{2\pi i m\tau})$, Im $\tau > 0$, and satisfies the transformation equation $(c\tau+d)^{-1/2}\eta(A\tau) = v(A)\eta(\tau)$ for every $A \epsilon \Gamma$, the modular group, where $v(A)$ is a complicated 24th root of unity depending on A. Let G be the set of all $A \epsilon \Gamma$ for which $v(A)=1$. *Then G is not a group,* but there are groups that are subsets of G, e.g., $\{S^{24}\}$, where $S = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$. *Main Theorem.* Every subgroup of Γ that is a subset of G is cyclic. Moreover $G \subset \Gamma'$, the commutator subgroup of Γ.

Minimax error selection of a discrete univariate distribution with prescribed componentwise bounds, A. J. Goldman and P. R. Meyers, *J. Res. Nat. Bur. Stand. (U.S.),* **72B** (Math. Sci.), No. 4, 263-271 (Oct.-Dec. 1968).

Key words: Linear programs; mathematical models; operations research.

The topic treated is that of finding a reproducible, plausible and computationally simple method of selecting a discrete frequency distribution with prescribed upper and lower bounds on its components. The problem is shown to be tractable when a minimax error selection criterion is employed, and "error" is measured by maximum absolute deviation between components. In this case one obtains a linear program of a special form admitting explicit solution. The vertices of the polyhedron of optimal solutions can also be found explicitly, and so their centroid can be calculated if unique specification is required.

Minimax error selection of a discrete univariate distribution with prescribed componentwise ranking, A. J. Goldman, *J. Res.*

Nat. Bur. Stand. (U.S.), **72B** (Math. Sci.), No. 4, 273-277 (Oct.-Dec. 1968).

Key words: Mathematical models; minimax estimation; probability distribution.

The topic treated is that of finding a reproducible, plausible and computationally simple method of selecting a discrete frequency distribution with a prescribed ranking of its components. The problem is shown to be tractable when a minimax error selection criterion is employed, and "error" is measured by maximum absolute deviation between components. The vertices of the polyhedron of optimal solutions can also be found explicitly, and so their centroid can be calculated if unique specification is required.

On the signs of the ν-derivatives of the modified Bessel functions $I_\nu(x)$ and $K_\nu(x)$, D. O. Reudink, *J. Res. Nat. Bur. Stand. (U.S.)*, **72B** (Math. Sci.), No. 4, 279-280 (Oct.-Dec. 1968).

Key words: Bessel functions; ν-derivatives.

It is proved that $\partial I_\nu(x)/\partial\nu$ is negative and $\partial K_\nu(x)/\partial\nu$ is positive when $x > 0$ and $\nu > 0$.

Comparison of finite-difference computations of natural convection, K. E. Torrance, *J. Res. Nat. Bur. Stand. (U.S.)*, **72B** (Math. Sci.), No. 4, 281-301 (Oct.-Dec. 1968).

Key words: Enclosures; finite-difference; fluid flow; natural convection; numerical.

Five numerical methods were compared for calculating two-dimensional, transient natural convection in an enclosure. Both implicit and explicit procedures were considered. Requirements for numerical stability were derived from analysis and experience, and when satisfied, the calculated flows for all methods were found to be similar. Consideration was also given to the accuracy and (energy and vorticity) conservation of the methods. One method was found to be conservative and stable without a restriction on the spatial mesh increment. This method can be successfully applied to nonlinear flows, but care must be exercised due to the presence of truncation errors which introduce false transport mechanisms.

Generalized inverses and solutions of linear systems, J. Z. Hearon, *J. Res. Nat. Bur. Stand. (U.S.)*, **72B** (Math. Sci.), No. 4, 303-308 (Oct.-Dec. 1968).

Key words: Generalized inverse; linear systems; matrix.

For an arbitrary complex matrix A we consider (1) the set of all matrices B such that $ABA = A$ and AB is Hermitian and (2) the set of all matrices B such $ABA = A$ and BA is Hermitian. It is shown that if B is in (1) then $x = By$ is a least-squares solution of $Ax = y$ and that if B is in (2) then $x = By$ is the solution of minimum Euclidian norm of the consistent systems $Ax = y$. The connection is exposed between the properties of the generalized inverses in (a) and (b) and the fact that among all matrices X satisfying $AXA = A$, that with minimum Euclidian norm is the Moore-Penrose inverse of A.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICAL SCIENCES, VOLUME 73B, JANUARY-DECEMBER 1969

January-March 1969

A table of integrals of the error functions, E. W. Ng and M. Geller, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 1-20 (Jan.-Mar. 1969).

Key words: Astrophysics; atomic physics; Error functions; indefinite integrals; special functions; statistical analysis.

This is a compendium of indefinite and definite integrals of products of the Error function with elementary or transcendental functions. A substantial portion of the results are new.

Fourier coefficients of Mathieu functions in stable regions, H. Fruchting, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci), No. 1, 21-24 (Jan.-Mar. 1969).

Key words: Bisection method; eigenvalues; Fourier coefficients; Mathieu functions.

A method for calculating the Fourier coefficients of Mathieu functions in stable regions based on the method of bisection and Miller's recurrence algorithm is introduced. Some Fourier coefficients are calculated and compared with those given earlier by Tamir and Wang. It is shown that the method of Tamir and Wang fails for indices in the neighborhood of integers.

A note on the *T*-transformation of Lubkin, W. D. Clark, H. L. Gray, and J. E. Adams, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 25-29 (Jan.-Mar. 1969).

Key words: Convergence acceleration techniques; epsilon-transformation; nonlinear series transformation; numerical methods; series summability methods.

This paper is concerned with a sequence-to-sequence transformation studied extensively by Samuel Lubkin [*J. Res. NBS* **48**, 228-254 (1952)]. Lubkin has studied the rate of convergence of the transformed sequence, $\{T_n\}$, versus the original sequence, $\{S_n\}$. In this respect, the authors have shown that a more accurate evaluation of the transformation is achieved by the comparison of $\{T_n\}$ with $\{S_{n+1}\}$ instead of $\{S_n\}$. The main theorems proved are rate-of-convergence comparisons between $\{T_n\}$ and $\{S_{n+1}\}$ where $\{S_n\}$ is the sequence of partial sums of a convergent series whose terms are of constant sign or else are alternating.

The cylinder problem in thermoviscoelasticity, W. S. Edelstein, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 31-40 (Jan.-Mar. 1969).

Key words: Cylinder; Neumann series; thermoviscoelasticity.

Solutions are obtained for several axially symmetric plane strain problems involving a hollow circular viscoelastic cylinder. The cylinder is assumed to be subject to planar, axially symmetric body force and temperature fields. Displacement, traction, and mixed boundary conditions are considered.

Relations within sequences of congruential pseudo-random numbers, P. H. Verdier, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 41-44 (Jan.-Mar. 1969).

Key words: Congruential generators; multidimensional distributions; random number generators.

Conditions are exhibited under which simple, approximate linear relations may be found between sets of successive choices made by congruential pseudo-random number generators. These relations imply that the distributions in n-dimensional space produced by such generators can be very highly nonuniform. The results are illustrated with several examples. Restrictions on the parameters of the generator to minimize difficulties of this sort are discussed.

On the mean dimensions of restricted random walks, P. H. Verdier and E. A. DiMarzio, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 45-46 (Jan.-Mar. 1969).

Key words: Lattice; nonreversing walk; polymer dimension; random walk.

A simple method is presented for obtaining mean dimensions of certain restricted random walks on lattices.

The cube of every connected graph is 1-hamiltonian, G. Chartrand and S. F. Kapoor, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 47-48 (Jan.-Mar. 1969).

Key words: Cube of a graph; graph; hamiltonian.

Let G be any connected graph on 4 or more points. The graph G^3 has as its point set that of G, and two distinct points u and v are adjacent in G^3 if and only if the distance between u and v in G is at most three. It is shown that not only is G^3 hamiltonian, but the removal of any point from G^3 still yields a hamiltonian graph.

Minimum-length covering by intersecting intervals, W. A. Horn, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 1, 49-51 (Jan.-Mar. 1969).

Key words: Covering problems; Manhattan metric.

This paper considers the problem: Given a sequence $\{I_i\}_1^n$ of intervals on the real axis, find a sequence $\{J_i\}_1^n$ of closed intervals which minimizes the sum-of-lengths $S=\Sigma_1^n|J_i|$ subject to $I_i \subseteq J_i$ and $J_i \cap J_{i+1} \neq \phi$ for all i. The paper gives a simple algorithm for determining the J_i and notes that linear programming can be applied to the more complicated problem where S is changed to $\Sigma_1^n \alpha_i |J_i|$, $\alpha_i > 0$.

April–June 1969

An evaluation of linear least squares computer programs, R. H. Wampler, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 59-90 (Apr.-June 1969).

Key words: Computer programs; Gram-Schmidt orthogonalization; Householder transformations; least squares; linear equations; orthogonalization; orthogonal polynomials; regression; rounding error; stepwise regression.

Two linear least squares test problems, both fifth degree polynomials, have been run on more than twenty different computer programs in order to assess their numerical accuracy. Among the programs tested were representatives from various statistical packages as well as some from the SHARE library. Essentially five different algorithms were used in the various programs to obtain the coefficients of the least squares fits. The tests were run on several different computers, in double precision as well as single precision. By comparing the coefficients reported, it was found that those programs using orthogonal Householder transformations or Gram-Schmidt orthonormalization were much more accurate than those using elimination algorithms. Programs using orthogonal polynomials (suitable only for polynomial fits) also proved to be superior to those using elimination algorithms. One program, using congruential methods and integer arithmetic, obtained exact solutions. In a number of programs, the coefficients reported in one test problem were sometimes completely erroneous, containing not even one correct significant digit.

The traffic assignment problem for a general network, S. C. Dafermos and F. T. Sparrow, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 91-118 (Apr.-June 1969).

Key words: Algorithm; least cost; traffic allocation; transportation.

A transportation network is considered. The traffic demands associated with pairs of nodes and the (convex) traveling cost functions associated with the links are assumed given. The two problems of finding the traffic patterns which either minimize the total cost or equilibrate the users' costs are formulated, and algorithms are constructed for the solution of these problems.

Sufficient conditions for the instability of numerical integration methods, A. I. Abdel Karim, *J. Res. Nat. Bur. Stand. (U.S.),* 73B (Math. Sci.), No. 2, 119-123 (Apr.-June 1969).

Key words: Numerical integration; stability.

In a previous paper, a general theorem was investigated for the stability of numerical integration methods for the solution of systems of differential equations. In this paper, further theorems are developed as sufficient conditions for the instability of numerical integration methods. Applying these theorems, the instability of known formulas are checked easily at a glance.

The second orthogonality conditions in the theory of proper and improper rotations. II. The intrinsic vector, H. Gelman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 125-138 (Apr.-June 1969).

Key words: Axis and angle of rotation; coordinate inversion; coordinate reflection; improper rotations; matrices; orthogonal transformations; proper rotations; rigid rotations; rotation.

The properties of the intrinsic vector associated with a real three-by-three orthogonal transformation, are derived. For proper rotations the problem of extracting the axis and angle or a rotation from its matrix representation, is considered. It is shown that the intrinsic vector allows the determination of the axis and angle as unambiguously as possible, thus remedying the ambiguous treatment of this problem in the literature. Several examples of this use of the intrinsic vector are given. Its properties for improper rotations are also discussed.

The second orthogonality conditions in the theory of proper and improper rotations. III. The conjugacy theorem, H. Gelman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 139-141 (Apr.-June 1969).

Key words: Conjugacy; conjugacy theorem; conjugate rotations; matrices; orthogonal group; orthogonal transformations; rotation; rotation group; rotation-inversions.

The second orthogonality conditions are used to provide a concise proof of the theorem that two rotation matrices connected by an orthogonal similarity transformation have the same angles of rotations. This theorem is discussed in the context of its applicability to the problem of decomposing the real orthogonal group 0(3) into its classes of conjugate elements.

Subgroups of $SL(t,Z)$, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 143-144 (Apr.-June 1969).

Key words: Congruence subgroup property; free groups; free products; higher modular groups.

It is shown that if $t \geqslant 3$, then no subgroup of $SL(t,Z)$ of finite index is free (in fact is not even the free product of cyclic groups). Here $SL(t,Z)$ is the multiplicative group of $t \times t$ matrices over the integers of determinant 1.

Cuttable and cut-reducible matrices, R. B. Marimont, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 145-151 (Apr.-June 1969).

Key words: Compartmental systems; connectivity; graph; matrix.

An n square matrix having an $(n-1)$ principal minor which is block diagonal (or reducible) is called cuttable (or cut-reducible). The connectivity matrix of a graph having a cutpoint is cuttable. While neither block diagonal nor reducible, cuttable and cut-reducible matrices share with these matrices some of the theoretical and computational simplicity derived from a natural division into principal submatrices which are relatively independent of each other. Solution of linear compartmental systems are shown to be simplified by the presence of a cutpoint in the system.

Automorphic integrals with preassigned periods, J. Lehner, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 153-161 (Apr.-June 1969).

Key words: Automorphic form; automorphic integral; fundamental region; group; Poincaré series.

Let Γ be a discrete group of real 2×2 matrices of determinant 1. Generalizing the usual notion of abelian integral, Eichler has defined $\Phi(\tau)$ to be an automorphic integral of degree $2n-2$ on Γ if (1) $\Phi|A = \Phi + \omega_A$ for all $A \epsilon \Gamma$. Here n is a positive integer, ω_A is a polynomial in τ of degree $2n-2$ or less, and $\Phi|A = (c\tau + d)^{2n-2}\Phi(A\tau)$, where τ is confined to the upper half-plane. A consequence of (1) is that (2) $\omega_{AB} = \omega_A|B + \omega_B$. If Φ has at most poles but no logarithmic singularities, Φ is said to be of the second kind and this requires (3) $\omega_A = Q|(A-1)$ for all elements A that fix a real cusp of a fundamental region of Γ, where Q is a polynomial of degree $\leqslant 2n-2$. Eichler proved that the necessary conditions (2) and (3′) are also sufficient for the existence of a Φ on Γ with the preassigned "periods" ω_A, but only when Γ is a subgroup of finite index in the modular group. Here (3′) is a stronger version of (3). In the present paper this is generalized to all groups Γ that are finitely-generated and have translations, and we use the correct conditions (2), (3) rather than (2), (3′).

A digital computer technique for calculating the step response of lumped or distributed networks, J. R. Andrews and N. S. Nahman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.). No. 2, 163-176 (Apr.-June 1969).

Key words: Digital computer program; distributed networks; inverse Laplace Transformation; lumped networks; Rosenbrock cursor; step response; transmission line.

This paper discusses a technique to solve step response problems for lumped or distributed networks with the aid of a digital computer. The Rosenbrock graphical cursor technique for obtaining the step response from the frequency response through the inverse Laplace Transformation was adapted for computer use. In addition, it was modified to increase its accuracy when used with a digital computer.

The response of a series RLC lumped network is computed and the numerical solution is compared to the analytical solution. Also, a numerical solution is given for the step response of a transmission line processing skin-effect metal loss and Debye dielectric loss.

Symmetry and the crossing number for complete graphs, T. L. Saaty, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 2, 177-186 (Apr.-June 1969).

Key words: Complete graphs; intersections, symmetry.

This paper studies the minimum number of intersections of edges in a complete graph on n vertices drawn in the plane. The proofs are first given for $n \leq 10$. A theorem on the maximum number of intersections is also given. Geometric representations of these cases are included. Symmetry of the representations is then discussed as it applies to extensions from small values of n to larger values maintaining the minimality of the number of intersections. Based on a symmetry conjecture given in the paper, a proof is given for the general case of the minimum intersection problem.

July–September 1969

A table of integrals of the exponential integral, M. Geller and E. W. Ng, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 191-210 (July-Sept. 1969).

Key words: Diffusion theory; exponential integral; indefinite integrals; quantum mechanics; radiative equilibrium; special functions; transport problems.

This is a compendium of indefinite and definite integrals of products of the Exponential Integral with elementary or transcendental functions. A substantial portion of the results are new.

Principal ideals in matrix rings, M. Newman and S. Pierce, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 211-213 (July-Sept. 1969).

Key words: Dedekind ring; matrix ring; non-Noetherian ring; principal ideal ring.

It is shown that every left ideal of the complete matrix ring of a given order over a principal ideal ring is principal, and a partial converse is proven.

The second orthogonality conditions in the theory of proper and improper rotations. IV. Solution of the trace and secular equations, H. Gelman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 215-223 (July-Sept. 1969).

Key words: Closed form of rotation matrix; orthogonal transformation; rotation; rotation matrix; secular equation; trace equation; trace formula.

The equation which connects the trace of a rotation matrix and that of its square, and the secular equation for a rotation matrix, both of which are direct results of the second orthogonality conditions, are solved by purely analytic methods based on the group property and the periodicity property of rotation matrices. The point is thus made that the well known formulas for the trace of a rotation matrix in terms of the angle of rotation and for the rotation matrix itself in terms of the axis and angle of rotation, are closely related to the algebraic properties of rotation matrices.

Minimax error selection of a univariate distribution with prescribed componentwise bounds and ranking, A. J. Goldman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 225-230 (July-Sept. 1969).

Key words: Linear programs; mathematical models; minimax estimation; operations research; probability distribution.

The topic treated is that of finding a reproducible, plausible and computationally simple method of selecting a discrete frequency distribution with a prescribed ranking of its components and prescribed upper and lower bounds on these components. The problem is shown to be tractable when a minimax error selection criterion is employed, and "error" is measured by maximum absolute deviation among components. In this case one obtains a linear program of a special form admitting explicit solution.

Minimax adjustment of a univariate distribution to satisfy componentwise bounds and/or ranking, A. J. Goldman, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 231-239 (July-Sept. 1969).

Key words: Linear programs; mathematical models; minimax estimation; operations research; probability distribution.

Consider a discrete probability distribution, represented by an n-vector **a**. This paper treats the problem of adjusting **a** as little as possible, in the sense of minimizing $\max_i |x_i - a_i|$, to obtain a distribution **x** which satisfies given componentwise bounds $\mathbf{L} \leq \mathbf{x} \leq \mathbf{U}$, or a given componentwise ranking, or both. The resulting linear programs are shown to admit special explicit solution algorithms.

On the application of some interpolating functions in physics, A. J. Jerri, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 241-245 (July-Sept. 1969).

Key words: Cardinal series; interpolation; Regge poles; special functions.

J. M. Whittaker considered interpolating equidistant samples by using the cardinal series. In this paper we consider the extension provided by the generalized sampling theorem of Kramer for nonequidistant samples. We calculate some sampling functions for cases of interest in mathematical physics. In particular, this includes the S-matrix contribution due to Regge poles, especially when a series expansion other than that of Fourier-Legendre type is needed.

Commutator groups and algebras, L. Greenberg, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 247-249 (July-Sept. 1969).

Key words: Adjoint representation; commutator; Lie algebra; Lie group.

Let H and K be connected, Lie subgroups of a Lie group G. The group $[H,K]$, generated by all commutators $hkh^{-1}k^{-1}(h \epsilon H, k \epsilon K)$ is arcwise connected. Therefore, by a theorem of Yamabe, $[H,K]$ is a Lie subgroup. If $\mathfrak{H}, \mathfrak{K}$ denote the Lie algebras of H and K, respectively, then the Lie algebra of $[H,K]$ is the smallest algebra containing $[\mathfrak{H}, \mathfrak{K}]$, which is invariant under $ad\mathfrak{H}$ and $ad\mathfrak{K}$. An immediate consequence is that if H and K are complex Lie subgroups, then $[H,K]$ is also complex.

On a class of nonlinear transformations and their applications to the evaluation of infinite series, H. L. Gray and W. D. Clark, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 3, 251-274 (July-Sept. 1969).

Key words: Aitken transformations; G-transformations; nonlinear transformations; rapidity of convergence.

In this paper the problem of increasing the rate of convergence of infinite sequences and series is considered by means of a class of nonlinear transformations. The transformations employed are the discrete analogue of the so called G-transformations and the theory surrounding them is investigated in some detail. The theoretical results are demonstrated by numerous examples.

October-December 1969

Temperature renormalization in the non-linear Vlasov problem, W. L. Sadowski and Z. G. Ruthberg, *J. Res. Nat. Bur. Stand. (U.S.),* **73B** (Math. Sci.), No. 4, 281-291 (Oct.-Dec. 1969).

Key words: Expansion coefficients; Hermite polynomials; non-linear; numerical; plasma; truncation error; Vlasov equation.

Ways of improving the representation of the velocity distribution function in the solution of the non-linear Vlasov equation are discussed. Hermite polynomial coefficients for temperature renormalization are derived. Transformation properties of Hermite polynomials necessary to do this are discussed. Analytic expressions for the truncation error of the temperature renormalized functions are compared with the computer results.

Selective excitation of harmonics in a collisionless plasma by two counterstreaming electron beams, W. L. Sadowski and Z. G. Ruthberg, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73B** (Math. Sci.), No. 4, 293-300 (Oct.-Dec. 1969).

Key words: Electron trapping; non-linear; numerical; selective harmonic excitation; two-stream; velocity distribution; Vlasov equation.

The possibility of selective harmonic excitation in a one-dimensional plasma that obeys the Vlasov equation is discussed. Electron beams, collimated in velocity space, are used for this purpose. Conditions on the velocity distribution function to achieve selective excitation are given. The velocity distribution function is expanded in Gram-Charlier series and the expansion coefficients are given. Bounds on truncation errors of the expansion are derived and compared with computer results.

Simultaneous contractification, A. J. Goldman and P. R. Meyers, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73B** (Math. Sci.), No. 4, 301-305 (Oct.-Dec. 1969).

Key words: Contractions; functional analysis; metric spaces; topology.

Consider a finite family of continuous self-mappings of a topological space X, with a common fixed point. Suppose that for each member of the family, X has a metric for which that member is a contraction. It is shown that if the family is commutative, then X has a metric under which all members are (simultaneously) contractions. Additional hypotheses are given which ensure the same conclusion in the noncommutative case.

A theorem on convex hulls, W. A. Horn, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73B** (Math. Sci.), No. 4, 307-308 (Oct.-Dec. 1969).

Key words: Convex geometry; convex sets.

Let p be a point in the interior K° of the convex hull $K=K(S)$ of a bounded point-set S in a real Hilbert space. A quantity $R(p)$ is determined such that every closed ball of radius $>R(p)$, if it contains p, must also meet S.

The partitioning of interaction in analysis of variance, J. Mandel, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73B** (Math. Sci.), No. 4, 309-328 (Oct.-Dec. 1969).

Key words: Factorial experiments; interaction; nonadditivity; principal components; surface fitting.

A method is presented for the analysis of data representing functions of two variables, when the response can be tabulated in a rectangular array. The procedure is based on a partitioning of the row by column interaction effects into a sum of terms, each of which is the product of a row factor by a column factor. The factors in each term are estimated by a method involving the extraction of characteristic roots.

The method contains as special cases a number of procedures used for the handling of non-additivity in two way arrays. It is very useful for the fitting of empirical surfaces, but it is also applicable to cases in which the data depend on qualitative rather than quantitative factors.

Comparisons with other techniques are made and an illustrative example is given.

Highly restricted partitions, H. Gupta, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73B** (Math. Sci.), No. 4, 329-350 (Oct.-Dec. 1969).

Key words: Generating functions; graph of a partition; partitions.

The function $g(n, m, h, k)$, which enumerates the number of partitions of n into exactly k summands each less than or equal to m and in which the number of different summands is exactly h, is here tabulated and studied.

3.3. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 72C, JANUARY-DECEMBER 1968

January-March 1968

Acceleration due to gravity at the National Bureau of Standards, D. R. Tate, *J. Res. Nat. Bur. Stand.* (*U.S.*), **72C** (Eng. and Instr.), No. 1, 1-20 (Jan.-Mar. 1968).

Key words: Absolute gravity; acceleration; free-fall; gravity; Potsdam.

A determination of the absolute value of the acceleration due to gravity was completed in June 1965 at the National Bureau of Standards near Gaithersburg, Maryland. The determination resulted in a value of 980.1018 centimeters per second squared for a reference point on the first floor of the Engineering Mechanics Building. The result was published in *The Journal of Research of the National Bureau of Standards,* Vol. 70C, No. 2, Engineering and Instrumentation, page 149, April-June 1966. The present paper describes in detail the apparatus and the techniques employed and presents the summarized data from which the value was derived.

Deflection of thin circular elastic plates under symmetrically distributed loading, A. F. Kirstein and R. M. Woolley, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Engr. and Instr.), No. 1, 21-26 (Jan.-Mar. 1968).

Key words: Bassali's theory; deflection; elasticity; flexure; point supports; symmetrically distributed load; thin plates.

A special application of Bassali's solution for transverse flexure of thin elastic plates supported at several points is presented for the case of concentric symmetrically distributed load. Equations for deflection are presented for the case where the point supports lie within the loaded area. Under special conditions the numerical results from these equations coincide with those of Nadai's.

A dynamic method for determining the vapor pressure of carbon dioxide at 0 °C, J. L. Edwards and D. P. Johnson, *J. Res. Nat. Bur. Stand.* (*U.S.*) **72C** (Eng. and Instr.), No. 1, 27-32 (Jan.-Mar. 1968).

Key words: Carbon dioxide; fixed point; hypsometer; pressure standard; purification; vapor pressure.

The vapor pressure of carbon dioxide at 0 °C, or at 0.01 °C, has been used as a fixed point on the pressure scale. Comparisons between laboratories may be affected equally by pressure measurements, temperature measurements, and the purity (and possibly isotope composition) of the sample. A dynamic method for establishing this pressure is described, utilizing a device similar to those used to realize the sulfur and steam points on the International Practical Temperature Scale. Advantages of the method include rapid establishment of equilibrium conditions, and the automatic purification of the carbon dioxide. Results obtained indicate a sample-to-sample reproducibility better than one part in 25,000. The method is suggested as being suitable for general use in realizing the CO_2 point of the pressure scale. This experiment yielded a value for the vapor pressure at 0 °C of 3.48516 MN m^{-2} or 26,140.8 mm Hg; at the triple point of water, 0.01 °C, it was 3.48608 MN m^{-2} or 26,147.7 mm Hg.

An adiabatic saturation psychrometer, L. Greenspan and A. Wexler, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 1, 33-47 (Jan.-Mar. 1968).

Key words: Adiabatic saturation; gas mixtures; humidity; hygrometer; mixing ratio; moist gas; psychrometer; psychrometric factor; saturation; thermodynamic wet-bulb temperature; vapor content; wet-bulb.

An adiabatic saturation psychrometer for measuring the humidity of gases, as well as the vapor content of vapor-gas mixtures, is described. The instrument behaves in accordance with predictions deduced solely from thermodynamic considerations. With water-air, water-hydrogen, carbon tetrachloride-hydrogen, carbon tetrachloride-oxygen and toluene-air systems, at room temperature, atmospheric pressure, and gas flow rates of 1.3 to 5.2 liters per minute, measured wet-bulb temperatures agree with calculated "thermodynamic wet-bulb temperatures" to within the accuracy of the measurements and the uncertainties in the published thermodynamic data used in the computations. For the water-air system, the systematic and random errors due to these sources are estimated at 0.027 deg C and 0.019 deg C respectively. The agreement between the calculated and measured wet-bulb temperature is 0.029 deg C, which at a dry-bulb temperature of 25 °C and an ambient pressure of 1 bar is equivalent to an uncertainty in relative humidity which varies from 1/8 to 1/4 percent. The time constant is a function of the gas flow rate; at flow rates of 3.75 to 5.2 liters per minute, the time constant is of the order of 3/4 minute.

An injection method for self-calibration of inductive voltage dividers, W. C. Sze, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 1, 49-59 (Jan.-Mar. 1968).

Key words: Calibration; in-phase deviation; inductive voltage divider; measurements; quadrature deviation; ratio calibration; transformer; two-stage voltage transformer; voltage divider; voltage ratio.

A self-calibration or "boot-strapping" injection method for determining the voltage ratio and phase angle deviations of inductive voltage dividers utilizes specially constructed transformers for step and differential voltage injections without reference to the fundamental electrical units or standards. Construction details of transformers, derivation of equations, and systematic evaluation of uncertainties are presented. Calibration of certain ratios involving a combination of dial settings on several decades can be obtained as readily as that of a single decade. The accuracy of the results obtainable at 10 kHz is within 2×10^{-7} of input for deviations less than 10 ppm of input and within 1×10^{-6} for deviations up to 100 ppm of input. This same calibration technique can readily be used to cover a frequency range from 1 to 20 kHz.

Bolometric voltage and current (Bolovac) standard for high and microwave frequencies, M. C. Selby, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 1, 61-79 (Jan.-Mar. 1968).

Key words: Current measurement; measurement voltages; microwave current; microwave voltages; transmission-line voltages; voltage measurements.

A standard of voltages and currents for lumped-constant, coaxial, and other circuits operating in the TEM mode has been developed. Its approximate potential ranges are 1 MHz to 20 GHz in frequency, 0.05 to 10 volts, and 5 microamperes to 10 amperes. The principle may be used with bolometric, thermoelectric, photoelectric or other sensing elements consisting of thin film conducting or semiconducting disks located in the transverse plane of the TEM mode. Application and advantages are described and a comprehensive error analysis is presented. Figures illustrating construction details of one of the models of the Bolovac are included.

An admittance meter technique to measure the complex permeability at VHF, A. L. Rasmussen and C. M. Allred, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 1, 81-89 (Jan.-Mar. 1968).

Key words: Admittance meter; attenuation calibration; lossy magnetic materials; magnetic measurement methods; permeability; rf magnetic materials; VHF bridge; VHF magnetic materials.

An admittance meter technique may be used in evaluating and comparing accurately and conveniently the complex permeability of magnetic materials from 30 MHz to ~ 100 MHz. The admittance meter has three coaxial lines fed from a common source at a common junction point, two lines being terminated by shorts and the third by 50Ω. The currents in the lines are detected by three electrically connected parallel loops each located close to the common junction point of the lines. The loops are adjustable to one minute of rotation and follow closely a sine law. The complex permeability of a sample is derived from measurements with a sample in and out of one of the shorted coaxial lines. The estimated error from 30 MHz to 100 MHz is from ~ 1 to ~ 10 percent for sample inductance from $3 \cdot 10^{-9}$ to 10^{-7} H and sample resistance $5 \cdot 10^{-1}$ to 10^{2}Ω. Error of inductance is ~ 1 percent from 30 MHz to 200 MHz for low-loss samples using calibrated sample data. Using precision 50Ω, low-contact resistance lines, the sample impedance error attainable is estimated as ~ 1 percent for the above limits of impedance and measurements can be extended to above 100 MHz. The equations for the inductance and the resistance of the sample are expressed in terms of calibrated values for the settings of two loops, the calibrated resistance value of the 50Ω termination, the calibrated or calculated impedance components of the sample line, and the inductance of an equivalent air core.

April-June 1968

Analysis and design of an oscilloscope deflection system with a calculable transfer function, D. M. Stonebraker, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 2, 117-125 (Apr.-June 1968).

Key words: Deflector; drift space; oscilloscope; standard; strip-line; transfer function.

An oscilloscope deflector is described, which has a calculable transfer function. The deflector is analyzed, leading to its transfer function, in terms of the complex frequency variables. A practical strip line deflector, usable as a pulse standard, is designed; and its frequency response, sensitivity, bandwidth, rise time, step function, and impulse response are calculated. The predicted deflection is down to 70 percent of its d-c value at 2.82 GHz, while the step-response 10 to 90 percent rise time is 148 picoseconds. The effects of a drift space on the oscilloscopic display is also discussed. Results are compared with a well-known expression for the parallel plate deflector structure.

Calculation of substitution error in barretters, S. Jarvis, Jr., and J. W. Adams, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 2, 127-237 (Apr.-June 1968).

Key words: Barretter; bolometer; microwave power measurements; substitution error.

This paper describes a mathematical analysis for determining the value of the substitution error of a bolometer with a Wollaston-wire element (barretter). The analysis reflects all significant nonlinearities in the heat flow, including some not covered before, and includes all appreciable heat transport mechanisms simultaneously.

The values of substitution error thus obtained, in conjunction with efficiency data obtained by microwave techniques, will be very useful in extending power meter calibrations to frequency ranges where extremely accurate microcalorimeters are not available.

Analysis of *n*-degree elliptical elastic rings of nonuniform cross section, R. A. Mitchell, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 2, 139-160 (Apr.-June 1968).

Key words: Curved bar analysis; elasticity; force transducer; *n*-degree elliptical ring; nonlinear programming; optimization; proving ring; structural design; theory.

A curved bar structural analysis is developed for an *n*-degree elliptical elastic ring with sinusoidally varying cross-section dimensions, where the *n*-degree ellipse is defined by $(x/a)^n + (y/b)^n = 1,\ n \geqslant 2.0$. A sequential grid constrained optimization method is used to search for a minimum weight design in six dimensional shape parameter space. Numerical results indicate that rings of this shape can be designed to have considerably less weight and greater flexibility than comparable circular rings with uniform cross-section dimensions.

Applications of coaxial chokes to a-c bridge circuits, D. N. Homan, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 2, 161-165 (Apr.-June 1968).

Key words: Bridge; capacitance; coaxial cable; ground loop; inductance; magnetic core; stray magnetic field.

One or more turns of coaxial cable on a magnetic core form a coaxial choke which may be used to suppress unwanted loop currents in a-c bridge circuits. A review of several applications of coaxial chokes to a-c bridge circuits is presented. These applications include suppressing ground loop currents, assuring unique definition in the measurement of small 3-terminal capacitors, reducing stray magnetic field and reducing voltage drops in leads caused by large ground capacitance current. There is also a discussion of techniques for greatly increasing the effectiveness of the coaxial choke.

Creep rupture properties of Ti-8Al-1Mo-1V alloy, W. D. Jenkins and W. A. Willard, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 2, 167-174 (Apr.-June 1968).

Key words: Creep; engineering design; high temperatures; phase changes; rupture; titanium alloy.

Creep tests were made at 600, 800, 1000, and 1200 °F (588, 699, 811, and 921 °K) on duplex-annealed Ti-8Al-1Mo-1V alloy specimens. Creep-test conditions were selected to produce creep rates ranging from 0.1 to 50,000 percent per 1,000 hours and rupture times ranging from 0.1 to about 10,000 hours. Conformance of the test data to creep theories was obtained over a limited range of stress, strain, creep rate and temperature. Creep behavior was influenced by microstructural changes during creep and by prior thermal-mechanical treatment. Engineering-design curves are included in this paper.

July-September 1968

Gas density balance design considerations, E. C. Creitz, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 3, 187-195 (July-Sept. 1968).

Key words: Chromatographic detector; density detector; gas density; gas detector.

The Nerheim gas density balance operates by measuring the flow produced by differences in density between a sample and a reference gas in the earth's gravitational field. It has been considered theoretically in order to outline the characteristics of the gas flow system, those of the flow measuring anemometers, and the effects of detector volume on peak separation and sensitivity. It is shown that both design parameters and operating conditions affect the performance of the device, and that properly considered compromises can improve its characteristics.

Standard mismatch—the production of controlled small reflections in waveguides, L. Lewin, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 3, 197-201 (July-Sept. 1968).

Key words: Controlled small reflections; mismatch; reflector posts; waveguide.

The reflection properties of possible suitable structures, for producing small accurately controlled reflections in rectangular waveguide, are examined and a choice made of cylindrical posts for a more detailed study.

A number of sources of error due to ohmic loss, positioning and shape are investigated, and it is shown that both the inductive and capacitive post can meet reasonable specifications, but that the latter is the more suitable on almost all counts. Attention to post size and tilt is necessary, but the accuracies needed lie well within the range achievable by good engineering practice.

Viscoelastic behavior of dental amalgam, P. L. Oglesby, G. Dickson, M. L. Rodriguez, R. M. Davenport, and W. T. Sweeney, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 3, 203-213 (July-Sept. 1968).

Key words: Amalgam; creep; dental; steady-state creep; stress-strain; transient creep; viscoelastic.

Measurements made on dental amalgam in tension indicate that amalgam exhibits three types of viscoelastic phenomena: (1) instantaneous elastic strain, (2) retarded elastic strain (transient creep), and (3) viscous strain (steady-state creep). The combination of elastic plus retarded strain can be represented by an equation of the form $\epsilon = A\sigma + B^2\sigma^2$ where A and B are functions of time but not of the stress, σ. The viscous strain rate can be represented by an equation of the form $\epsilon_v = K\sigma^m$ where K and m are constants of the material. By applying a nonlinear generalization of the Boltzmann superposition principle to a general equation describing the creep behavior of amalgam, the results of creep tests can be directly related to the results of stress-strain tests.

The steady-state creep behavior of dental amalgam, G. Dickson, P. Oglesby, and R. Davenport, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 3, 215-218 (July-Sept. 1968).

Key words: Amalgam; creep; creep activation energy; dental amalgam; silver amalgam.

The steady-state creep behavior of a dental amalgam subjected to tensile stresses of 500 to 4000 psi (3.4×10^6 to 2.8×10^7 N/m^2) was investigated over the temperature range of 23 to 52 °C (296 to 325 K). It was found that the creep behavior can be represented by the equation:

$$\epsilon_v = K\sigma^m e^{-E/RT}$$

where ϵ_v is the creep rate, K and m are constants of the material, σ is the stress, E is the activation energy for the process, R is the gas constant and T is the temperature. Values of the constants determined for the dental amalgam were $K = 2.31 \times 10^9$, $m = 3.45$ and $E = 35{,}300$ cal/mol (148,000 joule/mole).

October-December 1968

Theoretical and experimental study on longitudinal impact of tapered rods, L. R. Hettche, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 4, 231-241 (Oct.-Dec. 1968).

Key words: Aluminum; experiments; longitudinal impact; numerical solution; one-dimensional; plastic-wave propagation; rate-independent theory; tapered rods.

To examine the adequacy of the one-dimensional, rate-independent theory of plastic-wave propagation for annealed, commercially pure aluminum, experimental results from the longitudinal impact of uniform and tapered rods are compared to a theoretical analysis. The theoretical description is a numerical solution which utilizes the characteristic properties of the governing equations to construct difference relations for a constant mesh spacing. Numerical evidence of convergence and stability of the solution is presented. A constant-velocity boundary condition is defined by the axial collision of identical specimens, 6 inches (152 mm) in length and tapered slope varying between ±0.03, using a 3/4-inch (19mm) bore gas gun. Strain-time profiles are measured at cross-section distances of 1, 2, and 4 inches (25, 51, and 102 mm) from the impact face with resistance gages. Quantitative agreement between theoretical prediction and experimental data, e.g., dispersive features and unloading patterns of the strain wave, show the theory and method of solution to be a reasonably accurate model of the deformation. The selection of the specimen geometry as the experimentally controllable parameter in the longitudinal impact experiment is found to be a useful testing method in investigating the dynamic response of materials.

Analytical studies of probe conduction errors in ground temperature measurements, B. A. Peavy, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 4, 243-247 (Oct.-Dec. 1968).

Key words: Earth temperature; probe conduction errors; steady periodic heat flow.

Vertical probes with temperature sensing elements placed at fixed positions along their length are commonly used for measuring earth temperature variations with time. Mainly for structural reasons, the probes are comprised of materials whose thermal properties are not the same as those of the surrounding earth, so that the temperatures as measured at a given time by the probe are not the same as that for the undisturbed earth. A mathematical analysis for steady periodic, two-dimensional heat flow in a two body composite has been made to determine the probe conduction errors in ground temperature measurements. Several examples are given to show the relative magnitude of probe conduction errors.

Nonlinear constrained optimization by a nonrandom complex method, R. A. Mitchell and J. L. Kaplan, *J. Res. Nat. Bur. Stand. (U.S.),* **72C** (Eng. and Instr.), No. 4, 249-258 (Oct.-Dec. 1968).

Key words: Curved bar analysis; discrete variables; elastic; force transducer; minimum weight; n-degree elliptical ring; nonlinear programming; nonrandom complex method; optimization; rib-stiffened plate; structural analysis.

A nonrandom complex method is described for application to optimization problems characterized by nonlinear objective and constraint functions involving continuous and/or discrete optimization variables. The method is a mutation of the "complex" method (involving a pseudo-random process) developed by M. J. Box. Application of the method is demonstrated by two minimum weight structural analysis problems: (1) an n-degree elliptical elastic ring with sinsusoidally varying cross section dimensions; and (2) a rib-stiffened, simply supported elastic plate. The ring problem has six continuous independent variables, and the plate problem has four independent variables, two of which are discrete.

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PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 73C, JANUARY-DECEMBER 1969

January-June 1969

An interferometer for measuring gradients in both refractive index and thickness of large or small optics, J. B. Saunders, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Engr. and Instr.), Nos. 1 and 2, 1-4 (Jan.-June 1969).

Key words: Interferometer; optical homogeneity; refractive index.

A small aperture prism interferometer is described for measuring refractive index and thickness gradients between pairs of adjacent points in both small and large optics. It is relatively free from vibration problems and thermal gradients are reduced to a minimum by confining the two component beams of light to a relatively small space. Large specimens are tested by scanning them with the light beam.

A Kerr electro-optical technique for observation and analysis of high-intensity electric fields, E. C. Cassidy and H. N. Cones, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Engr. and Instr.), Nos. 1 and 2, 5-13 (Jan.-June 1969).

Key words: Dielectric liquids; electro-optical measurements; electrostatic field measurements; high voltage measurements; Kerr cell; laser applications; potential measurements; pulse measurements.

A Kerr electro-optical technique, which permits observation and analysis of high intensity electric fields in nitrobenzene-filled Kerr cells, is described. Two-dimensional visual images, similar to those achieved in photoelastic-mechanical stress analysis, of the field distribution are afforded by the fringe pattern produced by the Kerr effect when high direct voltages are applied to the cell. Analysis of the field profile, by measurement of the fringe positions, permits calibration of the system for measurement of high voltage pulses. The Kerr constant of the liquid and space-resolved determinations of relative field strength, actual field strength (in volts per centimeter), and potential are also derived.

Student-*t* deviate corresponding to a given normal deviate, B. L. Joiner, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Eng. and Instr.), Nos. 1 and 2, 15-16 (Jan.-June 1969).

Key words: Standard deviation; statistics; Student-*t*; table of Student-*t*; uncertainties.

A table is given of the t deviate that corresponds to a given normal deviate z in the sense that the probabilities outside the t value and outside the z value are identical. This table enables those who are accustomed to expressing uncertainties in terms of 1σ, 2σ, 3σ, or 4σ limits to give statistically equivalent limits when the standard deviation σ is not known and consequently must be estimated from small samples.

A heat loss compensated calorimeter and related theorems, S. R. Domen, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Eng. and Instr.), Nos. 1 and 2, 17-20 (Jan.-June 1969).

Key words: Absorbed dose; calorimeter; heat flow theorems; heat loss compensation.

A new calorimetric design and measuring technique are proposed for reducing uncertainties caused by temperature gradients. A theoretical analysis reveals a mathematical theorem concerning heat transfer and its electrical analog.

Laboratory measurements of air cavity temperature in a passenger car tire, B. G. Simson and J. Mandel, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Eng. and Instr.), Nos. 1 and 2, 21-24 (Jan.-June 1969).

Key words: Temperature sensitivity; tires.

The air cavity temperature of a passenger car tire, running on a test wheel, was measured for different combinations of load, speed, and pressure. An empirical function was developed to illustrate the way in which the air cavity temperature of tires can be related adequately to given values of speed, load, and inflation pressure within the range covered by this laboratory experiment. The standard deviation computed from the residuals of the fit was 5 °F (≃ 2.8 °C).

July-December 1969

Design features of a precision ac-dc converter, L. A. Marzetta and D. R. Flach, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Eng. and Instr.), Nos. 3 and 4, 47-55 (July-Dec. 1969).

Key words: AC; DC; operation; precision; rectifier; transfer.

With the availability today of high performance operational amplifiers and related components, it is possible to construct an instrument for ac-dc transfer work that meets the requirements of a standards laboratory. Transformation of measured average a-c values into d-c voltage is possible with a predictable accuracy of 20 parts per million up to 1 kHz. Precision of operation is assured from dc to 100 kHz.

An improved high-precision calibration procedure for reference standard hydrometers, H. A. Bowman and W. H. Gallagher, *J. Res. Nat. Bur. Stand.* (*U.S.*), **73C** (Eng. and Instr.), Nos. 3 and 4, 57-65 (July-Dec. 1969).

Key words: Calibration; density; hydrometer; hydrometer calibration; reference hydrometer; specific gravity; standard hydrometer.

This paper describes a method of calibrating hydrometers which, although no more accurate than the technique used heretofore at the National Bureau of Standards, reduces calibration time from several days to a few hours. The procedure is based upon easily measured hydrometer weight, stem scale geometry, and flotation level measurements at only one liquid density. The reliability of this single level is improved by observing the hydrometer flotation under various weight loads. The calibration experiment is oriented toward automatic data reduction so the finished calibration report is of much wider applicability than the simple correction table derived from the older experiment.

The nuclear quadrupole resonance magnetometer: A new method for the precision measurement of the magnitude and direction of magnetic fields, M. Linzer, *J. Res. Nat. Bur. Stand. (U.S.),* **73C** (Eng. and Instr.), Nos. 3 and 4, 67-73 (July-Dec. 1969).

Key words: Magnetometer; nuclear quadrupole resonance.

A theoretical investigation of the feasibility of a magnetometer based on the observation of the Zeeman splitting of a nuclear quadrupole resonance line is presented. With a single crystal of potassium chlorate as the sensor, an nqr magnetometer with center frequency of 28 MHz and bandwidth of 10 MHz could cover a range of 10 nT to greater than 1 T. Precision at specific crystal orientations should approach 10 nT in the magnitude of the field, at flux densities exceeding 100 μT, and $(65/B)$ microradians in the direction of the field where B is the flux density in mT. If circularly polarized rf excitation is employed, a precision of 10 nT could be achieved at flux densities less than 100 μT. Accuracy of the flux density measurements is limited by the uncertainty in the gyromagnetic ratio of ^{35}Cl, which at the present time is approximately 1×10^{-4}. The effect of the small asymmetry parameter which characterizes the ^{35}Cl resonance in $KClO_3$ is analyzed. Various experimental arrangements are proposed to record the magnitude and direction of the field, to obtain high resolution at low fields and good linearity at high fields, to overcome the difficulties due to the presence of a small asymmetry parameter, and to make an instantaneous measurement of the Zeeman splitting frequency.

Optical FM system for measuring mechanical shock, L. D. Ballard, W. S. Epstein, E. R. Smith, and S. Edelman, *J. Res. Nat. Bur. Stand. (U.S.)*, **73C** (Eng. and Instr.), Nos. 3 and 4, 75-78 (July-Dec. 1969).

Key words: Accelerometer; calibration; Doppler; interferometer; laser; shock measuring; single-sideband.

A technique is described for calibrating shock accelerometers by measuring the Doppler shift in light frequency produced by the change in velocity of a target. The system employs a quadrature laser interferometer and a single-sideband carrier insertion circuit to distinguish between positive and negative velocities.

3.4. MONOGRAPHS

Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Monogr. 25, Section 6. **Standard x-ray diffraction powder patterns, Section 6.-Data for 60 substances,** H. E. Swanson, H. F. McMurdie, M. C. Morris, and E. H. Evans, Nat. Bur. Stand. (U.S.), Monogr. 25, Sec. 6, 101 pages (June 1968).

> Key words: Constants; crystal; lattice; measurements; powder-patterns; reference-intensities; standard; structure; x-ray diffraction.

Standard x-ray diffraction powder patterns are presented for 60 substances. Fifty-four of these patterns represent experimental data and 6 are calculated. The experimental x-ray powder diffraction patterns are made with a Geiger counter x-ray diffractometer, using samples of high purity. All d-values were assigned Miller indices determined by comparison with theoretical interplanar spacings and from consideration of space group extinctions. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were obtained from published crystal structure data. The reported peak height intensities for calculated patterns were converted from integrated intensities.

Reference intensity values based upon the strongest line of corundum (113) in a 50 weight percent mixture are given for 98 materials.

Monogr. 25, Section 7. **Standard x-ray diffraction powder patterns, Section 7.-Data for 81 substances,** H. E. Swanson, H. F. McMurdie, M. C. Morris, and E. H. Evans, Nat. Bur. Stand. (U.S.), Monogr. 25, Sec. 7 (Sept. 1969).

> Key words: Crystal structure; integrated intensities; latttice constants; peak intensities; powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray diffraction powder patterns are presented for 81 substances. Forty-five of these patterns represent experimental data and 36 are calculated. The experimental x-ray powder diffraction patterns were obtained with a Geiger or proportional counter x-ray diffractometer, using samples of high purity. All d-values were assigned Miller indices determined by comparison with computed interplanar spacings and consideration of space group extinctions. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were computed from published crystal structure data. Both peak height and integrated intensities are reported for the calculated patterns.

Monogr. 70, Volumes I and II. See Nat. Bur. Stand. (U.S.), Misc. Publ. Suppl. to 240, 757 pages (Apr. 1967).

Monogr. 70, Volume III. **Microwave spectral tables. Volume III. Polyatomic molecules with internal rotation,** P. F. Wacker, M. S. Cord, D. G. Burkhard, J. D. Petersen, and R. F. Kukol, Nat. Bur. Stand. (U.S.), Monogr. 70, Vol. III, 275 pages (June 1969).

> Key words: Barrier height; centrifugal distortion constant; coherent radiation technique; dipole moment; hindered rotation; internal rotation; microwave spectra; molecular spectra; polyatomic molecules; quadrupole coupling constants; rotational constant; spectral lines.

Measured frequencies, assigned molecular species, and assigned quantum numbers are given for about 9,000 spectral lines of polyatomic molecules with internal rotation observed by coherent radiation techniques. Molecular data, such as rotational constants, dipole moments, and various coupling constants, determined by such techniques, are also tabulated. References are given for all included data.

Monogr. 70, Volume IV. **Microwave spectral tables. Volume IV. Polyatomic molecules without internal rotation,** M. S. Cord, J. D. Petersen, M. S. Lojko, and R. H. Haas, Nat. Bur. Stand. (U.S.), Monogr. 70, Vol. IV, 429 pages (Oct. 1968).

> Key words: Centrifugal distortion constant; coherent radiation technique; dipole moment; l-doubling; microwave spectra; molecular spectra; polyatomic molecules; quadrupole coupling constants; rotational constant; spectral lines.

Measured frequencies, assigned molecular species, and assigned quantum numbers are given for about 14,000 spectral lines of polyatomic molecules without internal rotation observed by coherent radiation techniques. Molecular data, such as rotational constants, dipole moments, and various coupling constants, determined by such techniques, are also tabulated. References are given for all included data.

Monogr. 70, Volume V. **Microwave spectral tables. Volume V. Spectral line listing,** M. S. Cord, M. S. Lojko, and J. D. Petersen, Nat. Bur. Stand. (U.S.), Monogr. 70, Vol. V, 538 pages (June 1968).

> Key words: Diatomic molecules; hyperfine; microwave spectra; molecular spectra; polyatomic molecules; rotational quantum numbers; spectral lines.

This volume is a listing of the spectral lines reported in Volumes I, III, and IV of the Microwave Spectral Tables. These lines are listed according to ascending magnitude of frequency and should provide a ready reference.

Monogr. 104. **Colorimetry,** I. Nimeroff, Nat. Bur. Stand. (U.S.), Monogr. 104, 50 pages (Jan. 1968).

> Key words: Color dictionaries; color vision; colorimeters; photoelectric tristimulus; spectrophotometric colorimetry; visual colorimetry.

The definition of color, as a characteristic of light, and the basic principles of its measurement are given. The reduction of spectrophotometric data to three chromaticity coordinates by means of the three-function CIE standard observer system for colorimetry is described. Various methods of direct colorimetry, and visual and photoelectric methods of colorimetry by differences from material standards are treated. The most useful collections of material color standards are described and the most widely used one-dimensional color scales are explained. The limitations of several colorimetric methods: spectrophotometric, photoelectric, and visual, are discussed. (Supersedes NBS Circ. 478).

Monogr. 105. **Acid-base behavior in aprotic organic solvents,** M. M. Davis, Nat. Bur. Stand. (U.S.), Monogr. 105, 156 pages (Aug. 1968).

> Key words: Acid-base behavior; acidity and basicity scales; aprotic organic solvents; hydrogen bonding; titrations.

A unified picture of acid-base behavior in aprotic organic solvents is presented, based on an extensive survey of the literature and experimental results of the author and associates. Evidence given to support this picture includes data pertaining to colligative properties of acids, bases, and salts and also conductance, dielectric constants, distribution between immiscible solvents, and spectral absorption in the infrared, visible, and ultraviolet. The acids upon which attention is centered are proton-donor compounds that are measurably ionized in water, such as aliphatic and aromatic carboxylic acids, substituted phenols, and mineral acids. The bases of principal interest are likewise compounds capable of forming ions in water, for example, aliphatic and aromatic amines and derivatives of guanidine or pyridine. The solvents emphasized are hydrocarbons and halohydrocarbons, but data for dipolar aprotic solvents (for example, acetone, acetonitrile, and nitrobenzene) are included. Contrasts in acid-base behavior and in acidity and basicity scales in aprotic and water-like solvents are discussed.

The role of hydrogen bonding in aprotic solvents is discussed at length. Important types of hydrogen-bonded structures include chelate rings; self-associated acids, bases, and salts; hydrogen-bonded ion pairs; and homo- and heteroconjugate cations and anions. Examples are given in which hydrogen bonding of these types affects such properties as the absorption spectrum of a salt, the catalytic effect of an acid, and the accurate location of a titration endpoint.

Monogr. 106. **Nickel and its alloys,** S. J. Rosenberg, Nat. Bur. Stand. (U.S.), Monogr. 106, 160 pages (May 1968).

Key words: Alloys; corrosion-resisting alloys; copper-nickel alloys; electroplating; electrical resistance alloys; heat resisting alloys; magnetic alloys; maraging steels; nickel; stainless steels; steels.

This monograph reviews available information on the production, properties, and uses of high-purity and commercial forms of nickel, and on the properties and applications of its important alloys, both ferrous and nonferrous. It is a revision of National Bureau of Standards Circular 592, issued in 1958. (Supersedes NBS Circ. 592.)

Monogr. 107. **Acceleration due to gravity at the National Bureau of Standards,** D. R. Tate, Nat. Bur. Stand. (U.S.), Monogr. 107, 24 pages (June 1968).

Key words: Absolute gravity; acceleration; free-fall; *g*; gravity; Potsdam.

A determination of the absolute value of the acceleration due to gravity was completed in June 1965 at the National Bureau of Standards near Gaithersburg, Maryland. The determination resulted in a value of 980.1018 centimeters per second squared for a reference point on the first floor of the Engineering Mechanics Building. The result was published in the Journal of Research of the National Bureau of Standards, Vol. **70C,** No. 2, Engineering and Instrumentation, page 149, April-June 1966. The present paper describes in detail the apparatus and the techniques employed and presents the summarized data from which the value was derived.

Monogr. 108. **Oscillator strengths and transition probabilities for 3288 lines of Fe I (2100-9900 Å),** C. H. Corliss and J. L. Tech, Nat. Bur. Stand. (U.S.), Monogr. 108, 68 pages (Mar. 1968).

Key words: Fe I; iron; oscillator strengths; spectrum; spectrum of neutral iron; transition probabilities in Fe I.

A homogeneous set of intensity-related data has been calculated for 3288 spectral lines of Fe I in the region from 2100 to 9900 angstroms. The quantities tabulated in the present monograph include log $(gf\lambda)$, log (gf), gf, f, gA, and A. The data are presented on the absolute scale established in a previous work by Corliss and Bozman. In that work and the later extensions of it by Corliss and Warner, the calculation of gf-values included the application of an empirically determined normalization correction to the level populations, the normalization being given as a function of upper energy level for the transition. Since recent investigations do not support these excitations corrections in the case of Fe I and certain other spectra, the present tabulation incorporates a removal of that normalization function. This recalculation affects the values for all lines whose upper energy levels lie above 46000 cm^{-1} and should significantly improve the internal consistency of the present data.

Monogr. 109. **Investigation of the exploding wire process as a source of high temperature studies,** E. C. Cassidy, S. Abramowitz, and C. W. Beckett, Nat. Bur. Stand. (U.S.), Monogr. 109, 53 pages (Nov. 1968).

Key words: Electrical discharges; exploding wire; high current; high speed; high speed photography; high temperature; high voltage; light sources; time-resolved electrical measurements; time-resolved spectroscopy.

Numerous experiments with electrically exploded wires are described. The results include time-resolved measurements of electrical energy, power, voltage, and current during the discharge; periodic still and high-speed photographs of the entire explosion process; integrated and time-resolved measurements of the intensity and spectral distribution of the radiation emitted; and time-resolved absorption spectra from the products of the discharge, with emphasis on observations of the spectrum of the AlO molecule. The apparatus, instrumentation, and fast-measurement techniques developed in order to permit these direct experimental observations and measurements, under the extreme and transient conditions of the explosive discharge, are also described. Results from calculations of the composition, entropy, enthalpy, and density of the explosion mixture are given.

Monogr. 110. **Infrared spectroscopy of carbohydrates. A review of the literature,** R. S. Tipson, Nat. Bur. Stand. (U.S.), Monogr. 110, 24 pages (June 1968).

Key words: Analysis; carbohydrates; conformations; infrared spectra; spectrometry; structure.

A survey has been made of the literature on the infrared spectroscopy of carbohydrates, in order to assemble and systematize information in this field. The Monograph discusses principles and instrumentation, sampling techniques, comparison of samples, and the interpretation of the spectra, particularly as regards functional groups of carbohydrates and their derivatives, correlations for the fingerprint region and beyond, and conformational studies. In addition, examples are discussed of the use of infrared spectra for qualitative and quantitative purposes and in the determination of structure. Special techniques are briefly described, including use of plane-polarized radiation, the technique of attenuated total reflection, and Raman spectra.

Monogr. 111. **Technology of liquid helium,** R. H. Kropschot, B. W. Birmingham, and D. B. Mann, Editors, Nat. Bur. Stand. (U.S.), Monogr. 111, 380 pages (Oct. 1968).

Key words: Conservation; cryoelectronics; cryogenics; cryopumping; helium; liquefaction; magnets; purification; refrigeration; safety; storage; thermodynamic properties; transportation.

The discovery of the element helium was made just 100 years ago in 1868. Today helium is produced in large quantities and used in many technological applications. This treatise is a source document containing information on helium resources, production, conservation, themodynamic properties, liquefaction and refrigeration techniques, transportation and storage of liquid and safety requirements. It also contains a discussion of uses for liquid and cold gas in cryoelectronics, superconductivity, bubble chambers, cryopumping and missile and space systems. The book brings together articles by noted authorities in cryogenic technology in which they discuss their specialized field in great depth.

Monogr. 112. **An introduction to the description and evaluation of microwave systems using terminal invariant parameters,** G. F. Engen, Nat. Bur. Stand. (U.S.), Monogr. 112, 27 pages (Oct. 1969).

Key words: Attenuation; impedance; microwave power; precision connector; terminal invariant.

The description and evaluation of microwave systems is usually by means of microwave circuit analysis, which may be regarded as an extension of the practice at lower frequencies. In order to insure its validity, it is necessary to postulate that the different components, which comprise the microwave system, are interconnected via uniform and lossless waveguide, and which is usually (but not necessarily) restricted to single mode operation. As a consequence, precision (uniform) waveguide and connectors are usually considered necessary elements for an accurate experimental evaluation of a microwave system.

It is possible to avoid this requirement in an alternative formulation where the description is based upon net power, instead of the complex traveling wave amplitudes. In this reformulation the basic parameters include available power, maximum efficiency (or intrinsic attenuation), and several different "mismatch factors." The important feature of these parameters is their "terminal invariant" property, i.e., their invariance to an arbitrary shift in the terminal reference surface (in an assumed lossless region).

In this way the precision waveguide and connector requirement is avoided for an important class of measurement problems. In addition the physical model, upon which the description is based, is a simple one which provides improved insight into mismatch errors and corrections.

3.5. HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies. In many cases recommended requirements are given official status through their incorporation in local ordinances by State and municipal regulatory bodies.

H105-1. **Specifications and tolerances for reference standards and field standard weights and measures. 1. Specifications and tolerances for field standard weights,** T. M. Stabler, Editor, Nat. Bur. Stand. (U.S.), Handb. 105-1, 10 pages (Apr. 1969).

Key words: Cooperation for uniformity of measurements; field standard weights; specifications; tolerances; weights and measures inspection.

These specifications and tolerances are intended to set forth minimum requirements for standards used in the field by State and local weights and measures officials in the official examination of weighing and measuring devices used in commerce. They should be considered also as appropriate for device installers and repairmen.

Although the National Bureau of Standards has no regulatory authority in this area, its organic legislation (31 Stat. 1449) specifically authorizes "The custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards . . . and cooperation with the States in securing uniformity in weights and measures laws and methods of inspection."

H106. **CODASYL COBOL journal of development 1968,** Nat. Bur. Stand. (U.S.), Handb. 106, 344 pages (July 1969).

Key words: COBOL; CODASYL; journal.

This document is a report to the COBOL community from the Conference on Data Systems Languages (CODASYL) Common Business Oriented Language (COBOL) Programming Language Committee. It is an official report documenting the development activities of CODASYL through July 1968.

3.6. MISCELLANEOUS PUBLICATIONS (Series changed to Special Publications)

As the name implies, this series provided material of a particular nature and quality in fields of the Bureau's competence. It included proceedings of NBS-sponsored national and international conferences devoted to the state-of-the art, as well as precision measurement and calibration volumes, NBS Research Highlights, and other special publications.

M260, 1968 Edition. **Standard reference materials. Issued by the National Bureau of Standards,** Nat. Bur. Stand. (U.S.), Misc. Publ. 260, 48 pages, 1968 Edition (Jan. 31, 1968).

Key words: Analysis; catalog; certificate; characterization; composition; price list; property of material; purity of material; standard reference materials; standards.

This catalog describes the various Standard Reference Materials issued by the National Bureau of Standards. These materials are used to calibrate measurement systems and provide scientific information that can be referred to a common base. A schedule of prices and quantities is included for each material, as well as directions for ordering. Listed are the types and compositions of those chemical standards that are presently available. Announcements of new standard reference materials are made in the Federal Register, in scientific and trade journals, and in the Technical News Bulletin of the National Bureau of Standards. Changes affecting the current status of the various standards will be indicated by an insert sheet available quarterly from the Bureau. (Supersedes NBS Misc. Publ. 260, 1968 Edition.)

M278 Supplement. **Bibliography on atomic transition probabilities, May 1966 through December 1967,** B. M. Glennon and W. L. Wiese, Nat. Bur. Stand. (U.S.), Misc. Publ. 278, 46 pages (Apr. 1968).

Key words: Allowed; atomic; discrete; forbidden; transition probability.

A supplement to NBS Miscellaneous Publication 278, Bibliography on Atomic Transition Probabilities is presented, which covers the most recent literature on this subject from May 1966 through December 1967. The papers are arranged according to elements and stages of ionization, and the method employed and class of transitions are indicated behind each reference. Only articles on discrete transitions, both allowed and forbidden, are listed. Papers containing data for more than 20 individual elements or stages of ionization are collected separately in front of the list in order to keep this bibliography at a reasonable size. Also included is a selected list of papers dealing with the subject of transition probabilities from a general point of view.

3.7. SPECIAL PUBLICATIONS (Formerly Miscellaneous Publications)

This series includes proceedings of high-level national and international conferences sponsored by NBS, precision measurement and calibration volumes, NBS Research Highlights, and other special publications appropriate to this grouping, such as administrative pamphlets, wall charts and bibliographies.

SP236, 1969 Edition. **NBS frequency and time broadcast services. Services provided by NBS standard frequency stations WWV, WWVH, WWVB, and WWVL,** Nat. Bur. Stand. (U.S.), Spec. Publ. 236, 16 pages (1969).

Key words: Broadcast of standard frequencies; high frequency; low frequency; standard frequencies; time signals; very low frequency.

Detailed descriptions are given of the technical services provided by the National Bureau of Standards radio stations WWV, WWVH, WWVB, and WWVL. These services are: (1) Standard radio frequencies; (2) Standard audio frequencies; (3) Standard musical pitch; (4) Standard time intervals; (5) Time signals; (6) UT2 corrections; (7) Radio propagation forecasts; and (8) Geophysical alerts. In order to provide users with the best possible services, occasional changes in broadcasting schedules are required. This publication shows the schedules in effect on January 1, 1969. Annual revisions will be made. Current data relating to standard frequencies and time signals are available monthly in the Time and Frequency Services Bulletin. Advance notices of changes occurring between revisions will be sent to users of NBS broadcast services who request such notice on the basis of need. (Supersedes NBS Special Publication 236, 1968 Edition.)

SP236, 1968 Edition. **Services provided by NBS standard frequency stations WWV, WWVH, WWVB, and WWVL,** Nat. Bur. Stand. (U.S.), Spec. Publ. 236, 15 pages (1968).

Key words: Broadcast of standard frequencies; high frequency; low frequency; standard frequencies; time signals; very low frequency.

Detailed descriptions are given of the technical services provided by the National Bureau of Standards radio stations WWV, WWVH, WWVB, and WWVL. These services are: (1) Standard radio frequencies; (2) Standard audio frequencies; (3) Standard musical pitch; (4) Standard time intervals; (5) Time signals; (6) UT2 corrections; (7) Radio propagation forecasts; and (8) Geophysical alerts. In order to provide users with the best possible services, occasional changes in the broadcasting schedules are required. This publication shows the schedules in effect on January 1, 1968. Annual revisions will be made. Current data relating to standard frequencies and time signals are available monthly in the Time and Frequency Services Bulletin. Advance notices of changes occurring between revisions will be sent to users of NBS broadcast services who request such notice on the basis of need. (Supersedes NBS Misc. Publ. 236, 1967 Edition.)

SP250, 1968 Edition. **Calibration and test services of the National Bureau of Standards,** Nat. Bur. Stand. (U.S.), Spec. Publ. 250, 199 pages (May 1968).

Key words: Calibration services; fees for testing; test fee schedule; test procedures.

This publication contains a descriptive listing, item by item, of most of the test and calibration work done at the National Bureau of Standards with the respective fees. The content is fully indexed providing easy access to data on specific measurement services. Included also is information about the Bureau's organization and statutory functions, the procedures for requesting tests, and the reports issued thereon. Throughout the text various other publications are mentioned which form a bibliography in measurement techniques. This publication supersedes Miscellaneous Publication 250, 1965 Edition, and is incorporated by reference in the Federal Register. (Supersedes NBS Misc. Publ. 250, 1965 Edition.)

SP260, July 1969 Edition. **Standard reference materials. Issued by the National Bureau of Standards.** Nat. Bur. Stand. (U.S.), Spec. Publ. 260, July 1969 Edition, 44 pages (July 1969).

Key words: Analysis; catalog; certificate; characterization; composition; price list; property of material; purity of material; standard reference materials; standards.

This catalog describes the various Standard Reference Materials issued by the National Bureau of Standards. These materials are used to calibrate measurement systems and provide scientific information that can be referred to a common base. A schedule of prices and quantities is included for each material, as well as directions for ordering. Listed are the types and compositions of those chemical standards that are presently available. Announcements of new standard reference materials are made in the Federal Register, in scientific and trade journals, and in the Technical News Bulletin of the National Bureau of Standards. Changes affecting the current status of the various standards will be indicated by an insert sheet available quarterly from the Bureau. (Supersedes NBS Misc. Publ. 260, 1968 Edition.)

SP260-16. **Standard reference materials: homogeneity characterization of NBS spectrometric standards IV: preparation and microprobe characterization of W-20% Mo alloy fabricated by powder metallurgical methods,** H. Yakowitz, R. E. Michaelis, and D. L. Vieth, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-16, 30 pages (Jan. 1969).

Key words: Electron probe analysis; metallography; powder metallurgy; spectrometric standards; Standard Reference Materials; W-Mo alloys.

A significant problem of the National Bureau of Standards Standard Reference Materials program is the provision of standards suitable in homogeneity for use with microanalytical techniques such as the spark source mass spectrograph and the electron probe microanalyzer. An interim approach to the problem has been the extended homogeneity characterization of selected existing standards. This paper describes the preparation and evaluation of the first NBS standard tested specifically from the beginning for application to electron probe microanalyzers. The standard designated SRM 480 is a tungsten-20 weight percent molybdenum alloy prepared by a powder metallurgy process. Based on the results of about 1500 determinations for both tungsten and molybdenum electron probe microanalysis, the material was found to be of high homogeneity at about the micrometer level of spatial resolution. The coefficient of variation for molybdenum was 2.5% and that for tungsten 1.5%. Correction of relative intensity ratios to obtain concentrations is discussed in terms of input parameter uncertainties such as mass absorption coefficients, and electron backscatter factors. The result of studies for atomic number correction and effects on operating voltage on the microprobe absorption correction, will be given. It is concluded that SRM 480 should be a valuable addition to any microprobe laboratory doing quantitative analyses.

SP260-18. **Calibration of NBS secondary standard magnetic tape (computer amplitude reference) reference tape amplitude measurement "process A,"** S. B. Geller, P. A. Mantek, and N. G. Cleveland, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-18, 41 pages (Nov. 1969).

Key words: Average peak signal level, computer amplitude reference; magnetic tape; master standard; saturation curves; secondary standard; signal level calibration; standard reference materials; unrecorded reference.

This publication describes the design and operation of the NBS signal amplitude measuring system (Process A) that is used for calibrating unrecorded Secondary Standard Magnetic Tapes (Computer Amplitude Reference). The signal level calibration is made with respect to a reference signal level derived from the NBS Master Standard Magnetic Tape (Computer Amplitude Reference) that is kept in repository at NBS. The techniques for measuring and recording the data that accompany each Secondary Standard Magnetic Tape in the form of strip chart recordings and saturated curves are described.

SP295. **Electronic composition in printing.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., June 15-16, 1967, R. W. Lee and R. W. Worral, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 295, 133 pages (Feb. 1968).*

Key words: Character generation; composition language; computer technology; computerized text processing; electronic composition; electronic computer; electronic printing; GRACE; Linotron; MACRO coding; MEDLARS; microfilm; photocomposition; Photon; programming; text editing.

A Symposium on Electronic Composition in Printing was held at the Gaithersburg, Md. Laboratories of the National Bureau of Standards June 15 and 16, 1967. Sponsored by the NBS Center for Computer Sciences and Technology, the symposium was a state-of-the-art review of a rapidly advancing field of computer application with great potentialities for increased efficiency and savings in the Federal Government.

Twenty-nine papers were presented and are published in this Proceedings. They include a diverse group by industry representatives reporting recent technological advancements in the field. Several papers define government policy and describe the new Linotron system of photocomposition at the Government Printing Office; another series is devoted to nongovernment applications and research; and a final group details specific applications within several Government agencies.

SP296. **Mass transport in oxides.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., October 22-25, 1967, J. B. Wachtman, Jr. and A. D. Franklin, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 296, 224 pages (Aug. 1968).*

Key words: Crystal defects; diffusion; ionic conductivity; mass transport; oxides; stoichiometry.

This Special Publication presents the Proceedings of the Conference on Mass Transport in Oxides, held at the National Bureau of Standards in Gaithersburg, Md., from October 22 to October 25, 1967, under the joint sponsorship of the Bureau and the Advanced Research Projects Agency. Invited papers reviewed mass transport in alkali and silver halides as background, and topics relating to oxides including point defects, (both experiment and theory), lattice dynamics and ionic interactions, atomistic mechanisms of diffusion and ionic conduction, chemical diffusion, defect complexes, assessments of the experimental situation for diffusion and ionic conduction, and the availability of good research materials. In contributed papers, attention was focused on color centers in alkaline earth oxides, cation diffusion in MgO, transport of both cations and anions in transition metal oxides, and coulometric and emf techniques for obtaining transport data. A panel discussion summarized the work of the conference.

SP297. **Report of the 52d National Conference on Weights and Measures, 1967,** R. L. Koeser, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 297, 226 pages (May 1968).*

Key words: Conference; weights and measures—history; weights and measures—laws; weights and measures—regulations; weights and measures—technical requirements; weights and measures.

This is a report of the proceedings (edited) of the Fifty-second National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Washington, D.C., June 26-30, 1967 and attended by State, county, and city weights and measures officials and representatives of the Federal Government, business, industry, railroads, and associations.

SP298. **Quantitative electron probe microanalysis.** Proceedings of a Seminar held at the National Bureau of Standards, Gaithersburg, Md., June 12-13, 1967, K. F. J. Heinrich, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 298, 305 pages (Oct. 1968).

Key words: Atomic number effect; biological specimens; electron probe microanalysis; electron scattering; fluorescence by the continuum; quantitative analysis; stereometric analysis; x-ray absorption; x-ray emission.

A seminar was held at the National Bureau of Standards in June 1967 to examine critically the factors involved in quantitative electron probe microanalysis. Major consideration was given to proposed methods for data evaluation, and to requirements for further work in theory, in measurement, and in the preparation of standards. This volume contains a series of invited papers which formed the basis of discussion at the seminar. Topics covered include corrections for the atomic number effect, for x-ray absorption, and for fluorescence by characteristic lines and the continuum. The various ways to derive a simplified model of the complex electron-target interaction are critically analyzed by several authors, and the accuracy of several proposed methods is compared by error histograms constructed on the basis of hundreds of analyses of materials of known composition. Applications to the analysis of biological specimens and to problems of stereometric analysis are also discussed.

SP299, Volumes 1 and 2. **Neutron cross sections and technology.** Proceedings of a conference held in Washington, D.C., March 4-7, 1968, D. T. Goldman, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 299, Vol. 1, 660 pages and Spec. Publ. 299, Vol. 2, 718 pages (Sept. 1968).*

Key words: Cross sections; neutrons; nuclear data; nuclear technology; reactors.

The Second Conference on Neutron Cross Sections and Technology was held in Washington, D.C. on March 4-7, 1968. Papers from this Conference have been published in two volumes as follows: Volume I, Sessions A-D, pages 1-640; Volume II, Sessions E-H, pages 641-1337. These volumes contain the texts of the invited and contributed papers of the Conference. Topics covered include: The need for neutron data in fields of science and technology; standard data and flux measurements; the determination of neutron cross sections by theoretical and experimental techniques; a presentation of recently measured data and their utilization in a variety of applications. These two volumes are sold as a set.

SP300, Volume 1. **Precision measurement and calibration. Selected papers on statistical concepts and procedures,** H. H.

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*See pages 41A–41K for a list of the papers presented.

Ku, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 1, 436 pages (Feb. 1969).

Key words: Accuracy; analysis of measurement data; design of experiments; functional relationships; interlaboratory tests; measurement process; precision; statistical concepts in measurements; systematic error.

This volume is one of an extended series which brings together the previously published papers, monographs, abstracts, and bibliographies by NBS authors dealing with the precision measurement of specific physical quantities and the calibration of the related metrology equipment. The contents have been selected as being useful to the standards laboratories of the United States in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation.

Volume 1 deals with methodology in the generation, analysis, and interpretation of precision measurement data. It contains 40 reprints assembled in 6 sections: (1) The Measurement Process; (2) Design of Experiments in Calibration; (3) Interlaboratory Tests; (4) Functional Relationships; (5) Statistical Treatment of Measurement Data; (6) Miscellaneous. Each section is introduced by an interpretive foreword, and the whole is supplemented by abstracts and selected references.

SP300, Volume 2. **Precision measurement and calibration temperature. Selected NBS papers on temperature,** J. F. Swindells, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 2, 520 pages (Aug. 1968).

Key words: Acoustical thermometry; cerous magnesium nitrate thermometer; error analysis; liquid-in-glass thermometry; reprints; resistance thermometry; spectroscopic thermometry; standards; temperature scales; thermoelectric thermometry.

This volume is one of an extended series which brings together the previously published papers, monographs, abstracts, and bibliographies by NBS authors dealing with the precision measurement of specific physical quantities and the calibration of the related metrology equipment. The contents have been selected as being useful to the standards laboratories of the United States in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation.

Volume 2 contains reprints through June 1967 covering the general topics: Uncertainties, Temperature Scales, Resistance Thermometry, Thermoelectic Thermometry, Liquid-in-Glass Thermometry, Optical Pyrometry, and Spectroscopic Thermometry. A selected bibliography covering the period from January 1953 through December 1965 is included. (Supersedes in part NBS Handb. 77, Vol. II.)

SP300, Volume 3. **Precision measurement and calibration. Selected NBS papers on electricity—low frequency,** F. L. Hermach and R. F. Dziuba, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 3, 498 pages (Dec. 1968).

Key words: Ac-dc transfer standards; capacitors; current transformers; dielectric measurements; electrical calibrations; electrical measurements; electrical standards; electrical units; high voltage measurements; inductive voltage dividers; inductors; magnetic measurements; resistance apparatus; resistors; standard cells; voltage transformers; zener diodes.

This volume is one of an extended series which brings together some of the previously published papers, monographs, abstracts and bibliographies by NBS authors dealing with the precision measurement of specific physical quantities and the calibration of the related metrology equipment. The contents have been selected as being useful to the standards laboratories of the United States in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation.

Volume 3 contains reprints through 1967 on d-c and low-frequency electrical measurements covering the following topics: Electrical Units, Electrical Standards, Standard Cells, Zener Diodes, Resistors, Resistance Apparatus, Capacitors, Inductors, Instruments, AC-DC Transfer Standards, Transformers, Inductive Voltage Dividers, High Voltage Measurements, Dielectric Measurements, and Magnetic Measurements. A selected list of NBS publications on electrical measurements is also included.

SP301. **Molecular dynamics and structure of solids.** Proceedings of the Second Materials Research Symposium held at the National Bureau of Standards, Gaithersburg, Md., October 16-19, 1967, R. S. Carter and J. J. Rush, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 301, 580 pages (June 1969).*

Key words: Crystal; crystal structure; diffraction; lattice dynamics; molecular dynamics; molecular solid; rotation; spectroscopy; vibration.

This volume is based on material presented at the Second Materials Research Symposium of the National Bureau of Standards, held October 16-19, 1967. It provides a review of the application of spectroscopic and diffraction techniques to the study of the structure and dynamics of molecular solids. Invited papers on the theory and practice of the major experimental methods, including neutron and x-ray diffraction, neutron inelastic scattering, infrared and Raman spectroscopy and nuclear magnetic resonance, serve as a background for the more detailed presentation and discussion of results which follows. The topics covered in a series of invited and contributed papers include the lattice dynamics of molecular crystals, the spectroscopy and crystal structure of organic and inorganic solids and the dynamics of polymers.

SP302. **Thermal conductivity.** Proceedings of the seventh conference held at the National Bureau of Standards, Gaithersburg, Md., November 13-16, 1967, D. R. Flynn and B. A. Peavy, Jr., Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 302, 820 pages (Sept. 1968).*

Key words: Conductance; conductivity; contact conductance; contact resistance; electrical conductivity; electrical resistivity; heat transfer; Lorenz function; resistivity; temperature; thermal conductivity; thermal diffusivity; thermal resistivity; thermophysical properties.

The Seventh Conference on Thermal Conductivity was held at the National Bureau of Standards on November 13-16, 1967. This volume contains the texts of the papers presented. Topics covered include surveys of the present state of knowledge regarding the thermal conductivity of different materials, descriptions of different apparatuses for measuring thermal conductivity, new experimental data on the thermal conductivity or diffusivity of a variety of materials, and correlations between experimental results and theoretical predictions.

SP303. **Mechanical and thermal properties of ceramics.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., April 1-2, 1968, J. B. Wachtman, Jr., Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 303, 275 pages (May 1969).*

Key words: Ceramics; elasticity; fracture; inelastic deformation; melting point; standards; thermal conductivity; thermal expansion; thermal radiation; viscoelasticity.

The proceedings of the Symposium on Mechanical and Thermal Properties of Ceramics, held at the National Bureau of Stan-

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*See pages 41A-41K for a list of the papers presented.

dards in Gaithersburg, Md., on April 1-2, 1968 are presented. The symposium was cosponsored by the American Ceramic Society, the American Society for Testing and Materials, and the National Bureau of Standards. Attention was concentrated upon properties primarily of structural and/or high temperature use including melting points, thermal expansion, thermal conductivity, thermal radiation properties, elasticity, viscoelasticity, inelastic deformation, and fracture. The dependence of these properties upon composition and microstructure was surveyed and the importance of controlling these features of character to insure reliability of ceramics was emphasized. The procedures by which American ceramists formulate standards and specifications to assist in insuring reliability were summarized.

SP304. **The modernized metric system—The international system of units (SI),** Nat. Bur. Stand. (U.S.), Spec. Publ. 304, 1 chart (1968).

Key words: English measurement system; measurement systems; metric system; SI units.

Attractively printed by a four-color process, this illustrated wall chart presents the six base units of the present-day form of the Metric System, or International System (internationally adopted abbreviation: SI) as it is now being called, some derived units defined directly in terms of the base units, and the relation between SI units and the U.S. customary units—foot, pound, quart, etc. The present edition of the chart (the last one was issued in 1963) has been completely redesigned and takes into account the adoption of the "atomic second" as the SI unit of time and changes in definitions or terminology for the units of temperature and luminous intensity.

Like its predecessors, this version of the chart is expected to find widespread use as a visual aid in classrooms. The importance of the information it provides is assured by the extensive adoption of the International System of Units by scientists, its official adoption for everyday use in a large number of countries, and its increasing acceptance in trade and industry in the United States.

Occupying approximately the upper third of the chart are: an introductory statement concerning the International System and its relation to the U.S. customary units; full-scale drawings of a meter stick and a yard stick, side by side; perspective drawings of cubes with volumes of 1 cubic decimeter and 1 liquid quart, respectively, giving a good idea of both their absolute and relative sizes; and similar drawings of platinum-iridium cylinders of mass 1 kilogram and 1 pound, respectively.

The lower two-thirds of the chart is divided into six panels, one for each of the six base SI units: the meter (length), second (time), kilogram (mass), kelvin (temperature), ampere (electric current), and candela (luminous intensity). Name, abbreviation, and definition are given for each, accompanied by pictorial or schematic drawings that illustrate the definitions or essential parts of the standards that embody the units. Also defined are the SI units of area, volume, frequency, speed, acceleration, force, work or energy, power, electric voltage, and electric resistance. The lower halves of the last two panels provide space for two tables. One table gives common equivalents and conversions from SI to U.S. customary units and vice versa. The other lists the prefixes adopted for use with SI units, to provide names of decimal multiples and submultiples, ranging from the prefix "tera," which multiplies the unit by 10^{12}, to the prefix "atto," which corresponds to multiplication by 10^{-18}. (Supersedes NBS Misc. Publ. 232.)

SP304 A. **Brief history and use of the English and metric system of measurement,** Nat. Bur. Stand. (U.S.), Spec. Publ. 304A, 4 pages (1968).

Key words: English measurement system; measurement systems: metric system; treaty of the meter.

The customary units of measurement used in the United States are an outgrowth of our colonial origin, while the metric system was developed to replace discordant units of measurement used in various parts of France and much of Europe. For various reasons the metric system became accepted as a principal language of science and was adopted in many nations of the world. This paper sketches the parallel development of these systems of measurement up to the present time and presents a chart detailing the International System of Units—a modernized metric system. This publication includes a one-third size version of the color chart of the Modernized Metric System (SP304).

SP305. **Publications of the National Bureau of Standards 1966-1967,** B. L. Oberholtzer, Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

Key words: Articles; publications.

All published work by National Bureau of Standards authors from the middle of 1966 to the end of 1967, both in the extensive publications issued by NBS itself and in outside publications, is covered in this latest supplement to the NBS catalog. Each title is accompanied by complete bibliographic information, plus a list of key words and an abstract, both prepared by the authors. In addition, there is information on the NBS publishing program, purchase procedures, publication announcement services, and price lists.

Information in the catalog is accessible through two indexes: an author index and a key word index. In the latter, the group of key words for each catalog entry is permuted so that each key word appears once as the first in the group, and therefore determines the alphabetical order in which the group appears in the index. The user can thus locate papers of interest to him through the subject-related key words.

SP306-1. **Bibliography on the analyses of optical atomic spectra. Section 1. ^{1}H-^{23}V,** C. E. Moore, Nat. Bur. Stand. (U.S.), Spec. Publ. 306-1, Sec. 1, 89 pages (Sept. 1968).

Key words: Analyses of atomic spectra; atomic spectra, H thru V; bibliography, atomic spectra; elements, spectra of H thru V; references to atomic spectra; spectra, atomic.

The three published volumes on "Atomic Energy Levels," NBS Circ. 467, contain for each spectrum the bibliography that was used in compiling the data. The present work is a continuation of these bibliographies arranged in the same form. The time interval is the span from the respective dates of the earlier publications to the present. The selection of references is restricted to those needed for the preparation of revised tables of atomic energy levels and multiplets.

The bibliography is being published in three sections each of which covers the same elements as the respective volumes of AEL. The present section contains reference lists for the elements 1 H through 23 V, corresponding to Volume I. The spectra of a given element are listed in order of increasing stage of ionization. Listings are included for spectra of the 23 elements.

The original papers have been examined for nearly all of the quoted references. A selected list of general literature references is also included.

SP306-2. **Bibliography on the analyses of optical atomic spectra. Section 2. ^{24}Cr-^{41}Nb,** C. E. Moore, Nat. Bur. Stand. (U.S.), Spec. Publ. 306-2, Sec. 2, 63 pages (Feb. 1969).

Key words: Analyses of atomic spectra; atomic spectra, Cr through Nb; bibliography, atomic spectra; elements, spectra of Cr through Nb; references to atomic spectra; spectra, atomic.

The three published volumes on "Atomic Energy Levels," NBS Circ. 467, contain for each spectrum the bibliography that was used in compiling the data. The present work is a continuation of these bibliographies arranged in the same form. The time interval is the span from the respective dates of the earlier publications to the present. The selection of references is restricted to those needed for the preparation of revised tables of atomic energy levels and multiplets.

The bibliography is being published by sections, each of which covers the same elements as the respective volumes of AEL. Section 1 was issued in September 1968; it contains references for the elements ^{1}H through ^{23}V, corresponding to AEL Volume I.

The present section is similarly arranged, giving references to the spectra of the elements ^{24}Cr through ^{41}Nb, corresponding to AEL Volume II. For a given element the spectra are listed in order of increasing stage of ionization.

The original papers have been examined for nearly all of the quoted references.

SP306-3. **Bibliography on the analyses of optical atomic spectra. Section 3. ^{42}Mo-^{57}La and ^{72}Hf-^{89}Ac,** C. E. Moore, Nat. Bur. Stand. (U.S.), Spec. Publ. 306-3, Sec. 3, 37 pages (May 1969).

Key words: Analyses of atomic spectra; atomic spectra; bibliography, atomic spectra, Mo through La, Hf through Ac; elements, spectra of Mo through La, Hf through Ac; references to atomic spectra; spectra, atomic.

The three published volumes on "Atomic Energy Levels," NBS Circ. 467, contain for each spectrum the bibliography that was used in compiling the data. The present work is a continuation of these bibliographies arranged in the same form. The time interval is the span from the respective dates of the earlier publications to the present. The selection of references is restricted to those needed for the preparation of revised tables of atomic energy levels and multiplets.

The bibliography is being published by sections, each of which covers the same elements as the respective volumes of AEL. Section I was issued in September 1968; it contains references for the elements ^{1}H through ^{23}V, corresponding to AEL Volume I. Section 2 appeared in February 1969; as in AEL Volume II, the references cover the elements ^{24}Cr through ^{41}Nb.

The present section is similarly arranged, giving references to the spectra of the elements, ^{42}Mo through ^{57}La and ^{72}Hf through ^{89}Ac, similar to AEL Volume III. For a given element the spectra are listed in order of increasing stage of ionization.

The original papers have been examined for nearly all of the quoted references.

SP306-4. **Bibliography on the analyses of optical atomic spectra. Section 4. ^{57}La-^{71}Lu and ^{89}Ac-^{99}Es,** C. E. Moore, Nat. Bur. Stand. (U.S.), Spec. Publ. 306-4, Sec. 4, 55 pages (Aug. 1969).

Key words: Analyses of rare-earth spectra; atomic spectra; La through Lu, Ac through Es; rare-earth spectra; references to atomic spectra; spectra, atomic: elements, spectra of rare-earths.

There is a steady demand for information on rare-earth spectra. In an attempt to satisfy this need the present bibliography has been prepared. It comprises Section 4, concludes this publication, and completes the coverage of the Periodic Table. The references listed have been selected on a general basis as those needed for the preparation of Volume 4 of "Atomic Energy Levels."

Since rare-earth structure is revealed in the neighboring spectra, ^{57}La and ^{89}Ac, the references for these elements are repeated in the present Section, which contains the two groups of elements: ^{57}La to ^{71}Lu and ^{89}Ac to ^{99}Es. A selected list of general literature references is also included.

Nearly all of the quoted references have been checked from the original papers.

SP307. **Wolf-Rayet stars.** Proceedings of a symposium held at the Joint Institute for Laboratory Astrophysics, National Bureau of Standards, Boulder, Colo., June 10-14, 1968, **K. M.** Grebbe and R. N. Thomas, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 307, 286 pages (Dec. 1968).*

Key words: Atomic cross sections; atmospheric aerodynamics; diagnostic spectroscopy; non-equilibrium gases; stellar instability; Wolf-Rayet stars.

A symposium on Wolf-Rayet stars was held at the Joint Institute for Laboratory Astrophysics on the campus of the University of Colorado, Boulder, Colorado, June 10-14, 1968. The Wolf-Rayet stars represent the most extreme example studied on an interaction between aerodynamic motions and a radiation field to produce a high temperature, large-scale plasma in a steady but non-equilibrium state. As such these stars provide a perfect example of the kind of gaseous ensemble that JILA was created to study. In order to understand them, we require a knowledge of gases with temperatures between 10^4 and 10^7 °K and differential velocities between 0 and 10^3 km/sec. In particular we need information on radiative and collisional atomic cross sections for a wide range of ions, on collective interactions of ions and photons, on methods of diagnostic spectroscopy, and on velocity fields generated by convective, gravitational, nuclear, radiative, rotational, thermal, and other instabilities. The material of the symposium was divided into four broad topics: the distribution, physical properties and evolutionary status of Wolf-Rayet stars; the detailed features of their spectra; the interpretations of these features and the models on which they are based; and finally a survey of the material and ideas arising out of the symposium itself. This volume contains the introductory summaries of each of these broad topics, together with an edited version of the discussions which followed.

SP308. **Technical highlights of the National Bureau of Standards, Annual Report Fiscal Year 1968,** Nat. Bur. Stand. (U.S.), Spec. Publ. 308, 216 pages (Nov. 1968).

Key words: Annual report; technical highlights.

This is an illustrated digest of NBS technical and scientific activities during the fiscal year ending June 30, 1968. It lists major programs as they were carried out by the three NBS institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology and by the Bureau's Center for Radiation Research. Summaries are given of typical projects in measurement engineering, applied mathematics, electricity, metrology, mechanics, heat, atomic physics, radio standards, laboratory astrophysics, cryogenics, analytical chemistry, polymers, metallurgy, inorganic materials, physical chemistry, engineering standards, weights and measures, invention and innovation, vehicle systems research, product evaluation, building research, electonic technology, technical analysis, computer sciences, and radiation research. Also included are discussions of the Clearinghouse for Federal Scientific and Technical Information, the National Standard Reference Data System, Standard Reference Materials program, and national and international cooperative activities.

SP309, Volume 2. **Computer literature bibliography 1964-1967,** W. W. Youden, Nat. Bur. Stand. (U.S.), Spec. Publ. 309, Vol. 2, 385 pages (Dec. 1968).

Key words: Author index; coden; computer bibliography; information retrieval; permuted index; title word index.

This bibliography is a continuation of NBS Miscellaneous Publication 266, *Computer Literature Bibliography, 1946 to*

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*See pages 41A–41K for a list of the papers presented.

1963, and is intended as a further service to the computer community. It contains approximately 5,200 references to computer literature published during the years 1964 through 1967. The Bibliography Section includes the full title and the names of all of the authors of each item published in 17 journals, 20 books composed of chapters by individual authors, and 43 conference proceedings. In addition, references to all items that were reviewed in the IEEE Transactions on Electronic Computers have been included.

The Title Word Index Section provides the means for locating an item if any part of its title is known. Likewise, it can be used to identify all items whose titles include a particular word or phrase. The Author Index Section lists all authors of each item, but does not indicate whether an individual is its sole author.

SP310. **Nuclear standards for chemistry and technology.** Proceedings of a Symposium on Standards in Nuclear Chemistry and Technology held at the 156th National Meeting of the American Chemical Society, Atlantic City, N.J., September 8-9, 1968, H. F. Beeghly, J. P. Cali, and W. W. Meinke, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 310, 261 pages (Dec. 1968).*

Key words: Activation analysis standards; isotope reference standards; nuclear fuel burn-up standards; radiation effect standards; radioactivity standards; standards for nuclear chemistry; standards for nuclear technology.

Many diverse organizations are engaged in developing the nuclear standards needed by science, industry, and government for the rapidly growing field of nuclear technology. Often there has been inadequate communication between these groups and insufficient opportunity to get an overall picture of the needs of the country for the many different kinds of standards necessary for this new industry. The Symposium sponsored by the American Chemical Society Division of Nuclear Chemistry and Technology in cooperation with the Committee on Standardization Relations brought together most of the groups with interests in standards for nuclear chemistry and technology to identify the problems, to discuss present programs, and to outline future needs for standards in this broad field. Standards for purposes of the symposium were defined very broadly to include standard materials, standard procedures, standard specifications, standard data, and engineering standards. The mechanisms available for standardization, the "state of the art" in standardization in many areas of the nuclear field, some indications of unmet needs, and estimates of future needs were discussed in a series of papers and panel discussions which are presented here in either complete or summary form.

SP311. **Report of the 53d National Conference on Weights and Measures, 1968,** R. L. Koeser, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 311, 182 pages (Mar. 1969).*

Key words: Conference; weights and measures—history; weights and measures—laws; weights and measures—regulations; weights and measures—technical requirements; weights and measures.

This is a report of the proceedings (edited) of the Fifty-third National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Washington, D.C., June 17-21, 1968 and attended by State, county, and city weights and measures officials and representatives of the Federal Government, business, industry, railroads, and associations.

SP312, Volumes I and II. **Modern trends in activation analysis.** Proceedings of the 1968 International Conference held at the National Bureau of Standards, Gaithersburg, Md., October 7-11, 1968, J. R. DeVoe, Editor and P. D. LaFleur, Assistant Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 312, Vol. I, 691 pages and Vol. II, 676 pages (June 1969).*

Key words: Activation analysis; applications; archaeology; biology; charged particles; computation; conference; criminology; data handling; geochemistry; industry; neutron; nuclear reactions; photons; radiation detectors; radiochemical separation.

A conference on Modern Trends in Activation Analysis was held at the National Bureau of Standards, October 7-11, 1968. Volume I contains texts of two invited plenary lectures, one on the applications of activation analysis and one on radiochemical separations, contributed papers, remarks by honored guests, and synopses of discussion sessions by each chairman. Topics covered include applications of activation analysis in the environmental sciences, biology, medicine, archaeology, criminology, geochemistry, geology, and industry. Also included are studies on radiochemical separations. Volume II contains texts of three plenary lectures, one on nuclear reactions, one on radiation detectors and data processing, and one on computation methods in activation analysis. Contributed papers, remarks by honored guests, and synopses of discussion sessions by chairmen are included. Topics covered include nuclear reactions in activation analysis, radiation detectors, data handling and processing, computation methods, error analysis, and information retrieval. These two volumes are sold as a set.

SP313. **Making valuable measurements.** Proceedings of the 1968 Standards Laboratory Conference, H. L. Mason, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 313, 177 pages (May 1969).*

Key words: Metrology management; National Conference of Standards Laboratories; physical measurement.

The National Conference of Standards Laboratories is a nonprofit, laboratory-oriented organization whose purpose is to promote cooperative efforts toward solving the common problems faced by standards laboratories in their organization and operation. Established in 1961 under the sponsorship of the National Bureau of Standards, NCSL has a membership of more than 200 organizations. Three biennial national meetings have been held previously as well as a number of specialized regional workshops.

The theme of the 1968 Standards Laboratory Conference is "Making Valuable Measurements." The papers presented will attempt to answer the Who? When? Where? How? and Why? of making valuable measurements. The conference provides an opportunity for discussion of problems confronting laboratory managers and calibration personnel.

Representatives of member organizations of the National Conference of Standards Laboratories met at the Boulder facility of the National Bureau of Standards August 25-29, 1968. Major addresses were given by A. V. Astin and J. L. Sloop. Reports and discussions at eight sessions covered the management of valuable measurements: the management of equipment and data, measurement agreement comparisons, international practices, Defense Department activities, NBS activities, NCSL liaison, and NCSL committee work.

SP314. **Ion-Selective Electrodes.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., January 30-31, 1969, R. A. Durst, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 314, 474 pages (Nov. 1969).*

Key words: Ion-selective electrodes; specific-ion electrodes; review of ion-selective electrodes; symposium proceedings.

This volume contains a review of ion-selective electrodes, emphasizing the non-glass types, and provides a thorough and critical evaluation of the subject. It consists of eleven invited review papers and selected discussions from the Symposium on

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*See pages 41A–41K for a list of the papers presented.

Ion-Selective Electrodes held at NBS on January 30-31, 1969. This publication provides a comprehensive survey of the field and should prove very valuable in advancing the state of the art. The chapters include discussions on the theory, characteristics, and methodology of all types of ion-selective electrodes; their use in thermodynamic, kinetic, and complex-ion studies; standards; pure and applied research in various biomedical areas of interest; industrial analysis and control systems; and applications to diverse analytical problems. Both the present status and future potential of these sensors are discussed in a wide range of scientific disciplines, from the physical sciences to biomedicine. Extensive bibliographies provide an excellent survey of the literature for anyone using or anticipating the use of these electrodes.

SP315. **Bibliography on the high temperature chemistry and physics of materials, October, November, December 1968,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315, 72 pages (Jan. 1969).

Key words: Bibliography, high-temperature chemistry; chemistry at high temperatures, bibliography; high temperature; high-temperature chemistry, bibliography.

A classified collection of references to scientific research performed at temperatures above 1000 °C and published in the world literature during the fourth quarter of 1968.

SP315-1. **Bibliography on the high temperature chemistry and physics of materials, January, February, March 1969,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315-1, 81 pages (April 1969).

Key words: Bibliography, high temperature; chemistry, high temperature; high temperature chemistry; materials properties; research at high temperatures; thermophysical properties.

The bibliography consists of references to research involving temperatures above 1000 °C, which were noted by the contributors during the above three-month period. Since this is intended primarily as a current-awareness bibliography, there is no cross-referencing or indexing. This issue contains about 700 references roughly grouped under fifteen subject headings.

SP315-2. **Bibliography on the high temperature chemistry and physics of materials, April, May, June 1969,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315-2, 74 pages (July 1969).

Key words: Bibliography, high temperature; chemistry, high temperature; high temperature chemistry; materials properties; research at high temperatures; thermophysical properties.

The bibliography consists of references to research involving temperatures above 1000 °C, which were noted by the contributors during the above three-month period. Since this is intended primarily as a current-awareness bibliography, there is no cross-referencing or indexing. This issue contains about 700 references roughly grouped under fifteen subject heading.

SP315-3. **Bibliography on the high temperature chemistry and physics of materials, July, August, September 1969,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315-3, 90 pages (Oct. 1969).

Key words: Bibliography, high temperature; chemistry, high temperature; high temperature chemistry; materials properties; research at high temperatures; thermophysical properties.

The bibliography consists of references to research involving temperatures above 1000 °C, which were noted by the contributors during the above three-month period. Since this is intended primarily as a current-awareness bibliography, there is no cross-referencing or indexing. This issue contains about 825 references roughly grouped under fifteen subject headings.

SP316. **Hydraulic research in the United States 1968,** G. Kulin, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 316, 331 pages (June 1969).

Key words: Hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; project summaries.

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1967-1968 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

SP318. **Report of the 54th National Conference on Weights and Measures 1969,** R. L. Koeser, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 318, 270 pages (Nov. 1969).*

Key words: Conference, weights and measures—laws; weights and measures—regulations; weights and measures—technical requirements; weights and measures—history; weights and measures.

This is a report of the proceedings (edited) of the Fifty-fourth National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Washington, D.C., June 9-13, 1969 and attended by State, county, and city weights and measures officials and representatives of the Federal Government, business, industry, railroads, and associations.

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*See pages 41A–41K for a list of the papers presented.

3.7.1 Conference Papers

SP295. **Electronic composition in printing.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., June 15-16, 1967, R. W. Lee and R. W. Worral, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 295, 133 pages (Feb. 1968). See page 36 for abstract.

Technology of Electronic Composition: an Overview, L. H. Hattery.
The Linotron System, D. H. Rollert.
Computer Image Drawing from Digital Data, M. V. Mathews.
High-Speed 901 Zip, A. G. Bernardo.
The Videograph Text Editor, G. T. Gerlach.
The PhotoTextSetters, A. J. Smith.
A Videocomp Systems Approach, A. H. Coleman.
Micromation—Its Impact on the Photocomposing Industry, J. J. Kalagher.
IBM's Position in Electronic Composition and Text Editing, H. E. Weiss.
An Introduction, P. A. Ziemer.
Transition on the Tiber—A New Look at the G.P.O., The Hon. J. L. Harrison.
Present and Projected Policies of the J.C.P., J. F. Haley.
Introductory Remarks, G. E. Roudabush.
Chemical Information—A Computer, and Photocomposition, B. G. Lazorchák.
The Impact of Electronic Composition on Commercial Printing and Publishing, W. C. Lamparter.
Computerized Typesetting Projections, K. B. Ludwig.
Classification in Computerized Text Processing, R. P. Wishner.
System 70, J. W. Seybold.
A Brief Overview, S. N. Alexander.
Comments, M. E. Stevens.
Electronic Composition within the Department of Health, Education and Welfare, E. R. Lannon.
Electronic Composing System Applications, J. J. Boyle.
Use of GRACE at N.L.M., R. E. Bogart.
Computer Typesetting Program at NBS, W. R. Bozman.
Typewriter-to-Computer Roster Publication and Maintenance, A. North.
Implications of the Electronic Composition System for DSA Publications, W. J. Beran.
Conversion to Linotron, V. G. Kehler.

SP296. **Mass transport in oxides.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., October 22-25, 1967, J. B. Wachtman, Jr. and A. D. Franklin, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 296, 224 pages (Aug. 1968). See page 36 for abstract.

Mass Transport in the Face-Centered Cubic Alkali and Silver Halides, L. M. Slifkin.
Diffusion of Sodium in Sodium Chloride in an Applied Electric Field, R. J. Friauf and V. C. Nelson.
Characterization of Point Defects in Oxides, J. E. Wertz.
Theory of the Energetics of Simple Defects in Oxides, I. M. Boswarva and A. D. Franklin.
Lattice Dynamics and Ionic Interactions, J. Slater.
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Self-Shielding Corrections in Photon Activation Analysis, G. J. Lutz.

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Determination of Carbon in High Purity Iron by Irradiation in Photons, G. Revel, T. Chaudron, J. L. DeBrun, and P. Albert.

Charged Particle Activation Analysis for Carbon, Nitrogen, and Oxygen in Semiconductor Silicon, T. Nozaki, Y. Yatsurugi, N. Akiyama, and I. Imai.

^{7}Be as a Dosimeter During Photon Activation of Iodine, J. A. Cardarelli, E. S. Dell, and B. A. Burrows.

Some Recently Determined Photonuclear Reaction Yields and Cross Sections for Formation of Several Isomers, H. R. Lukens.

Spectrum, Yield and Use of Fast Neutrons Produced by 20 MeV Helium-3 Ions, 14 MeV Protons and 7.5 MeV Deuterons on a Thick Beryllium Target, E. Bruninx.

The Production of Fast Neutrons by Small Cyclotrons, A. A. Fleischer.

Use of a 60 MeV Linac for Fast and Variable Energy Neutron Activation Analysis, P. E. Wilkniss.

Blank Considerations in 14 MeV Neutron Activation Analysis for Trace Oxygen, S. S. Nargolwalla, E. P. Przybylowicz, J. E. Suddueth, and S. L. Birkhead.

Activation Analysis of Chloride and Iodide in Photographic Emulsions Using 14.7 and 2.8 MeV Neutrons, E. P. Przybylowicz, G. W. Smith, J. E. Suddueth, and S. S. Nargolwalla.

Long Term Operating Experience with High Yield, Sealed Tube Neutron Generators, P. L. Jessen.

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A High Output Sealed-Off Neutron Tube with High Reliability and Long Life, O. Reifenschweiler.

On-Stream Activation Analysis Using Sample Recirculation, J. B. Ashe, P. F. Berry, and J. R. Rhodes.

Fast Neutron Continuous Activation Analysis of Dilute Solutions, R. E. Jervis, H. Al-Shahristani, and S. S. Nargolwalla.

Use of Very Short-Lived Nuclides in Nondestructive Activation Analysis with a Fast Shuttle Rabbit, M. Wiernik and S. Amiel.

Cyclic Activation Analysis, W. W. Givens, W. R. Mills, Jr., and R. L. Caldwell.

An Analog Computer Controlled Gamma-Ray Spectrometer for Comparative Activation Analysis, P. C. Jurs and T. L. Isenhour.

Determination of Trace Quantities of Uranium in Biological Materials by the Nuclear Track Technique, B. S. Carpenter.

Surface Analysis of Medium Weight Elements by Prompt Charged Particle Spectrometry, C. Olivier and M. Peisach.

Californium-252: A New Neutron Source for Activation Analysis, W. C. Reinig and A. G. Evans.

Comparison of Solid State and Scintillation Gamma-Ray Spectrometry in Analysis, A. F. Voigt, D. E. Becknell, and L. Menapace.

Measurement and Comparison of Detector Efficiencies, J. A. Dooley.

Instrumentation for Computerized Neutron Activation Analysis, D. D. Tunnicliff, R. C. Bowers, and G. E. A. Wyld.

An Anticoincidence Shielded Ge(Li) Gamma-Ray Spectrometer and its Application to Neutron Activation Analysis, J. A. Cooper, L. A. Rancitelli, R. W. Perkins, W. A. Haller, and A. L. Jackson.

A Coincidence-Anticoincidence System for Activation Analysis Employing a Split NaI(Tl) Annulus and a Large Volume Ge(Li) Detector, R. L. Currie, R. McPherson, and G. H. Morrison.

A Dual Channel Analyzer and Efficient Coincidence Systems for Activation Analysis, R. A. Johnson.

Characteristics and Applications of a Large Sodium Iodide Detector Assembly, J. L. Parker, D. M. Holm, and B. K. Barnes.

A Compton-Suppressed Coincidence Gamma-Ray Scintillation Spectrometer with Large NaI(Tl) Crystals, B. A. Euler, D. F. Covell, and S. Yamamoto.

Computerized Quantitative Analysis of High-Resolution Spectra, J. A. Dooley, J. H. Gorrell, P. Polishuk, and M. Young.

On-Line Data Analysis of Digital Pulse-Height Spectra, J. I. Trombka and R. L. Schmadeback.

Spectral Data Handling Systems, F. P. Brauer and J. E. Schlosser.

"Hevesy", A Computer Program for Analysis of Activation Analysis Gamma-Ray Spectra, H. P. Yule.

Development of a Direct Connection Between an Activation Analysis Laboratory and an IBM 360/65 Computer, F. Girardi, G. Guzzi, G. Di Cola, W. Becker, and A. Termanini.

Developments in the Use of Small Digital Computers in Activation Analysis Systems, T. B. Pierce, R. K. Webster, R. Hallett, and D. Mapper.

On-Line Activation Analysis with a PDP-9 Computer, C. J. Thompson.

Man-Machine Interaction in Analysis of Pulse-Height Spectra, W. R. Burrus.

The NBS Automated Activation Analysis Information Retrieval System, G. J. Lutz, R. J. Boreni, R. S. Maddock, and W. W. Meinke.

Edge-Punched Card Literature Retrieval System for Activation Analysis, T. Braun, E. Bujdoso, and M. Miskei.

Isotopes Information Center, P. S. Baker.

Catalogue of Gamma Rays Emitted by Radionuclides, M. A. Wakat.

Computerized Identification of Reactor-Produced Isotopes, J. A. Dooley, J. H. Gorrell, J. M. Thompson, and E. Hoffman.

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Regression Analysis of Gamma-Ray Spectrometer Data with an Application to the Assay of Human Radioactivity Burdens, B. Pasternack and N. Harley.

Computer Gain Changing of Scintillation Spectra, J. J. Steyn and D. G. Andrews.

A Computer Method of Peak Area Determinations from Ge(Li) Gamma Spectra, H. R. Ralston and G. E. Wilcox.

Quantitative Analysis of Unknown Mixtures by Computer Reduction of Ge(Li) Spectra, R. Gunnink and J. B. Niday.

A Computer-Based System for Neutron Activation Analysis, D. D. Tunnicliff and G. E. A. Wyld.

Rapid Manual Resolution of Multi-Component Gamma-Ray Photopeaks, H. R. Lukens.

Computer Studies of Complex Full Energy Peaks Using Second and Third Derivatives, H. P. Yule.

The Precision of Multi-Element Techniques in Activation Analysis, R. F. Coleman.

Contribution to Improvements in Accuracy and Reproducibility of Routine Activation Analysis, F. Dugain.

Precision in the Neutron Activation Analysis for Gold in Standard Rocks G-1 and W-1, K. Fritze and R. Robertson.

High Precision Activation Analysis of Sodium Using an Internal Standard Technique, R. H. Marsh and W. Allie, Jr.

NBS Standard Reference Materials Available for Activation Analysis, W. W. Meinke and J. P. Cali.

The Role of Activation Analysis in the NBS Standard Reference Material Program, J. P. Cali.

An Oxygen Standard for the Determination of Oxygen in Steel by 14 MeV Neutron Activation Analysis, R. Gijbels, A. Speecke, and J. Hoste.

A High Purity Cellulose as a Possible Biological Reference Material, L. A. Rancitelli, T. M. Tanner, and W. A. Haller.

Microstandards for Activation Analysis, D. H. Freeman.

SP313. **Making valuable measurements.** Proceedings of the 1968 Standards Laboratory Conference, H. L. Mason, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 313, 177 pages (May 1969). See page 40 for abstract.

Measurements for Society, J. L. Sloop.

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Metrology and Calibration in DOD Quality and Reliability Operations, M. L. Fruechtenicht.

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The Instrumentation and Measurement Group of the Institute of Electrical and Electronic Engineers, F. L. Hermach.

Joint Activities of the Instrument Society of America and NCSL, O. L. Linebrink.

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New Directions for NBS Outputs, E. C. Wolzien.
Highlights of the NBS Boulder Laboratories, T. M. Flynn.
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Progress in Adopting the Metric System in the United Kingdom, A. H. A. Wynn.
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The Value of International Meaurements, R. H. C. Foxwell.
Large Problems of Small Countries, L. Frank.
Developments in the Canadian Measurement System, J. G. Cameron.
The Advantages and Disadvantages of Industrialized Nations Developing and Supporting a Dual System of Weights and Measures, J. S. Weber.
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Adjusting Calibration Intervals, R. H. Johnson.
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An Information System for Standards Laboratories, W. J. Anson.
Administrative Problems in the Introduction of an Automatic Measuring System, G. W. Pentico.
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Calibration Data Collection and Utilization, W. L. Bates.
Value Engineering Techniques—A Way of Managing Valuable Measurements, P. I. Harr.
Government's View of Contractor's Management of Valuable Measurements, H. B. Berkowitz.
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Weapon System User Management of Measurements, R. Y. Bailey.
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SP314. **Ion-Selective Electrodes.** Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., January 30-31, 1969, R. A. Durst, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 314, 474 pages (Nov. 1969). See page 40 for abstract.

Theory of Membrane Electrode Potentials: An Examination of the Parameters Determining the Selectivity of Solid and Liquid Ion Exchangers and of Neutral Ion-Sequestering Molecules, G. Eisenman.
Solid-State and Liquid Membrane Ion-Selective Electrodes, J. W. Ross, Jr.
Heterogeneous Membrane Electrodes, A. K. Covington.
Reference Electrodes, A. K. Covington.
Thermodynamic Studies, J. N. Butler.
Activity Standards for Ion-Selective Electrodes, R. G. Bates and M. Alfenaar.
Studies with Ion-Exchange Calcium Electrodes in Biological Fluids: Some Applications in Biomedical Research and Clinical Medicine, E. W. Moore.
Ion-Selective Electrodes in Biomedical Research, R. N. Khuri.
Analytical Studies on Ion-Selective Membrane Electrodes, G. A. Rechnitz.
Industrial Analysis and Control with Ion-Selective Electrodes, T. S. Light.
Analytical Techniques and Applications of Ion-Selective Electrodes, R. A. Durst.

SP318. **Report of the 54th National Conference on Weights and Measures 1969,** R. L. Koeser, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 318, 270 pages (Nov. 1969). See page 41 for abstract.

To Save Your Life, P. J. Brown.
Activities of the Office of Weights and Measures, T. M. Stabler.
Weights and Measures Inspection in Federal Establishments:
Department of Defense, A. L. Borchers.
Post Office Department, J. W. Duchesne.
The Development and Use of National Voluntary Standards, D. L. Peyton and D. R. Mackay.
The Role of Weights and Measures Officials in the Metric Study, A. G. McNish.
Panel on Fair Packaging and Labeling:
Department of Commerce, E. A. Vadelund.
Food and Drug Administration, J. Gomilla.
Federal Trade Commission, E. W. Johnson.
Department of Agriculture, W. J. Minor.
Internal Revenue Service, R. O. Jolin.
Weights and Measures—What's That?, M. Dana.
The Coming Trends in Produce Merchandising, R. B. Crosset, Jr.

3.8. APPLIED MATHEMATICS SERIES

Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers and others engaged in scientific and technical work. Some of the volumes are reissues of the Mathematical Tables prepared by the Project for the Computation of Mathematical Tables conducted by the Works Projects Administration for the City of New York under the scientific sponsorship of NBS.

AMS60. **Matrix representations of groups,** M. Newman, Nat. Bur. Stand. (U.S.), Appl. Math. Series 60, 82 pages (July 1968).

Key words: Algebraic numbers; groups; matrices; representations.

The theory of group representations is presented from the matrix standpoint. Many special representations are worked out in detail, and there are appendices on the elements of the theory of algebraic numbers.

AMS61. **Lectures on modular forms,** J. Lehner, Nat. Bur. Stand. (U.S.), Appl. Math. Series 61, 77 pages (Dec. 1969).

Key words: Automorphism; finite field; genus; Hecke operator; Klein's invariant; linear transformation; modular form; Riemann surface.

This book is an expository account of the theory of modular forms and its application to number theory and analysis. The first chapter defines modular forms and develops their most important properties. The second and third chapters introduce the Hecke modular forms. A Hecke form *f* is a simultaneous eigenfunction of a family of linear operators T_p, where p runs over the positive primes. The eigenvalue corresponding to T_p is the pth Fourier coefficient a(p) of *f*. The Fourier coefficients of *f* are multiplicative, i.e., $a(mn) = a(m)\,a(n)$ when m and n have no common divisors. The intimate connection of these results to the theory of certain zeta-functions is indicated in a note to Chapter 3. The fourth chapter is devoted to the automorphisms of a compact Riemann surface. It is shown what groups of linear-fractional transformations with coefficients in a finite field can be the group of automorphisms of a compact Riemann surface. In the last two chapters congruences and other arithmetic properties are developed for the Fourier coefficients of Klein's absolute modular invariant. Analogies with the Hecke theory as well as with the Ramanujan congruences for the partition function are discussed.

3.9. NATIONAL STANDARD REFERENCE DATA SERIES

Includes the evaluated reference data and critical reviews of long-term interest that are produced by data centers within the NSRDS network. The National Standard Reference Data System is a Government-wide effort to provide the U.S. technical community with effective access to the quantitative data of physical science, critically evaluated and compiled for convenience.

NSRDS-NBS12. **Tables for the rigid asymmetric rotor: transformation coefficients from symmetric to asymmetric bases and expectation values of P_z^2, P_z^4, and P_z^6,** R. H. Schwendeman, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 12, 102 pages (June 1968).

Key words: Angular momentum; asymmetric rotor; eigenfunction; microwave spectra; rotational spectrum; transformation coefficients.

Tables of computed quantities associated with the rigid asymmetric rotor are presented. The first group of tables gives transformation coefficients from symmetric to asymmetric rotor bases. These coefficients permit the eigenfunctions of the asymmetric rotor to be written in terms of symmetric-rotor eigenfunctions. In Part II the angular-momentum expectation values (P_z^2), (P_z^4), and P_z^6 are tabulated. In both sets of tables values are given at intervals of 0.1 in the asymmetry parameter κ and for $J \leqq 15$. The tabulated quantities find use in the analysis of microwave rotational spectra and the rotational fine structure in vibrational and electronic band spectra.

NSRDS-NBS13. **Hydrogenation of ethylene on metallic catalysts,** J. Horiuti and K. Miyahara, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 13, 66 pages (June 1968).

Key words: Critical data; ethylene; hydrogenation; metallic catalysts; reaction mechanisms; reaction rates.

Reaction rate data for the catalyzed hydrogenation of ethylene, primarily in the presence of unsupported metallic catalysts, are critically reviewed. Reaction mechanisms are discussed in detail, and a statistical mechanical treatment of the reaction is given, according to the generalized theory of reaction starting from the well-known procedure of Glasstone, Laidler, and Eyring. Data for single-element catalysts and alloys are included and interpreted, as are data illustrating differences due to the physical form of the catalyst (film, foil, wire, powder, and some supported systems). Problems are discussed concerning reproducibility of experimental results over repeated runs, and as a function of catalyst pretreatment. The data is analyzed in 29 graphs and 29 tables, some of which are very extensive. The bibliography includes 141 references.

NSRDS-NBS14. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

NSRDS-NBS15. **Molten salts: Volume 1. Electrical conductance, density, and viscosity data,** G. J. Janz, F. W. Dampier, G. R. Lakshminarayanan, P. K. Lorenz, and R. P. T. Tomkins, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 15, 145 pages (Oct. 1968).

Key words: Data compilation; density; electrical conductance; molten salts; standard reference data; viscosity.

Data on the electrical conductance, density and viscosity of single-salt melts were compiled from a comprehensive search of the literature up to December 1966 and a critical assessment made of the compiled data. Recommended values were determined and are presented as functions of temperature in the form of equations and tables.

The results for some 174 compounds as single-salt melts are reported; no attempt was made in the present effort to embrace the results for molten salt mixtures. Data are presented for fluorides, chlorides, bromides, iodides, carbonates, nitrites, nitrates, oxides, sulfides, sulfates, and a miscellaneous group.

NSRDS-NBS16, Part 2. **Thermal conductivity of selected materials,** C. Y. Ho, R. W. Powell, and P. E. Liley, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 16, Part 2, 154 pages (Feb. 1968).

Key words: Critical evaluation; gases; graphites; metallic elements; metals; recommended values; standard reference data; thermal conductivity.

The work presented in this report comprises the critical evaluation, analysis, and synthesis of the available thermal conductivity data and the generation of recommended values for twelve metallic elements, mainly for the solid state, for a range of graphites, and for three fluids in the gaseous state. These are cadmium, chromium, lead, magnesium, molybdenum, nickel, niobium, tantalum, tin, titanium, zinc, zirconium, Acheson graphite, ATJ graphite, pyrolytic graphite, 875S graphite, 890S graphite, acetone, ammonia, and methane. For each of the materials recommended values are given over a wide range of temperature.

NSRDS-NBS17, Part 3. **Tables of molecular vibrational frequencies,** T. Shimanouchi, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 17, Part 3, 43 pages (Mar. 1968).

Key words: Data; frequencies; molecular; spectral; tables; vibrational.

A compilation of vibrational frequency data for selected molecules is being conducted at the University of Tokyo in cooperation with the National Standard Reference Data Program of the National Bureau of Standards as a part of an international effort to compile and evaluate physical and chemical data. This report, as a continuation of Part 1 published as NSRDS-NBS-6, and Part 2 published as NSRDS-NBS-11, contains fundamental vibrational frequencies of 54 molecules together with vibrational assignments, sources of data, brief comments, and citations of references. The procedures used for the preparation of tables are the same as given in Part 1. The fundamental frequencies are obtained mainly from the infrared and Raman spectra. When these are not available, other experimental data such as microwave results are taken into account. The selection of vibrational fundamentals from observed data is based upon careful studies of the spectral data and comprehensive mathematical analyses. The tables were designed to provide a concise summary needed for the computation of ideal gas thermodynamic properties. They may also provide a convenient source of information to those who require vibrational energy levels and related properties in molecular spectroscopy, analytical chemistry, and other fields of physics and chemistry.

NSRDS-NBS18. **Critical analysis of the heat-capacity data of the literature and evaluation of thermodynamic properties of copper, silver, and gold from 0 to 300 °K,** G. T. Furukawa, W G. Shaba, and M. L. Reilly, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 18, 53 pages (Apr. 1968).

Key words: Calorimetry; copper; Debye theta (θ); electronic coefficient of heat capacity; enthalpy; entropy; Gibbs energy; gold; heat capacity; silver; temperature scales; thermodynamic properties.

The literature sources of heat-capacity data on copper, silver, and gold between 0 and 300 °K have been compiled and the data critically analyzed. Tables of heat capacity (C_p), enthalpy ($H-H_0^\circ$), entropy (S°), Gibbs energy ($G-H_0^\circ$), enthalpy function ($(H-H_0^\circ)/(T)$), and Gibbs energy function ($(G-H_0^\circ)/(T)$) have been obtained from the analyses. The literature values of the heat capacity, the electronic coefficient of heat capacity (γ), and the 0 °K limiting Debye characteristic temperature ($\theta_D(0)$) are compared with the selected values. The sources of the data are tabulated chronologically along with the temperature range of measurements, purity of sample, and the pertinent experimental procedures used. A bibliography of the references is listed. A brief appraisal of low-temperature calorimetry is given.

NSRDS-NBS19. **Thermodynamic properties of ammonia as an ideal gas,** L. Haar, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 19, 13 pages (Aug. 1968).

Key words: Ammonia; ideal gas; thermodynamic functions.

Thermodynamic functions for ammonia as an ideal gas at one atmosphere pressure have been evaluated. The contribution of the highly anharmonic out-of-plane vibrational mode, including its large coupling with rotation and its coupling with the other vibrational modes, is considered in detail. Tables of C_P°/R, $(H^\circ-E_0^\circ)/RT$, $(E_0^\circ-G^\circ)/RT$, and S°/R have been calculated at closely spaced intervals from 50 to 5000 °K within an overall uncertainty of less than 0.1 percent at 1000 °K. (Reprinted from the Journal of Research of the NBS—A. Physics and Chemistry, Vol. 72A, No. 2, March-April 1968).

NSRDS-NBS20. **Gas phase reaction kinetics of neutral oxygen species,** H. S. Johnston, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 20, 54 pages (Sept. 1968).

Key words: Chemical kinetics; dissociation; isotopic exchange; oxygen atom; oxygen molecule; ozone; recombination; review.

The available data for reactions among neutral oxygen species, oxygen atoms, oxygen molecules and ozone, have been reviewed. Selected data have been reanalyzed and used to establish values for the rates of these reactions:

$$O_2 + M \rightarrow O + O + M \quad — \quad (M = O_2, Ar)$$

$$O + O + M \rightarrow O_2 + M \quad — \quad (M = O_2)$$

$$O_3 + M \rightarrow O + O_2 + M \quad — \quad (M = O_2, O_3, He, Ar, N_2, CO_2)$$

$$O + O_2 + M \rightarrow O_3 + M \quad — \quad (M = O_2, O_3, He, Ar, N_2, CO_2)$$

$$O + O_3 \rightarrow O_2 + O_2$$

$$O + O_2 \rightarrow O + O_2 \text{ (isotopic exchange)}$$

NSRDS-NBS22. **Atomic transition probabilities. Volume II. Sodium through calcium,** W. L. Wiese, M. W. Smith, and B. M. Miles, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 22, 306 pages (Oct. 1969).

Key words: Allowed and forbidden transitions; aluminum; argon; calcium; chlorine; magnesium; oscillator strengths; phosphorus; potassium; silicon; sodium; sulfur; transition probabilities.

Atomic transition probabilities for about 5,000 spectral lines of the second ten elements, based on all available literature sources, are critically compiled. The data are presented in separate tables for each element and stage of ionization. For each ion the transitions are arranged according to multiplets, supermultiplets, transition arrays, and increasing quantum numbers. Allowed and forbidden transitions are listed separately. For each line the transition probability for spontaneous emission, the absorption oscillator strength, and the line strength are given along with the spectroscopic designation, the wavelength, the statistical weights, and the energy levels of the upper and lower states. In addition, the estimated accuracy and the source are indicated. In short introductions, which precede the tables for each ion, the main justifications for the choice of the adopted data and for the accuracy rating are discussed. A general introduction contains a detailed discussion of the critical factors entering into each major experimental and theoretical method. It also includes a general critical assessment of the widely used Coulomb approximation, and a number of illustrative examples for the exploitation of regularities of systematic trends among oscillator strengths.

NSRDS-NBS23. **Partial Grotrian diagrams of astrophysical interest,** C. E. Moore and P. W. Merrill, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 23, 70 pages (June 1968).

Key words: Atomic spectra; Grotrian diagrams; partial Grotrian diagrams.

This publication is a reprint of Appendix A of the book by Paul W. Merrill entitled, "Lines of the Chemical Elements in Astronomical Spectra" (Carnegie Inst. Wash. Publ. 610, 1956). It contains partial Grotrian Diagrams of selected spectra of astrophysical interest, which give wavelengths, multiplet numbers and key letters for the transitions shown. The diagrams are accompanied by tabular keys in which the key letters indicate related lines in spectra similar in structure to those illustrated in the diagrams. There are 39 diagrams of spectra between hydrogen and nickel and tabular keys for 90 spectra between lithium and rhenium.

NSRDS-NBS24. **Theoretical mean activity coefficients of strong electrolytes in aqueous solutions from 0 to 100 °C,** W. J. Hamer, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 24, 276 pages (Dec. 1968).

Key words: Activity coefficients; electrolytes; interionic attraction expressions.

In determining the activity coefficients of electrolytes in aqueous solutions from the freezing point to the boiling point of the solvent, various equations have been used in the treatment of the data. This paper gives values for activity coefficients of electrolytes of various valence types from 0 to 100 °C, and for ionic strengths from zero to 0.1 molal or 0.1 molar, as calculated by seven different equations based on the theory of interionic attraction. These equations are those of Debye and Hückel, Güntelberg, Davies, Scatchard, and Bjerrum, and what may be termed an extended Güntelberg equation and an extended Scatchard equation.

NSRDS-NBS25. **Electron impact excitation of atoms,** B. L. Moiseiwitsch and S. J. Smith, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 25, 120 pages (Aug. 1968).

Key words: Atom; electron; excitation; experimental; helium; hydrogen; impact; review; theoretical.

The experimental and theoretical literature about the electron impact excitation of atoms is reviewed. Theoretical methods ranging from the Bethe and Born approximations to the close coupling approximations are discussed and intercompared. Where possible, on theoretical grounds or through intercomparison, the reliability of the various methods is discussed.

A general critique of the optical method of measuring excitation functions is given, with the objective of promoting higher quality future experimental work. A critical study of existing experimental work leads to the conclusion that most workers have ignored important physical and instrumental effects, and it may be presumed that the data in the literature is subject to many unrecognized systematic errors. The literature on hydrogen and helium is discussed critically. The literature on the alkalis, heavy rare gases, mercury, cadmium and zinc is surveyed but the quality of the literature does not support critical review beyond some general comments about the physics of these atoms.

NSRDS-NBS26. **Ionization potentials, appearance potentials, and heats of formation of gaseous positive ions,** J. L. Franklin, J. G. Dillard, H. M. Rosenstock, J. T. Herron, K. Draxl, and F. H. Field, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 26, 289 pages (June 1969).

> Key words: Appearance potential; compilation; data; heat of formation; ionization potential; ions; positive ions.

This is a compilation of ionization and appearance potentials of positive ions published from 1955 through June 1966. The compilation lists the ion formed, the parent species from which it was formed, the other products of the process, the threshold energy for the formation of this ion, and the method by which this data was obtained.

Where feasible, the heat of formation at 298 K of the positive ion has been computed for each entry using auxiliary thermochemical data. From these computed values "best" values have been chosen.

NSRDS-NBS27. **Thermodynamic properties of argon from the triple point to 300 K at pressures to 1000 atmospheres,** A. L. Gosman, R. D. McCarty, and J. G. Hust, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 27, 151 pages (Mar. 1969).

> Key words: Argon; compressibility factor; enthalpy; entropy; equation of state; internal energy; Joule-Thomson coefficient; P-V-T; specific heat; vapor pressure; virial coefficient.

Tabular values of density, internal energy, enthalpy, and entropy of liquid and gaseous argon are presented for temperatures from 83.8 to 300 K at pressures of 0.01 to 1000 atmospheres. Diagrams of specific heats, compressibility factor, and entropy are included. The properties presented are calculated from an equation of state which was fitted to experimental P-ρ-T data from the world literature. Extensive comparisons were made between the equation of state and the experimental data, and deviation plots are presented. The second virial coefficient and Joule-Thomson inversion curve were also calculated and comparisons made with values from other sources. A vapor pressure equation which covers the range from the triple point to the critical point is also given.

NSRDS-NBS28. **Molten salts: Volume 2. Section 1. Electrochemistry of molten salts: Gibbs free energies and excess free energies from equilibrium-type cells,** G. J. Janz and Chr. G. M. Dijkhuis. **Section 2. Surface tension data,** G. J. Janz, G. R. Lakshminarayanan, R. P. T. Tomkins, and J. Wong, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 28, 116 pages (Aug. 1969).

> Key words: Critically evaluated data; equilibrium electrochemical cells; excess entropies; excess Gibbs free energies; Gibbs free energies; molten salt mixtures; molten salts; surface tension; thermodynamics of molten salts.

This book consists of two sections as follows:

Section 1. The critical evaluation of excess free energies of binary molten salt mixtures with a common ion from equilibrium-type electrochemical cells is described in this report. For this purpose calculations using the original emf data were systematically undertaken to establish comparisons of free energy values of various workers that would be significant. The reversibility of electrodes is investigated by comparing the electromotive force of cells with a single molten salt as liquid electrolyte with thermochemical data.

Section 2. Data on the surface tensions of single salt melts have been systematically collected and evaluated. Results are given for 106 inorganic compounds over a range of temperatures where available.

NSRDS-NBS29. **Photon cross sections, attenuation coefficients, and energy absorption coefficients from 10 keV to 100 GeV,** J. H. Hubbell, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 29, 85 pages (Aug. 1969).

> Key words: Attenuation coefficient; Compton scattering; cross section; energy absorption coefficient; gamma rays; pair production; photoelectric absorption; photons; x-rays.

This report updates and extends previous NBS tabulations. Section 1 contains the information of most immediate practical use: (a) a tabulation of the attenuation coefficient for 23 elements ($_1$H to $_{92}$U) between 10 keV and 100 GeV and (b) a tabulation of the energy absorption coefficient for air, water, and 18 elements between 10 keV and 10 MeV, and for air, water, and 7 elements up to 100 MeV. Section 2 contains detailed information on the predominant processes (photoelectric absorption, Compton scattering and pair production) and a brief discussion of other processes which combine to give the attenuation coefficient. Theoretical and experimental data are reviewed, and auxiliary tables and approximation formulas are given. Section 3 contains tabulations of cross sections for the predominant processes between 10 keV and 100 GeV for 23 elements and for 13 compounds and mixtures.

NSRDS-NBS30. **High temperature properties and decomposition of inorganic salts, Part 2. Carbonates,** H. H. Stern, and E. L. Weise, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 30, 32 pages (Dec. 1969).

> Key words: Carbonates; thermal decomposition; thermodynamic functions.

The literature dealing with the high-temperature behavior of inorganic carbonates has been critically reviewed. Free energy functions of reactants and products of the decomposition reactions were calculated and have been tabulated from 298 °K up to as high a temperature as possible. Free energy functions and equilibrium constants of reactions were tabulated. Auxiliary data on phase transitions, densities, and kinetics of thermal decomposition have also been included. The literature of the endothermic decomposition kinetics of solids, as it applies to carbonates, has been reviewed.

3.10. BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

These publications, similar in style and content to the NBS Building Materials and Structure Reports (1938-59), are directed toward the manufacturing, design, and construction segments of the building industry, standards organizations, officials responsible for building codes, and scientists and engineers concerned with the properties of building materials.

BSS7. **Organic coatings. Properties, selection, and use,** A. G. Roberts, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 7, 202 pages (Feb. 1968).

> Key words: Application; coatings; coating systems; corrosion-inhibiting; Federal specifications; fire-retardant; lacquer; latex; multicolor; organic coatings; paint; pigments; polymers; properties; resins; selection; substrates; surface preparation; varnish; water-thinned.

This publication was prepared to fill the need for a comprehensive, unifying treatise in the field of organic coatings. Besides presenting practical information on the properties, selection, and use of organic coatings (and certain inorganic coatings), it provides basic principles in a number of important areas such as polymer structure, coatings formulation, pigment function, use of thinners, coating system compatibility, and theory of corrosion. Each chapter deals with a major area of the coatings field, including types of coatings, properties of synthetic resins, selection of coating systems, storage and safety, application methods, and surface preparation and pretreatment. There is also a consolidating chapter with illustrative examples of solutions to typical coatings problems. Interrelationships among the various areas of information are indicated through appropriate cross-referencing in the text. Specific references to Federal, Military, and other specifications are given where pertinent, and an entire chapter is devoted to a quick guide and summary of Federal specifications for organic coating materials. Finally, a selected bibliography and a comprehensive index are provided. While written primarily to meet the informational needs of the engineer, architect, maintenance superintendent, and responsible coatings procurement officer, the treatise is sufficiently broad in scope to serve as a general manual, a concise text, or a convenient reference source in the field of organic coatings.

BSS8. **Interrelations between cement and concrete properties, Part 3. Compressive strengths of portland cement test mortars and steam-cured mortars,** (Contains section 7 and section 8.) R. L. Blaine, H. T. Arni, and M. R. DeFore, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 8, Part 3, 101 pages (Apr. 1968).

Section 7. **Compressive strength of test mortars.**

> Key words: Chemical composition; fineness; heat of hydration; strength gain of portland cements; trace elements.

The relationships between cement characteristics and compressive strength of 1:2.75 (cement to graded Ottawa sand) mortars of standard consistency at ages of 24 hours to 10 years, and made with 199 cements of different types, were studied by fitting multivariable regression equations with the aid of a digital computer. The dominant variables associated with the differences of compressive strength, strength gain, and strength ratios were different at the various test ages, and after different curing conditions. The additional use of certain trace elements with commonly determined independent variables resulted in a significantly better fit between the equations and the observed data. Interactions between the fineness values and other independent variables were noted. Certain parallelisms and differences were noted with respect to variables associated with compressive strength differences at various ages and the heat of hydration of the cements at these ages.

Section 8. **Compressive strength of steam-cured portland cement mortars.**

> Key words: Accelerated curing of cements; autoclave curing of portland cement mortars; chemical composition; compressive strength of portland cement; compressive strength of steam-cured cements; mortars; steam curing of portland cement mortars; trace elements.

The relationships between the chemical and physical characteristics of 161 portland cements and the compressive strengths of 2-inch mortar cubes made from those cements after both low- and high-pressure steam, as well as moist-air curing, were studied by computing multivariable regression equations with the aid of a digital computer, and determining which of the independent variables appeared to have a significant relationship to the compressive-strength values. An increase in C_3A, SO_3, and K_2O each appeared associated with higher compressive strengths with the low-pressure-steam-cured specimens but not with 28-day strengths of the 23 °C moist-air-cured specimens. Increases of C_3A, C_3S, C_2S, SO_3 and fineness were all associated with higher strength values when autoclave curing was started after 5 hours, but when started after 24 hours, variations of neither C_3A nor C_3S appear to have any effect. The use of certain of the trace elements in the equations together with commonly determined variables resulted in a reduction in variance although the coefficients of the individual trace elements were, in most instances, not highly significant.

BSS9 to BSS12. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

BSS13. **Shrinkage and creep in prestressed concrete,** P. H. Petersen and D. Watstein, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 13 (Mar. 22, 1968).

> Key words: Creep; loss of prestress; prestressed concrete; relaxation; shrinkage; variable prestress.

The loss of prestress resulting from creep and shrinkage in concrete was investigated for concrete specimens made with Type I portland cement and with Type III portland cement. The primary variables in this study were: (1) Relative humidity at which the concrete was maintained while under observation. (2) Age of the concrete at the time it was prestressed. (3) Ratio of prestress to strength; variation of this parameter required that the ratio of reinforcement be a variable. (4) Mass ratio factor defined as the ratio of the cross-section area of concrete specimen to its surface area per unit length.

Forty-nine sets of specimens were fabricated and tested; each set consisted of a prestressed specimen and an otherwise identical companion specimen without reinforcement.

The length changes with time were observed at intervals up to an age of 500 days. These observations were made for concretes subjected to different levels of prestress, and for concretes prestressed at different ages. Length changes in nonreinforced companion specimens were also obtained. Thus this study is concerned with elastic deformation occurring at time of stress transfer, shrinkage or swelling, and creep.

BSS14. **Experimental determination of eccentricity of floor loads applied to a bearing wall,** D. Watstein and P. V. Johnson, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 14 (June 1968).

Key words: Bearing pads; bearing walls; brick masonry; design of bearing walls; eccentricity of applied loads.

The eccentricity of the loads applied to a specially calibrated compressive strut simulating a brick bearing wall was experimentally determined for a variety of bearing materials and conditions of contact. In one series of tests, an I-beam was bedded in high strength gypsum plaster, bonded and unbonded. For the unbonded plaster bed the eccentricity ratio increased with the applied load to a maximum value of about 0.42, while for the bonded plaster bearing this ratio decreased to an average value of about 0.24 at the maximum load.

In the second series of tests the eccentricity was observed for an I-beam supported on neoprene rubber pads, capped and uncapped, of different thicknesses, and of different bearing length. In general the eccentricity ratio increased slightly with the applied load. Lack of intimate contact between the I-beam and the rubber pad 1/8 in thick resulted in an eccentricity ratio of about 0.40, or nearly the same as for unbonded plaster bearing. Intimacy of contact produced by plaster capping resulted in a marked reduction in the eccentricity ratio to about 0.29; the confinement of the bearing length of the rubber pad to one-half of that used in previous tests and placing it at the extreme end of the beam, further reduced the eccentricity ratio to about 0.18, and to 0.13 for a rubber pad 0.25 in thick.

BSS15. **Interrelations between cement and concrete properties, Part 4. Shrinkage of neat portland cement pastes and concretes,** (Contains section 9 and section 10.) R. L. Blaine, H. T. Arni, and D. N. Evans, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 15, Part 4, 79 pages (Mar. 1969).

Section 9. **Shrinkage of hardened portland cement pastes,** R. L. Blaine, H. T. Arni, and D. N. Evans.

Key words: Chemical composition of portland cements; cracking of portland cements; cracking resistance of cements; portland cement; shrinkage of portland cements; trace elements.

The relationship between cement properties and drying shrinkage of partially hydrated neat cement pastes of normal consistency made of a large number of portland cements of different types and composition were studied by fitting multivariable regression equations with the aid of a digital computer. The time of cracking of annular specimens restrained from shrinking by a steel core varied from 0.1 to more than 40 hours. The principal variables which appeared to have the greatest effect were the fineness and K_2O and C_4AF contents of the cements. The fineness and K_2O contents of the cements appeared to have the greatest effect on the nonrestrained shrinkage of prisms at the time of cracking of the annular specimens. The shrinkage of neat cement bars after 1, 6, 27 days, and 6 months in laboratory air differed greatly with different cements. The principal variables appeared to be the C_3A, SO_3, and C_3A/SO_3 ratios. Other commonly determined variables were associated with each of the above test values. The trace elements, other than Na_2O and K_2O, were not generally associated with the shrinkage or cracking characteristics.

Section 10. **Shrinkage and expansion of concrete,** R. L. Blaine and H. T. Arni.

Key words: Cement composition; expansion-shrinkage ratios; portland cement concrete; shrinkage of concrete; trace elements.

The relationship between the cement characteristics and the drying shrinkages of concretes made of a large number of cements of different types and compositions, as well as the subsequent expansions when the concretes were rewetted, were studied by fitting multivariable regression equations with the aid of a digital computer. Specimens 6 × 8 × 16 inches, were made using 5.5 bags of cement (nominal) per cubic yard with a water/cement ratio of 0.635, as well as with a slump of 5 ± 1 inches. Increases in C_3A, C_4AF, fineness of the cement, and air content of the concrete were associated with increases in both shrinkage on drying and expansion on rewetting of the concretes. Increases in Na_2O, SO_3, and ignition loss of the cements were associated with decreases in the shrinkage values of the concretes. None of the individual trace elements, except possibly Rb and SrO, were associated to a highly significant degree with shrinkage or expansion characteristics of the concretes. The use of trace elements in equations with other more commonly determined variables resulted in a significant reduction in variance. There was no relationship between the shrinkage of concrete specimens moist cured 14 days and then dried in laboratory air for eight weeks, and the shrinkage of neat cements, moist cured only 24 hours and then dried in laboratory air. Higher values for dynamic Young's modulus of elasticity of the concretes were associated with lower shrinkage and expansion values.

BSS16. **Techniques for the survey and evaluation of live floor loads and fire loads in modern office buildings,** J. O. Bryson and D. Gross, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 16, 32 pages (Dec. 1968).

Key words: Fire loads; live floor loads; loads survey techniques; occupancy loads.

The procedures and techniques developed for measuring and evaluating the live floor loads and fire loads in modern office buildings are summarized. The main features of a computer program for analyzing the data are outlined. This program provides a tabulation of the data, some statistical properties, and selected graphical relationships between the measured loads and the characteristics and usage of the structure. A rationale is developed which is intended to achieve the ultimate goal—easier and less expensive means of surveying live loads in buildings and their combustible content.

Two office buildings have been surveyed in a pilot evaluation of the survey techniques—the National Bureau of Standards Administration Building in Gaithersburg, Maryland, and the U. S. Civil Service Commission in downtown Washington, D.C. Typical results are presented to illustrate the computer output.

BSS17. **Causes of variation in chemical analyses and physical tests of portland cement,** B. L. Bean and J. R. Dise, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 17, 34 pages (Mar. 1969).

Key words: Chemical analyses; physical tests; portland cement.

Variations in testing that could lead to the rejection of a material fully conforming to specification requirements, or the acceptance of a material with undesirable chemical or physical properties, are apparent in the results reported by laboratories participating in comparative tests of portland cements. Many of the causes for variation in chemical analyses and physical test results are listed in this discussion, and remedies for some of the more frequently encountered deficiencies in apparatus and methods are suggested. Particular consideration is given to problems which do not seem to have been covered in sufficient detail in previous discussions of cement testing procedures. Literature references are given for additional information. (Supersedes NBS Monograph 28.)

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BSS18. **Smoke and gases produced by burning aircraft interior materials,** D. Gross, J. J. Loftus, T. G. Lee, and V. E. Gray, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 18, 29 pages (Feb. 1969).

Key words: Aircraft materials; combustion products; fire tests; interior finish; smoke; toxic gases.

Measurements are reported of the smoke produced during both flaming and smoldering exposures on 141 aircraft interior materials. Smoke is reported in terms of specific optical density, a dimensionless attenuation coefficent which defines the photometric obscuration produced by a quantity of smoke accumulated from a specimen of given thickness and unit surface area within a chamber of unit volume. A very wide range in the maximum specific optical density was observed. For the majority of materials, more smoke was produced during the flaming exposure test. However, certain materials produced significantly more smoke in the absence of open flaming.

During the smoke chamber tests, indications of the maximum concentrations of CO, HCl, HCN, and other selected potentially toxic combustion products were obtained using commercial colorimetric detector tubes. A study was made of the operation, accuracy, and limitations of the detector tubes used. Measurements of the concentrations of HCl were also made using specific ion electrode techniques.

Qualitative identification of the major components of the original test materials was accomplished primarily by infrared absorption spectrophotometry.

BSS19. **A study of the variables involved in the saturating of roofing felts,** S. H. Greenfeld, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 19, 18 pages (June 1969).

Key words: Absorption; asphalts; felts; moisture; roofing; saturation.

The degree of saturation of a No. 27 felt with a typical roll saturant and a No. 55 felt with roll, mixed, and shingle saturants varied with saturation time and pressure, saturant temperature and viscosity, felt conditions, and press roll pressure and clearance. Optimum temperature and viscosity ranges were determined for each asphalt-felt combination. Both pressure and vacuum increased the completeness of saturation under optimum conditions, but frequently shortened the working temperature range in which optimum saturation could be produced.

Rate and degree of moisture and liquid water absorption decreased with increasing saturation. Air permeability decreased with increasing saturation. The consequences of some of these findings are discussed.

BSS23. **Hail resistance of roofing products,** S. H. Greenfeld, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 23, ll pages (Aug. 1969).

Key words: Asphalt shingles; built-up roofing; hail; roofing; shingles; storm damage.

A test was developed for evaluating the hail resistance of roofings, in which synthetic hailstones (ice spheres) of various sizes were shot at roof assemblies at their free-fall terminal velocities. Indentations, granule loss and roofing fracture were observed. The following conclusions have been made from these results: (a) All roofing materials have some resistance to hail damage, but as the size of the hail increases, a level of impact energy is reached at which damage occurs. This level lies in the range of 1 1/2 to 2 inch (3.8–5.1 cm) hailstones for most prepared roofings. (b) Because of the ways in which prepared roofings are applied, most products have areas of different vulnerability. (c) The solidly supported areas of roofing tend to be the most resistant to hail damage. (d) Heavier shingles tend to be more hail-resistant than Type 235 shingles. (e) Weathering tends to lower the hail resistance of asphalt shingles. (f) Built-up roofs on dense substrates tend to resist hail better than those on soft substrates. (g) Built-up roofs made with inorganic felts tend to be more hail resistant than those made with organic felts. (h) Coarse aggregate surfacing tends to increase the hail resistance of roofing.

BSS24. **Natural weathering of mineral stabilized asphalt coatings on organic felt,** S. H. Greenfeld, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 24, 17 pages (Oct. 1969).

Key words: Additive; asphalt; durability; felt; stabilizer; weathering.

Sixteen years of outdoor weathering of laboratory-prepared smooth-surface and mineral-surfaced, felt-base roofing specimens has provided information on the effects of mineral additives on the durability of coating-grade roofing asphalts. Six finely divided mineral additives (blue black slate, clay, dolomite, fly ash, mica and silica) were evaluated at concentrations up to 60 percent in California, Mid-Continent and Venezuela asphalts. The mineral-surfaced specimens are all performing satisfactorily, and show only minor degrees of degradation. Of the smooth-surfaced specimens, the Mid-Continent asphalt performed the best and the California asphalt the poorest. The mica and blue black slate increased the durabilities of all three asphalts at all concentrations and two coating thicknesses. Fly ash, clay, dolomite and silica were beneficial in some combinations, but had little effect in others. In general, these early results from outdoor exposure tend to corroborate the results obtained on these coatings exposed in weatherometers.

BSS25. **Structural performance evaluation of a building system,** E. O. Pfrang and F. Y. Yokel, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 25, 127 pages (Nov. 1969).

Key words: Building systems; low-income housing; performance criteria; performance testing.

A full-scale, first-story portion of a building system was tested in the laboratory in such a manner as to simulate the structural behavior of a three-story building under both service and potential ultimate loading conditions. Additional tests were performed on the system components to provide behavioral data needed for the evaluation of the system.

Performance criteria for the evaluation of the structural safety and adequacy of certain building systems were developed. This report presents the results of the physical tests performed in the evaluation of the safety and structural adequacy of one such system, and discusses their significance. The report also presents data concerning the complex interaction between components which takes place in the building system.

The primary conclusions reached were: (1) The system, as erected in the laboratory, satisfied the performance criteria which were set for its evaluation with a substantial margin. As a system, it exhibited strength and stiffness in excess of service and ultimate load requirements. (2) The walls of the system behaved as an integral part of the structure. They provided most of the stiffness of the system with respect to lateral loads, and provided a significant portion of the stiffness against vertical loads.

3.11. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

The publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding (1) uniform Federal information processing standards resulting from provisions of Public Law 89-306 (the Brooks Bill), and (2) data elements and codes standards in data systems developed under the provisions of Bureau of the Budget Circular No. A-86. FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

FIPS PUB 0. **General description of Federal Information Processing Standards register,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 0, 8 pages (Nov. 1, 1968).

Key words: Federal Information Processing Standards Register; general description.

This document defines the responsibilities for the Register, defines its contents and categories of standards, and suggests a method for establishing and maintaining standards within an activity.

FIPS PUB 1. **Code for information interchange. Hardware standard interchange codes and media,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 1, 4 pages (Nov. 1, 1968).

Key words: Federal Information Processing Standard; code for interchange.

This document provides administrative, policy, and guidance information relative to the implementation and utilization of the standard code for information interchange.

The technical specifications of this standard are available to Federal Government activities from the General Services Administration Specifications Activity at a cost of 40 cents per copy. Refer to FIPS 1. Others may obtain copies from the United States of America Standards Institute for $2.00 per copy. Refer to USA Standard X3.4-1968. The technical specifications define a code and character set for use in Federal information processing systems, communications systems and associated equipments.

FIPS PUB 2. **Perforated tape code for information interchange. Hardware standard interchange codes and media,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 2, 4 pages (Nov. 1, 1968).

Key words: Federal Information Processing Standard; perforated tape code for information interchange.

This document provides administrative, policy, and guidance information pertaining to the implementation and utilization of the standard perforated tape code for information interchange. The technical specifications of this standard are available to Federal Government activities from the GSA Specifications Activity at 45 cents per copy. Refer to FIPS 2. Others may obtain copies from the United States of America Standards Institute for $1.50 per copy. Refer to USA Standard X3.6-1965. The technical specifications of the standard specify the representation of the Federal Standard Code for Information Interchange (FIPS 1) on perforated tape used in Federal information processing systems, communications systems, and associated equipments.

FIPS PUB 3. **Recorded magnetic tape for information interchange (800 CPI, NRZI). Hardware standard interchange codes and media,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 3, 4 pages (Nov. 1, 1968).

Key words: Federal Information Processing Standard; recorded magnetic tape for information interchange (800 CPI, NRZI).

This FIPS PUB provides administrative, policy, and guidance information relative to the implementation and utilization of the standard recorded magnetic tape (800 characters per inch, NRZI (non-return-to-zero—change to one) method of recording) for information interchange.

The technical specifications of this standard are available to Federal Government activities from the GSA Specifications Activity at 70 cents per copy. Refer to FIPS 3. Others may get copies from the United States of America Standards Institute for $2.50 per copy. Refer to USA Standard X3.22-1967. The technical specifications of the standard provide a format and recording standard for 1/2 inch, 9-track magnetic tape and reels used in Federal information processing systems and associated equipments. It is one of a series of standards implementing the Federal Standard Code for Information Interchange (FIPS 1) in magnetic tape media.

FIPS PUB 4. **Calendar date (Federal general data standard representations and codes),** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 4, 4 pages (Nov. 1, 1968).

Key words: Calendar date; Federal Information Processing Standard.

This publication announces the adoption of a Federal standard for representing calendar dates used in the interchange of formatted machine sensible coded data between and among agencies. The technical specifications (FIPS 4) are affixed to the FIPS PUB.

FIPS PUB 5. **States of the United States (Federal general data standard representations and codes),** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 5, 4 pages (Nov. 1, 1968).

Key words: Federal Information Processing Standard; States of the United States.

This publication announces a standard identification and code for representing the 50 states, the District of Columbia, and the outlying areas of the U.S., all of which are considered to be "first order subdivisions." These codes are for use in the interchange of formatted machine sensible coded data between and among agencies. The technical specifications of the standard (FIPS 5) are affixed to the FIPS PUB.

FIPS PUB 6. **Counties of the States of the United States (Federal general data standard representations and codes),** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 6, 32 pages (Nov. 1, 1968).

Key words: Counties of the States of the United States; Federal Information Processing Standard.

This FIPS PUB announces a standard identification and code for representing the counties of the 50 states of the United States for use in the interchange of formatted machine sensible coded data between and among agencies. Also included are the independent cities of the States of Maryland, Missouri, and Virginia which are treated as county equivalents. The technical specifications of the standard (FIPS 6) are affixed to the FIPS PUB.

FIPS PUB 7. **Implementation of the code for information interchange and related media standards. Hardware standards interchange codes and media,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 7, 14 pages (Mar. 7, 1969).

Key words: Federal Information Processing Standard; hardware standards interchange codes.

This FIPS PUB provides further details covering the implementation of the Code for Information Interchange (FIPS 1), Perforated Tape Code for Information Interchange (FIPS 2), and Recorded Magnetic Tape Code for Information Interchange (800 CPI, NRZI) (FIPS 3). The publication includes a letter of approval of these standards by the President of the United States and a letter with attachments by the Secretary of Commerce providing details and policy of their implementation.

FIPS PUB. 8. **Metropolitan statistical areas. Federal general data standard representations and codes,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 8, 8 pages (June 9, 1969).

Key words: Data standard; representations and codes; SMSA; standard metropolitan statistical area.

This FIPS PUB announces standard identifiers and codes for representing the Standard Metropolitan Statistical Areas (commonly referred to as "S-M-S-A's") for use in the interchange of machine sensible data between and among agencies. The general concept of a S-M-S-A is one of an integrated economic and social unit with a recognized large population nucleus. S-M-S-A's were defined and developed to meet the need for the presentation of general-purpose statistics by agencies of the Federal Government. The technical specifications of the standard (FIPS 8) are affixed to the FIPS PUB.

Another document which should be used in conjunction with FIPS PUB 8 is Bureau of the Budget publication, "Standard Metropolitan Statistical Areas 1967," which provides definitions for the composition and structure of each S-M-S-A. This publication is available from the Superintendent of Documents at a price of 30 cents a copy.

FIPS PUB 9. **Congressional districts of the United States. Federal general data standard representations and codes,** H. S. White, Jr., Editor, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 9, 4 pages (November 14, 1969).

Key words: Congressional districts of the United States; Federal Information Processing Standard.

Congressional districts are considered to be any of the districts into which a State is divided for the purpose of electing representatives to the House of Representatives of the United States Congress. This standard provides codes for representing the congressional districts identified in the various Congresses of the United States.

3.12. PRODUCT STANDARDS

This series comprises voluntary standards that establish (1) dimensional requirements for standard sizes and types of various products, (2) technical requirements for the product, and (3) methods of testing, grading, and marking these products. The objective is to define requirements for products in accordance with the principal demands of the trade.

PS0-67. **Editorial format for Product Standards,** D. R. Mackay, Editor, Nat. Bur. Stand. (U.S.), Prod. Stand. 0-67, 10 pages (July 1968).

Key words: Editorial format; product standards; standards format.

The Editorial Format provides a general guide for the use of the Technical Standards Coordinators or proponent groups in preparing drafts of proposed standards which are to be developed under the "Procedures for the Development of Voluntary Product Standards." The Editorial Format is developed in two parts: the first dealing with the basic contents of a Product Standard and the second providing detailed instructions for the writing of such standards.

PS1-66 to PS7-66. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

PS8-67. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

PS9-68. **Fabrics for book covers,** J. W. Eisele, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 9-68, 13 pages (Apr. 1968).

Key words: Bookbinders; book cloths; book covers; buckrams; starch filled: impregnated; testing procedures.

This Standard covers the requirements and test procedures for seven groups of plain finished book cloths and buckrams which are impregnated or starch filled and which are used in the bookbinding industry for book covers. Definitions which apply to this standard are also included. (Supersedes NBS Commercial Standard CS7-40.)

PS13-69. **Uncored slab urethane foam for bedding and furniture cushioning,** J. W. Eisele, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 13-69, 6 pages (Dec. 1969).

Key words: Cellular; flexible; slab; uncored; urethane foam.

The foam covered by this Product Standard is intended for uses such as inserts for mattresses and cushions for indoor and outdoor furniture. This Standard provides material and dimensional requirements for uncored slab urethane foam and requirements and methods of test for the specific properties of load bearing capacity, permanent set, moisture resistance, fatigue resistance, and resiliency. The fatigue requirements will be revised to incorporate dynamic fatigue specifications when adequate data are available. Methods for marking and labeling to indicate compliance with this Standard are also provided.

3.13. TECHNICAL NOTES

Designed to supplement the Bureau's regular publications program, Technical Notes provide a publication medium for communications and reports on data of limited or transitory interest. They often serve as final reports on work sponsored at NBS by other Government agencies.

TN270-3. **Selected values of chemical thermodynamic properties. Tables for the first thirty-four elements in the standard order of arrangement,** D. D. Wagman, W. H. Evans, V. B. Parker, I. Halow, S. M. Bailey, and R. H. Schumm, Nat. Bur. Stand. (U.S.), Tech. Note 270-3, 267 pages (Jan. 1968).

Key words: Enthalpy of formation; entropy; Gibbs energy of formation; heat of formation; specific heat; thermodynamic properties.

The tables contain values where known of the enthalpy and Gibbs energy of formation, enthalpy, entropy, and heat capacity at 298.15 K (25 °C), and the enthalpy of formation at 0 K, for all inorganic substances and organic molecules containing not more than two carbon atoms, for the first thirty-four elements in the standard order of arrangement. (Supersedes NBS Tech. Notes 270-1 and 270-2.)

TN270-4. **Selected values of chemical thermodynamic properties. Tables for elements 35 through 53 in the standard order of arrangement,** D. D. Wagman, W. H. Evans, V. B. Parker, I. Halow, S. M. Bailey, and R. H. Schumm, Nat. Bur. Stand. (U.S.), Tech. Note 270-4, 152 pages (May 1969).

Key words: Enthalpy of formation; entropy; Gibbs energy of formation; heat capacity; heat of formation; thermodynamic properties.

Tables of selected values of the enthalpy and Gibbs energy of formation, enthalpy, entropy, and heat capacity at 298.15 K (25 °C) and the enthalpy of formation at 0 K, are given for compounds of mercury, copper, silver, gold, nickel, cobalt, iron, palladium, rhodium, ruthenium, platinum, iridium, osmium, manganese, technetium, rhenium, chromium, molybdenum, and tungsten.

TN359. **Two-phase (liquid-vapor), mass-limiting flow with hydrogen and nitrogen,** J. A. Brennan, D. K. Edmonds, and R. V. Smith, Nat. Bur. Stand. (U.S.), Tech. Note 359, 24 pages (Jan. 30, 1968).

Key words: Choking; hydrogen; nitrogen; shocks; two-phase flow.

Experimental data on critical (choked) mass flow in a constant area test section are presented. The data are compared to some simple analytical models which have been recommended for design purposes. The data show the same general behavior as that reported for other noncryogenic fluids.

TN360. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN361. **Saturated liquid densities of oxygen, nitrogen, argon, and parahydrogen,** H. M. Roder, R. D. McCarty, and V. J. Johnson, Nat. Bur. Stand. (U.S.), Tech. Note 361, 70 pages (Jan. 31, 1968).

Key words: Argon; density; nitrogen; oxygen; parahydrogen; pressure; saturated liquid; temperature; uncertainties; volume.

Integrated tables of pressure, volume, and temperature for the saturated liquid, from the triple point to the critical point, of oxygen, nitrogen, argon, and parahydrogen are presented. The tables include entries of integral values of temperature in both Kelvin and Rankine, and integral values of pressure in both atmospheres and psia. Volumes and densities in three different units and a density ratio are tabulated for each entry. Estimates of the uncertainty of the tabulated data are given.

TN362. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN363. **Computer solutions for thermal-acoustical oscillations in gas-filled tubes,** M. T. Norton and R. C. Muhlenhaupt, Nat. Bur. Stand. (U.S.), Tech. Note 363, 86 pages (Nov. 30, 1967).

Key words: Cryogenics; liquid helium; thermal oscillations.

A digital computer program to determine solutions for thermal-acoustical oscillations in gas-filled pipes is described. Using a typical temperature gradient and tube length from test data, the program calculates the effect of changes in heat transfer coefficient, friction factor, and pipe diameter. Details of the program are explained. A comparison is made between computation and one particular test datum point. Although the calculations are based on helium as the media, the program can accommodate any fluid treated as a perfect gas.

TN364. **Slush hydrogen pumping characteristics,** D. E. Daney, P. R. Ludtke, D. B. Chelton, and C. F. Sindt, Nat. Bur. Stand. (U.S.), Tech. Note 364, 41 pages (Apr. 1968).

Key words: Cavitation; centrifugal pump; cryogenic pump; liquid-solid hydrogen mixtures; slush hydrogen.

The pumping characteristics of liquid-solid mixtures of parahydrogen (slush hydrogen) were investigated using a centrifugal type liquid hydrogen pump with a specific speed range of 1600 to 3100. Performance tests at 8,000, 11,000, 14,000, and 19,000 rpm and cavitation tests at 11,000 and 14,000 rpm were made. As predicted by theory, the developed head for liquid and slush hydrogen are the same when the difference in density is considered. The pump efficiency, cavitation constant and NPSH requirements for slush hydrogen are also the same as for the triple-point liquid. After 34 minutes running time with slush hydrogen out of a total running time of 79 minutes, the pump components showed no wear over that expected from operation in liquid.

TN365. **Survey of electrical resistivity measurements on 16 pure metals in the temperature range 0 to 273 °K,** L. A. Hall, Nat. Bur. Stand. (U.S.), Tech. Note 365, 114 pages (Feb. 1968).

Key words: Aluminum; beryllium; cobalt; copper; compilation; electrical resistivity; gold; indium; iron; lead; low temperature; magnesium; molybdenum; nickel; niobium; platinum; silver; tantalum; tin.

Experimental electrical resistivity data for 16 pure metals have been compiled, tabulated, and graphically illustrated for a temperature range of 0 to 273 °K. A section has been prepared for each particular metal which includes references, brief comments concerned with preparation of sample, purity, and any other pertinent information, tabulated data, and graph.

TN366. **An analysis of the Brayton cycle as a cryogenic refrigerator,** R. C. Muhlenhaupt and T. R. Strobridge, Nat. Bur. Stand. (U.S.). Tech. Note 366. 116 pages (Aug. 1968).

Key words: Brayton; cryogenics; refrigeration.

The performance of a Brayton-cycle refrigerator has been computed taking into account the efficiencies of the various components. The results are presented in graphical form. These charts give the input power requirements, mass flow rate, pertinent temperatures, and allow selection of the optimum high pressure for a given set of component characteristics.

TN367. **A bibliography of thermophysical properties of methane from 0 to 300 °K,** L. A. Hall, Nat. Bur. Stand. (U.S.), Tech. Note 367, 121 pages (May 1968).

Key words: Bibliography; equation of state; low temperature; mechanical properties; methane; thermodynamic properties; transport properties.

References together with an abbreviated abstract are presented for mechanical, thermodynamic, and transport properties of methane from 0 to 300 °K published up to December 1967. A total of 660 articles have been indexed. Each article has been reviewed and coded with regard to properties studied, type of article (i.e., experimental, theoretical, etc.), and method of presentation of data. The temperature and pressure ranges for each property under consideration are also given. An index has been prepared according to property with four sub-categories: solid, liquid, gas up to 200 °K, and gas above 200 °K.

TN368. **Solution of the Abel integral transform for a cylindrical luminous region with optical distortions at its boundary,** E. R. Mosburg, Jr., and M. S. Lojko, Nat. Bur. Stand. (U.S.), Tech. Note 368, 27 pages (July 12, 1968).

Key words: Abel inversion; Abel transform; emissivity profile; plasma diagnostics; radiance profile.

The use of orthogonal polynomial expansions in the calculation of the Abel integral transform is discussed. Particular attention is directed to the effects of optical and instrumental distortions when the luminous region is contained by a cylindrical glass tube. An easily calculable solution of the Abel integral is presented which reduces the effect of such distortions by employing a weighting function which has a maximum at the center and vanishes at the boundary. This approach results in a more accurate solution of the Abel integral transform in the case where significant optical and instrumental distortions are present near the boundary of the luminous region.

TN369. **Interferometric measurements of the complex dielectric constant of liquids,** W. S. Lovell and L. M. Thiel. Nat. Bur. Stand. (U.S.), Tech. Note 369, 89 pages (Aug. 1968).

Key words: Approximation errors; complex dielectric constant; convergence confidence interval; contour diagrams; dielectric liquid; diffraction; experimental apparatus; Fresnel equations; generalized Newton iteration function; imperfect reflections; interferometric measurements; interferometry; least squares iteration function; liquid dielectrics; method of selected points; millimeter waves; multiple reflections; outliers; perpendicular polarization; quasi-optics; reflection coefficient; transverse displacement; vector solution.

Paper I. Errors in the "perfect square" approximation.—Errors arising from the use of a "perfect square" approximation in treating free-space, interferometric measurements of the complex dielectric constant of liquids are described. It is shown that such errors (1) are generally positive, (2) often exceed values previously estimated for the measurement technique as a whole, and (3) are not generally predictable without some prior knowledge of the dielectric properties of the material being investigated. In addition, these errors depend upon the dielectric thickness over which data are incorporated into the calculations. Finally, an anomaly in the calculations previously attributed to experimental error is shown to arise from the "perfect square" approximation itself. It is concluded that this approximation may at best provide initial estimates for ϵ' and ϵ'' which may then be used in a more complete mathematical treatment.

Paper II. Experiment apparatus.—Design details of a free-space, millimeter-wave interferometer are described. The apparatus radiates at oblique incidence to an air-dielectric-metal configuration placed between dissimilar horns. Errors arising from the quasi-optical nature of this radiation are described, and quantitative data are presented which demonstrate techniques for minimizing such errors. The techniques employed should have general applicability in millimeter-wave measurements. For the particular instrument described, the errors are shown to be of such magnitude that experimental reflection coefficient profiles should conform to an adequate theoretical description. A means for more accurate measurements of the complex dielectric constant of liquids is then provided.

Paper III. Derivation of the absolute reflection coefficient.—For measurements of the complex dielectric constant of liquids by free-space reflection and interference of electromagnetic radiation, a theoretical reflection coefficient for the air-dielectric-metal configuration is derived. The derivation is based on a model which treats multiple reflections within the dielectric explicity. As an extension of earlier theory, this reflection coefficient incorporates effects of (1) imperfect reflections at the dielectric-metal interface, together with other losses, and (2) radiation sources presenting nonplanar wavefronts and having finite bandwidths. Effects arising from a finite sample or receiving surface are also discussed.

Paper IV. A numerical method for determining the best complex dielectric constant.—A numerical method is presented for determining the best complex dielectric constant $\epsilon^* = \epsilon' - i\epsilon''$ from an experimental record obtained at millimeter-wavelengths from free-space, interferometric measurements of liquids. The method of selected points is applied to the reflection coefficient expression to obtain a set of simultaneous equations which is solved for an initial vector solution using the generalized Newton iteration function. The principle of least squares is then applied to achieve the best fit between the reflection coefficient expression and experimental record. The desired values of ϵ' and ϵ'' are included as components of a final vector solution of the best fitting theoretical curve.

TN370. **Calibration principles and procedures for field strength meters (30 Hz to 1 GHz),** H. E. Taggart and J. L. Workman, Nat. Bur. Stand. (U.S.), Tech. Note 370, 157 pages (Mar. 1969).

Key words: Calibration procedures; dipole antennas; field strength meters; loop antennas.

The National Bureau of Standards has been calibrating many types of field strength meters and their related antennas at frequencies up to 1000 MHz for several years. Various techniques of measurement have been investigated regarding accuracy, calibration time, ease of operation, and reliability. This report discusses some of these calibration techniques in detail, and in some cases lists step-by-step procedures for performing the complete calibration. Typical calibration data are used to take the reader from the beginning of the calibration to the completed test report. All measurement setups are clearly illustrated, listing the equipment necessary to perform the calibration. Methods of calibrating two basic types of antennas are described: (1) the loop antenna at frequencies from 30 Hz to 30 MHz and (2) half-wavelength dipole antennas from 30 to 1000 MHz. Two methods of calibrating loop antennas are discussed in detail, the standard-field method and the injection method. The standard-antenna method of calibrating dipole antennas is fully described. Measurement uncertainties of various methods are discussed. This report was written to help technical personnel actively participate in antenna calibration work. Hopefully this information will help people to set up new calibration services and to improve existing calibrating facilities.

TN371. **Transistorized low voltage regulator circuits and design,** J. H. Rogers, Nat. Bur. Stand. (U.S.), Tech. Note 371, 38 pages (Sept. 1968).

Key words: D-C amplifier; design equations; differential amplifier; dual regulator; integrated circuit; output resistance; power dissipation; power supply; preregulator; regulation factor; ripple voltage; transistor; voltage regulation; zener diode.

Simplified design equations and circuits are presented for three separate transistor voltage regulator circuits covering the range of 2 to 30 volts. Examples of design, use of equations, selection of components and performance data are presented. An appendix is included to show the use of recent integrated circuit (I.C.) voltage regulators.

TN372. **Mathematical techniques for EPR analysis of $S = 5/2$ ions in C_2 symmetry. Application to Fe^{3+} in quartz,** R. L. Peterson, L. M. Matarrese, and J. S. Wells, Nat. Bur. Stand. (U.S.), Tech. Note 372, 23 pages (June 1969).

Key words: Electron paramagnetic resonance; ferric ion; synthetic quartz.

Various formulas and mathematical techniques useful for the analysis of the EPR spectra of ions of angular momentum 5/2 in sites of C_2 symmetry are presented. Special emphasis is given to the spectrum of Fe^{3+} in synthetic brown quartz. Included are: matrix elements of the Racah operators for arbitrary direction of the axis of quantization relative to the crystalline electric field axes, spectral line-position formulas based upon a usage of second-order perturbation theory which is somewhat different from the usual, and line-intensity formulas.

TN373. **Radio-frequency measurements in the NBS Institute for Basic Standards,** R. S. Powers and W. F. Snyder, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 373, 116 pages (June 1969).

Key words: Accuracy; calibration services; measurements; measurement techniques; radio frequency; uncertainties of measurement.

This volume is a collection of diagrams, tables, and text material, which has been assembled to show the interrelationships between various radio frequency measurements made by the Institute for Basic Standards (IBS). In particular, the measurements are those which lead to services provided to the public or to other government agencies. These services include not only calibrations made for fees, but the broadcast services of the four NBS radio stations. Measurements made as part of the IBS research and development program are not included.

The information included is designed to give the users and potential users of the radio frequency services a clearer understanding of the origins of the measurement output of IBS in this field.

TN374. **Incipient and developed cavitation in liquid cryogens,** D. K. Edmonds and J. Hord, Nat. Bur. Stand. (U.S.), Tech. Note 374, 31 pages (Feb. 1969).

Key words: Cavitation; cryogens; incipience.

Cavitation characteristics of liquid hydrogen and liquid nitrogen flowing in a transparent plastic venturi have been determined and conventional cavitation-inception-parameter curves are given. Representative developed-cavitation data, consisting of pressure and temperature measurements within fully-developed cavities, are also given; measured temperatures and pressures within the cavities were generally not in thermodynamic equilibrium. Existing theory was used to obtain equations which correlate the experimental data for developed cavities in liquid hydrogen or liquid nitrogen. The theory is extended to include the effect of cavity thickness and the experimental data are used to evaluate the results. Some recommendations for future work are given.

TN375. **Tables of bias functions, B_1 and B_2, for variances based on finite samples of processes with power law spectral densities,** J. A. Barnes, Nat. Bur. Stand. (U.S.), Tech. Note 375, 39 pages (Jan. 1969).

Key words: Spectral density; statistics; unbiased estimate; variance.

D. W. Allan showed that if y(t) is a sample function of a random noise process with a power law spectral density (i.e., $S_y(f) = h|f|^\alpha$), then there is generally bias to the estimated variance of y, defined as

$$\sigma_y^2(N,T,\tau) = 1/N - 1 \sum_{n=1}^{N} (\bar{y}_n - \langle \bar{y} \rangle)^2,$$

where N is the number of samples, y_n is the average value of y(t) over the n-th interval of duration τ, T is the time between the beginnings of any two successive sample intervals, and

$$\langle \bar{y} \rangle \equiv 1/N \sum_{n=1}^{N} \bar{y}_n.$$

Allan also showed that, under these conditions, the expectation value of the estimated variance is proportional to $\tau\mu$ where μ is a constant related to α, the exponent in the spectral density; i.e.,

$$E[\sigma_y^2(N,T,\tau)] \propto \tau^\mu.$$

Based on this work one may define the two bias functions

$$B_1(N,r,\mu) \equiv \frac{E[\sigma_y^2(N,T,\tau)]}{E[\sigma_y^2(2,T,\tau)]}$$

and

$$B_2(r,\mu) \equiv \frac{E[\sigma_y^2(2,T.\tau)]}{E[\sigma_y^2(2,T,\tau)]},$$

where $r \equiv T/\tau$ and the B's are functions of μ through their dependence on y(t).

If one has a sample variance, $\sigma_y^2(N_1, T_1, \tau_1)$, the bias functions allow one to give an unbiased estimate for $\sigma_y^2(N_2, T_2, \tau_2)$ provided the spectral type is known (i.e., μ is known).

The tables give values of $B_1(N,r,\mu)$ and $B_2(r,\mu)$ accurate to four significant figures for the following values of N,r,μ:

$\mu = -2.0$ to 2.0 in steps of 0.2;

N = 4, 8, 16, 32, 64, 128, 256, 512, 1024, ∞;

r = 0.001, 0.003, 0.01, 0.03, 0.1. 0.2, 0.4, 0.8, 1, 1.01, 1.1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, ∞.

TN376. **Unassigned.**

TN377. **Slush hydrogen fluid characterization and instrumentation,** C. F. Sindt, P. R. Ludtke, and D. E. Daney, Nat. Bur. Stand. (U.S.), Tech. Note 377, 69 pages (Feb. 1969).

Key words: Cryogenic; flow restrictions; friction angle; gel; liquid-solid mixtures; particle size; plug flow; slurry flow; slush hydrogen.

Areas of the slush hydrogen fluid characterization program covered are production, transfer, and storage of liquid-solid mixtures.

An experiment has been performed in which a second component was added to liquid hydrogen to determine the effect on the size of the solid particles produced by the freeze-thaw method. Also, an experiment performed with 4.4 percent oxygen in nitrogen resulted in particles an order of magnitude smaller in size than those normally observed in freeze-thaw production of pure nitrogen slush.

The friction angle of settled solids of slush hydrogen on several metals was determined for surface finishes ranging from 2 to 110 micro inches rms. The angle at which solids slide from the surface was found to be a function of the surface finish.

Data were taken in the flow loop over a range of velocities from 1.5 to 40 ft/sec (0.46 to 12.2 m/s). The friction losses determined from the flow data are compared to losses predicted for Newtonian fluids. Losses with slush of solid fractions from 0.1 to 0.4 were found to be lower than with triple-point liquid hydrogen at the higher Reynolds numbers.

Liquid-solid mixtures of hydrogen with solid fraction of 0.5 were transferred through three types of flow restrictions. The restrictions were a globe valve, an orifice, and a venturi. Losses through the restrictions were essentially the same with the high solid fraction slush as with triple-point liquid.

A brief review of the pumping characteristics of slush hydrogen is presented. A comparison of developed head, efficiency, cavitation constant, and net positive suction head is discussed.

Gelling of slush hydrogen with pyrogenic silica was accomplished with solid fractions from 0 to 0.2. The amount of gelling agent required to gel slush was found to be proportional to the liquid volume of the slush.

TN378. **Preparation and characterization of slush hydrogen and nitrogen gels,** A. S. Rapial and D. E. Daney, Nat. Bur. Stand. (U.S.), Tech. Note 378, 43 pages (May 1969).

Key words: Gels; liquid hydrogen gels; liquid nitrogen gels; liquid-solid hydrogen mixtures; rocket propellants; slush hydrogen; slush hydrogen gels; slush nitrogen gels.

An experimental apparatus has been developed for the gelation of slush hydrogen, and slush hydrogen was gelled for the first time. Measurements of the weight-bearing capacity of the gel as a function of mass percent gelant were made for liquid and slush nitrogen and hydrogen. These measurements verify the simple models discussed here for gelled liquid and slush within the experimental accuracy; the models predict a reduction in gelant concentration from 38 mass percent to 25 mass percent in going from the Normal Boiling Point liquid hydrogen to slush hydrogen of 0.40 solid fraction for the silica gelant used in this work. Reduction in the mass percent gelant for other gelants should be similar.

TN379. **Standard time and frequency: its generation, control, and dissemination from the National Bureau of Standards time and frequency division,** J. B. Milton, Nat. Bur. Stand. (U.S.), Tech. Note 379, 27 pages (Aug. 1969).

Key words: Clock synchronization; frequency and time dissemination; primary frequency standard; standard frequency broadcasts; time interval; time scales.

The Time and Frequency Division of the National Bureau of Standards produces the NBS time scales, AT(NBS), SAT(NBS), and UTC(NBS). These time scales are developed by utilizing the properties of the NBS frequency standard, NBS-III. The main byproduct of these time scales is the operational clock systems. These operational clock systems are used, among other things, to calibrate the clocks and secondary standards necessary for the operation of the NBS radio stations, WWV, WWVB, WWVL, and WWVH. These stations transmit SAT(NBS), UTC(NBS), and various tones, alerts, and corrections for time-of-day information.

TN381. **Some applications of the Josephson effect,** R. A. Kamper, L. O. Mullen, and D. B. Sullivan, Nat. Bur. Stand. (U.S.), Tech. Note 381, 63 pages (Oct. 1969).

Key words: Josephson effect; superconductivity; thermometry; tunnel junctions.

We describe techniques for fabricating permanent Josephson junctions between thin films of niobium and lead, and for absolute noise thermometry at very low temperatures using the Josephson effect. We discuss the possible benefits of applying superconductivity to nuclear magnetic resonance detection, and review other applications of the Josephson effect.

TN382. **Laser power and energy measurements,** D. A. Jennings, E. D. West, K. M. Evenson, A. L. Rasmussen, and W. R. Simmons, Nat. Bur. Stand. (U.S.), Tech. Note 382, 64 pages (Oct. 1969).

Key words: Calorimetry; laser; laser calorimetry; laser energy; laser power.

Most laser calorimeters operate in a constant temperature environment. The calorimeters can be used as deflection devices or the data can be analyzed by extrapolation or integration. Consideration of the heat flow problem common to all of these methods points up the underlying assumptions and the possible errors involved.

Calorimeters for measuring the output energy of pulsed ruby and neodymium glass lasers have been built and calibrated. The absorbing medium is an aqueous solution of $CuSO_4$. Calibration of laser energy detectors has an estimated uncertainty of ± 2 percent for input energies of 0.1J to 100J. Comparisons of absorption cell calorimeters with metal plate calorimeters agree within 1 percent.

Instrumentation is described that is used for the calibration of CW laser power meters. The calibration unit employs an absorption cell calorimeter to calibrate the output of a photovoltaic cell transfer detector. The power meter to be calibrated is then compared to the calibrated output of the transfer detector. The calibrations are within an accuracy of 4 percent.

A discussion and description is also given of several types of calorimeters that have been used to measure the output of a 100 watt CO_2 laser. The most recent design provides for measurement from 1 watt to 5 kilowatts with a measured accuracy of better than 3 percent.

TN400 to TN406. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN407. **Applications of a time-sharing computer in a spectrochemistry laboratory: optical emission and x-ray fluorescence,** S. D. Rasberry, M. Margoshes, and B. F. Scribner, Nat. Bur. Stand. (U.S.), Tech. Note 407, 58 pages (Feb. 1968).

Key words: Analytical chemistry; calculations; computers; emission spectroscopy; programming; spectrochemical analysis; time-sharing computer; x-ray spectroscopy.

A time-sharing computer system employing the Dartmouth College Basic compiler has been in use in this laboratory for more than two years, and it has been applied to both routine and non-routine calculations. Descriptions are given of the computer system and its associated programming language and commands. Typical applications and advantages and disadvantages of the system are discussed. An appendix contains descriptions of 13 programs thought to be of interest to other optical and x-ray spectrochemistry laboratories. Examples of input and output are given with each of these programs.

TN408 to TN416. See Nat. Bur. Stand. (U.S.). Spec. Publ. 305, 221 pages (Apr. 1969).

TN417. **Spectral emission properties of NBS standard phosphor samples under photo-excitation,** C. F. Shelton, Nat. Bur. Stand. (U.S.), Tech. Note 417, 31 pages (Mar. 1968).

Key words: Phosphors; photo-excitation; photoluminescence; spectral emission; spectral radiometry; standard phosphor samples.

The photo-excitation spectral emission properties of 10 of the 14 NBS standard phosphor samples have been determined. Pressed tablets of the phosphors were excited by radiation from a mercury arc lamp, passing through a narrow band-pass filter to obtain either 2537Å or 3650Å excitation. The measurement system is described, correction of the data is discussed, and the spectral emission data are presented. Relative quantum efficiencies were calculated. The results are compared with measurements reported by two other laboratories.

TN418. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN419. **Accessory equipment and teletypewriter modifications for remote computer consoles,** C. H. Popenoe and R. C. Thompson, Nat. Bur. Stand. (U.S.), Tech. Note 419, 22 pages (Feb. 1968).

Key words: Remote access; teletype; time-sharing.

Equipment auxiliary to, and simple modifications of a teletypewriter are described which enable it to be used more efficiently as a remote console of a computer. The descriptions and drawings are sufficiently detailed to enable one to duplicate the modifications or construct the auxiliary equipment with little or no design effort.

Among the items treated are: pushbutton word generators, providing automatic typing of often used programming instructions; and option switches for full or half-duplex operation, for inserting the sixth bit for lower case letters, and the eighth bit for parity compatibility.

TN420 to TN421. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN422. **Activities of the NBS Spectrochemical Analysis Section July 1966 to June 1967,** B. F. Scribner, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 422, 84 pages (Jan. 1968).

Key words: Computing; digital readout; electron probe; gold analysis; isotope dilution method; laser probe; liquid Q-switch; mass attenuation coefficients; microphotometer; optical spectrometry; plasma torch; platinum analysis; preconcentration; selenium analysis; spark source mass spectrometry; spectrochemical analysis; standard reference materials; sulfur analysis; time-shared computer; x-ray absorption coefficients; x-ray fluorescence analysis; vacuum spectrometer.

A summary is given of activities of the NBS Spectrochemical Analysis Section for the year July 1966 through June 1967. In optical spectrometry, studies were made of (1) the effectiveness of a liquid Q-switch for laser pulse control and (2) the applicability of the high-frequency plasma torch in atomic emission and absorption spectroscopy. Two papers on laser probe spectrochemical analysis were published. In electron probe microanalysis an alignment procedure was developed for the x-ray spectrometer, data on x-ray mass absorption coefficients were collected and critically evaluated, and a review of techniques for scanning microprobe analysis was published. The factors entering into quantitative electron probe analysis are being investigated. In x-ray spectrometry studies were made of interferences especially in the analysis of complex alloys. A combination of techniques involving enrichment by electrodeposition, stable isotope dilution, and determination by the spark source mass spectrometer has provided an accurate method for trace analysis. Improvements in the Section's equipment, including digital readout devices, and developments in computer applications are also discussed. Listings are given of 15 publications and 23 talks by members of the Section during the year.

TN423. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN424. **Analytical coordination chemistry: Titrimetry, gravimetry, flame photometry, spectrophotometry, and gas evolution July 1966 to June 1967,** O. Menis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 424, 106 pages (Jan. 1968).

Key words: Absorption and fluorescence spectrophotometry; arsenic; atomic absorption; beryllium; DTA studies; dysprosium in a glass; flame emission; gases in metals; gravimetry; homogeneous precipitation; impurities in zinc and selenium; Li_2O in glass; nitrogen; oxygen in titanium; titrimetry.

In the related areas of gravimetry, titrimetry, flame emission and atomic absorption spectroscopy, absorption and fluorescence spectrophotometry, and gases in metals, the versatile aspects of coordination chemistry have, in several instances, been uniquely exploited to yield either more precise and accurate results or lower detection limits. Fivefold improvement in the gravimetric analysis for beryllium has been obtained by means of an incomplete homogeneous precipitation followed by a selective spectrophotometric examination of the filtrate. In the field of thermal analysis a survey of fifteen compounds has revealed several promising, future standards for DTA studies covering the range of 75 to 900 °C. In the section on titrimetry highly precise procedures are described for the determination of boron and beryllium. Various instrumental parameters have been investigated in flame emission and atomic absorption spectroscopy in order to optimize such variables as nebulizer-burner and oxidant-fuel systems, elimination of interferences, and source difficulties. The use of chelate extraction systems has led to the extension of detection limits to the submicrogram level for impurities in zinc and selenium, while modified electronics has permitted the precise determination of 10 percent Li_2O in glass with a relative standard deviation of better than 0.2 percent. In absorption and fluorescence spectrophotometry the research aspect of ternary complexes or mixed chelates are described together with their potential use at the nanogram-picogram level. In the same area improvement in accuracy has been obtained by controlled dissolution of samples in closed systems with particular attention being given to the determination of arsenic in cast iron. Also described in this section is the differential spectrophotometric determination of dysprosium in a glass to be used as a neutron flux monitor, in which case the relative error was reduced to less than 0.25 percent. Finally, in the area of high vacuum fusion a new standard was certified for oxygen in titanium and in two titanium alloys. In addition, research in the use of the same technique for the determination of nitrogen has apparently eliminated the problem of low values that have in the past so frequently plagued the analyst.

TN425 to TN428. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN429. **Separation and Purification Section: summary of initial activities February 1966 through June 1967,** D. H. Freeman, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 429, 48 pages (Feb. 1968).

Key words: Ion exchange; purification; reagents; zone refining.

This report describes the initial growth and research activities of the Separation and Purification Section since its formal organization in February 1966.

A research capability for the study and refined adaptation of ion exchange materials is described. There are new activities reported for the areas of extreme purification, chemical reagents, organic chemicals, including the use of crystallization for the achievement, protection, and measurement of chemical purity. Specific studies have been conducted in the purification of mineral acids, nitrobenzene, and the development of zone refining methods.

TN430 to TN431. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN432. **Connection tables from Wiswesser chemical structure notation—a partial algorithm,** G. F. Fraction, J. C. Walker, and S. J. Tauber, Nat. Bur. Stand. (U.S.), Tech. Note 432, 63 pages (Sept. 1968).

Key words: Acyclic; benzene; chemical structure notations; connection tables; contractions; ring system; syntax analysis; transformation algorithm; Wiswesser.

An algorithm has been developed for transforming certain types of Wiswesser organic structure notations into connection tables. Acyclic and benzene structures are treated, and provision has been made for all of the types of contractions used by the Wiswesser notation system. A separate algorithm is presented for treating linearly fused ring aggregates. A syntax has been developed to describe those portions of Wiswesser notations which refer to non-benzene ring systems.

TN433. **Input/output packages for the systems 360 assembly language processor,** P. A. D. deMaine, Nat. Bur. Stand. (U.S.), Tech. Note 433, 14 pages (Sept. 1968).

Key words: Assembly language; card punch; card read; input/output; on-line print; system 360.

Three input-output (I/O) software packages for use with the Assembly Language Processor (ALP) of the Systems 360 are described. They are for card read, on-line-print and card punch operations. A single pseudo-operation statement, which contains all required formats and addresses, suffices for the execution of each input-output package. Printed error and guide messages aid in program debugging. In addition to the conventional formats (A, I, F and E), Systems 360 column binary (X) and hexadecimal (J and B) are permitted. With a single pseudo-operation these I/O packages can handle up to eight individual items or arrays of any length in a single or mixed format.

TN434 to TN435. See Nat. Bur. Stand. (U.S), Spec. Publ. 305, 221 pages (Apr. 1969).

TN436. **Studies of calibration procedures for load cells and proving rings as weighing devices,** G. B. Anderson and R. C. Raybold, Nat. Bur. Stand. (U.S.), Tech. Note 436, 22 pages (Jan. 1969).

Key words: Calibration; force; load cells; proving rings; transducers; uncertainty; weighing.

Elastic devices such as load cells and proving rings, when used with comparison measurement techniques, yield uncertainties orders of magnitude smaller than generally accepted. Their use, in direct reading application, is affected by numerous characteristics of materials, as well as the techniques of application and interpretation of data. This paper is intended to present progress made in the evaluation of calibration techniques, to the end that such transducers may be used with a predictable uncertainty in direct reading applications. Attempts are being made to formulate calibration procedures which are consistent with application procedures. The confusion existing in the derivation and application of practical force units is considered sufficient justification for a brief discussion of forces derived from mass standards and gravitational acceleration.

TN438. See Nat. Bur. Stand. (U.S.), Spec. Publ. 305, 221 pages (Apr. 1969).

TN439. **A laser-source integrating sphere reflectometer,** G. J. Kneissel and J. C. Richmond, Nat. Bur. Stand. (U.S.), Tech. Note 439, 70 pages (Feb. 1968).

Key words: Diffuse reflectance; graphite; high temperature reflectance; infrared reflectance; integrating sphere reflectometer; laser; reflectance; sodium chloride coating; synchronous amplification; thoria; tungsten.

A reflectometer was developed for measuring the absolute spectral reflectance of materials at temperatures up to 2500 °K. The equipment included (1) a helium-neon laser as the source, capable of operation at 0.6328, 1.15 or 3.39μm, (2) a 35 cm diameter integrating sphere coated with sodium chloride, (3) a lead sulfide detector, and (4) a radio frequency generator for heating the specimen by induction. A spike filter transmitting at the laser wavelength in front of the detector absorbed most of the background radiation from the hot specimen, and a chopped incident beam together with synchronous amplification of the signal from the detector was used to eliminate the effect of the remaining background radiation. The integrating sphere could be evacuated, or operated under a slight positive pressure of purified helium. An error analysis showed that the measured absolute reflectances are in error by less than one percent. Preliminary data are presented for thoria, tungsten and graphite. Graphite was found to be stable in reflectance on heating to 2150 °K in vacuum. Both thoria and tungsten were somewhat unstable in reflectance on heating in vacuum.

TN440. **Disclosure on: Autoeditor—a semi-automatic copy-editing apparatus,** D. Robbins, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 440, 49 pages (Apr. 1968).

Key words: Automatic capitalization; automatic deletions; automatic stop for revision; editorial mark sensing; manual additions; narrative text editing; punched paper tape typewriter.

This note is a disclosure on a semi-automatic apparatus for incorporating editorial revisions in narrative text using punched paper tape combined with mark-sensing techniques. Pencil marks placed on the original draft by the editor are sensed and arranged to automatically capitalize the first letter of a word, to capitalize an entire word, or stop the apparatus at the point where a change is to be made. Addition of text is entered manually with an electric typewriter; deletion of text is accomplished by activating a "mark skip" key which advances the tape without typing until the next control mark is sensed.

TN441. **Tabulation of published data on Soviet electron devices through October 1967,** C. P. Marsden, Nat. Bur. Stand. (U.S.), Tech. Note 441, 98 pages (July 1968).

Key words: Electron devices; electron tubes; Soviet electron devices; semiconductors.

This tabulation includes published data on Soviet electron devices as collected from publications, mostly handbooks published by the various ministries and institutes of the USSR. Information is given on all active devices ranging from receiving to microwave devices, semiconductor devices, and miscellaneous devices such as, for example, photographic flash tubes and thermistors. (Supersedes NBS Tech. Note 265).

TN442. **An empirical formula for the coherent scattering cross section of gamma rays,** A. Nath and A. M. Chose, Nat. Bur. Stand. (U.S.), Tech. Note 442, 16 pages (Apr. 1968).

Key words: Coherent scattering; Delbrück; empirical formula; gamma rays; nuclear Thomson; Rayleigh.

An empirical formula has been developed for estimating coherent scattering cross sections of γ-rays of energies below 1.5 MeV and in the range of $0 - 2.5$mc units of momentum transfer. The formula has been compared with the experimental data available in the literature in the case of Pb, Sn and Cu scatterers for different photon energies between $0.279 - 1.33$ MeV. Experimental data, in general, have been found to be in good agreement with the results of the empirical formula, the deviation being within ± 10 percent in most of the cases. The empirical formula has also been compared with the form factor results of Nelms and Oppenheim and with the accurate theoretical data of the Birmingham group. The latter is in excellent agreement with the empirical formula.

TN443. **A computer oriented single-fingerprint identification system,** J. H. Wegstein, Nat. Bur. Stand. (U.S.), Tech. Note 443, 28 pages (Mar. 1968).

Key words: Classification; computer; descriptor; file; fingerprint; identification; pattern-recognition.

A procedure is described for computing a set of numerical descriptors that identify a single fingerprint. The procedure starts with the X and Y coordinates and the individual directions of the minutiae (ridge endings and bifurcations) of a fingerprint impression. Sets of descriptors are computed corresponding to groups or constellations of these minutiae. Descriptors corresponding to various fingerprint impressions are stored on magnetic tape. A fragment of a fingerprint impression such as occurs in a latent fingerprint may also be used.

A second computer program reads the descriptors corresponding to two different fingerprint impressions from magnetic tape. A score is computed that indicates how well the two impressions match. Preliminary experimental results suggest that this procedure might be suitable as a basis for a single-fingerprint classification system.

TN444. **Reform: a general-purpose program for manipulating formatted data files,** R. McClenon and J. Hilsenrath, Nat. Bur. Stand. (U.S.), Tech. Note 444, 28 pages (Aug. 1968).

Key words: File editor; fixed-field file editor; Fortran program; insert program; packing program; reformatting; report generator; unpacking program.

A program listing and description is given of REFORM, an independent program with which it is possible to manipulate and edit files containing as many as nine different fixed-field card formats. It can select or abridge information from any of the cards and print that information, or reformat new cards in any desired order or arrangement. Provision is made for introducing as many as twenty-six arbitrary strings of characters, each of which may be up to seventy-nine characters in length, thereby permitting the insertion of labels, headings, or comments into the file. The program, which operates on the 1108 computer at NBS, is written in ASA FORTRAN, and care has been taken to reduce to a minimum the program changes required to make the program run on other computers.

TN445. **A bibliography on methods for the measurement of inhomogeneities in semiconductors (1953-1967),** H. A. Schafft and S. G. Needham, Nat. Bur. Stand. (U.S.), Tech. Note 445, 47 pages (May 1968).

Key words: Bibliography; electron voltaic; measurement methods; photoconductivity; photovoltaic; point potential probe; semiconductor material inhomogeneities; spreading resistance; voltage breakdown.

About 130 papers which deal with the measurement techniques useful in detecting the type and location of various inhomogeneities, primarily in germanium and silicon, are listed with key words. The types of inhomogeneities considered are those in impurity concentration, resistivity, mobility, diffusion length, lifetime, surface conditions, crystal perfection, and p-n junctions. Some of the twenty-two effects or methods used to detect these inhomogeneities are: photovoltaic, electron-voltaic, photoconductivity, one-, two- and four-point probe, spreading resistance, and voltage breakdown. There are three indexes: a reference tabulation according to key words, a reference tabulation according to methods or effects used to detect an inhomogeneity, and an author index.

TN446. **PRECISE: A multiple precision version of Omnitab,** A. E. Bean and J. Hilsenrath, Nat. Bur. Stand. (U.S.), Tech. Note 446, 84 pages (June 1968).

Key words: Double precision; elementary functions; equation solver; linear equation solver; magnetic tape utility program; multiple-precision computing; multiple-precision programming; PRECISE; triple-precision; user's manual.

This users manual describes PRECISE—a completely assembled interpretive program for the IBM 7090/7094 which enables the user to carry out arithmetic operations and function generation in multiple precision (accuracy to 28 significant figures). PRECISE operates as a sub-monitor under the IBSYS or DC-IBSYS monitor systems. Appendixes describe how jobs are set up to be run under the PRECISE sub-monitor, and how the system may be expanded to include new subroutines. The program, which responds to instructions in the form of plain English sentences or contractions thereof, has provision for handling numbers out of the normal 7090/7094 range. It handles numbers as large as 10 to the 10 to the 9 power. Other features of the program include: free-field input; a work-sheet of 7,500 cells (3 × 2500 computer words) which can be dimensioned by the user at run time (75 rows by 100 columns, 300 rows by 25 columns, etc.); solution of systems of linear equations in as many as 85 unknowns; flexible formatting; tape handling facility; and row and column sums. A description of the UOM Multiple Precision Package (SHARE Dist. No. 3081) is included as an appendix.

TN447. **Research on high temperature materials at the National Bureau of Standards,** E. Passaglia, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 447, 19 pages (July 1968).

Key words: High temperature materials; materials properties.

The National Bureau of Standards, with support from the Advanced Research Projects Agency of the Department of Defense, has begun a program on High Temperature Materials. This program includes projects on properties of high temperature materials, projects on their preparation, and others designed to explain basic phenomena limiting the use of materials at high temperatures. A summary of the progress in this program is given here.

TN448. **Status report. National standard reference data system, April 1, 1968,** E. L. Brady, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 448, 132 pages (June 1968).

Key words: Atomic and molecular data; chemical kinetics; colloid and surface properties; data systems design and development; information services; mechanical properties; nuclear data; solid state data; standard reference data; thermodynamic and transport properties.

This report summarizes the status of activities of the NBS Office of Standard Reference Data as of April 1968. It provides a detailed review of the data compilation activities within the seven broad categories of the technical scope of the program: (1) nuclear data, (2) atomic and molecular data, (3) solid state data, (4) thermodynamic and transport data, (5) chemical kinetics, (6) colloid and surface properties, and (7) mechanical properties. Progress in data systems design and development and in information services are reviewed. Certain problem areas of the program are identified. The appendix includes: (1) a listing of information and data centers associated with the Office of Standard Reference Data, (2) publications of the National Standard Reference Data System, and (3) a listing of organizations, groups, or individuals compiling or evaluating data.

TN449. **Research on laser standards and materials at the National Bureau of Standards,** K. G. Kessler, E. Passaglia, and N. N. Winogradoff, Editors, Nat. Bur. Stand. (U.S), Tech. Note 449, 32 pages (June 1968).

Key words: Holography; laser energy; laser materials; laser power; laser radiometry; laser standards; laser transitions; modulation of lasers; near and far field patterns; optical properties.

A brief report is presented on research in the areas of laser standards and laser materials now in progress at the National Bureau of Standards. Included are the measurement of the power and energy output of lasers, their near and far field patterns and their optical properties. The physical and chemical properties of laser materials are studied in an attempt to relate such properties to the operating characteristics of lasers.

TN450. **Unassigned.**

TN451. **Radiochemical Analysis Section: summary of activities July 1967 to June 1968,** J. R. DeVoe, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 451, 131 pages (Jan. 1969).

Key words: Backscatter geometry; computer programs for Mössbauer spectrometry; computers; corrosion products; counting statistics; cross sections; detection limits for analysis; electric field gradient tensors; flux monitors; interferometric Mössbauer spectrometer; Mössbauer instrumentation; Mössbauer spectrometry, NBS Linac; nickel-61; nuclear recoil; overflow counter; photonuclear reactions; proportional counter; quantitative Mössbauer spectrometry; standard reference materials.

This is the fifth summary of progress of the Radiochemical Analysis Section of the Analytical Chemistry Division at the National Bureau of Standards.

The sections' effort comprises four major areas: Mössbauer spectrometry, nuclear chemistry, nuclear instrumentation and the application of statistics in nuclear and analytical chemistry.

Studies in nuclear reactions have centered around measurement by time of flight mass spectrometry of helium-4 produced from reactions such as $^{7}Li(\gamma,\alpha)^{3}H$.

Statistical methods have been applied to the measurement of peaks in radiation spectra, to reporting trace amounts of radioactivity, to the calibration of Standard Reference materials, and to the reporting of detection limits of a system of measurement.

A procedure for cooling a moving absorber with a stationary source for Mössbauer spectrometry is described. A system for taking spectra using the scattering mode is described along with a large "pancake" shaped proportional counter that is used in the system. Theoretical interpretations of Mössbauer spectra of nickel compounds are given. Computer programs which incorporate constraints such as field intensity and quadrupole moments have been written. Several applications of Mössbauer spectrometry, such as surface corrosion studies are described. Preliminary data are given on the charge states of ^{119m}Sn after nuclear recoil. A technique for resolving some of the difficulties in quantitative analysis of chemical structures is also described.

An overflow counter for collecting more counts than the memory capacity of a pluse height analyzer is described. A sequential scanner for a frequency synthesizer has adapted the NBS Optical Interferometric Mössbauer Spectrometer from a constant velocity to a constant acceleration mode.

TN452. **Activities of the NBS Spectrochemical Analysis Section July 1967 through June 1968,** B. F. Scribner, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 452, 80 pages (Sept. 1968).

Key words: Computing; digital readout; electron probe; emulsion calibration; emulsion sensitivity; gold analysis; isotope dilution method; microprobe grid scanner; optical spectrometry; plasma torch; platinum analysis; preconcentration; silicon detector; spark source mass spectrometry; spectrochemical analysis; standard reference materials; time-shared computer; x-ray absorption coefficients; x-ray fluorescence analysis; x-ray mass attenuation coefficients; zinc analysis.

A summary is given of activities of the NBS Spectrochemical Analysis Section for the year July 1967 through June 1968. This covers research activities, improvement in equipment, and applications in analysis including the certification of standard reference materials. In optical spectrometry studies were completed on the plasma torch as a means of excitation of solutions, and on computer programs for the calibration of photographic emulsions. In electron probe microanalysis a matrix scanner for automatic point-by-point grid scans was tested and a lithium-drifted silicon detector was installed for non-diffractive x-ray dispersion. A study was made of color composites for combining the information of three x-ray area scans. In quantitative probe analysis, measurements were made of x-ray mass attenuation coefficients, and a study of atomic corrections is underway. In x-ray fluorescence considerable improvement was realized by replacement of electronics by solid state circuitry, and methods are being studied for corrections of interelement effects, utilizing the digital computer. Spark source mass spectrometry was applied, by means of chemical separations and by isotope dilution techniques, to the accurate determination of impurities in zinc, platinum, and gold. A critical study was made of the uniformity of response of ion-sensitive emulsions over the area of the plates used in the mass spectrometry. Improvements in the Section's equipment and further developments in computer applications are also discussed. Listings are given of 23 publications and 19 talks by members of the Section during the year.

TN453. **Electrochemical Analysis Section: summary of activities July 1967 to June 1968,** R. G. Bates, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 453, 88 pages (July 1968).

Key words: Acidity; analysis; conductance measurements; electrochemical analysis; electrochemistry of solutions; ionic activity; ion-selective electrodes; pD measurements; pH measurements; medium effects; solvent effects.

This survey of the activities of the Electrochemical Analysis Section, Analytical Chemistry Division, covers the period July 1967 to June 1968. An attempt is made to summarize a year's progress on the technical projects of the Section in such a way as to stress the program and capabilities of the organizational unit as a whole. Brief summaries of several lines of work under way are given. The review describes briefly new equipment and facilities acquired during the year. A major effort devoted to acidity measurements has led to new pH standards and new reference solutions for pD in heavy water. Solvent effects on acid-base phenomena in mixed solvents have shed some light on the factors, including solvent structure, governing ion-solvent interactions. A start was made on the study of ion-specific electrodes and the establishment of standard scales for ionic activity. Equilibrium data for hydrochloric acid in 92.41 wt. percent ethanol and for the ionization of carbonic acid in heavy water have been obtained. The establishment of conductance standards for oceanographic research was begun. The survey concludes with lists of the members of the Section staff, publications and manuscripts produced during the year, talks given by the staff, and committee assignments.

TN454. **Analytical Coordination Chemistry Section: summary of activities July 1967 to June 1968,** O. Menis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 454, 92 pages (July 1968).

Key words: Atomic absorption and atomic fluorescence spectrometry; differential thermal analysis; flame emission; gases in metals; gravimetry and titrimetry; spectrophotometry and spectrofluorometry; standard reference materials.

This annual report outlines the progress made in titrimetry, gravimetry, flame emission, atomic absorption and fluorescence, spectrophotometry, spectrofluorometry and the determination of gases in metals in conjunction with the analysis of Standard Reference Materials. It describes recent developments in instrumentation and in sample dissolution techniques and discusses some unique applications of coordination systems and ternary complexes.

In flame spectroscopy considerable progress was made in the development and testing of electrodeless discharge lamps, Xe-arc continuum sources, a.c. scanning systems, resonance detectors and improved nebulizer-burner combinations. The relative merits of flame emission, atomic absorption and atomic fluorescence were evaluated from theoretical and practical standpoints. Specialized instrumentation was also developed for use in thermal analysis studies and in spectrofluorometry. In the area of gases in metals, a new inert gas fusion apparatus having a unique sampling valve and gas flow system was constructed and coupled to a high sensitivity gas chromatograph. In addition, a new commerical inert gas fusion apparatus was tested and a vacuum fusion unit modified to permit more readily the successive determination of oxygen and nitrogen.

Studies were made of the dissolution of refractory materials containing volatile or easily hydrolizable components. Sealed Teflon-lined bombs and quartz tubes were successfully applied to the determination of trace nitrides in steels and niobium alloys and of antimony at the 10-50 ppm level in ferrous alloys. The latter was prerequisite to the provision of standards for correlating the presence of trace antimony in rotor blades with power turbine failures. Teflon-lined bombs were also used for the dissolution of clays prior to the determination of trace components.

The formation and extraction of ternary complex systems were investigated to provide enhanced spectrophotometric and spectrofluorometric sensitivity for trace metal determination. Improvement in the detection limits of existing procedures were effected by the use of micro-volume techniques. Also, the utilization of recently developed spectrofluorometric chelating agents have yielded significant improvement in sensitivity. Beryllium, for example, was readily determined in resin beads at the 50 picogram level.

Finally, a large number of Standard Reference Materials and potential standards were certified for their major, minor and trace constituents. These included clays, tungsten-molybdenum compacts, neutron flux glasses, aluminum alloys, organo-metallic compounds, ferrous alloys, solder, and high-purity and doped zinc, platinum and gold. Many of the values obtained were confirmed by independent methods.

TN455. **Microchemical Analysis Section: summary of activities July 1967 to June 1968,** J. K. Taylor, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 455, 145 pages (Oct. 1968).

Key words: Coulometric analysis; gas analysis; methods of chemical analysis; microchemical analysis; microscopic analysis; polarographic analysis; specific ion electrodes.

This report describes the research activities and scientific programs of the Microchemical Analysis Section of the Analytical Chemistry Division of the NBS Institute for Materials Research during the period July 1967 to June 1968. General activities are reported in the areas of gas analysis, polarography, potentiometry, coulometry, chemical microscopy, and classical microchemical analysis. Research activities described in some detail include: determination of trace amounts of oxygen in gases, development of a coulometric method for precise analysis of boric acid, improvements in microdetermination of silver and fluorine by null-point potentiometry, the electrochemical generation of fluoride ion, preparation of resin-bead particle standards, and determination of trace elements by the nuclear track technique. A number of microchemical procedures which have been developed for the analysis of a variety of materials are also included.

TN456. **Analytical Mass Spectrometry Section: summary of activities July 1967 to June 1968,** W. R. Shields, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 456, 54 pages (Nov. 1968).

Key words: Instrumentation; isotopic analyses; mass spectrometry; procedures.

This report describes the advances in instrumentation and the research activities of the Analytical Mass Spectrometry Section during the period July 1967 to June 1968.

Advances in instrumentation include the construction of the electronic interface automating both the control of the multistage instrument, and the digital readout and data reduction. A new and improved beam valve is also described.

Elements studied during this period include: B, Ni, Pb, Li, U, and Pu. Chemical procedures are given for B, Pb, CaF_2, U, and Pu; mass spectrometric procedures are given for B.

TN457. **Organic Chemistry Section: summary of activities July 1967 to June 1968,** R. Schaffer, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 457, 127 pages (Sept. 1968).

Key words: Acetylation; analysis of corn syrups; carbohydrate structure and characterization; cholesterol; clinical chemistry; creatinine; di-*O*-isopropylidene-D-*erythro*-pentulofuranose; D-psicose, dextrose; n.m.r. spectroscopy; nicotinic acid; 1,2:3-4-metallo-organic standard reference materials; periodic acid; polycyclic air-pollutants; polyhydroxy cyclic compounds; standard reference materials; sucrose; sulfonic Ka measurements; urea; uric acid.

This report describes work in progress in the organic Chemistry Section of the Analytical Chemistry Division of the NBS Institute for Materials Research. The following research areas are discussed:

Carbohydrate Synthesis, Structure, and Characterization: Novel Research Materials and Model Compounds. The reaction of sulfonic esters of D-mannitol with methoxide has been examined, and a new dianhydrohexitol has been isolated, and identified as 2,3:4,5-dianhydro-D-iditol. Methods for the esterification of tetrahydroxy-*p*-benzoquinone and benzenepentol, and the disproportionation of the former compound during acetylation have been studied. A novel method for acetylation in 100 percent phosphoric acid has been developed. The usefulness of bromine for oxidizing cyclohexanehexols into inososes and diketoinositols was investigated. Acetylations of certain inosose phenylhydrazones was proved to provide arylazocyclohexene derivatives, whereas previous workers had reported otherwise. NMR spectroscopy was used to determine the conformations of several bi- and tri-cyclic carbohydrate derivatives in solution, and the influence of substituents and of dipolar interactions on conformation was analyzed. The factors that determine the rates of reaction of the cyclic disulfones that are intermediates in the MacDonald-Fischer degradation of sugars were evaluated by pKa measurements and NMR analysis. Syntheses of "D-ribulose" and D-psicose have been carried out.

Clinical Chemistry. Extensive examinations of the properties of high-purity samples of creatinine, uric acid, and urea have been made, as a preliminary stage in the development of Standard Reference Materials for these compounds. The application of phase solubility analysis and differential scanning calorimetry has been studied where appropriate for evaluations of purity. The properties and methods for determining the purity of SRM cholesterol were studied.

Properties of Polycyclic Air-Pollutants. The oxidation of a variety of polycyclic, aromatic compounds by periodic acid was studied and found to proceed by (1) a free-radical mechanism that gives rise to coupling products, or (2) a two-equivalent oxidation mechanism that leads to quinonoid derivatives, or both. On treatment with periodic acid, azulene, a non-benzenoid, aromatic compound, gave a free-radical-containing, polymeric material having ionic properties.

Analytical Chemistry of Corn Sugars and Related Products. As a preliminary but basic step in a program for developing relationships between the compositions and physical properties of corn syrups prepared by various processes, a variety of methods have been explored for assaying the water content in syrups.

In order to describe experimental procedures adequately, it has occasionally been necessary to identify commercial materials and equipment in this report. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

TN458. **Activation Analysis Section: summary of activities July 1967 to June 1968,** P. D. LaFleur, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 458, 109 pages (Mar. 1969).

> Key words: Activation analysis; Cockcroft-Walton neutron generator; computer literature searching; extraction; group separations; homogeneity testing; hydrogen bis(2-ethylhexyl) phosphate; matrix effect; molybdenum; NBS LINAC; NBS reactor; photon activation analysis sensitivities; standard reference materials; zinc.

The facilities used by the reactor, LINAC and neutron generator groups for activation analysis are described. Proposed installation of four new irradiation terminals and a new pneumatic transfer tube system are outlined.

A new 2.5-mA neutron generator has been installed and the biological shield, pneumatic transfer system and the detector assembly modified. Studies of blank problems for oxygen determination and self-absorption corrections in photopeak analysis have resulted in greatly improved precision for Standard Reference Materials. Halide in photographic emulsions, using 14-MeV and 2.6-MeV neutrons, have been determined.

Considerable emphasis has been placed on the development of group radiochemical separations, SRM steel and high purity zinc samples have been analyzed using this technique.

Eighteen different SRMs were analyzed for a variety of elements and a variety of service analyses were performed.

The self-absorption effects of the matrix on irradiation photons were studied and calculations of sensitivities for photon activation analysis were made. Carbon in sulfur, yttrium in rare earth oxides and oxygen in sodium were determined by photon activation.

The extraction of metals by bis(2-ethylhexyl) orthophosphoric acid has been studied, and distribution coefficients are given for many of the transition metals. The results indicate enhanced applicability of this reagent for radiochemical separations.

Updated keys for computer literature searching and a sample output are included.

TN459. **Separation and Purification Section: summary of activities July 1967 to June 1968,** D. H. Freeman, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 459, 56 pages (Dec. 1968).

> Key words: Analytical distillation; clinical standards; crystallization; divinylbenzene; EDTA; ion exchange resins; microstandards; particulate matter; reagents; resin structure; ultra-pure reagents; urea; uric acid.

The research activities of the Separation and Purification Section are described, including their significance to the program of the Office of Standard Reference Materials. The work involves basic developments to characterize ion exchange resins using infrared spectrophotometry, stoichiometric analysis of resin structure, and the study of chain scission. The availability of spherical particles of homogeneous ion exchange resin has been exploited with the recently developed microstandards. Analytical gas chromatography has been developed with emphasis given to the specialized needs of measuring trace contaminants in purified organic compounds including divinylbenzene, EDTA, and clinical standards such as uric acid and urea. Purification capabilities involving the use of crystallization, analytical distillation, and of the newly installed low temperature (−30 °C) laboratory are described. The activities of the ultra-pure reagents project, including work on the laser light scattering measurement of traces of liquid borne particulate matter, on reagent preparation, and methods of reagent storage are described.

TN460. **Unassigned.**

TN461. **Tables of solutions to Bragg's equation for copper, cobalt, iron, and chromium $K\bar{\alpha}$ radiation and small diffraction angles,** J. P. Colson and E. S. Clark, Nat. Bur. Stand. (U.S.), Tech. Note 461, 75 pages (Aug. 1968).

> Key words: Bragg's equation; Co; Cr; Cu; Fe; $K\bar{\alpha}$ radiation; small angle.

Tables of solutions to Bragg's equation are presented for the $K\bar{\alpha}$ radiation of Cu(1.541838 Å*), Co(1.790260 Å*), Fe(1.937355 Å*), and Cr(2.291002 Å*). The value of 2θ is increased in increments of 0.001 degree from 0.001 to 2.999 degrees and in increments of 0.00001 radian from 0.00002 to 0.04999 radian. The solutions are rounded off to five digits.

TN462. **Nonnumeric data processing in Europe: a field trip report,** M. E. Stevens, Nat. Bur. Stand. (U.S.), Tech. Note 462, 66 pages (Nov. 1968).

> Key words: Artificial intelligence; automatic abstracting; automatic indexing; computational linguistics; computer centers; documentation; information storage; library automation; optical character recognition; pattern recognition; programming languages; selection and retrieval; speech and speaker recognition.

A number of nonnumeric data processing projects in the United Kingdom, Belgium, the Netherlands, Italy, Sweden, the Federal Republic of Germany, and the U.S.S.R. have been visited. Topics covered include character and pattern recognition; speech analysis, synthesis, and recognition; artificial intelligence; mechanized documentation and library automation; linguistic data processing, and computing and programming theory.

TN463. **Mössbauer effect study of magnetic ordering in copper-rich Cu-Ni-Fe alloys,** L. J. Schwartzendruber, Nat. Bur. Stand. (U.S.), Tech. Note 463, 138 pages (Aug. 1968).

Key words; Alloys; copper; gold; iron; magnetism; Mössbauer effect; nickel.

The ^{57}Fe Mössbauer effect has been observed in a series of copper rich Cu-Ni-Fe alloys, and for two samples of gold rich Au-Fe. At low temperatures most of these alloys order magnetically and the Mössbauer effect spectra develop typical six-line hyperfine field structure. For dissolved Fe the room temperature Cu-Fe and Au-Fe spectra consist of a doublet superimposed on a central line. In Cu-Ni-Fe the spectra at room temperature consist of a doublet with no evidence of a central line when the Ni concentration is above 10 atomic percent. The doublet separations at room temperature (and their estimated uncertainties) are 0.69 ± 0.02, 0.58 ± 0.02 and 0.22 ± 0.04 mm/sec in Au-Fe, Cu-Fe, and Cu-Ni-Fe respectively. By observation of the spectra in a magnetic field the doublet structure is shown to be due to magnetic interactions between Fe and other Fe or Ni atoms. Isomer shifts, metallurgy in Cu-Ni-Fe alloys, sample preparation techniques, and the Mössbauer effect equipment developed are also discussed.

TN464. **The NBS Alloy Data Center: function, bibliographic system, related data centers, and reference books,** G. C. Carter, L. H. Bennett, J. R. Cuthill, and D. J. Kahn, Nat. Bur. Stand. (U.S), Tech. Note 464, 199 pages (Aug. 1968).

Key words: Alloys; annotation; automated; bibliography; data; indexing; information; Knight shifts; metals; NMR; soft x-ray spectroscopy.

The Alloy Data Center, part of the National Standard Reference Data System, has two primary functions. One is to stimulate cooperation and coordination among the existing data centers in the area of the physical properties of well characterized alloys. The final data generated by these centers for publication should be consistent with one another where correlation or possible overlap exists. The other purpose is the collection (from publications as well as private communications), evaluation, and publication of data in some areas where special competence exists in the Alloy Physics Section. Of interest to the center are metals, semimetals, intermetallic compounds, and alloys. Excluded are those materials which have ill-defined constitutions and heat treatments. An automated system has been developed to meet the bibliographic needs of the center. This system will be described as well as the specific properties of interest. The system presently contains a complete annotated file on papers dealing with NMR Knight shift measurements. The soft x-ray spectroscopy compilation is being kept up-to-date with the same system.

TN465. **Measurement of carrier lifetime in semiconductors—an annotated bibliography covering the period 1949-1967,** W. M. Bullis, Nat. Bur. Stand. (U.S.), Tech. Note 465, 64 pages (Nov. 1968).

Key words: Bibliography; diffusion length; diode recovery; excess carrier lifetime; measurement methods; photoconductive decay; photoconductivity; photomagnetoelectric effect; recombination of excess carriers; semiconductors; surface photovoltage.

About 300 papers concerned with the measurement and interpretation of carrier lifetime in semiconductors are listed together with key words and a brief comment for each. Eight types of entries are included: Description of Methods, Analysis of Results, Standard Methods, Experimental Results, Theoretical Models, Auxiliary Procedures and Data, Reviews, and Books. Emphasis is placed on methods of carrying out measurements of carrier lifetime. Hence complete coverage was attempted and nearly two thirds of the entries appear in the first three categories. A large fraction of the papers listed describe the photoconductivity or photoconductive decay methods. The other most popular methods are based on diode characteristics or the photomagnetoelectric effect. In all, 35 methods for measuring carrier lifetime are represented by entries. In addition, representative papers which describe various models for recombination are included together with a number of papers which discuss the influence of surface recombination and trapping phenomena. Auxiliary procedures such as surface preparation, formation of ohmic contacts, control of temperature, and the like are described in some of the entries. Two indexes, a Key Word Index and an Author Index, are provided together with a classification of the various methods for measuring carrier lifetime.

TN466. **Matching fingerprints by computer,** J. H. Wegstein, J. F. Rafferty, and W. J. Pencak, Nat. Bur. Stand. (U.S.), Tech. Note 466, 17 pages (July 1968).

Key words: Computerized-fingerprint-identification; fingerprints; pattern-recognition.

A procedure is described for determining whether two fingerprint impressions were made by the same finger. The procedure uses the X and Y coordinates and the individual directions of the minutiae (ridge endings and bifurcations). The identity of two impressions is established by matching a constellation or group of minutiae in one impression with a corresponding constellation in the other impression in terms of the relative distances and relative angles of the minutiae.

TN467, Part 1. **Activation analysis: a bibliography,** G. J. Lutz, R. J. Boreni, R. S. Maddock, and W. W. Meinke, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 467, Part 1, 520 pages (Sept. 1968).

Key words: Activation analysis; bibliography; element determined; literature file; matrix analyzed; technique used.

References to activation analysis in the open literature are published from a computer readout. The first part of the two-part series contains references numbered according to their accession to the system. The second part contains an author index and three additional indices for "element determined," "matrix analyzed," and "techniques used." The two parts, when used together, permit a literature search defined by the three indices. Part 1 will be updated periodically by addenda containing new references while Part 2 will be periodically revised and replaced by new pages which include cross references to the new accessions. Part 1 is sold only with Part 2.

TN467, Part 2. **Appendices. Activation analysis: a bibliography,** G. J. Lutz, R. J. Boreni, R. S. Maddock, and W. W. Meinke, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 467, Part 2, 197 pages (Sept. 1968).

Key words: Activation analysis; bibliography; element determined; literature file; matrix analyzed; technique used.

References to activation analysis in the open literature are published from a computer readout. The first part of the two-part series contains references numbered according to their accession to the system. The second part contains an author index and three additional indices for "element determined," "matrix analyzed," and "technique used." The two parts, when used together, permit a literature search defined by the three indices. Part 1 will be updated periodically by addenda containing new references while Part 2 will be periodically revised and replaced by new pages which include cross references to the new accessions. Part 2 is sold only with Part 1.

TN468. **Unassigned.**

TN469. **NBS interagency transducer project,** P. S. Lederer, Nat. Bur. Stand. (U.S.), Tech. Note 469, 23 pages (Oct. 1968).

Key words: Dynamic calibration; evaluation; InterAgency Transducer Project; performance characteristics; telemetry; transducer.

For a number of years, the National Bureau of Standards has been engaged in a continuing project to study the performance of transducers, primarily those used in telemetry. This project has been supported by agencies of the Defense Department and NASA. This report provides a brief description of the background and history of the project, of its objectives, of some of the specialized facilities developed and used, and of some of the publications that have issued from the project.

TN470. **EDPAC: utility programs for computer-assited editing, copy production, and data retrieval,** C. G. Messina and J. Hilsenrath, Nat. Bur. Stand. (U.S.), Tech. Note 470, 80 pages (Jan. 1969).

Key words: Alphanumeric data files; computer-assisted text preparation; data retrieval; FORTRAN programs; free field text files; mechanized text editing.

A description and listings are given of EDPAC, a package of five related utility computer programs: SCRAMBLE, SUBSTITUTE, SEARCH, BLOCKSEARCH, JUSTIFY, and their subroutines. These programs perform transformations on alphanumeric data. The programs have been written in FORTRAN, with care taken to make them as system and machine-independent as possible, permitting their use on many different computers.

SCRAMBLE scans an input file for specified characters, which it replaces by different characters. SUBSTITUTE similarly replaces strings of characters by other strings. SEARCH and BLOCKSEARCH scan for the occurrence of certain strings and list the lines or blocks, respectively, in which they occur. JUSTIFY produces text, for printing on a card-controlled typewriter or on an extended character printer, which has been left- and right-justified between specified margins.

Some applications of the EDPAC programs are discussed. Emphasis is placed on computer-assisted text preparation.

TN472. **Methods of measurement for semiconductor materials, process control, and devices. Quarterly report July 1 to September 30, 1968,** W. M. Bullis, Editor, Nat Bur. Stand. (U.S.), Tech. Note 472, 45 pages (Dec. 1968).

Key words: Carrier lifetime; electrical properties; germanium; methods of measurement; microelectronics; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal properties; wire bonds.

This quarterly progress report describes NBS activities relating to: measurement of resistivity, carrier lifetime, inhomogeneities, and Hall effect in semiconductor crystals; study of infrared measurement methods, properties of deep-lying impurities (in InSb), and high field effects; establishment of a processing facility; evaluation of wire bonds; review of NASA measurement methods; and measurement of second breakdown in transistors, thermal properties of devices, and noise in microwave diodes. Projects on silicon nuclear radiation detectors and specification of germanium are also described. Supplementary data concerning staff, committee activities, technical and information services, and publications are included as appendixes. A list of ASTM Standards relevant to integrated circuit processing is also included.

TN473. **Laboratory-field comparison of built-up roofing membranes,** T. H. Boone, L. F. Skoda, and W. C. Cullen, Nat. Bur. Stand. (U.S.), Tech. Note 473, 15 pages (Dec. 1968).

Key words: Bituminous adhesive; bituminous built-up membranes; engineering properties; laboratory-field comparison; strength-thickness.

The values of breaking load, elongation and thermal expansion of nine bituminous built-up membranes prepared by roofing contractors under field conditions and by technicians in the laboratory were measured at subfreezing temperatures. The data indicated that the field-prepared specimens agreed favorably with laboratory-prepared specimens, although the samples from the field frequently reflected higher values for thermal-shock resistance than did their laboratory-prepared counterparts. The higher values were attributed to the smaller amounts of bitumen used between the plies of the field specimens. The results appeared to support the validity of the application of the "strength-thickness rule" to bituminous built-up membranes.

TN474. **Critically evaluated transition probabilities for Ba I and II,** B. M. Miles and W. L. Wiese, Nat. Bur. Stand. (U.S.), Tech. Note 474, 22 pages (Jan. 1969).

Key words: Ba I; Ba II; line strengths; oscillator strengths; transition probabilities.

Critically evaluated transition probabilities, in order of increasing quantum numbers, are compiled for Ba I and II from available literature sources.

TN475. **Methods of measurement for semiconductor materials, process control, and devices. Quarterly report October 1 to December 31, 1968,** W. M. Bullis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 475, 38 pages (Feb. 1969).

Key words: Carrier lifetime; die attachment; electrical properties; germanium; metallization; methods of measurement; microelectronics; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal resistance; thermographic measurements; wire bonds.

This second quarterly progress report in this series describes NBS activities relating to: measurement of resistivity, carrier lifetime, inhomogeneities, and Hall effect in semiconductor crystals; study of infrared measurement methods, properties of deep-lying impurities (in InSb), and high field effects; establishment of a processing facility; evaluation of aluminum metallization, wire bonds, and wafer die attachment; review of NASA measurement methods; and measurement of second breakdown in transistors, thermal properties of devices, and noise in microwave diodes. Projects on silicon nuclear radiation detectors and specification of germanium are also described. Supplementary data concerning staff, committee activities, technical services, and publications are included as appendixes.

TN476. **Line emission sources for concentration measurements and photochemistry,** W. Braun and T. Carrington, Nat. Bur. Stand. (U.S.), Tech. Note 476, 23 pages (Mar. 1969).

Key words: Absorption; analysis; gas; photochemistry; spectroscopy; vacuum ultraviolet.

When a resonance line is absorbed in its own gas, measurements of this absorption can be used to derive a value of the product, nf, of concentration of the absorber and f value of the transition. This line absorption process is also important in the study of fluorescence and photochemistry, where it is possible to produce atoms or molecules in a single quantum state without otherwise disturbing the system. The interpretation and success of these applications of line absorption depend critically on the shape of the line emitted by the light source. This is strongly influenced by the optical depth in the emitting region, and by the inevitable presence of a reversing layer through which the light must travel on its way out of the lamp. This paper presents a simple model which can be used to estimate the effects of these properties of the light source on the threshold and sensitivity of measurements of nf, and on the power which can be delivered to absorbing atoms outside the lamp. Emphasis is on the general principles of lamp design and diagnosis, rather than on accurate description of a particular lamp.

TN477. **The performance of roofing made with Asplund felts,** S. H. Greenfeld, Nat. Bur. Stand. (U.S.), Tech. Note 477, 27 pages (Mar. 1969).

Key words: Asphalt; Asplund; felt; mineral-surfaced roll roofing; shingles; wood fibers.

A study of the durability of roofing made with Asplund wood fibers was conducted from 1942 to 1967. Concentrations of 0 to 60 percent wood fibers (oak or pine) prepared by three variations of the Asplund process were evaluated. All the mineral-surfaced roll roofings and shingles were performing well after 25 years, with only four specimens showing more deterioration than the controls (only rags and paper in their felts). No differences in performance could be related to the felt composition.

TN478. **Some evolving conventions and standards for character information coded in six, seven, and eight bits,** J. L. Little, Nat. Bur. Stand. (U.S.), Tech. Note 478, 30 pages (May 1969).

Key words: ASCII; character codes; code extension; coded character sets; collating sequence; computer codes; data transmission codes; information code structure; international information code; Russian code standard; standard information codes; USASCII.

This Technical Note describes some of the properties of the USA Standard Code for Information Interchange, widely known as ASCII or USASCII. It also relates this code to similar international codes and presents the national code for Russia as an example of the worldwide acceptance of this code, which is comprised of seven information bits representing 128 coded characters. Some of the conventions which are evolving to relate these seven bit codes to six and eight bit computer codes are given, and conventions for extending the code to represent an unlimited repertoire of concepts is also given. Two alternate arrangements of the code table are shown to facilitate an understanding of its structure and application.

TN479. **A Fortran program for analysis of ellipsometer measurements,** F. L. McCrackin, Nat. Bur. Stand. (U.S.), Tech. Note 479, 82 pages (Apr. 1969).

Key words: Computer programs; ellipsometry; Fortran program; multiple films; optical constants; reflection coefficients; thin films.

A general Fortran program is given that performs the calculations required to analyze ellipsometer measurements. This program replaces the program given in NBS Technical Note 242, entitled "A Fortran Program for Analysis of Ellipsometer Measurements and Calculation of Reflection Coefficients From Thin Films." The main changes from the previous program are: (1) the new program is in Fortran IV and V rather than Fortran II; (2) the relative transmission of the wave plate is considered in analyzing ellipsometer readings; (3) an improved method is used for calculating the refractive index of a film; (4) the form of the input data is improved; (5) a method for calculating and correcting for tilt of the reflecting surface is given; (6) an improved method of calculating confidence limits for the calculated values of thickness and refractive index of a film is used; and (7) a method for calculating the optical constants of an adsorbing film of given thickness is included.

TN480. **Misalinement detector for axial loading fatigue machines,** D. C. Robinson, Nat. Bur. Stand. (U.S), Tech. Note 480, 15 pages (Apr. 1969).

Key words: Axial loading; fatigue machine; misalinement; test fixtures.

A strain gage device for measuring changes in alinement between the test fixtures of axial loading fatigue machines is described. Variations in fixture orientation are determined by measurement of the bending induced in a compliant beam clamped in parallel mounts attached to the test fixtures. Changes in bending with applied tension loads are an indication of alterations in the alinement between the load transmitting members of a machine. An approximately linear relationship was found to exist between changes in bending determined by the detector and the fatigue life of high strength fasteners for various levels of misalinement induced in a fatigue machine.

TN481. **A semi-automated single fingerprint identification system,** J. H. Wegstein, Nat. Bur. Stand. (U.S.), Tech. Note 481, 21 pages (Apr. 1969).

Key words: Computerized-fingerprint identification; fingerprints; pattern-recognition.

A system is described in which a fingerprint is manually coded by tracing certain ridges and noting events such as ridge endings and ridge beginnings. This code is sent by teleprinter to a central file where a computer identifies the fingerprint by comparing the code with codes previously entered in the file. The scheme for comparing codes is given along with some preliminary test results using typical fingerprints.

TN482. **Superconductive materials and some of their properties,** B. W. Roberts, Nat. Bur. Stand. (U.S.), Tech. Note 482, 129 pages (May 1969).

Key words: Bibliography; compilation of data; composition; critical field; critical temperature; crystallographic data; low temperature; superconductivity.

This is a noncritical compilation of data on superconductive materials that has been extracted from a portion of the literature published up to early 1968. The properties concerned are composition, critical temperature, critical magnetic field, crystallographic data, and lowest temperature tested for superconductivity. The compilation also includes, bibliography, general reference review articles and a special tabulation of high magnetic field superconductors. (Supersedes Tech. Note 408.)

TN483. **Construction and operation of a simple high-precision copper-point blackbody and furnace,** R. D. Lee, Nat. Bur. Stand. (U.S.), Tech. Note 483, 16 pages (May 1969).

Key words: Blackbody; optical pyrometry; radiometry.

Detailed instructions for the construction and operation of an inexpensive copper-point blackbody and furnace are presented. Such a source may be expected to realize the radiance temperature of 1083.3 °C (Int. 48) with an uncertainty of 0.2 °C and a variation in successive use of less than 0.033 °C. The furnace requires no inert gas or vacuum and utilizes only 225 watts to reach a melt in about an hour after turn on. Melts and freezes last about five minutes each and at least fifty melts and freezes are expected during the lifetime of the furnace.

TN484. **A review of rate constants of selected reactions of interest in re-entry flow fields in the atmosphere,** M. H. Bortner, Nat. Bur. Stand. (U.S.), Tech. Note 484, 62 pages (May 1969).

Key words: Attachment-detachment reaction; charge exchange reaction; collisional ionization reaction; evaluated rate constants; flow field kinetics; O_2-N_2 systems.

The major reactions normally encountered in flow field re-entry calculations for the oxygen nitrogen system are reviewed and a rate constant value for each reaction is recommended. Collisional ionization processes, charge exchange reactions and attachment-detachment reactions are included. Rate constant coefficients to fit the equation $k = aT^{b}e^{-c/T}$ are reported in tabular form for the selected rate constant. The data are also graphed as log k vs T(K). In all, over twenty forward and reverse reactions are reviewed. Additionally, a large number of rate constant values for reactions which also effect flow field calculations are given.

TN485. **An evaluation of certain methods for the chemical analysis of styrene-butadiene rubber,** E. J. Parks and F. J. Linnig, Nat. Bur. Stand. (U.S.), Tech. Note 485, 27 pages (July 1969).

Key words: Bound styrene; carbon black; chemical analysis; latexes; oil; organic acid; serums; soap; stabilizer; styrene-butadiene rubber (SBR); washes.

The applicability of available methods for the analysis of unvulcanized styrene-butadiene rubber (SBR, formerly GR-S) for organic acid and soap is influenced by the type of coagulation (alum or salt-acid), the type of acid present (fatty acid, rosin acid, or mixed acids), and the presence of carbon black or oil. No single method is universally applicable for the analysis of organic acid and soap, but reasonably unbiased results can be attained by proper selection of the available procedures.

The complete-solution procedure for alum-coagulated (AC) SBR has given reasonably good results for organic acid in samples containing mixed acids, while the extraction procedure using aqueous isopropanol-toluene azeotrope (ITA) gives good results for AC samples containing fatty acid only.

The complete-solution procedure for SBR coagulated with salt and acid gives less biased results for organic acid and soap than the aqueous ITA extraction procedure, but the latter should be used for all SBR containing carbon black and for estimating oil in oil-rubber masterbatches. Both complete-solution procedures and the ITA extraction procedure can be adapted for the determination of stabilizer and bound styrene. The present ASTM extraction procedure using ethanol-toluene azeotrope is less satisfactory than the other procedures.

TN486. **Some problems in measuring tread wear of tires,** S. Spinner and F. W. Barton, Nat. Bur. Stand. (U.S.), Tech. Note 486, 27 pages (Aug. 1969).

Key words: Statistics; tires; tread wear testing.

Some problems in tread wear testing of tires are discussed and methods for dealing with these problems are presented. Experimental data are shown to illustrate these methods. Finally some recommendations are made, based primarily on this information, in order to achieve greater uniformity and a statistically valid approach to tread wear testing.

TN487. **Considerations in computing the useful frequency range of piezoelectric accelerometers,** N. Newman, Nat. Bur. Stand. (U.S.), Tech. Note 487, 20 pages (June 1969).

Key words: Electrical excitation; lowest resonant frequency; mechanical excitation; piezoelectric accelerometer; usable frequency range.

This paper analyzes two lumped-parameter models for computing the usable frequency range of piezoelectric accelerometers. The analyses indicate why application of an electrical excitation to the piezoelectric element of a mounted pickup does not, in general, give the same result as application of a mechanical acceleration to the structure on which the pickup is mounted. Tabular results of the computations for various sets of parameters indicate those cases for which the electrical drive will give resonant frequency values within 2 percent of those for the pickup mounted on a vibrating structure. For these parameter sets, the electrical drive can be used as a reliable substitute.

TN488. **Methods of measurement for semiconductor materials, process control, and devices. Quarterly report January 1 to March 31, 1969,** W. M. Bullis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 488, 44 pages (July 1969).

Key words: Carrier lifetime; die attachment; electrical properties; gamma detectors; germanium; gold-doped silicon; indium antimonide; metallization; methods of measurement; microelectronics; nuclear radiation detectors; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal resistance; thermographic measurements; wire bonds.

This quarterly progress report, third of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal emphasis is placed on measurement of resistivity, carrier lifetime, and electrical inhomogeneities in semiconducting crystals; evaluation of wire bonds; and measurement of thermal properties of semiconductor devices. Other tasks involve: study of infrared measurement methods, deep-lying impurities in InSb, gold in silicon, and high field effects; establishment of a processing facility; evaluation of aluminum metallization and wafer die attachment; review of NASA measurement methods; and measurement of Hall effect in semiconductor crystals, second breakdown in transistors, and noise in microwave diodes. Related projects on silicon nuclear radiation detectors and specification of germanium are also described. Supplementary data concerning staff, committee activities, technical services, and publications are included as appendixes.

TN489. **Tables of response functions for silicon electron detectors,** M. J. Berger, S. M. Seltzer, S. E. Chappell, J. C. Humphreys, and J. W. Motz, Nat. Bur. Stand. (U.S.), Tech. Note 489, 62 pages (Aug. 1969).

Key words: Detector response function; electron back-scattering; electron energy absorption; electron transmission; silicon detectors.

Calculated response functions are presented which describe the pulse-height distributions produced by monoenergetic electrons incident on silicon detectors. It is assumed that the direction of incidence is perpendicular, and that the detectors are wide enough so that lateral leakage of energy is insignificant. The validity of the calculations has been confirmed experimentally for incident energies between 0.25 MeV and 1.0 MeV and detectors with thicknesses between 0.061 mm and 3.0 mm. The calculated response functions cover a wider range of conditions, including fourteen energies between 0.15 MeV and 5.0 MeV and ten detector thicknesses between 0.05 and 10.0 mm. At energies $\geqslant$ 1 MeV, response functions are given not only for bare detectors but also for an arrangement in which the detectors are shielded on the transmission side by another detector operating in anti-coincidence.

TN490. **Thermal gradient effects on thirteen flush mounted pressure transducers,** L. Horn, Nat. Bur. Stand. (U.S.), Tech. Note 490, 23 pages (Aug. 1969).

Key words: Pressure measurement errors; pressure transducers; response; temperature; thermal gradients; zero shift.

Thirteen different flush mounted pressure transducers of seven manufacturers were tested by creating a thermal gradient in them and recording the resultant zero shifts. Photographs of typical outputs are shown and the results are compared. A typical recording shows these general characteristics: (1) a very rapid change in output reaching a peak in a second or less, (2) a more gradual shift which reaches a peak in a time which may be a few seconds or more than a minute, and (3) a shift in reading which remains as long as the gradient is maintained. Examples were found in which each of these were positive or negative. The magnitude in a few cases was small, in many was a large fraction of its range, and in one case well in excess of the full scale range.

TN491. **Gravity measurements and the standards laboratory,** D. R. Tate, Nat. Bur. Stand. (U.S.), Tech. Note 491, 10 pages (Aug. 1969).

Key words: Absolute gravity; deadweight; force; geodetic pendulum; gravity; gravity meter; Potsdam system; standard gravity; units of force.

The local value of the acceleration due to gravity is a fundamental datum for almost every standards laboratory as it, together with accurate standards of mass, is the basis for the standards involving force. Instruments used as standards in this area include precise deadweight piston gages, deadweight calibrators for force transducers, liquid manometers, and earth field accelerometer calibrators. The practical realization of the absolute ampere and the absolute volt require a knowledge of force. This paper presents the basic information about how gravity measurements are made and outlines procedures for obtaining a suitable value for a given location. It also gives a brief discussion of the background and meaning of the term "standard gravity," and its application in the computation of forces in units of the pound-force and the kilogram-force.

TN494. **ARPA-NBS program of research on high temperature materials,** A. D. Franklin, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 494, 28 pages (Sept. 1969).

Key words: Copper; creep; crystal growth; diffusion; enthalpy; evaporation; fracture; glass band structure; high temperature materials; mass transport; materials properties; mechanical relaxation; oxides; polymers; pyrolytic graphite; transition metal borides.

Brief reviews are given of work performed during the period of July 1 to December 31, 1968, on a number of projects concerning High Temperature Materials. Topics include the optical constants of titanium, diffusion of oxygen in oxides, growth of Al_2O_3 bicrystals by chemical vapor deposition, high temperature creep in copper, fracture in glass, the electronic structure of transition metal borides and related compounds, the enthalpy of pyrolytic graphite at high temperatures, the mechanism of volatilization of polymers, and the interaction between mechanical relaxation and annealing in polymers.

TN495. **Methods of measurement for semiconductor materials, process control, and devices. Quarterly Report April 1 to June 30, 1969,** W. M. Bullis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 495, 45 pages (Sept. 1969).

Key words: Carrier lifetime; die attachment; electrical properties; gamma detectors; germanium; gold-doped silicon; indium antimonide; metallization; methods of measurement; microelectronics; nuclear radiation detectors; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal resistance; thermographic measurements; wire bonds.

This quarterly progress report, fourth of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal emphasis is placed on measurement of resistivity, carrier lifetime, and electrical inhomogeneities in semiconductor crystals; evaluation of wire bonds; and measurement of thermal properties of semiconductor devices. Other tasks involve study of infrared measurement methods, deep-lying impurities in InSb, gold in silicon; and high field effects; establishment of a processing facility; evaluation of aluminum metallization and wafer die attachment; review of NASA measurement methods; and measurement of Hall effect in semiconductor crystals, second breakdown in transistors, and noise in microwave diodes. Related projects on silicon nuclear radiation detectors and specification of germanium are also described. Supplementary data concerning staff, committee activities, technical services, and publications are included as appendixes.

TN496. **Rare gas resonance lamps,** R. Gorden, Jr., R. E. Rebbert and P. Ausloos, Nat. Bur. Stand. (U.S.), Tech. Note 496, 55 pages (Oct. 1969).

Key words: Aluminum window; extinction coefficients; ionization quantum yield; photochemistry; photoionization; rare gases; resonance lamps; saturation ion current.

Rare gas resonance lamps having high spectral purity, high intensity, and long lifetimes have successfully been manufactured. The design and filling procedure for these lamps is described in detail. Particular operational characteristics of the xenon, krypton, argon, neon, and helium resonance lamps are also given. Windows suitable for use with each of these lamps are described, with particular emphasis given to the procedure for fabricating thin aluminum windows for use with neon and helium lamps. In addition, a method for determining extinction coefficients and ionization quantum yields based on the measurement of saturation ion currents is described.

TN497. **The effects of extended high-temperature storage on the performance characteristics of several strain gage pressure transducers,** R. Williams, Nat. Bur. Stand. (U.S.), Tech. Note 497, 22 pages (Oct. 1969).

Key words: Life testing; pressure transducer; sensitivity shift; strain gage; temperature cycling; temperature storage; zero shift.

This publication reports the results of a test program to evaluate the effects of high-temperature storage on the performance characteristics of several types of commercial strain gage pressure transducers. The results obtained indicate shifts in the zero pressure output and the sensitivity, some of which are permanent. The equipment used and the procedure followed are described.

TN499. **Multiple scattering corrections for the associated-particle neutron time-of-flight technique,** A. C. B. Richardson, Nat. Bur. Stand. (U.S.), Tech. Note 499, 68 pages (Oct. 1969).

Key words: Associated-particle; cross-section; Monte Carlo; multiple scattering; neutron; time-of-flight.

The computer code, MAGGIE, for the calculation of multiple scattering and sample attenuation in neutron differential cross-section measurements, has been revised and corrected. The particular case of the scattering geometry required by the associated-particle time-of-flight is considered in detail.

TN503. **Electrochemical Analysis Section: summary of activities July 1968 to June 1969,** R. G. Bates, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 503, 99 pages (Aug. 1969).

Key words: Acidity; analysis; conductivity; electrochemical analysis; electrochemistry of solutions; ionic activity; ion-selective electrodes; pD measurements; pH measurements; medium effects; solvent effects; standard reference materials.

This survey of the activities of the Electrochemical Analysis Section, Analytical Chemistry Division, covers the period July 1968 to June 1969. An attempt is made to summarize a year's progress on the technical projects of the Section, to indicate the composition and capabilities of the unit as a whole, and to stress the Section's role in the mission of the Institute. Brief summaries of several lines of work under way are given. The concept of a broad program on acidity measurements is outlined, and new efforts to provide assistance in clinical acid-base measurements are summarized. Progress toward reference standards for the calibration of ion-selective electrodes is reported. Equilibrium data for phosphoric acid in heavy water, for piperazinium ion in 50 wt percent methanol-water, and for hydrochloric acid in a solvent composed of 2-methoxyethanol (80 wt percent) and water (20 wt percent) have been obtained. Considerable effort has been devoted to the development of new standard reference materials, including standards for conductivity measurements. Lists of publications, talks, and committee assignments of staff members are given.

TN504. **Analytical Coordination Chemistry Section: summary of activities July 1968 to June 1969,** O. Menis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 504, 120 pages (Oct. 1969).

Key words: Certification of standard reference materials; differential thermal analysis; flame emission and atomic absorption; gases in metals; spectrofluorimetry; spectrophotometry.

Research developments are described in flame emission and atomic absorption spectrometry, spectrophotometry, spectrofluorometry, differential thermal analysis and the analysis and certification of Standard Reference Materials. The application of ac wavelength scanning and second derivative measurements of spectral line intensities serve to overcome broad-band and continuum interferences of matrices in flame emission analysis. It also provides for the analysis of samples as small as 50 μl. In atomic absorption studies of arsenic, basic corrections for spectral interferences are given.

New spectrophotometric methods have been developed for the analysis of multicomponent systems. These include the simultaneous determinations of cobalt, nickel and copper with 2,3-quinoxalinedithiol and of vanadium and iron with β-isopropyltropolone. The extraction of ternary ion association complexes initially containing non-colored or non-fluorescent organic cations, followed by displacement of these groups by highly colored or highly fluorescent dye cations directly in the organic phase, has provided a means of simultaneously improving sensitivity and selectivity in absorption and fluorescence spectrophotometry. The determinations of gold and uranium are described to illustrate the approach. Spectrofluorometric studies of the determination of rare earth elements in synthetic borate glass are also presented.

Instrument modifications and temperature measurement techniques now provide a tenfold increase in the precision of measurements of phase transition temperatures of quartz and potassium nitrate on differential thermal analysis standards.

Procedures, analytical data and background information are presented for Standard Reference Materials of steels, cast and nodular irons, ferrosilicon, high-purity materials, neutron flux monitor wire, organo-metallic compounds, glasses, and clays. These descriptions include atomic absorption methods for copper in steel, magnesium in nodular iron, impurities in calcium carbonate, high precision spectrophotometric methods for cobalt in aluminum wire, molybdenum and tungsten in microprobe standard, traces of iron and copper in high purity gold and methods for the determination of silica and aluminum in clays.

TN505. **Microchemical Analysis Section: summary of activities July 1968 to June 1969,** J. K. Taylor, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 505, 140 pages (Oct. 1969).

Key words: Chemical analysis; coulometric analysis; gas analysis; ionic equilibria; ion-selective electrodes; microchemical analysis; microscopic analysis; polarographic analysis.

This report describes the research activities and scientific programs of the Microchemical Analysis Section of the Analytical Chemistry Division of the NBS Institute for Materials Research during the period July 1968 to June 1969. General activities are reported in the areas of gas analysis, polarography, potentiometry, coulometry, chemical microscopy, and classical microchemical analysis. Research activities described in some detail include: gravimetric preparation of gas analysis standards; polarographic determination of trace elements in glass; fabrication and performance of a microfluorine electrode; elucidation of the boric acid-borate-mannitol system; investigation of the relation between the equilibrium point and inflection point in acidimetric titrimetry; coulometric determination of trace quantities of chromium; and determination of trace elements by nuclear track measurements. A number of procedures which have been developed for the analysis of a variety of materials, utilizing the techniques mentioned above, are also included.

TN507. **Organic Chemistry Section: summary of activities July 1968 to June 1969,** R. Schaffer, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 507, 145 pages (Oct. 1969).

Key words: Bilirubin analysis; calcium carbonate SRM; conformations by NMR; corn syrup analysis; creatinine SRM; D-glucose (clinical SRM); organic trace analysis; SRM's for clinical analysis; urea SRM; uric acid SRM; 6-amino-6-dexoy-D-glucose-6-^{15}N.

This report by the Organic Chemistry Section of the National Bureau of Standards' Institute for Materials Research summarizes a year's scientific activities; consequently, it covers both work that was completed and some that is still in progress. It reports new work on carbohydrates and polyhydroxy cyclic compounds, and analytical studies leading to (*a*) the development of Standard Reference Materials for clinical chemistry, (*b*) characterizations of trace quantities of organic compounds, and (*c*) understanding the properties of starch hydrolyzates.

In research on carbohydrates, rules on selective hydrolysis of certain ketose acetals, a new crystalline derivative of potential use as an SRM for "D-ribulose," conformations of compounds having *m*- and *p*-dioxane rings, and a synthesis of ^{15}N-labeled "6-amino-D-glucose" are described.

Work on polyhydroxy cyclic compounds has shown that (*a*) phenylosotriazoles of diketoinositols favor a half-chair conformation, (*b*) mercuric acetate is a superior reagent for preparing these osotriazoles, (*c*) acetylation in 100 percent phosphoric acid gives an octaacetoxydibenzo-*p*-dioxin from 4,6/5-trihydroxy-1,2,3-cyclohexanetrione, whereas acetylation in pyridine had been shown to produce aromatized products, (*s*) periodic acid oxidizes phenylhydrazino to phenylazo derivatives, and (*e*) phenylformazans and bis(phenylhydrazones) form highly colored salts with strong acids.

In examining a variety of commercial samples of bilirubin in the course of developing an SRM for clinical analysis, data have been obtained by several techniques, including thin-layer chromatography and thermogravimetric analysis. Visible spectrophotometry gave data on the stability of bilirubin dissolved in a variety of solvents. Measurements were made by the diazo assay. A materials-balance analysis of bilirubin samples was developed.

Various chromatographic procedures, used to examine a supply of D-glucose as an SRM, are described. Measurements of optical rotation in water and methyl sulfoxide, and other analytical data, are also given. Some of the work pertaining to the creatinine, urea, calcium carbonate, uric acid, and cholesterol SRM's that have been issued are presented.

Finally, work on the detection and identification of trace quantities of a few organic compounds is summarized, and the description and statistical evaluations of several methods developed for the characterization of the properties of corn starch hydrolyzates are summarized.

TN510. **Use of a time-shared computer system to control a Hall effect experiment,** W. M. Bullis, W. R. Thurber, T. N. Pyke, Jr , F. H. Ulmer, and A. L. Koenig, Nat. Bur. Stand. (U.S.), Tech. Note 510, 46 pages (Oct. 1969).

Key words: Computer-controlled experiment; data acquisition system; digital scanner; experiment-computer interface; Hall effect; system control module; teletypewriter interface; time-shared computer.

An experimental time-shared computer system has been used to control and collect data from a Hall effect experiment. In addition to selection of the voltage sequence and control of specimen current and magnetic flux directions, the computer exerts positive control over the specimen temperature in accordance with a series of thermocouple voltages entered by the operator at the beginning of the run. The interface circuitry is constructed from four general purpose modules and a single special purpose unit. Details of the interface system and the programs used to control the experiment and to perform intermediate calculations are given. It was found that the time-shared system was well-suited to control an experiment of this type. The demands on the computer were essentially similar to those required by a human user interacting in a conversational mode. Substantial savings in time over manual data collection and reduction were realized; a temperature run with 38 to 40 data points between 10 and 320 K could be completed in less than 4 hours.

4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED BY OTHERS, 1966–1969

Reprints from the journals listed in this section may often be obtained directly from the authors. See page 19 for additional information.

9528. Abramowitz, S., Levin, I. W., **Force fields for some Group VI hexafluorides,** *J. Chem. Phys.* **44,** No. 9, 3353-3356 (May 1, 1966).

Key words: Band contours; force fields; gas phase; infrared; sulphur hexafluoride; tellurium hexafluoride; vibration-rotation.

The Coriolis zeta constants were determined for the infrared active F_{1u} modes of SF_6 and TeF_6 from gas phase band contour measurements. These Coriolis data were applied toward determining the general force fields for these Group VI hexafluorides.

9529. Abramowitz, S., Levin, I. W., **Vibrational analysis of SeF_6 and WF_6,** *Inorg. Chem.* **6,** 538-541 (1967).

Key words: Coriolis constants; force field; infrared; SeF_6; vibration-rotation; WF_6.

The gas phase infrared vibration-rotation spectra of SeF_6 and WF_6 have been observed in the region of their infrared active fundamental absorption bands. Coriolis coupling constants, evaluated from the observed contours, are used as constraints for the general force fields for these molecules.

9530. Achenbach, P. R., **Performance criteria for building components and systems,** *Proc. Porcelain Enamel Institute Forum, University of Illinois, Urbana, Ill., Sept. 28-30, 1966,* **28,** 176-195 (1966).

Key words: Building components; codes; laboratory procedures; performance characteristics; performance criteria; specifications; standards.

The Building Research Division of the National Bureau of Standards has conducted a number of technical investigations which led to the development of new test procedures for evaluating the significant performance requirements of building components and systems. These investigations have typically produced performance data which could be used by appropriate organizations in establishing criteria of acceptability. Laboratory studies of this type have been completed on underground heat distribution systems, ducts for heating and air conditioning systems, and sanitary plumbing fixtures and a similar study is in progress on exterior wall systems for residential buildings. In each of these studies the Building Research Division has collaborated with multi-discipline task groups of the Building Research Advisory Board of the National Academy of Sciences-National Research Council in developing the list of important performance characteristics in qualitative language. The work done on these projects is used to illustrate the sequence of activities required in developing performance criteria, the importance of collaboration among representatives of industry, professional societies, codes and standards organizations, and government bodies in selecting acceptable performance levels, the problems involved in devising adequate laboratory test procedures for building components made of widely-differing materials, and the incomplete state of administrative procedures for implementation of performance criteria on a national scale.

9531. Achenbach, P. R., Phillips, C. W., Penney, R. W., **A testing and rating method for refrigerated trucks with respect to cooling load,** *Annex to Proc. Intern. Inst. Refrigeration, Comm. VII,* pp. 29-35 (London, England, Sept. 1966).

Key words: Air leakage; cooling load; refrigerated trucks; solar heating; testing and rating methods.

A testing and rating method for refrigerated delivery trucks has been developed under the sponsorship of the U.S. Department of Agriculture and the Truck Body and Equipment Association. The method is applicable to insulated vehicles used for short-haul delivery of frozen food at a low temperature or fresh produce at a medium temperature. It involves a measurement of the steady-state transmission of heat from ambient air to cargo space under selected conditions of test and the use of a correction factor for the effect of solar radiation on a stationary vehicle. The essentials of the testing and rating procedure and of the laboratory studies carried out to develop the procedure are described.

9532. Achenbach, P. R., **Air-to-air heat pumps for military housing,** *Military Eng.* **384,** 270 (July-Aug. 1966).

Key words: Air-to-air heat pumps; annual energy cost; energy usage; residential air conditioning.

The National Bureau of Standards has performed laboratory and field studies of electric air-to-air heat pumps as a part of the technical investigations sponsored by the three agencies of the Department of Defense. These studies have developed information on the coefficient of performance and heating and cooling capacities of typical systems used for residential applications, design data useful for estimating energy usage and maximum power demand for similar installations, some information relative to the unexpectedly high rate of motor-compressor failure, and comparisons of the annual cost of year-around air conditioning using heat pumps and gas heating systems combined with conventional air conditioners for cooling. The annual cost of heating and cooling these military houses with air-to-air heat pumps averaged about $100 for a unit electric energy cost of 0.8¢/kWh.

9533. Alexander, S. N., **Computer languages and their use,** *Am. Mgmt. Assoc. Mgmt. Bull.* **79,** 8-12 (1966).

Key words: Documentation of software; economics of software; man/machine interface problems; problem-oriented languages; software usage.

Three levels of computer programming languages are discussed in terms of their effectiveness as tools for solving the man/machine interface problem. In this respect, the least effective of the three is the assembly level language which in general is used only when maximum system performance is required. At the next level of effectiveness are the procedure-oriented languages such as FORTRAN, COBOL, and ALGOL. In general, these are at a level of abstraction considerably above that of machine commands, but are still not at the working level of the average application analyst. The third level, problem-oriented languages, are generally much closer to the specific mode of expression used by the analyst in describing the solution to a given problem. Several examples of this type of language are given including some that make use of ordered or graphical arrangements of inputs to facilitate the external mode of expression. The paper concludes with brief discussions of software documentation and the economic aspects of software development and utilization.

9534. Allan, D. W., **Statistics of atomic frequency standards,** *Proc. IEEE* **54,** No. 2, 221-230 (Feb. 1966).

Key words: Atomic frequency standards; power spectral density; short- and long-term frequency stability.

A theoretical development is presented which results in a relationship between the expectation value of the standard deviation of the frequency fluctuations for any finite number of data samples and the infinite time average value of the standard deviation, which provides an invariant measure of an important quality factor of a frequency standard. A practical and straightforward method of determining the power spectral density of the frequency fluctuations from the variance of the frequency fluctuations, the sampling time, the number of samples taken, and the dependence on system bandwidth is also developed. Additional insight is also given into some of the problems that arise from the presence of "flicker noise" (spectrum proportional to $|\omega|^{-1}$) modulation of the frequency of an oscillator.

The theory is applied in classifying the types of noise on the signals of frequency standards made available at NBS, Boulder Laboratories, such as: masers (both H and $N^{15}H_3$), the cesium beam frequency standard employed as the U.S. Frequency Standard, and rubidium gas cells.

"Flicker noise" frequency modulation was not observed on the signals of masers for sampling times ranging from 0.1 second to 4 hours. In a comparison between the NBS hydrogen maser and the NBS III cesium beam, uncorrelated random noise was observed on the frequency fluctuations for sampling times extending to 4 hours; the fractional standard deviations of the frequency fluctuations were as low as 5 parts in 10^{14}.

9535. Allion, H. H., **Calibration and use of laminar flowmeters,** (Proc. 25th Annual Gas Measurement Short Course, Aug. 25, 1965), *West Virginia Univ. Tech. Bull.* **77,** 34-43 (1965).

Key words: Accuracy; calibration; compressible flow; differential meter and effects; fluid meter; incompressible flow; laminar flow; Mach number; Reynolds number; viscous flow; volumetric flow.

The laminar meters discussed are made of one or more uniform passages each having a depth or diameter small in relation to its length. Resistance to flow is largely viscous and may be analyzed in a fairly simple fashion in the incompressible case. For gas flow in these meters, treatment of the effects of deviations from incompressible theory is quite complex; however, errors resulting from ignoring these deviations when predicting meter response at other than calibration conditions are apparently less than the measurement errors over a fairly wide range of conditions. In some applications linear response and independence from pressure level may be approximated closely.

9536. Allred, C. M., Lawton, R. A., **A precision current comparator,** (Annual ISA Conf., New York, N.Y., Oct. 1966), *ISA Preprint,* No. 12.8-2-66 (1966).

Key words: Antenna; attenuation; comparator; current; phase; precision.

A technique capable of precise comparison of currents in different parts of a network or between currents in different networks is discussed. With proper conditions, this comparison can be done with negligible perturbation of the networks under measurement. Experiments on a coaxial system at 30 MHz are discussed.

9537. Andrews, D. H., **Of time and frequency,** *Book, How to Listen to the World,* pp. 3-7 (World Publ., Hellerup, Denmark, Jan. 1967).

Key words: Atomic time; frequency and time; International Time Bureau; standard audio frequencies; standard radio frequencies; time and frequency; worldwide radio stations.

Following a short historical background of timekeeping, the author proceeds to describe Universal Time and how it is approximated by Atomic Time with corrections prescribed by the International Time Bureau. The use of radio broadcasts by various nations to disseminate time signals, standard radio frequencies and standard audio frequencies is described. Other services are also noted. The article includes an extensive listing of worldwide radio stations broadcasting standard frequencies and/or time signals. This tabulation is divided into two parts; Table I listing stations using frequencies above 1 megahertz, and Table II listing stations using frequencies below 1 megahertz.

9538. Arenhovel, H., Danos, M., Greiner, W., **Photonuclear effect in heavy deformed nuclei,** *Phys. Rev.* **157,** No. 4, 1109-1125 (May 20, 1967).

Key words: Collective model; nuclear Raman effect; nuclear structure; photon absorption cross sections; photon scattering; photonuclear effect.

The theory of Raman scattering is extended to include electric quadrupole radiation. The results obtained are used to compute the elastic and Raman scattering cross sections of heavy deformed nuclei. The dipole and quadrupole resonances are described by a previously developed theory which includes surface vibrations and rotations. The computed cross sections are compared with experimental data for all those nuclei where both absorption and scattering cross sections are available. Some discrepancies still exist in certain details; however, the overall agreement between theory and experiment is very good.

9539. Armstrong, G. R., **Calorimetry,** *1967 McGraw-Hill Yearbook of Science and Technology,* pp. 124-127 (1967).

Key words: Calorimetry, biological; calorimetry, international; calorimetry, new developments; calorimetry, review; fuel calorimetry.

The present status of calorimetry is reviewed. Several new and promising instruments for accurate calorimetry and the development of new or improved techniques for calorimetric processes are discussed. The relationship of calorimetry to the U.S. fuel technology, to the rocket propellant program, and to molecular biophysics is briefly discussed.

9540. Arni, H. T., **Resistance to weathering,** Significance of Tests of Concrete and Concrete Making Materials, *Am. Soc. Testing Mater. Spec. Tech. Publ.* **169A,** 261-274 (1966).

Key words: Concrete; de-icing scaling; durability; freezing-and-thawing; weathering.

Deterioration due to physical processes produced by exposure to natural weathering is discussed. The most recent theories on the mechanisms of freezing-and-thawing damage are presented, and freezing-and-thawing tests now specified and proposed are discussed. The effects of de-icing chemicals and of weathering processes other than freezing and thawing are also considered.

9541. Arp, V. D., Collier, R. S., Kamper, R. A., Meissner, H., **One-dimensional solutions of the Ginzburg-Landau equations for thin superconducting films,** *Phys. Rev.* **145,** No. 1, 231-236 (May 6, 1966).

Key words: Ginzburg-Landau theory; magnetic field; superconductor; thin film.

Solutions to the Ginzburg-Landau equations have been obtained for plane films in a longitudinal magnetic field. Only symmetrical one-dimensional solutions were generated, but without restrictive assumptions on κ or ψ. The critical field has been calculated from these solutions as a function of κ and d/λ. Curves are given to show how the behavior of films at the critical field depends on the various parameters involved.

The computer solutions join smoothly onto those derived in the limit $\psi \to 0$. The limit of validity of these solutions in the face of the vortex solutions of Abrikosov and the asymmetrical solutions of Saint-James and deGennes is determined, and a "phase diagram" in the κ, d plane for all types of solutions is suggested.

9542. Ashley, A., Douglas, C. A., **Can infrared improve visibility through fog?,** *Illum. Eng.* **61,** No. 4, 243-250 (Apr. 1966).

Key words: Atmospheric optics; aviation lighting; infrared; visual range.

The fundamental system parameters-atmospheric attenuation, detector sensitivity, radiant intensity of source, and effects of background are examined to determine whether or not the use of infrared sources and detectors, instead of visible sources and the eye, for marking airport runways and taxiways offer sufficient potential to warrant further consideration of their use as airport marker "lights". The evaluation is based on theory and previous experimental work. At present there are no advantages in the use of infrared sources and detectors as a replacement for the current visible sources and further consideration is not warranted at this time.

9543. Ausloos, P., **Radiation and photochemistry,** *Ann. Rev. Phys. Chem.* **17,** 205-236 (1966).

Key words: Photochemistry; radiation chemistry.

A critical review of major publications on Photochemistry and Radiation Chemistry published in 1965.

9544. Ausloos, P., Lias, S. G., **H_2S as a free-radical interceptor in the gas-phase radiolysis and photolysis of propane,** *J. Chem. Phys.* **44,** No. 2, 521-529 (Jan. 1966).

Key words: Free radicals; H_2S; ion-molecule reactions; photolysis; propane; radical scavenger; radiolysis.

The gas-phase photolysis (1236 Å) and the γ-ray radiolysis of C_3D_8 has been investigated in the presence of varying concentrations of H_2S. When 10% or more H_2S is added to C_3D_8, the majority of the D, CD_3, C_2D_3, and C_2D_5 radicals abstract an H atom from H_2S to form HD, CD_3H, C_2D_3H, and C_2D_5H, respectively. The fully deuterated molecules formed in these mixtures result from the unimolecular elimination of a stable molecule from C_3D_8 or $C_3D_8^+$ and from fast bimolecular processes such as ion-molecule reactions or CD_2 insertions.

The mechanisms of the radiolysis and the photolysis proposed in earlier studies have been re-examined in the light of the information derived from the $C_3D_8-H_2S$ experiments and of some additional photolysis experiments on $CD_3CH_2CD_3-NO$ mixtures. The results indicate that the modes of decomposition of the neutral excited propane molecule are as follows:

$$\begin{aligned} C_3D_8 &\to C_2D_6+CD_2, \\ &\to CD_4+C_2D_4, \\ &\to D_2+C_3D_6, \\ &\to CD_3+C_2D_5, \\ &\to D+C_3D_7. \end{aligned}$$

The internally excited C_2D_4, C_2D_5, C_3D_6, and C_3D_7 species formed in these primary processes decompose to form D, CD_3, C_2D_2, C_2D_3, and C_2D_4 unless they are collisionally stabilized.

In the radiolysis of $C_3D_8-H_2S$ mixtures, yields of the free radicals can be adequately accounted for by taking into account the modes of fragmentation of the parent ion and of the excited propane. The $C_2D_5^+$ ions are shown to react with H_2S in part by the deuteron-transfer reaction

$$C_2D_5^+ + H_2S \to C_2D_4 + DH_2S^+.$$

The effect of pressure and the effectiveness of HI as a free-radical interceptor in the radiolysis have been examined.

9545. Ausloos, P., Lias, S. G., Scala, A. A., **Investigating ion-molecule reactions by analyzing neutral products formed in the radiolysis and photoionization of hydrocarbons,** *Adv. Chem. Ser.* **58,** 264-277 (1966).

Key words: Analysis of neutral products; ion-molecule reactions; neutral products; photoionization of hydrocarbons; radiolysis and photoionization of hydrocarbons.

The analysis of neutral products from the radiolysis and photoionization of suitable deuterium labeled hydrocarbons or hydrocarbon mixtures provides information concerning (a) the relative rates of H^+, H^-, H_2^-, and H_2 transfer reactions, and (b) the structure of the reacting ion or reaction complex. The reaction cross-section of a given ion with various alkanes generally increases with increasing polarizability of the neutral molecule. The actual increase in rate is, however, faster than that of the collision cross-section given by: $2\pi e(\alpha/\mu)^{1/2}$. Good quantitative and qualitative agreement exists between the information on reactions of parent ions obtained from gas phase radiolysis studies and that derived from photoionization experiments carried out at wavelengths slightly above the ionization energy of the molecule.

9546. Baird, R. C., **RF measurements of the speed of light,** *Proc. IEEE* **55,** No. 6, 1032-1039 (June 1967).

Key words: Methods and limitations; recent results; review; speed of light.

Modern RF measurements of the speed of light are reviewed, with emphasis on those methods capable of attaining an accuracy of 1.0 km/s or better. The geodimeter and microwave interferometer methods are discussed in some detail because of the significant role they have played in arriving at our present value for *c*. Serious limitations of the microwave resonant cavity method are pointed out and brief mention is made of the electrical units and band spectrum methods. A recent measurement by Karolus and Helmberger, who obtained the value 299 792.1±0.2 km/s, is mentioned. Some experimental factors that should be considered in planning future speed-of-light measurements are presented, and an experiment involving lasers, now in progress at NBS, is described briefly. The conclusion is that the presently accepted value of 299 792.5±0.3 km/s is still valid. Only two or three measurements have been completed since its adoption nearly ten years ago and they are not of sufficient accuracy to warrant re-evaluation of *c*.

9547. Unassigned.

9548. Barber, D. J., **Electron microscopy of irradiation-induced defect clusters in magnesium fluoride,** *Phys. Stat. Solids* **16,** 531-547 (1966).

Key words: Dislocation loops; electron microscopy; magnesium fluoride; point defects; precipitation; radiation damage.

The passage of electrons through thin crystals of magnesium fluoride produces point defects. These defects are mobile at temperatures normally attained under the electron beam, and they can give rise both to dislocation loops and to precipitate platelets. The aggregation of these radiation-induced defects can be controlled by using a cooled specimen stage in the electron microscope. This allows the growth and characteristics of the defect clusters to be studied. Dislocation loops lie on $\{011\}$ planes and they sometimes show stacking fault contrast; their Burgers vectors are $1/2\langle 01\bar{1}\rangle$ and $\langle 01\bar{1}\rangle$. Prolonged irradiation can produce precipitates on and within the loops. Higher beam intensities produce precipitates directly. The nature of the loops and precipitates is discussed in relation to the production of point defects by ionization mechanisms and irradiation-stimulated migration.

9549. Barbrow, L. E., **Photometry,** *Encyclopedia of Physics*, pp. 516-519 (Reinhold Publ. Corp., New York, N.Y., 1966).

Key words: Luminance; luminous flux; luminous intensity; photometric brightness; photometry; reflectance; transmittance.

The photometric quantities luminous density and flux, illuminance and luminance, and luminous reflectance, transmittance, directional reflectance factor, and directional transmittance factor are defined, the methods of measuring them are briefly described, and the factors which affect the accuracy of the measurements are discussed. Included is a table of the currently internationally agreed-upon symbols for the photometric and related radiometric quantities and units.

9550. Barger, R. L., **Rare-gas collision broadening in the lowest $^3P_1$ level of Cd,** *Phys. Rev.* **154,** No. 1, 94-97 (Feb. 5, 1967).

Key words: Cadmium; cross sections; double resonance; level crossing.

Alignment depolarization collision cross sections have been measured for the lowest $^3P_1$ level of cadmium broadened by the rare gases. Cross sections obtained with the Hanle effect (zero-field level crossing) and the method of modulated-light double resonance are the same within approximately 5%. They agree with theoretical predictions except in the case of helium, for which the measured cross section is nearly twice as large as the theoretical value. Average experimental values (units of 10^{-16} cm^2) for He, Ne, Ar, Kr, and Xe, respectively, are 51, 52, 81, 118, and 165.

9551. Barghausen, A. F., **Medium-frequency sky wave propagation in middle and low latitudes,** *IEEE Trans. Broadcasting* **BC-12,** No. 1, 1-14 (June 1966).

Key words: Absorption; antennas; broadcasting; ground waves; ionosphere; medium frequency; polarization; propagation; radio; reflection coefficients; sky waves.

A comparison is presented between empirically derived medium frequency sky wave propagation curves for the United States and Europe. Substantial differences are noted when the respective curves are applied to other geographical areas than those intended at the time of their derivation. Using the same data and recent measurements of the reflection coefficients at vertical incidence, a set of semi-empirical curves are derived which are believed to be applicable to both areas.

Finally, it is shown that none of these propagation curves are pertinent to the low latitudes where very large polarization coupling losses are observed. A short sample of measurements is presented with a brief explanation using simplified magnetoionic theory to account for these losses.

9552. Barnes, J. A., **Atomic timekeeping and the statistics of precision signal generators,** *Proc. IEEE* **54,** No. 2, 207-220 (Feb. 1966).

Key words: Atomic frequency standards; atomic time; stability; statistics.

Since most systems that generate atomic time employ quartz crystal oscillators to improve reliability, it is essential to determine the effect on the precision of time measurements that these oscillators introduce. A detailed analysis of the calibration procedure shows that the third finite difference of the phase is closely related to the clock errors. It was also found, in agreement with others, that quartz crystal oscillators exhibit a "flicker" or $|\omega|^{-1}$ type of noise modulating the frequency of the oscillator.

The method of finite differences of the phase is shown to be a powerful means of classifying the statistical fluctuations of the phase and frequency for signal generators in general. By employing finite differences it is possible to avoid divergences normally associated with flicker noise spectra. Analysis of several cesium beam frequency standards have shown a complete lack of the $|\omega|^{-1}$ type of noise modulation but an unexplained noise with a spectral variation proportional to $|\omega|^{-1/3}$ for frequency fluctuations was observed for $|\omega|$ less than 10^{-3} to 10^{-4} sec.$^{-1}$ depending on the particular standard.

9553. Barnes, J. A., Allan, D. W., **A statistical model of flicker noise,** *Proc. IEEE* **54,** No. 2, 176-178 (Feb. 1966).

Key words: Flicker; model; noise; statistical.

By the method of fractional order of integration it is shown that it is possible to derive the characteristics of flicker noise from those of "white," band limited noise. A formal expression for the relation of flicker noise to white noise is given. An approximate method, amenable to the use of digital computers, is also given for the generation of flicker noise modulated numbers from random, independent numbers.

9554. Barnes, J. A., **The development of an international atomic time scale,** *Proc. IEEE* **55,** No. 6, 822-826 (June 1967).

Key words: Atomic frequency standards; atomic time; coordination.

The paper reviews briefly the methods of generating atomic time and the errors inherent in the resulting scales. An atomic clock consists of an atomic frequency standard and an "integrator" to accumulate the phase of the signal. Because of noise perturbing the instantaneous frequency, an ensemble of identical atomic clocks will show a distribution of (epoch) times which is unbounded as the system evolves in time. The recognition of this problem has important consequences in national and international coordination of time scales and the construction of average atomic time scales.

Also of significance is the not completely resolved question of weighting of individual standards in the construction of average time scales. In spite of these difficulties it is pointed out that through coordination and proper data handling, most of the advantages of astronomical time scales can be realized by atomic time scales. A statement of some of the problems facing any attempts at coordination is presented without any suggested solutions.

9555. Bates, A. A., **Building code viewpoints,** (Building Research Institute Fall Conf., Codes Session, Washington, D.C., Nov. 16, 1966), *J. Bldg. Res. Inst.* **4,** No. 1, 48-49 (Jan.-Feb. 1967).

Key words: Building code; climate; control; coordinate; economics; geography; political; technical; technology; zoning.

The advancing technology of building as well as the steep continuing rise in costs, particularly of home-building, both make it inevitable that building will become an essentially industrialized activity. The unification of building codes is equally inevitable under the inescapable pressure for widened and simplified industrial markets. This is a world-wide trend already far advanced in all other developed countries. Rather than trying to obstruct the unification of building codes the industries and interests concerned would do well to organize their efforts toward an effective community of action which will make it possible to utilize modern technologies in the rebuilding of our cities. Ultimately in the United States as in every other advanced nation where precisely the same impersonal technological and economic forces are operative this will eventuate in a nation-wide building code. The problem is how to bring this about at a rate and in a manner which will best serve the interests of all concerned.

9556. Bates, R. G., **Acidity functions for amphiprotic media,** *Book, Chemistry of Nonaqueous Solvents* **1**, Chapt. III, 97-128 (Academic Press, Inc., New York, N.Y., 1966).

Key words: Acid-base behavior; acidity functions; nonaqueous media; pH.

The nature of acid-base interaction processes in solvents of varied characters is discussed and the usefulness of various units for measuring acidity in these media is examined. Both electrometric and indicator acidity functions are considered.

9557. Bates, R. G., **Acids, bases, and buffers,** (Proc. Symp. Current Concepts of Acid-Base Measurements, New York Academy of Sciences, New York, N.Y., Nov. 23, 1964), *Ann. N.Y. Acad. Sci.* **133,** Art. 1, 25-33 (1966).

Key words: Acids; bases; buffer capacity; pH scale.

The Arrhenius, Bronsted, and Lewis concepts of acidity are reviewed and expressions for the properties of buffer solutions are derived.

9558. Bates, R. G., **Electrometric methods of pH determination,** *Book, Standard Methods of Chemical Analysis, 6th Edition, IIIA. Instrumental Analysis,* Ed. F. J. Welcher, Chapt. 26, pp. 521-532 (D. VanNostrand Co., Inc., Princeton, N.J., 1966).

Key words: Glass electrodes; hydrogen electrodes; pH measurement.

This chapter discusses the nature of the definition of pH and the operational pH scale, describes the most useful pH-responsive electrodes and the most common reference electrodes and salt bridges, and sets forth the characteristics of modern pH instrumentation. Careful instructions for standardization of pH assemblies and for the measurement of the pH of unknown or test solutions are given, the limitations of experimental pH numbers are described, and the mode of interpretation of the measured pH is outlined.

9559. Bates, R. G., **Hydrogen-ion concentration,** *Encyclopedia of Chemical Technology, 2nd Edition* **11**, 380-390 (John Wiley and Sons, Inc., New York, N.Y., 1966).

Key words: Acidity; hydrogen ions; pH.

The definitions of acidity scales and methods for determining pH are reviewed.

9560. Bates, R. G., **pH determination,** *Encyclopedia of Industrial Chemical Analysis* **3**, 146-161 (John Wiley and Sons, Inc., New York, N.Y., 1966).

Key words: Glass electrodes; industrial analysis; pH determination; pH instrumentation; reference electrodes; temperature effects.

Procedures for the determination of pH by both electrometric and indicator methods are set forth. The NBS reference standard solutions are described. Other topics discussed include the limitations of measured pH values, glass electrodes and reference electrodes, pH instrumentation, temperature effects, and the special requirements of industrial pH control.

9561. Bates, R. G., **Proposal for the practical measurement of pH in amphiprotic and mixed solvents,** *Intern. Union Pure Appl. Chem. Info. Bull.* No. 26, 50-54 (Aug. 1966).

Key words: Amphiprotic and mixed solvent media; deuterium oxide; pH scale.

Procedures analogous to those on which a practical pH scale has been based can be used profitably to establish operational acidity scales in certain other amphiprotic and mixed solvent media. A universal pH scale relating proton activity uniformly to the aqueous standard reference state is not yet a practical possibility, but separate scales for each medium can be achieved and will fulfill most of the requirements. The best choice of unit appears to be pa_H^* or $-\log(m_{H}\cdot {}_s\gamma_H)$, where ${}_s\gamma_H$ is referred to the standard state in each particular medium *s*. Data for reference solutions in 50 wt. percent methanol and in deuterium oxide are given.

9562. Bates, R. G., **The Acheson medalist, Warren G. Vosburg, his life and career,** *J. Electrochem. Soc.* **113,** 309C (1966).

Key words: Acheson medal; electrochemistry; Vosburg, W. C.

Reflections on the personal life and professional career of the medalist.

9563. Bates, R. G., Robinson, R. A., **Acid-base behavior in methanol-water solvents,** (Proc. Intern. Symp. Electrochemical Society, Toronto, Canada, May 4-6, 1964), *Book, Chemical Physics of Ionic Solutions,* Chapt. 12, pp. 211-235 (John Wiley and Sons, Inc., New York, N.Y., 1966).

Key words: Acidity; acids; bases; medium effects; methanol-water solvents.

Data for (a) the standard potential of the cell Pt; H_2 (g., 1 atm), HX (in methanol-water solvents), AgX;Ag (where X = Cl, Br, or I); (b) the activity coefficients and relative partial molal heat content of HX in methanol-water media; and (c) the *pK* and related thermodynamic quantities for the dissociation of weak acids in these solvents have been collected and critically examined. When the observed solvent effects on *pK* for acids of different charge types are corrected for changes in the electrostatic energy of dissociation, one obtains a fairly uniform solvent parameter. The change of this parameter as methanol is added to the solvent confirms the view that enrichment with methanol produces a more basic mixture up to a composition of about 80 wt. % methanol, after which the total basicity declines as the water concentration becomes low. A standard activity scale for methanol-water solvents, based on the unit $p\mathrm{H}^*$, is proposed.

9564. Beatty, R. W., **Impedance measurements and standards for uniconductor waveguide,** *Proc. IEEE* **55,** No. 6, 933-941 (June 1967).

Key words: Impedance standard; reflection coefficient; reflectometers; standing-wave ratio; waveguide impedance.

A tutorial review is presented of the measurement of impedance and reflection coefficient in uniconductor waveguide. Impedance in a waveguide operating in a particular mode is defined and related to measured quantities such as the reflection coefficient and the VSWR.

Emphasis is given to the rectangular waveguide operating in its dominant mode and to the tuned reflectometer as an instrument for achieving the most accurate results. The evolution of the tuned reflectometer at NBS is outlined and recent techniques are discussed. Different types of standards of reflection coefficient are described and the advantages and limitations of each are mentioned.

9565. Beatty, R. W., **Microwave standards and measurements in the U.S.A., 1963-1966,** (Proc. XV General Assembly of URSI, Munich, Germany, Sept. 5-15, 1966), *Book, Progress in Radio Science 1963-1966,* Pt. 1, pp. 194-260 (International Scientific Radio Union, Munich, Germany, 1966).

Key words: Antenna gain; attenuation; field strength; impedance; measurement; microwave; noise; phase shift; power; progress; reflection coefficient; review; standards; survey.

A report is given on progress within the U.S.A. in the development of microwave standards and measurement methods at frequencies from 1 to 300 GHz. The period covered is the three years 1963-1966. The following topics are included within the scope of this report: power; noise; reflection coefficient and impedance; phase shift; attenuation and loss; and field strength and antenna gain.

9566. Beatty, R. W., **The system of electromagnetic quantities at frequencies above 1 GHz,** *Metrologia* **2,** No. 1, 46-54 (Jan. 1966).

Key words: Coaxial connectors; electromagnetic quantities; international comparisons of standards; microwave measurements; microwave standards.

The system of electromagnetic quantities at frequencies above 10^9 cycles per second is briefly described, giving emphasis to those techniques and standards which have been most thoroughly evaluated and tested. The quantities included are power, noise temperature, reflection coefficient and impedance, phase shift, attenuation, and field strength. The measurement of frequency and wavelength, and of the microwave properties of materials is not within the scope of this paper.

In addition to a brief review, some of the problems involved in obtaining a higher order of accuracy are discussed. Comparisons of standards of different nations are mentioned and the benefits to be derived from such comparisons are described. Areas needing further research, as well as those which would benefit from international cooperation are designated.

Although a highly detailed and technical presentation is avoided, numerous references are given. In addition, a selected list of definitions is appended.

9567. Beatty, R. W., Weinschel, B. O., **Scanning the issue,** *Proc. IEEE* **55,** No. 6, 737-740 (June 1967).

Key words: Lasers; radiation; radio frequencies; radio frequency measurements; radio metrology; visible radiation.

This is the first special issue of the Proceedings of the IEEE to be devoted exclusively to the extensive subject of RF (radio frequency) measurements. Because it attempts to cover the entire field, the issue is rather large.

It consists entirely of invited papers which are grouped in two main sections; the first containing ten editorial and general articles, and the second containing 31 papers on specific technical subjects.

For the purpose of this issue, radio frequencies are considered to begin at approximately 30 kHz (30,000 cycles per second) and go upwards. The upper limit is not as yet clearly defined, but includes frequencies of coherent sources of visible radiation, such as lasers.

Because of the demanding requirements of military and space applications, many important improvements have recently been made in the science and art of RF measurements. Many are not yet covered in today's textbooks and are available here for the first time in one volume. This collection of techniques is designed to bring the engineer and scientist up to date and to serve as a reference issue on the present state-of-the-art of accurate RF measurements.

9568. Beehler, R. E., Glaze, D. J., **Evaluation of a thallium atomic beam frequency standard at the National Bureau of Standards,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 1 & 2, 55 (Mar.-June 1966).

Key words: Cesium standard; frequency standard; thallium standard.

The original NBS cesium standard (NBS. I) has been converted to a thallium standard and was operated for 1 1/2 years with a typical precision of 2 x 10^{-12} and an accuracy of 1 x 10^{-11}. Experiments are described which were performed to establish these precision and accuracy estimates. These results, which are comparable to those obtained with longer cesium standards, are considered sufficiently encouraging to justify the conversion of a longer cesium standard to thallium for a more thorough evaluation.

9569. Beehler, R. E., Glaze, D. J., **The performance and capability of cesium beam frequency standards at the National Bureau of Standards,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 1 & 2, 48 (Mar.-June 1966).

Key words: Atomic beam; cesium; frequency standard; U.S. frequency standard.

NBS. II, the older of the two cesium atomic beam frequency standards which are used alternatively as the United States Frequency Standard, has been operating for more than five years. The contribution to inaccuracy produced by uncertainties in the C field has been reduced by a factor of 30 to ±2 x 10^{-13}. The average precision of measurement (standard deviation of the mean) has been demonstrated to be 1 x 10^{-12} for averaging times of 1 hour and x 10^{-13} for 12 hours. The overall accuracy is considered to be ±8 x 10^{-12}. A new cesium standard, NBS. III, with an interaction length of 3.66 meters is in operation and has demonstrated an improved average precision of 5 x 10^{-13} over 1 hour and an accuracy of ±5 x 10^{-12}. The C field contributions to inaccuracy in this machine have been reduced to ±1 x 10^{-13}. Considerable effort has been devoted to the detection and elimination of small frequency shifts produced by various electronic components of the excitation systems. In spite of the various improvements effected, a small unexplained difference in frequency of 1 x 10^{-12} continues to exist between the standards. The extremely high stability of the difference frequency, however, suggests that resolution of the difficulties should result in an accuracy capability of perhaps ±1 x 10^{-12}.

9570. Beehler, R. E., Halford, D., Harrach, R., Allan, D., Glaze, D., Snider, C., Barnes, J., Vessot, R., Peters, H., Vanier, J., **An intercomparison of atomic standards,** *Proc. IEEE* **54,** No. 2, 301-302 (Feb. 1966).

Key words: Cesium; hydrogen maser; frequency comparison.

A group of two cesium beam frequency standards and three hydrogen masers were brought together for extensive intercomparisons at the National Bureau of Standards. After thorough evaluation of each of the two types of frequency standards a preliminary value of the free-space frequency for the transition $F=1 \leftrightarrow F=0$ of the ground electronic state in hydrogen has been obtained. This preliminary value is 1420, 405, 751.7860±0.0043 Hz. The uncertainty of 0.0043 Hz corresponds to an uncertainty of 3.2 parts in 10^{12}.

9571. Beers, Y., Russell, T. W., **Evaluation of a Stark voltmeter,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 380-388 (Dec. 1966).

Key words: CH_3CN (Acetonitrile); dipole moment; Fabry-Perot interferometer; Stark effect.

An absorption Stark voltmeter using a Fabry-Perot absorption cell with a rotational transition of CH_3CN at 36 GHz has been built and evaluated. The rotational constant and dipole moment of this molecule have been redetermined and found to have the values 9198.56±0.10 GHz and 3.9185±0.0020 Debye, respectively. The short term precision of the device as used as a standard cell was better than one part in 10^5, but there were unexplained drifts of 2 parts in 10^4 per day. The accuracy of the device as a means of measuring voltage in terms of atomic and molecular constants, is 5 parts in 10^4. The principal errors are due to the measurement of the plate spacing (which could be reduced by using an optical interferometer to measure spacing), pulling the interferometer resonance by the external circuit, and the effects of field nonuniformities due to the coupling holes.

9572. Beers, Y., **WWV moves to Colorado,** Part I, **QST 51,** No. 1, 11-14 (Jan. 1967); Part II, **QST 51,** No. 2, 30-55 (Feb. 1967).

Key words: Frequency broadcasts; history of broadcasts; standards of time and frequency; time and frequency.

This is a semi-popular account of the move of WWV from Greenbelt to Fort Collins, written at the request of the Editor of the leading amateur radio magazine "QST". It describes the role of NBS in providing standards of time and frequency, the history of the broadcasts, the usage of the broadcasts, and the new station.

9573. Bell, G. D., Paquette, D. R., Wiese, W. L., **Relative transition probabilities for prominent Ni I and Ni II lines in the near-ultraviolet,** *Astrophys. J.* **143,** No. 2, 559-572 (Feb. 1966).

Key words: Line strength; nickel-carbonyl; Ni I and Ni II; oscillator strength; relative measurements; transition probabilities; wall-stabilized arc.

Relative transition probabilities of 16 Ni I lines and 53 Ni II lines in the wavelength range from 2000-3600 Å have been measured with a wall-stabilized arc. The arc was operated at 10 amps in argon with a small admixture (.01%) of nickel-carbonyl. The spectrum was photoelectrically observed through the hollow electrodes. The relative intensity calibrations were performed with calibrated tungsten strip lamps or by utilizing the continuous emission of a hydrogen arc operated at known plasma conditions. The axis temperature of the argon nickel-carbonyl arc was determined from intensity measurements of argon lines of known transition probabilities and the application of the arc plasma equations. For the great majority of the relative f-values the experimental and theoretical uncertainties are 8 percent or better, but for a few weak lines the uncertainties go as high as 30 percent. Comparisons with other experimental and theoretical results are undertaken and fair agreement is obtained.

9574. Bender, P. L., **Polarization of cosmic OH 18-cm radiation;** *Phys. Rev. Letters* **18,** No. 14, 562-564 (Apr. 3, 1967).

Key words: OH radiation; polarization; saturation effect.

The mechanism suggested by Heer for producing polarization of OH stimulated emission has been investigated. It does not appear to be applicable to cosmic OH sources.

9575. Bennett, L. H., **Influence of an external magnetic field on nuclear resonance in ferromagnetic materials,** *J. Appl. Phys.* **37,** No. 3, 1242-1243 (Mar. 1, 1966).

Key words: Critical field; field dependence; nickel pellets; nickel powder; nuclear resonance; permeability.

The reduction in the amplitude of the nuclear magnetic resonance signal, as well as a change in line shape, upon the application of an external steady magnetic field has been measured for pure nickel at room temperature. Both the transverse and longitudinal configurations (steady field and rf field perpendicular and parallel, respectively) were measured for a sample of nickel powder and for bulk nickel. The signal amplitude drops faster in the longitudinal configuration than in the transverse for each specimen. The reduction in amplitude is considerably less for the pellets than for the powder. There is no sign of a critical field as previously reported. A comparison of the resonance results with the apparent permeabilities is presented.

9576. Bennett, L. H., Swartzendruber, L. J., **Ferromagnetic iron alloys lacking a hyperfine field at the iron site,** *Physics Letters* **24A,** No. 7, 359-360 (Mar. 27, 1967).

Key words: Alloys; cobalt; ferromagnetism; hyperfine fields; iron; moments; Mossbauer effect; superconductivity; titanium.

Although ferromagnetism has been reported for TiFe$_x$Co$_{1-x}$ when $0.3 \leqq x \leqq 0.7$, the Mossbauer effect shows no evidence for the existence of a localized moment at the iron site. Thus the magnetization is most likely due to a diffuse moment associated with the Ti atoms, implying itinerant ferromagnetism.

9577. Ben-Reuven, A., **Impact broadening of microwave spectra,** *Phys. Rev.* **145,** No. 1, 7-22 (May 1966).

Key words: Absorption; dielectric loss; gases; impact; line shape; microwave; permeability; permittivity; pressure broadening; relaxation; spectra.

A unified treatment of pressure-broadening phenomena in the microwave spectra of gases is worked out by adaptation of the theories of Baranger and Fano, in which the effects of inelastic collisions are properly taken into account. The rate of relaxation in non-resonant spectra (Debye relaxation) is expressed in terms of collision cross sections. Small deviations from the Debye shape are related to a second moment of the relaxation matrix. Damping in resonance lines is studied, taking into account the coupling of the positive and negative resonance transitions by collisions. A general expression of the line shape as a function of frequency and pressure is given in the impact approximation. The ammonia inversion spectrum serves to demonstrate its applicability.

9578. Ben-Reuven, A., **Symmetry considerations in pressure-broadening theory,** *Phys. Rev.* **141,** No. 1, 34-40 (Jan. 1966).

Key words: Collisions; gases; molecules; pressure broadening; radiation; relaxation; spectra; symmetry.

Symmetry properties of the Zwanzig-Fano relaxation matrix are studied. Its invariance under rotations and inversion is proven for isotropic gases, to all orders in the gas density. Each multipole radiation operator is confined to a distinct invariant subspace in the Liouville space of operators. These invariant subspaces form the basis for the reduction of the relaxation matrix; therefore, the various multipole spectra are broadened independently. Properties of the relaxation matrix under Liouville conjugation are studied, and expressions are given relating matrix elements in which Liouville-conjugate pairs of vectors are involved.

9579. Berkeley, J. F., Brenner, A., Reid, W. E., Jr., **Vapor deposition of tungsten by hydrogen reduction hexafluoride process variables and properties of the deposit,** *J. Electrochem. Soc.* **114,** No. 6, 561-568 (June 1967).

Key words: Deposition of tungsten; hydrogen reduction; investigation of variables; tungsten hexafluoride; vapor deposition.

An investigation of the variables involved in the deposition of tungsten from a mixture of tungsten hexafluoride and hydrogen has shown that the fastest rate of deposition (about 5 mils thickness in 2 min) was obtained at atmospheric pressure with a hydrogen/tungsten hexafluoride ratio of 1.5 (by volume) at a temperature of 800-850 °C. The presence of hydrogen fluoride or chloride in the reacting gases diminished the rate of deposition. The deposits had about the same hardness, electrical conductivity, and density as commercial wrought tungsten. The tensile strength of the deposits was about 30,000 lb/in.^{2}. The internal stress within the deposits was also about 30,000 lb/in.^{2}. Codeposition of carbon, from carbon monoxide, greatly increased the hardness of the deposits.

9580. Berger, M. J., Seltzer, S. M., **Additional stopping power and range tables for protons, mesons and electrons,** *NASA-SP* **3036** (1966).

Key words: Bremsstrahlung efficiency; electrons; mesons; protons; range; stopping power.

This report is a supplement to earlier tabulations in NAS-NRC Publication 1133 (also contained in NASA Reports SP-3012 and SP-3013). Data are given for liquid H_2, LiF, Si, Ge, propane and freon. In addition, earlier tables for electrons in muscle and bone are corrected.

9581. Berger, H. W., **The estimation of molecular weights of vinyl acetate copolymers in latex paints,** *J. Paint Technol.* **39,** No. 508, 310-315 (May 1967).

Key words: Copolymer; intrinsic viscosity; latex; Mark-Houwink; molecular weight; polymer; polyvinyl acetate.

A viscometric technique has been used for the estimation of the molecular weights of vinyl acetate copolymers used in manufacturing latex paints. The whole paint is diluted with boiling acetone and the dissolved polymer is separated from pigments by centrifuging. The intrinsic viscosity, $[\eta]$, of the polymer in acetone at 25 °C is obtained and used to calculate a quantity related to the molecular weight. The various values for a and K, the constants in the Mark-Houwink Equation, that have been reported in the literature for PVA in acetone are used empirically to derive the equation, $\log \overline{M} = 1.45 \log [\eta] + 5.521$. This equation is used as the basis for the estimation of the molecular weights of PVA copolymers in experimental latex emulsions, experimental paints formulated with those latexes, and proprietary paints.

9582. Berman, H. A., West, E. D., **Density and vapor pressure of nitromethane 26° to 200 °C,** *J. Chem. Eng. Data* **12,** No. 2, 197-199 (Apr. 1967).

Key words: Density and vapor pressure; nitromethane density; nitromethane vapor pressure; vapor and density pressure.

The density of nitromethane between 25 and 200 °C and its vapor pressure between 130 and 200 °C have been determined experimentally. Within these limits, the density is represented by the equation

$$d = 1.1615 - 1.1952 \times 10^{-3}\, t - 1.553 \times 10^{-6}\, t^2$$

and the vapor pressure by the equation

$$\log_e P = 10.8210 - 3905.39/(t + 260)$$

where d is in g/cm^3, P in atm, and t in °C.

9583. Bernstein, B., **Time-dependent behavior of an incompressible elastic fluid. Some homogeneous deformation histories,** *Acta Mechanica* **II,** No. 4, 329-354 (1966).

Key words: BKZ theory; biaxial strain; constant rate of strain; creep; elastic fluid; elastic strain energy function; finite strain; non-linear behavior; non-Newtonian fluids; normal stresses; pure shear; simple extension; simple shear; stress relaxation; time effects; uniaxial strain; viscoelasticity.

The theory of the incompressible elastic fluid is designed to describe viscoelastic behavior under finite strain. In terms of this theory it is shown how to calculate the stress response to any strain history. The calculations are carried out and the results displayed for a number of homogeneous strain histories. A knowledge of the response to single step stress relaxation in a given geometry allows one to calculate easily response to any other history in the same geometry. Furthermore, from biaxial stress relaxation data one may calculate the time dependent stress response in any geometry in a manner which resembles the method for predicting the equilibrium response in an isotropic elastic material. An important class of histories comprises the motions following the rest history. To calculate the stress response for such a motion over a given time interval it suffices to have stress relaxation data over the same time interval. Stress response is also calculated for some uniaxial strain histories as well as steady simple shear.

9584. Billick, I. H., Dishon, M., Shulz, M., Weiss, G. H., Yphantis, D. A., **The effects of rotor deceleration on equilibrium sedimentation experiments,** *Proc. Natl. Acad. Sci.-Natl. Res. Council* **56,** No. 2, 399 (Aug. 1966).

Key words: Centrifuge; equilibrium sedimentation; Lamm equation; rotor deceleration; sedimentation.

It is the purpose of this note to present some results of a combined numerical and theoretical analysis of rotor deceleration, applicable to equilibrium sedimentation experiments. These results indicate the magnitude of errors in the data from sedimentation experiments where rotor slowing occurs. Of possibly greater interest is the conclusion that artificially induced rotor slowing can be used to substantially speed up equilibrium sedimentation experiments. We have developed the theory for the rectangular approximation to the Lamm equation, and concurrently solved the Lamm equation numerically by a method already described. Detailed accounts of both the theoretical analysis and the numerical results will be presented elsewhere.

9585. Blair, B. E., Crow, E. L., Morgan, A. H., **Five years of VLF worldwide comparison of atomic frequency standards,** *Radio Sci.* **2,** No. 6, 627-636 (June 1967).

Key words: Analysis of variance; atomic frequency standard errors; portable clock; VLF propagation.

The VLF radio broadcasts of GBR(16.0 kHz), NBA(18.0 or 24.0 kHz), and NSS(21.4 kHz) have enabled worldwide comparisons of atomic frequency standards to parts in 10^{10} or better when received over varied paths and at distances up to 9000 or more kilometers. This paper summarizes a statistical analysis of such comparison data from laboratories in England, France, Switzerland, Sweden, Russia, Japan, Canada, and the United States during the 5-year period 1961-1965. The basic data are differences in 24-hour average frequencies between the local atomic standard and the received VLF radio signal expressed as parts in 10^{10}. The analysis of the more recent data finds the receiving laboratory standard deviations, α_i, and the transmission standard deviation τ, to be parts in 10^{11}. Averaging standard frequencies over an increasing number of days has the effect of reducing α_i and τ to some extent. The variation of the α_i with propagation distance is studied. The VLF-LF long-term mean differences between standards are compared with the recent portable clock tests, and there is agreement to parts in 10^{11} or better. To separate further the sources of variation, including propagation and receiving laboratory systems, in future VLF comparisons of widely separated atomic frequency standards, we propose long-term, round-robin experiments with portable atomic standards.

9586. Blunt, R. F., **Optical absorption of cobalt in manganese fluoride,** *J. Chem. Phys.* **44,** No. 6, 2317-2320 (Mar. 1966).

Key words: Cobalt in manganese fluoride; crystal spectra; manganese fluoride; optical absorption; polarized crystal spectra.

The polarized crystal spectra of cobalt-doped MnF_2 have been measured down to near 4.2 °K. Three broad, anisotropic bands near 7200, 14,000, and 20,000 cm^{-1} are seen that are presumably due to the spin-allowed ${}^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$, ${}^4A_{2g}(F)$, and ${}^4T_{1g}(P)$ transitions of substitutional Co^{2+}, $3d^7$ ions. The D_{2h} symmetry provided by the rutile structure of the MnF_2 lattice produced marked orthorhombic splitting of about 3000 cm^{-1} in the ${}^4T_{1g}(P)$ band. Several weak spin-forbidden bands are also seen. The observed anisotropy indicates that the ${}^4T_{2g}(F)$ band is largely magnetic dipole while the other two are electric dipole. These latter parity-forbidden transitions are aided by coupling with odd lattice vibrations. Application of the appropriate selection rules allows tentative identification of several of the states involved.

9587. Blunt, R. F., Cohen, M. I., **Irradiation-induced color centers in magnesium fluoride,** *Phys. Rev.* **153,** 1031-1038 (Jan. 1967).

Key words: Color centers; magnesium fluoride; radiation damage.

Color centers, produced by 50-kV x rays, have been studied in the rutile-structured MgF_2, largely at room temperature. An initial, slightly anisotropic, absorption band near 260 nm is tentatively identified as due to *F* centers. Subsequent optical bleaching results in the formation of a strong band at 370 nm and several weak bands, including one at 320 nm. Both of these appear only for $E \perp c$ and are believed to be due to *M* centers. This choice of models is suggested, in part, by the observation of typical trapped-electron ESR spectra in irradiated samples. Bleaching studies show that the 320-nm band arises from centers lying along the $\langle 110 \rangle$ directions, while the 370-nm band seems to be cylindrically symmetric about the *c* axis. Furthermore, the 320-nm band is reversibly convertible into the 370-nm band. Selection rules have been derived for $(ls)^2 \rightarrow (ls2p)$ transitions in each of the four possible *M*-center configurations permitted in the rutile structure. It is found that of the two types having F-F bonds in the (001) plane, one identifies rather well with the 370-nm band and the other with the 320-nm band.

9588. Boden, N., Gutowsky, H. S., Hansen, J. R., Farrar, T. C., **Nuclear magnetic relaxation studies of $(CD_3O)_2{}^{11}BH$,** *J. Chem. Phys.* **46,** 2849 (1967).

Key words: Boron-11; $H^{11}B(OCD_3)_2$; hydride; hydrogen; liquid; proton; quadrupole coupling constant; spin-spin coupling constant.

The relaxation of quadrupolar nuclei in liquids lends itself in favorable cases to the approximate determination of quadrupole coupling constants which are not readily accessible by other means. In the present Note we report such an estimate of the ^{11}B quadrupole coupling constant $e^2qQ_{11_B}/h$ in dimethoxy(d_6)borane(^{11}B), $(CD_3O)_2{}^{11}BH$. The result is 2.6 MHz. Also, an activation energy of approximately 1.2 kcal mole^{-1} was found for molecular reorientations in the liquid. The temperature-independent magnitude of the scalar internuclear coupling constant $J_{11_{BH}}$ was found to be 162.0 Hz, with an estimated uncertainty of ±1.0 Hz.

9589. Botter, R., Dibeler, V. H., Walker, J. A., Rosenstock, H. M., **Experimental and theoretical studies of photoionization-efficiency curves for C_2H_2 and C_2D_2,** *J. Chem. Phys.* **44,** No. 3, 1271-1278 (Feb. 1966).

Key words: C_2D_2; $C_2H_2^+$; $C_2D_2^+$; C_2H^+; C_2D^+; mass spectrometer; monochromator; photoionization.

Photoionization-efficiency curves for C_2H_2 and C_2D_2 have been remeasured in the wavelength region from onset of ionization to 600 Å, using a gold-coated grating and the Hopfield continuum as a photon source. The curve shapes of the molecule ions near threshold are compared with calculations of the Franck-Condon factors. Nearly exact agreement between experiment and calculation is obtained when taking into account hot bands. A general discussion is given for the shape of the molecule ion curve and for that of the fragment ions, C_2H^+ and C_2D^+. The observed onsets of ionization for the latter ions are 17.2_2 eV and 17.3_4 eV, respectively.

9590. Bowman, R. R., **Field strength: High accuracy measurements above 1 GHz,** *Proc. IEEE* **55,** No. 6, 981-990 (June 1967).

Key words: Antenna range design; field strength; gain corrections; high accuracy gain measurements; horn antennas; multi-path interference; two-antenna method.

To calibrate antennas for state-of-the-art field strength measurements, standard horns are needed with gain uncertainties well within ±0.1 dB. To attain this degree of accuracy for absolute gain measurements, the two-antenna method is recommended. This method is considered to be essentially an insertion loss measurement (with many additional problems and sources of error), and a working formula is derived that is suitable for gain measurements of high accuracy. The problems that appear to be most limiting in gain measurements, insufficient antenna separation and multi-path interference, are chosen for detailed discussion. (The discussion concerning multi-path interference has application to anechoic chamber evaluations and radar cross-section measurements as well as to gain measurements). It is concluded that error estimates of less than ±0.1 dB for horn gain measurements have been somewhat optimistic. Several ambiguities and sources of error have been overlooked or inadequately discussed, and additional discussion is presented to provide a more complete basis for horn gain measurements of high accuracy.

9591. Bozman, W. R., **Computer aided typesetting,** *Book, Advances in Computers* **7,** Chapt. 4, 195-207 (Academic Press, Inc., New York, N.Y., 1966).

Key words: Automation; computers; photocomposition; printing; publication; typesetting.

Several examples are given of typesetting prepared by a computer.

9592. Bradley, W. F., Graf, D. L., Roth, R. S., **The vaterite-type ABO_3 rare-earth borates,** *Acta. Cryst.* **20,** Pt. 2, 283-287 (Feb. 1966).

Key words: Borates; rare-earth; vaterite.

Approximate models for both the room temperature and high temperature modifications of the vaterite-type rare earth borate structure are deduced from X-ray powder diffraction data. A study of structure sensitive information, including optical properties and infrared absorption characteristics, leads to the conclusion that the low temperature form contains borate tetrahedra whereas the high temperature modification probably contains triangular borate ions inclined to the *c*-axis.

9593. Brady, G. W., McIntyre, D., Myers, M. E., Jr., Wims, A. M., **Critical scattering of the perfluoroheptane-iso-octane system,** *J. Chem. Phys.* **44,** No. 5, 2197-2198 (Mar. 1, 1966).

Key words: Correlation function; critical phenomena; critical scattering; scattered intensity; small angle x-ray scattering.

The critical opalescence of mixtures of perfluoroheptane-iso-octane near and at the critical concentration has been examined by x-ray scattering measurements over a large angular range.

The measurements are discussed and shown to agree well with the assumed correlation function proportional to $e^{-Kr} \cdot r^{-1.1}$ near the critical temperature.

9594. Brauer, G. M., **Dental applications of polymers: A review,** *J. Am. Dental Assoc.* **72,** 1151-1158 (May 1966).

Key words: Acrylic; dental resins; denture base materials; methacrylates.

The properties of acrylic polymers make them especially useful for denture base materials and plastic teeth. Plastic fillings have not been too successful due to their high coefficient of thermal expansion and lack of bonding to tooth structure. A cavity liner impervious to the mouth fluids that bonds to tooth structure is needed. If such a liner were available, the need for a filling material that matches the thermal expansion of the tooth would be less critical.

For taking impressions, silicones and polysulfides have been employed successfully. The possible application of other plastics such as epoxy, aziridino, polycarbonates and semi-organic polymers is reviewed.

9595. Brauer, G. M., **Measurement of the surface area and the heats of wetting of dentin powders,** (Proc. Second Workshop on Adhesive Restorative Materials, Charlottesville, Va., December 1965), *Book, Adhesive Restorative Dental Materials* **II**, 203-223 (Department of Health, Education, and Welfare, Public Health Service, Washington, D.C., 1966).

Key words: Dentin; heats of wetting; organic content of dentin; surface area.

This progress report describes the measurement of the "apparent heats of immersion" of powdered dentin which was characterized by surface area measurements and determination of organic matter. The specific surface of ground dentin which is nearly independent of particle size was found to be around 10 m^2/g. The percentage of volatile matter amounted to 30.0%. The measurement of the apparent heat of wetting of dentin gave a mean value from 5 runs of 0.894 cal/m^2, with a computed standard error of 0.040 cal/m^2 (or 7.96±0.35 cal/g). From the magnitude of this value it appears that there may be some chemical interaction between water and the surface of the dentin. (1 cal = 4.1840 joules.)

The difference in the "apparent heat of immersion" by aqueous solutions containing ionic species or organic functional groups and the heat of wetting of dentin by pure water is indicative of any reaction of the added species with components of the tooth surface. Measurements of these heats of reaction should assist in developing methods for modifying tooth surface and in determining those groups that will bond effectively to tooth structure in an aqueous environment.

9596. Brauer, G. M., **The relationship between laboratory tests on solubility of zinc oxide-eugenol type cements and their behavior in the mouth,** *N.Y. J. Dentistry* **37**, No. 4, 146-149 (Apr. 1967).

Key words: Filling material; *o*-ethoxybenzoic acid; solubility and disintegration; zinc oxide-eugenol cement.

The solubility and disintegration in water and dilute acids of zinc oxide-eugenol (ZOE) and especially modified cements of improved physical properties containing *o*-ethoxybenzoic acid (EBA) is considerably lower than that of other dental cements. Contrary to these laboratory findings EBA fillings fail rapidly under oral conditions. Thus, a low solubility value may be useful in comparing the relative solubility of products of similar composition, but is not necessarily an indication of the success of such restorations in the mouth. Development of a reliable test that accurately predicts length of clinical service will require more basic knowledge of the material and of the many parameters encountered in the oral cavity.

9597. Braun, W., McNesby, J. R., Bass, A. M., **Flash photolysis of methane in the vacuum ultraviolet. II. Absolute rate constants for reactions of CH with methane, hydrogen, and nitrogen,** *J. Chem. Phys.* **46**, No. 6, 2071-2080 (Mar. 15, 1967).

Key words: CH; flash photolysis; hydrogen; kinetic spectroscopy; methane; nitrogen; rate constant; vacuum ultraviolet.

By means of kinetic spectroscopy, the concentration of CH has been measured in the flash photolysis of methane. Measurements were made by following the attenuation of $C^2\Sigma^+ \leftarrow X^2\Pi$ Q branch at 3143 Å where the disappearance of CH is of the first order in CH. Experiments were conducted with pure methane, methane+H_2, and methane+N_2. The reactions and the corresponding rate constants in $mole^{-1}cm^3sec^{-1}$ are

$CH+CH_4 \rightarrow C_2H_5+H$	$k=2.0 \times 10^{12}$
$CH+H_2 \rightarrow CH_3$	$k=6.2 \times 10^{11}$
$CH+N_2 \rightarrow$ products	$k \simeq 4.3 \times 10^{10}$
$CH+CH \rightarrow C_2H_2$	$k \simeq 1.6 \times 10^{14}$

9598. Brenner, A., **Electrolysis of nonaqueous systems,** *Book, Advances in Electrochemistry and Electrochemical Engineering*, Ed. C. W. Tobias **5**, 205-248 (John Wiley and Sons, Inc., New York, N.Y., 1967).

Key words: Aluminum; beryllium; electrolysis; liquid ammonia; lithium; magnesium; nonaqueous systems, electrolysis of; potassium; sodium.

A survey is presented of the electrodeposition from organic solutions of lithium, sodium, potassium, beryllium, magnesium, and aluminum. The attempts to electrodeposit the rare earth metals are discussed. Also treated are the electrodeposition of metals from liquid ammonia and the electrolysis of essentially pure liquids, both organic and inorganic.

9599. Brenner, F. C., **The mechanics of durable press,** *J. Apparel Res. Found.* **1**, No. 2, 5-9 (Mar. 1966).

Key words: Durable press; fiber; uncured resin cellulose fabric; wash and wear performance.

Garments produced by the "durable press" processes exhibit superior "wash and wear" performance. The unique feature of the process is that the garment is made from an uncured resin treated cellulose fabric and the curing operation is carried out on the finished garment.

The treatment achieves its effect by reducing stresses built into the fabric and garment during manufacture. Stress is reduced by cutting the cellulose chains. The resin also coats the fibers with a lubricant and protects the fiber from penetration by water.

9600. Broberg, J. B. **Modular hardware for on-line handling of nuclear data,** *IEEE Trans. Nuclear Sci. NS*-**13**, No. 1, 192-198 (Feb. 1966).

Key words: Computer; data handling; instrumentation; nuclear; on-line.

At the National Bureau of Standards a flexible data handling system for use with the NBS Linac has been built. In developing this system the need for ease of modifications, ease of coding, and flexibility were carefully considered.

The NBS system is designed around a building block concept. Certain of these building blocks represent the necessary interface between the specialized input-output devices and the computer while the remainder of the blocks represent specific devices such as analog-to-digital converters, scalers, and other devices to facilitate man-machine communication at both local and remote stations.

The modular concept of both hardware and software development has allowed for great flexibility in the devices connected to the computer at any time and in the programs required for use with these devices. New hardware building blocks have been added to the system with no difficulty and with no change in existing programs.

The general building-block approach to the NBS system together with examples of specific units will be described.

9601. Brower, W. S., Fang, P. H., **Dielectric constants of $PbWO_4$ and $CaWO_4$,** *J. Appl. Phys.* **38,** No. 5, 2391 (Apr. 1967).

Key words: Calcium tungstate; dielectric constant; lead tungstate; single crystal.

The dielectric constants (ϵ') $PbWO_4$ and $CaWO_4$ were measured at 24.5 °C in air. Two specimens of each orientation were measured. The averages and deviations therefrom of the two measured values of the reflective dielectric constants are as follows:

$$PbWO_4 \epsilon' \| a 23.6 \pm 0.3; \ \epsilon' \| c 31.0 \pm 0.4;$$

$$CaWO_4 \epsilon' \| a 11.7 \pm 0.1; \ \epsilon' \| c 9.5 \pm 0.2.$$

9602. Brown, D. W., Wall, L. A., **The radiation-induced copolymerization of tetrafluoroethylene and 3,3,3-trifluoropropene at high pressure,** (Proc. Symp. Compilations of Data on Chemical and Physical Properties of Substances, 152nd National Meeting, Am. Chem. Soc., New York, N.Y., Sept. 13, 1966), *Polymer Preprint* **7,** No. 2, 1116-1132 (Sept. 1966).

Key words: Copolymerization; pressure; radiation and reactivity ratios; tetrafluoroethylene; trifluoropropene.

A study was made of the gamma-ray induced copolymerization of tetrafluoroethylene (TFE) and 3,3,3-trifluoropropene (TFP). Copolymerizations were carried out at 100 °C and 5000 atm pressure and at 21 °C and various pressures up to 8000 atm. The reactivity ratios calculated from the composition data indicate that the propagation rate constants favor addition of TFP by a factor of three to seven; individual values depended little on the polymerization pressure and temperature. Polymerization rates changed little with monomer composition between zero and 75% TFE; between 75 and 95% TFE they increased by a factor of ten. As many as 850,000 (molecules) were polymerized per 100 electron volts absorbed.

The copolymers are soluble in hexafluorobenzene at 29.6 °C if they contain less than 70% TFE. Intrinsic viscosities range from 0.1 to about 10 dl/g. From various considerations it appears likely that the degree of polymerization is about equal to the kinetic chain length in high pressure polymerizations at 21 °C; at autogenous pressure or at 5000 atm and 100 °C monomer transfer reduces the value considerably.

9603. Brown, E. H., **On the complex structure of the universe,** *J. Math. Phys.* **7,** No. 3, 417-425 (Mar. 1966).

Key words: Complex structure; electromagnetic fields; physical axioms; universe-complex structure.

A complex space-time is constructed from physical axioms. Both gravitational and electromagnetic fields are approximations to parts of a geometric object defined on this complex space, while other parts may represent strong and weak interactions. The intersections of the singularities of the three independent geometric invariants are identified as elementary particles. This identification leads to geometric definitions of mass and momentum and suggests the geometric significance of internal quantum numbers.

9604. Brown, P. J., **The role of NBS in motor vehicle safety research,** (Proc. Regional Meeting Society of Automotive Engineers, Gaithersburg, Md., Apr. 18, 1967), *SAE* No. 670204, p. 3 (June 1967).

Key words: Braking system; occupant restraint system research; research information exchange; role of NBS motor vehicle safety; tire system research.

The relationship of the National Traffic Safety Agency and NBS and an outline of the research programs in tire systems, occupant restraint systems, and braking systems. The immediate goals and objectives as well as the long-range objectives will be stipulated.

9605. Brown, R. L., **EPR spectrum of gas phase sulfur atoms,** *J. Chem. Phys.* **44,** No. 7, 2827-2828 (Apr. 1, 1966).

Key words: Atomic *g* factors; atomic hydrogen; atomic reactions; electron paramagnetic resonance; sulfur atoms.

Ground-state S atoms have been detected by means of their paramagnetic resonance spectrum among the products of a reaction of H_2S with discharged wet H_2. Atomic *g* factors were determined for the ^3P, and $^3P_2$ multiplet levels. The values were $g(^3P_1) = 1.501029 \pm 0.000042$ and $g(^3P_2) = 1.500541 \pm 0.000024$.

9606. Brown, R. L., Radford, H. E., **L-uncoupling effects on the electron-paramagnetic-resonance spectra of $N^{14}O^{16}$,** *Phys. Rev.* **147,** No. 1, 6-12 (July 8, 1966).

Key words: Electron-paramagnetic-resonance spectra; high resolution; L-uncoupling effects; microwave frequencies; S-band microwave frequencies; X-band.

High resolution paramagnetic resonance spectra have been obtained for the molecules $N^{14}O^{16}$ and $N^{15}O^{16}$ in the $J = 3/2$ and $J = 5/2$ rotational levels of the $^2\Pi_{3/2}$ ground state at X-band and S-band microwave frequencies. The results are: $g_J(N^{14}O^{16}; J = 3/2) = 0.777246 \pm 0.000018$, $g_J(N^{15}O^{16}; J = 3/2) = 0.778072 \pm 0.000020$; $g_J(N^{14}O^{16}; J = 5/2) = 0.316648 \pm 0.000045$; and $g_J(N^{15}O^{16}; J = 5/2) = 0.317617 \pm 0.000040$ for the molecular *g* factors. The indicated uncertainties are estimated limits of error. The measured *g* factors were compared with those calculated from the theory of magnetic effects on Λ-type doubling previously developed by Radford. Somewhat improved values for the Λ-type doubling frequencies and nuclear hyperfine structure coupling constants were also obtained.

9607. Brown, W. E., **Crystal chemistry of calcium phosphates,** *Proc. 1964 Technical Session on Cane Sugar Refining Research, New Orleans, La., Nov. 9-10, 1964,* pp. 26-34 (Agriculture Research Service, New Orleans, La., Mar. 1966).

Key words: Calcium phosphates; chemistry of calcium phosphates; crystal chemistry; thermodynamic and kinetic factors.

The capacity of the precipitate in the defecation step to remove impurities and its filterability are dependent on the physical and chemical nature of the crystallites. Depending on thermodynamic and kinetic factors prevailing at the time of precipitation, one or more of the salts hydroxyapatite, octacalcium phosphate, and anhydrous dicalcium phosphate, may form; variability in the process should be sought in the identity of the precipitate. The properties of the precipitate are thought to be especially dependent on the structural relationship between hydroxyapatite and octacalcium phosphate. Octacalcium phosphate may play a vital role in the growth of the crystallites even though it is metastable in the sugar solution.

Hydroxyapatite is the prototype for the principal crystalline phase in bone char. Two other calcium orthophosphates, beta-tricalcium phosphate and tetracalcium phosphate, can be stable under the conditions used to revivify bone char and may contribute to its chemical behavior.

9608. Brown, W. E., **Crystal growth of bone mineral,** *Book, Clinical Orthopaedics* **44,** 205-220 (J. B. Lippincott Co., Philadelphia, Pa., 1966).

Key words: Bone mineral; crystal growth; hydroxyapatite; octacalcium phosphate.

Formation of hydroxyapatite *in vitro* occurs either (1) through direct precipitation, or (2) by the initial formation of octacalcium phosphate followed by hydrolysis *in situ* to hydroxyapatite. The two processes lead to crystals with distinctive morphologies. A third process for the formation of hydroxyapatite (alternate precipitation of octacalcium phosphate and hydrolysis to hydroxyapatite on the unit-cell level) could lead to crystals with either morphology. Octacalcium phosphate plays a vital, albeit transitory, role in two of these processes and allows the interpretation of properties of apatitic materials without assumptions regarding the existence of arbitrary and ill-defined crystalline species. The effects of fluoride ions, in particular, on the properties of apatitic materials become understandable in terms of octacalcium phosphate as an intermediary in the crystallization of hydroxyapatite.

The role of octacalcium phosphate in the formation of tooth and bone is likely to be equally as great as that *in vitro*. Some of these possibilities are discussed for the first time.

9609. Brualdi, R., Newman, M., **Inequalities for the permanental minors of non-negative matrices,** *Can. J. Math.* **18,** 608-615 (1966).

Key words: Minors; non-negative matrices; permanents; stochastic matrices.

It is shown that if A is an n x n non-negative substochastic matrix then the r^{th} permanental compound of A is also substochastic. If in addition A is doubly stochastic, then it is shown that the sum of all principal permanental minors of order r does not exceed $(n-1/r)+(n-1/r-1)$ per (A), with equality if and only if A is the identity matrix.

9610. Burke, R. W., Menis, O., **Extraction-spectrophotometric determination of antimony as a ternary complex,** *Anal. Chem.* **38,** 1719 (Nov. 1966).

Key words: Antimony; brilliant green; dye impurity; extraction-spectrophotometric; ferrous and non-ferrous alloys; mechanism; sealed tube dissolution.

A critical examination is presented of the many parameters associated with the extraction-spectrophotometric determination of Sb^{+5} as the ternary chloro complex of brilliant green, a triphenylmethane dye. The basic problem of dissolving the sample without residue problems and without volatilization of antimony is also discussed. A sealed tube dissolution procedure yields only Sb^{+3}, the requisite form. The step-wise reactions that may preclude the formation of the colored complex are discussed in terms of the interaction of the following variables: Oxidation and hydrolysis mechanism, spectral dependency on final choice of oxidant, role of H^+ and Cl^- in the oxidation-extraction steps, the side reaction due to impurities in the dye, and the extraction characteristics of the ternary complex. The method has been applied to the analysis of both ferrous and non-ferrous standard reference materials with good success. The coefficient of variation is 2%.

9611. Bussey, H. E., **Measurement of RF properties of materials—a survey,** *Proc. IEEE* **55,** No. 6, 1046-1053 (June 1967).

Key words: Dielectric constant; dielectric loss; ferromagnetic resonance; permeability; radio materials measurement; review of radio materials.

Methods for radio and microwave measurements of dielectric and magnetic properties of materials are categorized, referenced, and placed in perspective. The reference period extends to mid-1966. Measurement errors are analyzed for appropriate cases where possible.

9612. Bussey, H. E., **Progress in measurement of electromagnetic properties of material, 1963 to mid-1966,** (Proc. XV General Assembly of URSI, Munich, Germany, Sept. 5-15, 1966), *Book, Progress in Radio Science 1963-1966,* Pt. 1, pp. 265-289 (International Scientific Radio Union, Munich Germany, 1966).

Key words: Bibliography; dielectric constant; ferromagnetic resonance; permeability; permittivity; review.

Progress on radio and microwave measurements of dielectric and magnetic properties of materials is reviewed mainly for the period 1963 to mid-1966. Important materials properties, theoretical analysis of circuits containing materials, and representative measurement methods are reviewed. In addition, some earlier basic work is referenced.

9613. Butler, T. W., Bloss, R. L., **A device for use in applying strain gages to cylindrical specimens,** *Exp. Mech.* **6,** No. 10, 528 (Oct. 1966).

Key words: Adhesive; application; curing; cylinder; installation; strain gage.

A simple device is described which applies a uniform pressure to the exterior of a cylindrical specimen. This device has been used in connection with a regulated air supply to apply pressure while curing strain gage installations.

9614. Calfee, R. F., Gates, D. M., **Calculated slant path absorption and distribution of stratospheric water vapor,** *Appl. Opt.* **5,** No. 2, 287-292 (Feb. 1966).

Key words: Atmospheric water vapor; calculated slant path; ratio model; water vapor.

A procedure is described for determining the amount and distribution of water vapor along a slant path through the atmosphere above 13.7 km. A multilayer analysis is used in which the transmittance of each layer is calculated and the accumulative effect obtained at the altitude of observation. The method depends upon the contribution of each line to the absorptance in a finite spectral region. From the analysis of recorded spectra a constant mixing ratio model is found to give a good fit.

9615. Calvert, W., **Observations of ionospheric irregularities and plasma resonances by the fixed-frequency topside sounder satellite,** (Proc. NATA Advanced Study Institute, Finse, Norway, April 1965), *Book, Electron Density Profiles in Ionosphere and Exosphere,* Ed. J. Frihagen, pp. 281-298 (North Holland Publ. Co., Amsterdam, The Netherlands, 1966).

Key words: Aurora; electrostatic wave; ionosphere; ionospheric ducting; ionospheric irregularity; ionospheric scattering; plasma resonance; radio sounding; satellite; topside.

The Explorer XX topside sounder is producing unique observations of ionospheric irregularities in electron density and of plasma-wave electrostatic resonances. The echoes from the irregularities are consistent with elongation along the earth's field and arise by two mechanisms: scattering and ducting. Scatter irregularities are invariably observed in sheets at high latitudes and are probably intimately associated with aurora. Duct irregularities, observed also at lower latitudes, are continuous between hemispheres and permit radio echoes from the conjugate reflection level. As the result of varying antenna attitude, the pattern of the resonance response is very complicated. While the patterns depend on gross changes in the conditions of observation, they are repeatable from day to day and give some insight into the excitation mechanism.

9616. Campbell, P. G., Wright, J. R., **Oxidation products in an oxygen-blown Kuwait asphalt,** *Ind. Eng. Chem. Product Res. Develop.* **5,** No. 4, 319-323 (Dec. 1966).

Key words: Additives; asphalt-Kuwait; flux; hardening; infrared spectroscopy; oxygen.

A Kuwait asphalt flux, which is ordinarily very difficult to harden, was treated with oxygen to prepare a coating-grade asphalt. Oxidative changes were measured by increase in softening point and by infrared spectroscopy. The infrared spectra of the coating-grade asphalt to which model organic compounds were added were compared with the spectrum of the original asphalt. The principal oxygen-containing products formed during hardening (oxidation), as assigned by infrared analysis, confirmed previous findings with asphalts from other geographical sources.

9617. Cannon, E. W., **Digital computers,** *Book, Encyclopedia of Physics,* Ed. R. M. Besancon, pp. 124-125 (Reinhold Publ. Corp., New York, N.Y., 1966).

Key words: Analog and digital computers; computers, digital; digital computers.

A general description of analog and digital computers is provided.

9618. Capps, W., Macedo, P. B., O'Meara, B., Litovitz, T. A., **Temperature dependence of the high-frequency moduli of vitreous B_2O_3,** *J. Chem. Phys.* **45,** No. 9, 3431-3438 (Nov. 1, 1966).

Key words: B_2O_3; high-frequency moduli; ultrasonic velocity.

Measurements of ultrasonic velocity allowed the calculation of the high-frequency shear and bulk moduli of B_2O_3 from 80 °C below to 300 °C above the glass transition. The temperature dependences of these moduli were found to be consistent with a semi-empirical extension of the theory of Zwanzig and Mountain.

9619. Case, W. E., Harrington, R. D., **Magnetization of iron for magnetometer calibrations,** *Proc. IEEE* **54,** No. 12, 2004-2005 (Dec. 1966).

Key words: Ferromagnetism; magnetization of pure iron; magnetometer calibration; measurement of magnetization.

It is shown that ultra pure iron spheres allow a simple and accurate calibration of vibrating sample magnetometers over a field range from 600 to 5000 oersteds using only one voltage and field reading. The same spheres may also be used to calibrate other types of magnetometers in this field range by simply assuming the magnetization M is related to the field H_0 by $M=(3)/(4\pi)H_0$.

9620. Casella, R. C., **Optical properties of $SrTiO_3$ under applied stress and electric field,** *Phys. Rev.* **154,** No. 3, 743-749 (Feb. 15, 1967).

Key words: Electro-optical effects; energy bands; selection rules; stress-optical effects; strontium titanate.

Motivated by recent experiments on the effects of uniaxial stress on the superconducting transition and normal-state transport properties of $SrTiO_3$, we have carried out a symmetry analysis, obtaining the perturbed band structure and optical selection rules for the cases of uniaxial stress along the (111) and (001) axes and of static electric field along (001). A comparison of the last case with $BaTiO_3$ in the C_{4v} ferroelectric phase suggests a model with a reversal in the order of the valence bands in $SrTiO_3$ relative to that proposed earlier. Selection rules for polarized light are obtained for both models and criteria for deciding experimentally which is correct are stated. An example is given of how the sign of the relative energy shift of the conduction valleys with stress may be determined optically.

9621. Casella, R. C., **Comparison of three spin alegebras employed in SU(6) theories,** *Phys. Rev.* **147,** No. 4, 962-964 (July 1966).

Key words: Hadrons; little group; spin algebras; SU(6); W spin.

The Lipkin-Meshkov (LM) W spin, Foldy-Wouthuysen (FW) mean spin, and an algebra constructed from the four generators of the Wigner little group provide SU(2) algebras which can be imbedded in an SU(6) description of moving hadrons. It is shown that when acting on particle states obeying the Dirac equation, all three are identical. Differences occur with regard to behavior under charge conjugation. In particular, the FW spin acts on particles and antiparticles alike and, in the quark model does not lead to the LM spin flip between the vector and pseudoscalar mesons.

9622. Cassel, J. M., Christensen, R. G., **Volume change on formation of native collagen aggregate,** *Biopolymers* **5,** 431-437 (1967).

Key words: Collagen; dilatometry; hydrophobic bonding; "native" aggregation; volume change.

The volume change which occurs in dilute tropocollagen solution as a result of the phase transition producing the "native" form of collagen aggregate has been measured dilatometrically. A volume increase of 0.8 x 10^{-3}ml/g. collagen in phosphate buffer (pH 7-7.5) was determined. The volume expansion is attributed to a reduction in the organization of water molecules around nonpolar surfaces of the individual tropocollagen units. This volume expansion is consistent with a previous hypothesis that hydrophobic bonding is the driving force in this collagen aggregation.

9623. Cassidy, E. C., Neumann, K. K., **Photographic and spectroscopic studies of exploding wires in a sealed vessel,** (Proc. 7th Intern. Cong. High-Speed Photography, Zurich, Switzerland, Sept. 12-18, 1965), *Book, Kurzzeitphotographie,* Ed. O. Helwich, pp. 178-185 (Verlag Dr. Othmar Helwich, Darmstadt, West Germany, 1967).

Key words: Electrical discharge; exploding wires; high-speed; photographic; spectrographic; time-resolved.

Investigations of the mixing process between exploding wires and a confined air environment are described. The various high-speed framing camera, combined framing camera and drum camera, drum camera, periodic still, and ultraviolet photographic techniques employed for time resolution of the explosion are described and illustrated. The photographic results are correlated with time-resolved (by photographic and photoelectric techniques) spectroscopic observations. Results have suggested a method and suitable intervals (during the explosion) for estimating the average temperature of the exploding vapor column. A phenomenon apparently due to reflecting shock waves was observed in a later stage of the explosion.

9624. Cassidy, E. C., Zimmerman, S. W., Neumann, K. K., **A method for time-resolved electrical measurements in high-current discharge experiments,** *Rev. Sci. Instr.* **37,** No. 2, 210-214 (Feb. 1966).

Key words: Circuit; electrical measurements; high-current circuit; high-current discharge; high-voltage circuit; resistive component; time-resolved electrical measurements; voltage.

A method for measurement of the resistive component of the instantaneous voltage across a sample installed in a high-voltage, high-current circuit is described. Simultaneous measurement of the current permitted time-resolved determination of electrical energy dissipation, power, and resistance of the sample. The system was calibrated calorimetrically, and measurements were made with exploding wire samples.

9625. Caswell, R. S., **Deposition of energy by neutrons in spherical cavities,** *Radiation Res.* **27,** No. 1, 92-107 (Jan. 1966).

Key words: Cavity chamber; energy deposition; linear energy transfer; neutrons; proportional counter.

A theoretical description of the interaction of neutrons with a spherical cavity has been developed in terms of four types of recoil particle interactions with the cavity called for convenience insiders, starters, stoppers, and crossers. Energy loss distributions are calculated for polyethylene-ethylene and tissue cavities and are found to agree with experimental measurements within the probable uncertainty of those measurements. Conditions for optimum use of proportional counter cavity dosimeters and the interpretation of measurements made with these instruments are discussed.

9626. Cataland, G., Plumb, H., **Calibration of germanium thermometers from 2°-20 °K,** (Proc. Intern. Inst. Refrigeration, Comm. 1, Boulder, Colorado, 1966, Annexe 1966-5), *Suppl. Bull. Inst. Intern. Froid,* pp. 153-163 (Louvain, Belgium, 1966).

Key words: Calibration at low temperature; germanium resistors; low temperature thermometry.

The National Bureau of Standards Provisional Temperature Scale 2-20 (1965) has been established for calibrating thermometers between 2° and 20 °K. The scale is the result of measurements with the National Bureau of Standards Acoustical Thermometer which determined isotherms of the speed of sound in helium-4 gas as a function of pressure. The isotherms were extrapolated to zero pressure, to approximate an "ideal gas", and from the intercepts values of temperature on the Thermodynamic Temperature Scale have been calculated. A group of reproducible germanium thermometers, calibrated at the isotherm temperatures, maintain the scale [NBS P 2-20 (1965)] against which submitted thermometers are calibrated.

To perform calibrations of submitted thermometers, a comparator was constructed. The temperature of the comparator can be maintained constant within 0.0005 °K for extended periods of time at any desired temperature within the calibration range. Calibrations of submitted thermometers consist of resistance determinations at approximately each degree from 2° to 20 °K. We attempt to fit a polynomial of the form

$$\log_{10} R = \sum_{n=0}^{m} A_n (\log_{10} T)^n,$$

– where the upper limit of m is varied in individual functional fittings from 3 to 8 – to the individual resistor's calibration. For some types of resistors reasonable fittings (±.005 °K) of the calibration data are achieved.

9627. Catanzaro, E. J., **Correlation of some Precambrian rocks and metamorphic events in parts of Wyoming and Montana,** *Mt. Geol.* **4,** No. 1, 9-21 (1967).

Key words: Correlation; geochronology; geology; Montana; Precambrian; Wyoming.

A survey of the geology and geochronology of six areas in Wyoming and Montana, including the Beartooth, Bighorn, Wind River, Little Belt and Medicine Bow Mountains, and southwestern Montana suggests the presence of only three dateable pre-Belt Precambrian events: (1) >3100 m.y. The formation of the detrital zircon material now found in the Beartooth Mountains rocks; (2) 2700 m.y. A metamorphic event in all six areas; (3) 1900 m.y. A metamorphic event in the Little Belt and Medicine Bow Mountains and southwestern Montana. The age results suggest the possibility of stratigraphic correlation of metasedimentary rock formations in all six areas.

9628. Catanzaro, E. J., **Triple-filament method for solid-sample lead isotope analysis,** *J. Geophys. Res.* **72,** No. 4, 1325-1327 (Feb. 15, 1967).

Key words: Isotopes; lead; mass spectrometry; triple-filament.

A triple-filament method for lead isotope analysis has been devised. The source consists of rhenium-ribbon sample filaments and a platinum ribbon ionizing filament. Samples may be mounted as $PbCl_2$, $Pb(NO_3)_2$, or $Pb(OH)_2$; the $Pb(OH)_2$ appears to have the best qualities. Stable lead ion signals of 6×10^{-11} amps are consistently obtained with 500 μg lead samples, while 20 μg samples give stable signals of 4×10^{-13} amps. The triple-filament method does not have the ionization efficiency of the single-filament PbS or PbC_2O_4 methods, but it has much greater precision. Ten analyses of a reference sample gave 95% confidence limits (per analysis) of $Pb^{204}/Pb^{206} = 0.054\%$, $Pb^{207}/Pb^{206} = 0.023\%$, and $Pb^{208}/Pb^{206} = 0.071\%$.

9629. Catanzaro, E. J., Murphy, T. J., **Magnesium isotope ratios in natural samples,** *J. Geophys. Res.* **71,** No. 4, 1271-1274 (Feb. 15, 1966).

Key words: Isotope ratios; magnesium; natural; relative; survey.

Magnesium isotope ratios of 60 natural samples, including carbonate, evaporite, silicate, oxide, sea water, brine, meteorite, and biological samples, were measured by thermal emission mass spectrometry. Statistical analysis of the data reveals no evidence of variations among the natural samples or between any of the natural samples and a reference sample of magnesium metal. The 95% confidence limits are ±0.11% and ±0.22% for the Mg^{24}/Mg^{25} and Mg^{24}/Mg^{26} ratios, respectively.

9630. Chamberlain, G. E., **Multichannel resonances in the inelastic scattering of electrons by helium,** *Phys. Rev.* **155,** No. 1, 46-51 (Mar. 5, 1967).

Key words: Cross section; electron; excitation threshold; helium; inelastic scattering; negative ion; resonance.

Resonance structure due to intermediate negative-ion states has been observed in the differential cross section for inelastic scattering of electrons at zero angle in helium. Resonances were observed in all four of the $1s \rightarrow 2s$, $2p$ channels within the incident-energy range of 19.5 to 24 eV.

9631. Chang, S. S., Bestul, A. B., Horman, J. A., **Critical configurational entropy at glass transformation,** *Proc. VII Intern. Cong. Glass, Brussels, Belgium, 1965,* pp. 26.1-26.15 (Gordon and Breach, New York, N.Y., 1966).

Key words: Configurational entropy; critical configurational entropy; glass transformations; molecular configurational relaxation.

When an equilibrium supercooled liquid transforms to a glass, the amount of configurational entropy which it possesses at the glass transformation is trapped into the glass. By two different methods, and a distinguishable variation of one of them, it is shown experimentally that the value of this configurational entropy at glass transformation for most glasses for which data exist to evaluate it is near 0.7 cal deg^{-1} per "bead" as defined by Wunderlich. These beads are equivalent to molecular chain links for polymers. The above stated result is obtained first by evaluating configurational entropy from experimental data on molecular configurational relaxation times, using a reinterpretation of the Williams-Landel-Ferry equation, for the temperature dependence of such relaxation times, in terms of configurational entropy rather then free volume. Secondly, the configurational entropy at glass formation is evaluated independently as the calorimetrically determined residual entropy of the glass at absolute zero temperature. In addition the above results imply a fixed value for the ratio of the glass transformation temperature to the reference temperature at which configurational entropy would vanish for an equilibrium supercooled liquid. This implication would provide a third method of evaluating configurational entropy at the glass transformation if the necessary reference temperature could be determined experimentally by a noncalorimetric method. The implications of the configurational entropy reinterpretation of the Williams-Landel-Ferry equation are examined.

9632. Chang, T. T., **Paramagnetic resonance spectrum of W^{5+} in rutile (TiO_2),** *Phys. Rev.* **147,** No. 1, 264-267 (July 8, 1966).

Key words: Paramagnetic resonance spectrum; resonance; rutile; tungsten.

The paramagnetic resonance spectrum of W^{5+} substitutional in TiO_2 was measured and analyzed. Both hyperfine lines and superhyperfine lines are observed. In the superhyperfine spectrum there is one group of relatively weak lines that is probably due to "forbidden" transitions. The g-factors are: $g_c = 1.4431$, $g_{110} = 1.5944$, $g_{110} = 1.4725$. The hyperfine coupling constants are $A_c = 63.7 \times 10^{-4}$ cm^{-1}, $A_{1\bar{1}0} = 92.5 \times 10^{-4}$ cm^{-1}, $A_{110} = 40.8 \times 10^{-4}$ cm^{-1}.

9633. Chivers, H. J. A., Hargreaves, J. K., **Slow fluctuations between conjugate points in the auroral absorption of cosmic noise,** *J. Atmos. Terrest. Phys.* **28,** 337-342 (1966).

Key words: Auroral absorption; conjugate points; cosmic noise; ionospheric absorption; slow fluctuations.

Ionospheric absorption is being measured with riometers at three pairs of conjugate points. When the ratio of absorption at a northern site to that at its southern conjugate is calculated for selected periods, it is found that the absorption ratio often exhibits slow fluctuations, which sometimes assume a quasi-sinusoidal appearance. Some properties of the fluctuations are described. Evidence is presented which indicates that the phenomenon is inter-hemispheric.

9634. Christ, W. W., Smith, G. V., **Comparison of the Hall-Petch parameters of zone-refined iron determined by the grain size and extrapolation methods,** *Acta Met.* **15,** 809-816 (May 1967).

Key words: Extrapolation methods; grain size; Hall-Petch parameters; iron, zone-refined; zone-refined, iron.

The dependence of the lower yield strength of zone-refined iron containing 0.0020 wt.% (carbon plus nitrogen) on grain size has been investigated at room temperature. In spite of the rather limited grain size variation possible with such pure metal, a meaningful determination of the Hall-Petch parameters has been made by the grain size method: friction stress -2.5 kg/mm^2, Petch slope -2.4 kg.mm$^{3/2}$. It is shown that tensile data obtained where the grain diameter is comparable to the minimum specimen dimension should not be included in the grain size method of analysis.

Analysis of tensile data by the extrapolation method produces Hall-Petch parameters which (1) are internally inconsistent, and (2) compare unfavorably with results of the grain size method. It is concluded that the extrapolation method in its present form is not an adequate substitute for the grain size method of evaluating the Hall-Petch parameters of iron.

9635. Cleek, G. W., **The optical constants of some oxide glasses in the strong absorption region,** *Appl. Opt.* **5,** No. 5, 771-775 (May 1966).

Key words: Fused silica; infrared absorption; infrared reflection; optical constants; oxide glasses; phosphate glass; silicate glasses.

The optical constants, n and k, have been calculated for fused silica, three silicate glasses and a phosphate glass from reflectance measurements made in the strong absorption region, from about 7 to 13 μm. Plots of the $2nkv$ product, which corresponds to the conductivity, as a function of frequency are used to determine the location of the resonance frequencies in the infrared.

9636. Codling, K., **Structure in the photoionization continuum of N_2 near 500 Å,** *Astrophys. J.* **143,** No. 2, 552-557 (Feb. 1966).

Key words: Absorption spectrum; extreme ultraviolet; photoionization; Rydberg series.

The absorption spectrum of neutral N_2 has been studied in the 100-600 Å region, utilizing the pure continuum radiated by the 180 MeV electron synchrotron as a background source. A 3-meter grazing incidence spectrograph of 0.06 Å resolution was used to photograph the spectrum. Discrete structure was observed only in the 470-570 Å region. This previously unobserved structure appears to correspond basically to a single state of neutral N_2 having vibrational spacings very similar to those of the known $C^2\Sigma_u^+$ state of N_2^+. There are signs of a second state; the two states appear to form a Rydberg series converging to a limit at 23.6 eV. The structure involves transitions to autoionizing electronic states lying at higher energies than any previously reported for neutral N_2.

9637. Codling, K., **Structure in the photoionization continuum of SF_6 below 630 Å,** *J. Chem. Phys.* **44,** No. 12, 4401-4402 (June 15, 1966).

Key words: Absorption spectrum; Rydberg series; SF_6; spectral region 80 Å to 630 Å; vibrational band.

The absorption spectrum of neutral SF_6 has been studied in the far ultraviolet spectral region (80 Å to 630 Å) using the pure continuum radiated by the NBS 180 MeV electron synchrotron as a background source. A well-developed vibrational band was observed in the 550-600 Å region. A Rydberg series of neutral SF_6 was observed in the 450-500 Å region, converging to a limit at 26.83 (±0.04) eV. Additional absorption features were evident with peaks at 435 Å and 350 Å. Absolute absorption cross-section measurements were made at 539, 584, and 704 Å. The values obtained were 170Mb, 70Mb, and 100Mb, respectively; the error in these measurements is thought to be no more than 25%.

9638. Codling, K., Madden, R. P., Ederer, D. L., **Resonances in the photoionization continuum of Ne I (20-150 eV),** *Appl. Phys. Rev.* **155,** No. 1, 26-37 (Mar. 5, 1967).

Key words: Absorption spectrum; analysis; Ne I; resonances; synchrotron light; 20-150 eV.

The absorption spectrum of neon in the region 20-150 eV has been studied photographically and photoelectrically, using synchrotron light as a background source. Discrete structure has been observed in three distinct energy ranges. The first is between the $^2P_{1/2,\ 3/2}$ limit near 22 eV, involving resonances analogous to those observed by Beutler in Ar, Kr, and Xe; the second is the region between 44 and 60 eV, the structure here being classified as due to two types of excitation: (i) the excitation of a subshell s electron, (ii) the simultaneous excitation of two outer p electrons; the third region is near 80 eV, where two weak resonances are observed, due presumably to the simultaneous excitation of a subshell s and an outer p electron. The resonance profiles of the states $2s2p^6np\ ^1P^\circ_1$, where $n = 3, 4$, and 5, and the two-electron excitation state $2p^4(^3P)3s3p\ ^1P^\circ_1$ have been studied quantitatively and values of q, Γ and ρ determined for each.

9639. Codling, K., Madden, R. P., Hunter, W. R., Angel, D. W., **Transmittance of tin films in the far ultraviolet,** *J. Opt. Soc. Am.* **56,** No. 2, 189-192 (Feb. 1966).

Key words: Absorption; films; spectra; tin; transmittance; ultraviolet; x-rays.

The transmission spectra of tin films ranging in thickness from 680 to 1690 Å have been studied in detail in the spectral range 1000-80 A, utilizing both photoelectric and photographic detection. The photoelectric results, using a multiline source, give measured values of transmittance, while the photographic results, using the pure continuum radiated by the NBS 180 MeV electron synchrotron, show the behavior of the transmittance curves between measured data points. These new measurements, giving continuous and extended information, allow an interpretation of the transmission characteristics of tin in terms of atomic and solid state parameters. In particular, the photographic data locate the $N_{IV,V}$ x-ray edges with increased accuracy [$N_V=23.8$ (±0.1) eV; $N_{IV}=24.9$ (±0.1) eV]. Of practical importance, a film of thickness 680 Å has a transmittance of over 20% from 700 to 525 Å. Of theoretical significance is a broad absorption feature centered near 190 Å, due to the high oscillator strength for transition of the 4*d* electron to continuum states of *f* symmetry.

9640. Collier, R. S., Kamper, R. A., **Energy gap of superconducting tin films in a magnetic field,** *Phys. Rev.* **143,** No. 1, 323-328 (Mar. 1966).

Key words: Electron tunneling; Ginzburg-Landau theory; magnetic field; superconduction; thin film; tin; vortex model.

We have observed the behavior of clean superconducting thin films of tin in both parallel and perpendicular magnetic fields. The results are quantitatively consistent with an interpretation based on the Ginzburg-Landau theory. For the parallel field we have generated one-dimensional numerical solutions of their equations, while for the perpendicular field we have used a refinement of a vortex model proposed by Tinkham which is based on their expression for free energy.

9641. Colson, J. P., Eby, R. K., **Melting temperatures of copolymers,** *J. Appl. Phys.* **37,** No. 9, 3511-3514 (Aug. 1966).

Key words: Comonomer concentration; comonomer defect; copolymers; defect energy; equilibrium melting temperature; lamella thickness; melting temperature; surface energy; tetrafluoroethylene-hexafluoropropylene.

The melting temperatures (532 to 580 °K) of copolymers of tetrafluoroethylene and hexafluoropropylene have been measured on a microscope hot stage. The copolymers had concentrations of perfluoromethyl groups between 0.0275 and 0.075 groups per carbon atom and lamella thicknesses which varied from 340 to 500 Å independently of comonomer concentration. An equation based on the concept of inclusion of the groups within the lamellar crystals as defects has been fitted to the data. The constants of fitting yield the equilibrium melting temperature, 616.6 ± 4.9 °K, the surface energy, $4.5 \times 10^{-13} \pm 1.6 \times 10^{-13}$ erg/fold, and the perfluoromethyl defect energy, 0.047 ± 0.003 eV/defect. Within the limits of error, these values are shown to be satisfactory by the possible comparisons with previously reported values or with values deduced from physical models. Neglecting the effect of lamella thickness yields a significantly poorer fit of the data.

9642. Cooper, J. W., Ormonde, S., Humphreys, C. H., Burke, P. G., **Autoionizing D states in He below the n = 2 level of He$^+$,** *Proc. Phys. Soc.* **91, 285-287 (1967).**

Key words: Autoionizing series; calculation; close coupling; level width; resonance.

Positions and widths of the autoionizing ^{1}D and ^{3}D levels lying below the n = 2 level of He$^+$ are calculated by close coupling methods and compared with experiment and previous calculations.

9643. Coriell, S. R., Parker, R. L., **Role of surface diffusion in stabilizing the surface of a solid growing from solution to vapor,** *J. Appl. Phys.* **37,** No. 4, 1548-1550 (Mar. 15, 1966).

Key words: Cylindrical and spherical shapes; solution or vapor; spherical shapes; vapor.

The effect of surface diffusion on the stability of shape of a solid growing by diffusion in a supersaturated solution of vapor is considered. Cylindrical and spherical shapes are treated. It is found that under some conditions surface diffusion can provide a significant enhancement of the stability.

9644. Cornog, J. R., Bryan, H. L., Jr., **Search methods with transistor patent applications,** *IEEE Spectrum* **3,** No. 2, 116-121 (Feb. 1966).

Key words: EDP system; patent; patent information retrieval; patent search; transistor.

As the world has become more technically oriented, the number of patent applications has been increasing also too rapidly for the Patent Office to assimilate them comfortably with current techniques. When an application for a patent is received, it must be evaluated as to novelty by a specialist who searches the prior art for similar patents. Previously, all such searches were done manually, which meant that the examiner had to rely entirely on his knowledge and experience. In an effort to remedy the situation the Office has instituted mechanized search methods. In order to ascertain the differences in patterns of thinking associated with manual and mechanized searches, a study was carried out in which a patent application in the transistor art was searched both manually and by a mechanized method. The mechanized search in this case permitted more patents to be analyzed more quickly but, being completely literal, it does not allow for hunches or browsing.

9645. Corruccini, R. J., **Properties of liquid hydrogen,** (Proc. Intern. Inst. Refrigeration, June 9-11, 1965), Chapter in *Liquid Hydrogen,* pp. 65-106 (Paris, France, 1965).

Key words: Cryogenic; hydrogen; liquid; low-temperature; properties.

A review is presented of the physics of liquid hydrogen, and extensive extracts are provided of the available data on those of its physical properties that are important in technology.

9646. Costrell, L., **Progress in nuclear electronics,** Chapter in *Radioisotopes for Aerospace, Part 1: Advances and Techniques,* pp. 1-13 (Plenum Press, New York, N.Y., 1966).

Key words: Modules; nuclear instruments; progress; standards; state-of-the-art.

At the conclusion of World War II nuclear instrumentation was to a great extent concerned with detectors that required essentially unsophisticated electronics. The advent of the scintillation counter in the late 1940's called for an order of magnitude improvement in the associated instrumentation. Introduction of the semiconductor radiation detectors with their tremendous energy resolution capabilities stimulated additional sophistication of nuclear electronics.

9647. Cox, A. P., Kuczkowski, R. L., **The microwave spectrum, structure, dipole moment, and quadrupole coupling of trans-nitrous acid,** *J. Am. Chem. Soc.* **88,** No. 22, 5071-5074 (Nov. 1966).

Key words: Dipole moment; microwave spectra; nitrous acid; quadrupole coupling constants; structure.

Mixtures of NO, NO_2 and H_2O in a waveguide cell have produced pressures of nitrous acid sufficient for the assignment of the trans-isomer by microwave spectroscopy. Accurate values of the B and C ground-state rotational constants have been determined for the normal, deuterated and nitrogen-15 species of trans-nitrous acid.

The data are consistent with the expected planar configuration and on this basis the following structure has been calculated for trans-nitrous acid:

$$\mathrm{N-O(H)} = 1.433, \mathrm{N-O} = 1.177, \text{and } \mathrm{O-H} = 0.954 \text{ Å}$$

$$\angle \mathrm{ONO} = 110°39' \text{ and } \angle \mathrm{NOH} = 102°3'.$$

Quadrupole coupling constants for the nitrogen-14 nucleus in the normal and deuterated species have been determined; the values for trans-HNO_2 are:

$$\chi_{aa} = 1.91, \chi_{bb} = -5.39 \text{ and } \chi_{cc} = 3.48 \text{ Mc/s.}$$

The components of the dipole moment in the nitrogen-15 molecule have been determined to be $\mu_a = 1.387 \pm 0.01$ D, $\mu_b = 1.223 \pm 0.06$ D and yield a value for the total dipole moment = 1.85±0.06 D inclined at an angle of 41°24′±24′ to the a principal axis.

The structure of trans-nitrous acid is discussed on the basis of this data.

9648. Coyle, T. D., Johannesen, R. B., Brinckman, F. E., Farrar, T. C., **Nuclear magnetic resonance studies of inorganic fluorides. II. Solvent effects on J(^{29}Si-^{19}F) in silicon tetrafluoride,** *J. Phys. Chem.* **70,** No. 5, 1682-1684 (May 1966).

Key words: Fluorine; fluorosilanes; nuclear magnetic resonance; SiF_4; silicon; solvent; spin coupling constants.

Solvent dependence of the ^{29}Si-^{19}F nuclear spin coupling constant has been observed for SiF_4 in solutions in a range of 24 solvents. Similar effects are noted in related molecules.

9649. Crawford, M. L., Hudson, P. A., **A dual-load flow calorimeter for RF power measurement to 4 GHz,** (Annual ISA Conf. New York, N.Y., Oct. 1966), *ISA Preprint* No. 12.8-3-66 (Oct. 1966).

Key words: Coaxial; flow calorimeter; radio frequency power.

A new dual-load flow coaxial calorimeter power meter has been constructed at the National Bureau of Standards, Boulder Laboratories. Designed for use as a reference standard, the frequency range of the calorimeter extends up to 4 GHz and beyond. The power range extends from 2 W to 100 W with an error limit of 0.38 percent.

Design details, error analysis, and results of intercomparison with other standards are given.

9650. Crow, E. L., **Optimum allocation of calibration errors,** *Ind. Quality Control* **23,** No. 5, 215-219 (Nov. 1966).

Key words: Calibration of errors; national standards; optimum allocation; secondary standards.

Answers are given to two questions, with emphasis on the second. (a) How do the errors accumulate from echelon to echelon in a hierarchy of calibrations? (b) If a certain accuracy is required at the final echelon of a hierarchy, what is the best way to achieve that accuracy, or, more specifically, what is the optimum allocation of errors among the echelons? The criterion for optimization is taken to be the minimization of the total cost of achieving a given accuracy.

9651. Cullen, W. C., Boone, T. H., **Progress in the development of a thermal-shock resistance factor for bituminous built-up roofing membranes,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **409,** 151-161 (Apr. 1967).

Key words: Development; roofing membrane; strength properties; thermally induced forces; Thermal-Shock Resistance Factor.

The resistance of bituminous built-up roofing membranes to thermally induced forces is considered in terms of their strength properties such as breaking load in tension, modulus of elongation and apparent linear thermal expansion coefficient. The development of a Thermal-Shock Resistance Factor is described and values are given for three bituminous built-up membranes at temperatures of −30 °F (−34.4 °C),0 °F (−17.8 °C) and 73 °F (22.8 °C). The apparent relation between the values obtained in the laboratory and the observed performance of roofing membranes in service is considered. The utilization of the Thermal-Shock Resistance Factor in the reduction of potential failures of bituminous built-up roofing membranes in service from thermally induced forces is also discussed.

9652. Currie, L. A., **Systematic errors in "recovery" and "detection" efficiency as related to radiochemical analysis,** Proc. 11th Annual Bio-Assay and Analytical Chemistry Meeting, Albuquerque, New Mexico, Oct. 7-8, 1965, *AEC* No. 651008, pp. 35 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 1967).

Key words: Bio-assay; carbon-14; detection efficiency; isotope dilution; "over-all" yield; radiochemical analysis; random errors; systematic errors; thorium chemical yield.

Evidence of systematic error in the assay of thorium arose when the chemical yield from a biological sample seemed to depend upon the detection method. When α-counting and spectrophotometry were applied to different aliquots of the same sample, following chemical purification, the discordant chemical yields pointed to variations in detection efficiency. The difficulty arises because determination of the chemical yield is based upon the known disintegration rate of a "spike" which has been chemically processed, and upon the detection efficiency, which is generally determined by means of a standard which may not have been chemically processed. Thus, if the nature of the original sample or the resultant material in any way influences the final detection efficiency, the calculated recovery and its relative variance must be incorrect.

Systematic errors in recovery and detection efficiency may be eliminated in one of two ways: (1) direct measurement of the "over-all" yield—the product of chemical yield and detection efficiency, (2) accurate determination of both the chemical yield and the detection efficiency by such methods as isotope dilution and internal (efficiency) monitoring, respectively. Experimental illustrations are given for analyses of thorium and of carbon-14.

9653. Cutkosky, R. D., Lee, L. H., **An improved transportable ten picofarad capacitor,** *Proc. 11^e Session, Comite Con. d'Electricite, May 10-12, 1965,* pp. 65-66 (Gauthier-Villars, Paris, France, 1965).

Key words: Capacitance standards; fused silica dielectric; picofarad capacitor; shock sensitivity; stability of value; ten picofarad capacitor; transportable ten picofarad capacitor; unit of capacitance; volume dependence.

By design modifications improvements have been achieved in the performance of 10-pF capacitance standards with fused silica dielectric as regards voltage dependence, shock sensitivity, and stability of value. It is suggested that standards of the new design are suitable for interlaboratory comparisons of the unit of capacitance.

9654. Danielson, B. L., **An optical power limiter,** *Appl. Opt.* **6,** No. 1, 158-159 (Jan. 1967).

Key words: Fluorescence; light flux; optical power limiter; photomultiplier tube; saturation.

A power limiting detector is described which is suitable for use in monitoring laser or other high intensity radiation in the 2900 to 3400 Å region. This device employs the saturable single crystal phosphor CaF_2(Ce, Mn) in connection with a photomultiplier tube which is sensitive to the sensitized Stokes-shifted Mn^{2+} fluorescence. The maximum fluorescent intensity of this crystal can be controlled by appropriate choice of impurity concentrations. Limiting the light flux in this way minimizes fatigue effects and possible damage due to inadvertent overloading of the photomultiplier tube.

9655. Danielson, B. L., **Saturation effects in the sensitized fluorescence of CaF_2 (Ce, Mn),** *Phys. Rev.* **142,** No. 1, 228-230 (Feb. 4, 1966).

Key words: Fluorescence; quantum efficiencies; resonant energies; sensitized fluorescence.

The visible fluorescence of Ce^{3+} and Mn^{2+} impurities in crystals of CaF_2 has been investigated under conditions of intense uv irradiation. A change in the fluorescent quantum efficiencies for both impurities is observed at high intensities. In particular, the resonant energy transfer from a Ce^{3+} sensitizer to a neighboring Mn^{2+} begins to saturate. A simple model is postulated to explain this effect. From this model an estimate can be made of the number of sensitizable sites surrounding the Ce^{3+} The rather large numbers obtained, about 150, may be due to some pairing of the Ce^{3+} and Mn^{2+} ions.

9656. Danos, M., Gillet, V., **Stretch scheme, a microscopic description of rotations in nuclei,** *Phys. Rev. Letters* **17,** No. 13, 703-705 (Sept. 26, 1966).

Key words: Nuclear levels; nuclear rotation; nuclear spectroscopy; nuclear structure; quantum mechanical precession; rotational states.

A good angular momentum wave function containing the maximum possible intrinsic angular momenta leads to rotational spectra. The rotational excitation energies arise from the residual two-body force.

9657. Danos, M., Greiner, W., **Treatment of nuclear reactions above the two-particle threshold,** *Z. Phys.* **202,** 125-149 (1967).

Key words: Configuration interaction; continuum states; nuclear reactions; nuclear structure; sequential decays; two-particle reactions.

In principle, an exact formalism for describing nuclear reactions above the two-particle emission threshold is developed. The eigenchannels, i.e., the eigenstates of the S-matrix, are computed directly from the shell model. No artificial assumptions have to be made about the properties of the rescattering of the two final state particles; the final state interactions are completely taken into account. Detailed prescriptions are given on how to reduce the exact description to a form amenable to numerical computations. Finally, long lived intermediate states leading to the so-called sequential decays can, if so desired, be singled out and treated separately. This again involves no specific assumptions. The treatment is applicable also above the three- or more-particle threshold.

9658. Danos, M., Greiner, W., **Eigenchannel theory of nuclear reactions,** *Phys. Rev.* **146,** No. 3, 708-712 (June 1966).

Key words: Nuclear continuum states; nuclear reactions; nuclear scattering; scattering matrix; shell model; S-matrix eigenstates.

A method is proposed by which the eigenstates and the eigenvalues of the S-matrix, i.e., the eigenchannels, can be directly computed from the nuclear problem, for example from the shell model. The calculation of all cross sections, viz. partial and total cross sections, is then exceedingly simple. The characteristics of the eigenchannels are described and the relation with other reaction theories is briefly discussed.

9659. Davis, J. C., **Technical committee 1.2 activities in psychrometry,** *ASHRAE J.* **8,** No. 4, 64 (Apr. 1966).

Key words: Instrumentation-measurement; metric psychrometric charts; psychrometric charts; psychrometric formula; temperature for moist air and enthalpy; thermodynamic watt bulb temperature.

9660. Davis, M. M., Hetzer, H. B., **Titrimetric and equilibrium studies using indicators related to Nile Blue A,** *Anal. Chem.* **38,** 451-461 (Mar. 1966).

Key words: Acid-base indicators; acidity in nonaqueous solvents; aprotic solvents; Methyl Yellow; Nile Blue A and derivatives; Nile Blue oxazone; nonaqueous acid-base spectrophotometry; nonaqueous acid-base titrations; phenyl diethyl Nile Blue; *p*-tolyl di-*n*-propyl Nile Blue base; relative strengths of indicator dyes; solvatochromism.

The behavior of Nile Blue A and several closely related dyes in nonaqueous spectrophotometry and titrimetry was explored. Nile Blue A was used as the salt, the anhydro-base, and the oxazone. The other dyes were the chloride or anhydro-base having an alkyl, aralkyl, or aryl group attached to the 5-amino nitrogen in place of hydrogen. The arylamino derivatives, though less basic than Nile Blue A, are much stronger than Methyl Yellow and are useful reference bases in aprotic solvents. Their applicability in determining stoichiometry and the relative strengths of strong and moderately strong acids is discussed. The strengths of the indicators relative to sulfonephthaleins and other common acid-base indicators are different in aqueous and non-aqueous solvents, pointing to a useful role in non-aqueous differentiating titrations.

9661. Davis, M. M., Paabo, M., **Comparative strengths of aliphatic acids and some other carboxylic acids in benzene at 25°,** *J. Org. Chem.* **31,** 1804-1810 (1966).

Key words: Absorbance data; acid-base association constants; acid dimerization constants; acidic strengths in benzene; aliphatic acids; benzene; bromophthalein magenta E; carboxylic acids; comparative strengths; diphenylguanidine; tetrabromophenolphthalein ethyl ester.

In continuation of earlier measurements (M. M. Davis and H. B. Hetzer, *J. Res. Natl. Bur. Std.* **60,** 569 (1958)), the strengths of the following acids (HA) in benzene have been determined: all of the straight-chain aliphatic acids containing from 2 to 20 carbon atoms except the 15- and 19-carbon acids; isobutyric acid and trimethylacetic (pivalic) acids; and *o*-benzoylbenzoic, *trans*-cinnamic, 2,4- and 2,5-dimethylbenzoic, 2-furoic, and 1- and 2-naphthoic acids. The relative strengths in benzene are expressed as equilibrium constants (K_{BHA}) for 1:1 association of HA with 1,3-diphenylguanidine (B) in the presence of the indicator acid (3′,3″,5′,5″-tetrabromophenolphthalein ethyl ester, "bromophthalein magenta E"). Dimerization constants ($K_{1,2}$) for some of the carboxylic acids have also been deduced from the absorbance data; the values compare favorably with those available from other measuring procedures. The new results conform to linear relationships between log K_{BHA} (benzene, B = DPG) and pK_a (water) derived previously for *meta*- and *ortho*-substituted acids. The significance of the results and other theoretical and experimental aspects of the work are discussed.

9662. Dean, J. W., Flynn, T. M., **Temperature effects on pressure transducers,** *ISA Trans.* **5,** No. 3, 223-232 (July 1966).

Key words: Cryogenic; flame; nuclear radiation; pressure transducers; temperature effects.

Temperature effects on pressure transducers have been determined both analytically and experimentally. Although the experimental work was performed at low temperatures, the analysis indicates that similar effects will result from cryogenic, flame, or nuclear radiation environments. These effects are classified as zero shifts, sensitive shifts, and thermal gradients. The prime causes of these effects are changes in material properties as a function of temperature and mismatching of material properties due to temperature gradients. Recommendations as to pressure-transducer mountings are made for the purpose of reducing the possibility of large, temperature-induced errors.

9663. De Simone, D. V., **Technological innovation: Its environment and management,** *U.S. Department of Commerce* **C1.2:T22** (Supt. Docs., Government Printing Office, Washington, D.C., Jan. 1967).

Key words: Innovation; invention; social invention; technology transfer.

A report of the Panel on Invention and Innovation of the Secretary of Commerce which gives seventeen key recommendations for improving the environment for invention and innovation. Three main factors were examined as they affect invention and innovation: taxation, finance, and competition. No major changes in the laws governing these factors were deemed necessary.

9664. De Simone, D. V., **The innovator,** *Engineer* **8,** No. 1, 8-9 (Jan.-Feb. 1967).

Key words: Innovation; invention; inventors; technical application.

The inventor is essential to the advance of new ideas in technology—the innovator, the key to the application of technology. The innate independence of both causes problems in the institutionalized development system. The advantages and disadvantages of corporate environment on inventiveness are discussed.

9665. Deslattes, R. D., **A two-crystal, vacuum monochromator,** *Rev. Sci. Instr.* **38,** No. 5, 616-620 (May 1967).

Key words: Double crystal instrument; vacuum instrument; x-ray spectrometer.

Design and construction of a vacuum two-crystal instrument for high resolution spectroscopy at long wavelengths is reported. The instrument provides for coordinated rotations of both crystals, source, and detector. The usable scan range is 8° in Bragg angle and is limited only by the characteristics of the tangent drive system.

9666. Deslattes, R. D., **Single axis, two-crystal x-ray instrument,** *Rev. Sci. Instr.* **38,** No. 6, 815-820 (June 1967).

Key words: Crystal x-ray instrument; single axis; two-crystal x-ray instrument; x-ray instrument.

Design features of a two-crystal instrument capable of measurements of diffraction angles to an accuracy of the order of 0.1″ are presented. The instrument is of simple geometry, employs a stable and massive chassis, and derives its precision from components of general availability. Diffraction angles are generated in 1° increments by a precise indexing mechanism and interpolated by means of a sine arm driven by a micrometer.

9667. Deslattes, R. D., Peiser, H. S., Bearden, J. A., Thomsen, J. S., **Potential applications of the x-ray/density method for the comparison of atomic-weight values,** *Metrologia* **2,** No. 3, 103-111 (July 1966).

Key words: Atomic weights; crystal densities; crystal perfection; experimental methods; lattice parameters.

Without presenting experimental details, this report outlines and reappraises the principles involved in measurement of crystal lattice parameters and density for the determinations of atomic-weight values.

Attention is drawn to the advantages to be derived from a comparison of densities and lattice spacings with those of a crystal of mononuclidic elements, rather than from absolute measurements of x-ray spacings and density.

Errors arising from physical and chemical imperfections are discussed as are the general techniques of adequate precision for density and lattice spacings measurements.

Recent literature data is used by way of illustration to derive the effective atomic weight of calcium appertaining to a group of calcite samples from that of a group of silicon crystals (really an unsuitable "standard"). The calcium value obtained is 40.0795±0.0019 (probable error); it compares with IUPAC's adopted 40.08 and a "physical value" of 40.078 from nuclidic masses and isotopic abundance measurements. There are several elements for which the x-ray/density method is judged to be potentially the most promising for atomic-weight re-determinations in the foreseeable future.

9668. Deslattes, R. D., Simson, B. G., **Demountable high power source for soft x-ray region,** *Rev. Sci. Instr.* **37,** No. 6, 753-754 (June 1966).

Key words: Continuum source; secondary excitation; x-rays.

A demountable x-ray source capable of operation up to three kilowatts is described. Construction is largely of stainless steel using elastomer seals. The source is of use in exciting secondary spectra and producing bremmstrahlung for absorption studies.

9669. Deslattes, R. D., Simson, B. G., LaVilla, R. E., **Gas density stabilizer for flow proportional counters,** *Rev. Sci. Instr.* **37,** No. 5, 596-599 (May 1966).

Key words: Flow gas counters; gas density stabilizer; gas gain.

A controller for gas density (pycnostat) is described with particular view to gain stabilization in flow proportional counters. The device is capable of operation at small flow rates and at pressures both above and below atmospheric. Constructional details and performance measurements are reported.

9670. Deslattes, R. D., Torgesen, J. L., Paretzkin, B., Horton, A. T., **Observations of dislocations in ammonium dihydrogen phosphate: Production of dislocation-free crystals,** *J. Appl. Phys.* **37,** No. 2, 541-548 (Feb. 1966).

Key words: Crystal perfection; diffraction topography; single crystals; solution growth.

The results of etch pit and diffraction topographic studies on ammonium dihydrogen phosphate (ADP) are reported. These studies were carried out on specimens sectioned by abrasive wheel and string-saw from large single crystals grown from aqueous solution. The two characterization methods are shown to be in approximate one-to-one correspondence in the case of sections produced by abrasive sawing.

Absence of both etch pits and topographic images in sections made by string-sawing of material well removed from the seed region is taken to indicate that this material is dislocation free. Preliminary results on the plasticity of ADP are reported. The mechanical results are consistent with dominant slip along the equivalent pair of tetragonal axes and minor, although significant, slip along the unique tetragonal axis. Diffraction contrast profiles calculated on the basis of these slip assignments by means of the schematic theory of contrast due to Bonse are in disagreement with the shape and parity of the observed images.

9671. Deutch, J. M., Zwanzig, R., **Anomalous specific heat and viscosity of binary van der Waals mixtures,** *J. Chem. Phys.* **46,** No. 5. 1612-1620 (Mar. 1, 1967).

Key words: Heat capacity; solution critical point; van der Waals mixtures; viscosity.

This article investigates the behavior of several properties of a model binary van der Waals mixture near the solution critical point. The behavior of the heat capacity is determined from an exact analysis of the partition function. For the shear and bulk viscosity, the time dependence of the currents appearing in the time correlation function formulas is determined from linearized hydrodynamic equations. For the heat capacity and the shear viscosity the results of this model are identical to those originally obtained by Fixman by a different procedure. Comparison is also made with the results obtained by Zwanzig and Mountain for these quantities in a one component van der Waals system near the liquid-vapor critical point. One finds, in qualitative agreement with available experiments, that the shear viscosity of a binary mixture diverges at the critical point while the shear viscosity of the one component system is well behaved. This is a consequence of the increasing lifetime of concentration fluctuations compared to density fluctuations as the critical point is approached.

9672. DeVoe, J. R., Spijkerman, J. J., **Mössbauer spectroscopy: Applications to aerospace,** Chapter in *Radioisotopes for Aerospace, Part 2, Systems and Applications,* pp. 254-269 (Plenum Press, Inc., New York, N.Y., 1966).

Key words: Aerospace; applications; materials structure analysis; Mössbauer Effect; spectrometer; standards.

The principle of the Mössbauer Effect will be discussed. A few possible applications of the technique with respect to physics and engineering in aerospace will be outlined. Of greater interest are the possible applications of the technique for determining chemical structure and solid state properties of materials. Solid phase transitions of materials subjected to severe conditions similar to that existing in space can be measured by Mössbauer Effect.

The National Bureau of Standards' Mössbauer spectrometer will be discussed and some data taken on a number of materials (such as tecktites, steels, glasses, and metal alloys) will be presented.

9673. deWit, R., Howard, R. E., **On the definition of the stacking-fault energy in binary alloys,** *Acta Met.* **14,** No. 3, 431-433 (1966).

Key words: Stacking-fault energy in binary alloys; thermodynamic treatments of the segregation of solute atoms in stacking faults.

We wish to discuss the relation between two recent thermodynamic treatments of the segregation of solute atoms at stacking faults in binary alloys. In one of these treatments, the equation relating the concentration of segregated solute to the stacking-fault energy is derived by means of an application of the Gibbs adsorption equation, while in the other treatment, the segregation equation is obtained by minimizing an expression for the free energy of the crystal, including the faulted region. The latter method of obtaining the segregation equation was used earlier by Suzuki. The segregation equations obtained by the two methods are different in form. We wish to point out, however, that this difference is only apparent and is due in part to a disguised difference in the way the stacking-fault energy is defined in the two treatments. We shall show that the possibility of such an ambiguity in the definition of stacking-fault energy arises in the case of an alloy but not in a pure metal.

9674. deWit, R., Ruff, A. W., Jr., **The elastic energies of non-regular hexagonal dislocation loops,** *Phil. Mag.* **15,** No. 137, 1065-1069 (May 1967).

Key words: Dislocation; elastic energy; loops; stacking fault.

The elastic energies of dislocation loops have been calculated as a continuous function of shape from equilateral triangle to hexagon. A smooth decrease in energy is found in this sequence; a relatively rapid change is associated with truncation of the triangle corners. The results compared with previous calculations for other geometric shapes. The effect of a stacking fault in the loop plane is also considered.

9675. Diamond, J. J., Dragoo, A. L., **Studies of molten alumina in the arc-image furnace,** *Rev. Hautes Temper. et Refract.* **3,** 272-279 (1966).

Key words: Alumina; arc-image furnace; heat of vaporization; molten alumina; temperature measurement; vaporization; vapor pressure; water in alumina; water vapor.

Aluminum oxide was melted in vacuum and in atmospheres of H_2, He, O_2, N_2, Ar, air, and water vapor with an arc-image furnace. Water vapor was found to dissolve rapidly in molten alumina and to boil out vigorously when it was made supersaturated in a water vapor atmosphere. In spite of this solubility water vapor does not appreciably enhance the vaporization of molten alumina. The rate of vaporization of molten alumina in vacuum was determined in the temperature range 2493 to 2606 °K and the mean third law heat of vaporization found to be 729.0 kcal mol^{-1}, with a standard error in the mean of 0.9 kcal mol^{-1}. Some problems associated with the measurement of the temperature of molten alumina were studied and are discussed.

9676. Dibeler, V. H., Reese, R. M., Krauss, M. D., **Mass spectrometric study of the photoionization of small molecules,** (Proc. 3rd Intern. Conf. Mass Spectrometry, Paris, France, Sept. 1964), *Book, Advances in Mass Spectrometry* **3,** 471-488 (Institute of Petroleum, London, England, 1966).

Key words: Mass spectrometer; mass spectrometric study; photoionization of small molecules: small molecules; ultraviolet monochromator; windowless vacuum.

A windowless vacuum ultraviolet monochromator and mass spectrometer are combined for the study of photoionization processes in the energy range 2000 to 600 Å (6 to 21 eV). The apparatus and techniques of measurement are described briefly and photoionization curves are given for the molecules: argon, krypton, xenon, hydrogen, deuterium, acetylene, acetylene-d_2, benzene and benzene-d_6. The ionization energies of the $^2P_{3/2}$ and $^2P_{1/2}$ states of the rare gases are measured and autoionized levels are observed between the doublets of krypton and xenon. The first ionization energies of H_2 and D_2 are measured and autoionization ascribed to the D and D', $'\pi_u$ state is observed. First ionization energies of C_2H_2, C_2D_2, C_6H_6 and C_6D_6 are measured and vibrational levels of the ground state of the ions are detected. No electronically excited state is observed in acetylene at energies below 14 eV. In benzene, autoionized Rydbergs are observed leading to a second onset of ionization about 2.2 eV above the first ionization threshold. The shape of the curve above the first onset suggests similar energies for the lowest bonding π and σ orbitals.

9677. Dise, J. R., **The role of the CCRL,** *Construct. Specifier* **20,** 54-60 (June 1967).

Key words: Cement and concrete testing laboratories; concrete and cement testing laboratories; inspection of cement and concrete testing laboratories.

The history and methods of operation of the Cement and Concrete Reference Laboratory are described together with the benefits which can be derived from the inspection of cement and concrete testing laboratories.

9678. Dodge, W. R., Coleman, J. A., Domen, S. R., Whittaker, J. K., **Lithium compensated silicon focal plane detectors for electron scattering spectrometers,** *Rev. Sci. Instr.* **37,** No. 9, 1151-1159 (Sept. 1966).

Key words: Electron scattering spectrometer; focal plane detectors; lithium-compensated silicon; low temperature radiation detectors; photonuclear physics apparatus; rectangular counters.

In order to utilize the inherent resolving power of a double focusing, 169.8°, 76.2 cm radius-of-curvature magnetic spectrometer being constructed at the National Bureau of Standards for elastic- and inelastic-electron nuclear scattering studies, focal plane counters were needed whose dimension along the direction of momentum dispersion was 1 mm. This paper describes the fabrication techniques and performance of lithium compensated silicon 1 x 1 x 60-mm radiation detectors which seem well suited for use as focal plane detectors for the above spectrometer. Differential and integral pulse height distributions for 10-40 MeV electrons incident on the counters are presented as a function of the temperature and bias voltage. Effects due to the finite width of the counters are discussed. A tunnel diode discriminator which provides the desired binary information to the NBS data processing system is described.

9679. Doepker, R. D., Ausloos, P., **Gas-phase radiolysis of cyclopentane. Relative rates of H_2^--transfer reactions from various hydrocarbons to $C_3H_6^+$,** *J. Chem. Phys.* **44,** No. 5, 1951-1958 (Mar. 1966).

Key words: Cyclopentane; gas-phase radiolysis; hydrocarbons; radiolysis.

The radiolysis of cyclo-C_5D_{10} has been investigated in the presence of various saturated and unsaturated perprotonated hydrocarbons. On the basis of the isotopic analysis of the propanes formed in these mixtures and several other experimental observations it is concluded that the $C_3D_6^+$ ion, which is the major ion produced in the fragmentation of $C_5D_{10}^+$, reacts with various saturated hydrocarbons (AH_2) as follows:

$$C_3D_6^+ + AH_2 \rightarrow CD_3CDHCD_2H + A^+. \qquad \text{(a)}$$

Rates of this process relative to that of the reference reaction

$$C_3D_6^+ + \text{cyclo-}C_5D_{10} \rightarrow C_3D_8 + C_5D_8^+ \qquad \text{(b)}$$

have been measured with an accuracy of better than 2%. It is suggested that the saturated hydrocarbons also transfer an H^- ion to $C_3D_6^+$ according to to the following reaction:

$$C_3D_6^+ + AH_2 \rightarrow C_3D_6H + AH^+. \qquad \text{(c)}$$

Although in agreement with theory the total rate of reaction of $C_3D_6^+$ with AH_2 is generally seen to increase with an increase in molecular weight of AH_2, there are appreciable variations in the rates of the H_2^--transfer reaction (a) versus that of the H^--transfer reaction (c) with a change in structure of the hydrocarbon molecule. Reaction (c) is usually favored when AH_2 is a branched hydrocarbon, except for neopentane which is entirely unreactive toward $C_3D_6^+$. Unsaturated hydrocarbons do not transfer an H_2^- ion to $C_3D_6^+$ but probably undergo a condensation-type process. The radiolysis of cylopentane has also been investigated in the presence of O_2, NO, and $(CH_3)_3N$. It is demonstrated that the $C_3H_6^+$ and $C_5H_{10}^+$ ions transfer their charge to NO, or $(CH_3)_3N$ and that at a pressure of 20 torr approximately 20% of the parent ions undergo ring opening prior to the charge-transfer process.

9680. Doepker, R. D., Ausloos, P., **Gas-phase radiolysis of cyclobutane,** *J. Chem. Phys.* **44,** No. 4, 1641-1647 (Feb. 1966).

Key words: Cycloalkanes; ion-molecule reactions; ion-pair yields; radiolysis; unimolecular decomposition.

The gas-phase radiolysis of cyclo-C_4H_8 and cyclo-C_4D_8 has been investigated in the presence of O_2, NO, H_2S, NH_3, and several organic compounds. From the products formed, it could be inferred that the following fragmentation processes occur:

$$C_4H_8^+ \rightarrow C_3H_5^+ + CH_3$$

$$C_4H_8^+ \rightarrow C_2H_4^+ + C_2H_4$$

$$C_4H_8^+ \rightarrow C_2H_5^+ + C_2H_3$$

$$C_4H_8^+ \rightarrow C_3H_4^+ + CH_4$$

At 20 torr, the ion-pair yields which can be ascribed to some of these processes are lower than the corresponding ion-pair yields observed in the mass spectrometer at a pressure of 10^{-5} torr.

When compounds such as NO(I.P. = 9.25 eV) or $(CH_3)_3N$(I.P. = 7.8 eV) are added to cyclobutane, butene (I.P. = 9.13 − 9.58 eV) is a major product. On the other hand, when organic or inorganic compounds whose ionization energy is higher than that of butene are added to cyclobutane, the yield of butene is, in most cases, negligibly small. The formation of butene can be tentatively accounted for by a ring opening of the parent ion followed by charge transfer. On the basis of this mechanism, a minimum value of 0.42±0.02 can be ascribed to $M(C_4H_8^+)/N$.

When an electrical field is applied in the saturation current region, during radiolysis of cyclobutane-NO mixtures, the yields of methane, ethane and butene which have the parent ion or fragments thereof as precursors, remain unchanged. On the other hand, the yields of products such as ethylene, allene, acetylene, and 1,3-butadiene whose formation is, in part, attributed to the decomposition of neutral excited molecules, are seen to increase due to increased excitation by electron impact. In the absence of an electrical field, the number of neutral excited molecule decompositions per ion pair is estimated to be $\leqq 0.65 \pm 0.05$.

9681. Doepker, R. D., Lias, S. G., Ausloos, P., **Photolysis of cyclopentane at 1470, 1236, and 1048-1067 Å,** *J. Chem. Phys.* **46,** No. 11, 4340-4346 (June 1, 1967).

Key words: Cycloalkanes; cyclopentane; free radical reactions; ion molecule reactions; photoionization; photolysis.

The photolysis of cyclopentane has been investigated at 1470, 1236 and 1048-1067 Å. The primary process, cyclo-$C_5H_{10} + h\nu \rightarrow C_5H_8 + H_2$ is of major importance at 1470 Å, but its quantum yield diminishes at shorter wavelengths where processes involving C-C cleavage become more predominant. The products formed in the gas-phase photolysis of cyclo-$C_5D_{10} - H_2S$ mixtures and in the solid-phase photolysis of cyclo-C_5H_{10} indicate that the excited cyclopentane molecule undergoes ring opening to form a 1-pentene molecule. In the gas phase, the internally excited 1-pentene decomposes entirely to form methyl and ethyl radicals. Evidence is also obtained for the occurrence of the dissociative process: $C_5H_{10} \rightarrow C_2H_4 + C_3H_6$ where C_3H_6 consists of cyclopropane and propylene. At 1048-1067 Å (11.6 − 11.8 eV), ionization is extensive (ionization potential of cyclo-C_5H_{10} = 10.5 V). Saturation current measurements yielded a value of 0.64 for $\eta_{C_5H_{10}}/\eta_{NO}$. On the basis of an isotopic analysis of the propane formed in the photoionization of $C_5D_{10} - C_5H_{10} - O_2$ mixtures it is shown that the parent ion dissociates as follows: $C_5H_{10}^+ \rightarrow C_3H_6^+ + C_2H_4$ and that the $C_3H_6^+$ ions participate in an H_2^- transfer reaction: $C_3H_6^+ + C_5H_{10} \rightarrow C_3H_8 + C_5H_8^+$. Fragmentation of the parent ion diminishes with an increase in pressure. The collisional deactivation process is more pronounced for the perdeuterated than for the perprotonated cyclopentane ion. The data also indicate that a fraction of the parent ions undergoes ring opening to form *cis*- or *trans*-2-pentene as a final product.

9682. Douglas, C. A., **Review of elementary theory of the photometry of projection apparatus,** *Illum. Eng.* **62,** No. 4, 246-253 (Apr. 1967).

Key words: Critical distance; illumination; light projectors; photometric distance; photometry; signal lighting.

Equations based upon simple geometric relations are developed for the illuminance produced by a projector such as a searchlight, beacon, or floodlight at a distance from the projector. When the beam is rotationally symmetrical but not collimated and the image, virtual or real, subtends a smaller angle at the point of observation than does the objective of the projector, illuminance varies inversely as the square of the distance to the image. If the angle subtended by the image is larger than that subtended by the objective, the illuminance varies inversely as the square of the distance to the objective. The distance at which the two angles are equal is defined as the critical distance. Equations relating critical distance to the radius of the source, the radius of the objective, and the magnification of the system are developed. Approximations for use when the beam of the projector is asymmetric are developed. Very good agreement was found between the computed variation of illuminance with distance and the measured variation of illuminance with distance for a projector forming a virtual image 150 feet behind the objective.

9683. Dibeler, V. H., Walker, J. A., **Photoionization efficiency curve for SF_6 in the wavelength region 1050 to 600 Å,** *J. Chem. Phys.* **44,** No. 12, 4405-4406 (June 15, 1966).

Key words: Electronically excited state; mass spectrometer; photoionization; Rydberg levels; sulfurhexafluoride; threshold energy.

The threshold energy of SF_5^+ at 811 Å (15.29 eV) has been determined by photoionization. An electronically excited state with a threshold at 750 Å (16.53 eV) resulting from partially resolved autoionizing Rydberg levels in the region of 775 Å has been observed also.

9684. Dunn, G. H., **Franck-Condon factors for ionization of H_2 and D_2,** *J. Chem. Phys.* **44,** No. 7, 2592-2594 (Apr. 1966).

Key words: Franck-Condon factors $H_2(^1\Sigma_g^+)$; ionization $D_2(^1\Sigma_g^+)$; vibrational eigenenergies D_2^+.

Franck-Condon factors for ionization of $H_2(^1\Sigma_g^+)$ and $D_2(^1\Sigma_g^+)$ are presented for 19 levels in $H_2^+(^2\Sigma_g^+)$ and 27 levels in $D_2^+(^2\Sigma_g^+)$. Comparisons are made with calculations, using less accurate potential functions for the molecular ion. Vibrational eigenenergies are given for D_2^+.

9685. Dunn, G. H., Van Zyl, B., **Electron impact dissociation of H_2^+,** *Phys. Rev.* **154,** No. 1, 40-51 (Feb. 1967).

Key words: Crossed beam technique; dissociation; electron impact; H_2^+.

The absolute cross section for dissociation of H_2^+ by electron impact has been measured for electron energies between 10 eV and 1500 eV using a crossed beam technique which is described in some detail. The measured cross section can be represented by the function $\sigma = 217/E \log_{10} E - 184$, where the cross section σ is in units of πa_0^2 and the electron energy E is in electron volts. Comparison is made with relevant theory, and the agreement in magnitude of the cross section between experiment and theory is found to be surprisingly (and possibly fortuitously) good. The shape of the cross section as described by the above expression does not agree well with theory.

9686. Eberhard, J. P., **Forces shaping the role of the architect,** *Proc. Second Architectural Center Conf., Boston, Mass., May 13-14, 1966,* p. 12 (Boston Architectural Center, Boston, Mass., May 1966).

Key words: Architectural design; design systems; technological design.

A panel discussion of the use of systems concept as applied to architectural design problems in the building process. The role of the architect as a designer in the larger complex of the city is discussed.

9687. Eberhard, J. P., **Technology for the city,** *Intern. Sci. Technol.* **57,** 18-29 (Sept. 1966).

Key words: City design; city systems; systems technology; technological planning.

The ability to build better cities lies in the technological base from which we work. Only when the "systems" characteristics of the city are recognized can technological resources be coupled to solving urban problems. When cities are seen as "continuous urban systems" unrestricted by political or geographical boundaries, we can create high-technology, systems-oriented companies with the capability to design and build better future cities.

9688. Eberhard, J. P., **The city as a system,** *Proc. Mid-American Conf. Urban Design, Kansas City, Mo., Mar. 30-31, 1966,* p. 2530 (Midwest Research Institute, Kansas City, Mo., 1966).

Key words: City design; city systems; city technology; systems technology.

A panel review of city problems analyzed in terms of the systems and subsystems operating in the city complex. Suggests that knowledge of the systems characteristics of the city offers ways to evaluate urban problems by planners. Systems approach is only logical way to apply modern technology to urban problems.

9689. Eby, R. K., Colson, J. P., **Relaxations in polyethylene: Orientation of the lamellar crystals,** *J. Accoust. Soc. Am.* **39,** No. 3, 506-510 (Mar. 19, 1966).

Key words: *a, c* face of cell; compliance; crystallization-oriented; lamella thickness; logarithmic-decrement; modulus; polyethylene; relaxations; shear; temperature; torsion pendulum.

A torsion pendulum has been used to make mechanical measurements on linear polyethylene between −175° and +110 °C at about one Hz. Samples which had been oriented by crystallization in a temperature gradient were measured together with unoriented but otherwise equivalent samples. The data are analyzed to show that the α relaxation in polyethylene is sensitive to the orientation of the deformation with respect to structural symmetry. For shearing in the *a, c* face of the unit cell and associated lamella boundaries the average overall direction is different from the average for shearing in all possible planes in the cell and boundaries. The γ relaxation does not exhibit this difference. The data show a lack of correlation between lamella thickness and various viscoelastic parameters such as the real part of the modulus and the magnitude of the relaxations. The results show a need for further mechanical measurements on samples that are more nearly perfectly oriented and more fully characterized with respect to structural details and imperfections.

9690. Eckerle, K. L., McWhirter, R. W. P., **Departures from the local thermal equilibrium in a magnetically-driven shock wave,** *Phys. Fluids* **9,** No. 1, 81-89 (Jan. 1966).

Key words: Electromagnetic T-tube; local thermal equilibrium; population density of atomic energy levels.

An experimental study is reported of the time-resolved spectrum of the plasma produced by the magnetically driven shock wave in a T-tube. It is shown that the population densities of the excited levels of helium ions in the plasma depart from the values they would have in Local Thermal Equilibrium. On the other hand, if LTE is assumed and the electron temperature estimated for the intensity ratio of He II (4686 Å) to He I (5876 Å), then in the conditions of the experiment an error of a factor of two in the electron temperature arises. The reason for the departure from LTE was shown to be the rapid rate of change of the plasma conditions (especially the electron temperature). This is so great that the ionization and recombination rates, being slower, cause the population densities to lag behind the electron density and electron temperature. These rates were found to be consistent with the rates calculated by Bates et al., in their collisional-radiative model for the ionization and recombination of hydrogen-like ions.

9691. Eckert, C. A., Renon, H., Prausnitz, J. M., **Molecular thermodynamics of simple liquids—mixtures,** *I & EC Fundamentals* **6,** No. 1, 58-67 (Feb. 1967).

Key words: Analytical partition function; molecular parameters; molecular size; simple liquids; thermodynamic properties.

Thermodynamic properties of simple liquids are calculated from an analytical partition function which is based on a modification of Prigogine's cell theory and on a three-parameter theorem of corresponding states. The partition function gives an excellent representation of the configurational properties of fifteen liquids ranging in molecular complexity from argon to neopentane. Three characteristic molecular parameters are sufficient to calculate the configurational energy and entropy, the volume, coefficient of expansion and compressibility. These parameters are a molecular size, a pair-potential energy, and a term which is closely related to non-central intermolecular forces; this last parameter is a nearly linear function of Pitzer's acentric factor. The main application of this statistical thermodynamic treatment follows from its straightforward extension to liquid mixtures as discussed in Part II.

9692. Edmiston, C., Krauss, M., **Pseudonatural orbitals as a basis for the superposition of configurations. I. He_2^+,** *J. Chem. Phys.* **45,** No. 5, 1833-1839 (Sept. 1, 1966).

Key words: Electronic energy; He_2^+; molecular quantum mechanics; pseudonatural orbitals.

The use of pseudonatural orbitals (PNO) is proposed to improve the rate of convergence in the superposition of configurations (SOC). Natural orbitals are determined for selected electron pairs in the Hartree-Fock field of the *n*-2 electron core and are then used as the basis for the total SOC calculation. Since these natural orbitals are not natural for the *n*-electron system they are considered false or pseudonatural orbitals when used in the *n*-electron problem.

The PNO basis has been applied to He_2^+ and H_3 to test the convergence. Complete results are reported here only for He_2^+. The PNOs are quite successful in speeding up the convergence of the SOC and rendering the calculation of correlation energy quite practical in general. Gaussian type orbitals (GTO) are used throughout and were not a serious impediment to obtaining quantitative accuracy. In fact, the large number of unoccupied Hartree-Fock orbitals consequent upon the use of a GTO basis permit a straightforward determination of the PNO orbitals.

9693. Edmonds, D. K., Smith, R. V., **Comparison of mass-limiting two-phase flow in a straight tube and in a nozzle,** *Proc. Symp. Two-Phase Flow, University of Exeter, Devon, England, June 21-23, 1965,* pp. 401-414 (University of Exeter, Devon, England, 1966).

Key words: Mass-limiting two-phase flow; nozzle; tube.

This paper reports the experimental data obtained at mass-limiting and near-mass-limiting conditions for a straight tube and two nozzle test sections. The experimental system was a Refrigerant 11 flow loop. Fluid qualities entering the test sections were 0.042, 0.116, and 0.156.

It was noted that as the pressure differential between the exit-plane and the receiver was increased the exit-plane pressure approached a constant value for all test sections. The mass flow also approached a constant value for the straight tube, but for the nozzles the mass flow continued to increase with increasing differential pressure but at a lower rate of increase. The deviations from the straight tube behavior were greater for the nozzle with the largest angle of convergence.

Predicted mass-limiting flow rates from the Fauske and a metastable model were compared with the experimental data. The models adequately predicted the flow rate for data where the exit-plane pressure was almost constant (within ±30%).

9694. Eicke, W. G., Jr., Ellis, H. H., **On long-term stability of Zener reference diodes,** *Proc. 11^e Session, Comite Con. d'Electricite, May 10-12, 1965,* pp. 73-77 (Gauthier-Villars, Paris, France, 1965).

Key words: Diodes, reference; long-term stability; reference diodes; Zener reference diodes.

This paper gives a summary of a three-year study of the stability of Zener diodes when operated intermittently or continuously. The diodes that were studied under intermittent use were in use for periods of 5 to 10 minutes with periods of two to four weeks between measurements. The diodes studied had normal voltage ranging from 8.1 to 9.2. The studies were conducted at 25.00± °C. The studies indicated that the Zener voltage gave stable output voltage to within 3 to 10 ppm over a three-year period.

9695. Eisenhart, C., Birnbaum, A., **Anniversaries in 1966-67 of interest to statisticians. Part II. Tercentennials of Arbuthnot and De Moivre,** *Am. Stat.* **21,** No. 3, 22-29 (June 1967).

Key words: Abraham De Moivre; *Annuities upon Lives*; "Argument for Divine Providence"; *Arithmetica Memorativa*; Bernoulli's theorem; *Doctrine of Chances*; generating functions; John Wallis; *Laws of Chance*; Martin Scriblerus; normal approximation; Poisson distributions; Scriblerus Club; statistical test; William Buckley.

Brief recognition is given to the quadricentennial of the publication of *Arithmetica Memorativa* (1567) of William Buckley (?-1550) and to the 350th anniversary of the birth of John Wallis (1616-1703), whose *Algebra* (1685) contained the earliest treatment of permutations and combinations in the English language. Much fuller recognition is accorded the tercentennials of the birth of John Arbuthnot (1667-1735), deviser of the earliest statistical test of significance; and of the birth of Abraham De Moivre (1667-1754), who made the most extensive, and the most important contributions to the purely mathematical theory of probability before Laplace (1749-1827), many of whose results he anticipated.

9696. Eisenhauer, C., **Development of the engineering method and some simplified methods of structure shielding analysis,** (Lecture Notes, OCD Summer Inst., Kansas State University, Manhattan, Kansas, 1962-1963, 1965), *TR-40, Radiation Shielding&Analysis and Design Principles as Applied to Nuclear Defense Planning,* **V-1—V-IV** (Supt. Docs., Government Printing Office, Washington, D.C., Nov. 1966).

Key words: Fallout protection in structures; radiation shielding; structures.

These lecture notes describe the technical basis for the procedures currently being used by the Office of Civil Defense to evaluate fallout protection in structures. The notes describe in detail how the equations and charts used in these procedures were derived from fundamental calculations of radiation shielding. Examples are given for simple structures.

9697. Ellerbruch, D. A., **UHF and microwave phase-shift measurements,** *Proc. IEEE* **55,** No. 6, 960-969 (June 1967).

Key words: Measurements; microwave; phase shift; standards; UHF; uncertainties.

A phase-shift standard, a measurement system, and the techniques for determining the corresponding limit of uncertainty are all required for obtaining the phase-shift characteristics of UHF and microwave components. Differential phase-shift standards, measurement techniques, and measurement uncertainties are all discussed in a general sense and a comprehensive bibliography is included to supplement the general discussion.

9698. Estin, A. J., Anderson, M. M., **Time-resolved microwave interferometry as a diagnostic tool for decaying plasma afterglows,** *Rev. Sci. Instr.* **37,** No. 4, 468-470 (Apr. 1966).

Key words: Density; diagnostic; electron; interferometry; microwave; plasma; time resolution.

Two laboratory techniques are described for making time-resolved microwave interferometry measurements of electron density in a decaying plasma afterglow. The time resolution is of the order of 10 microseconds and thus permits at least several hundred sampling periods in the decay of a typical helium afterglow. A simple criterion is given for the error introduced in phase on account of the time-varying medium.

9699. Evenson, K. M., Broida, H. P., **Measurements of collisional energy transfer between rotational energy levels in CN,** *J. Chem. Phys.* **44,** No. 4, 1637-1641 (Feb. 15, 1966).

Key words: Chemical bonds; cyanogen, molecular energy levels; electron transition; microwave spectroscopy; nuclear spins.

A microwave-optical technique which selectively populates a single rotational level of CN and permits the observation of the redistribution of this population was utilized to measure the rates of collisional energy transfer between rotational energy levels of the B doublet-sigma state of CN. CN was formed in the A doublet-Pi state by the addition of CH2C12 to the afterglow of a nitrogen discharge. The near coincidence of the K = 4, v = 0 level of the A doublet-Pi state with the K = 4, v = 0 level of the B doublet-sigma state permits microwave transitions near 10 GHz from the more populated Pi level to the sigma level. The increased population in the rotational levels neighboring the K = 4 level of the B doublet-sigma state was detected by measuring the increased optical emission due to the B doublet-sigma-A doublet-sigma transition near 3875 Å. Collisional energy transfer was measured over a pressure range from 0.1 to 5 torr for changes in rotational quantum number ranging from one to ten. It is shown that rotational transitions having changes in rotational quantum number greater than unity take place with high probability, contrary to the optical selection rule delta-K = plus or minus 1, and that approximately every gas kinetic collision produces a rotational transition. The relaxation time for the fourth rotational level was found to be 0.00000012 (plus or minus 30%) sec at a pressure of 1 torr.

9700. Farley, D. T., Jr., **Observations of the equatorial ionosphere using incoherent backscatter,** (Proc. NATA Advanced Study Institute, Finse, Norway, Apr. 1965), *Book, Electron Density Profiles in the Ionosphere and Exosphere,* Ed. J. Frihagen, pp. 446-469 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1966).

Key words: Backscatter; electron and ion temperature; electron density; equatorial ionosphere; incoherent backscatter; ionic composition.

Measurements of electron density, electron and ion temperature, and ionic composition have been made in Peru using the incoherent backscatter technique. The paper reports some of the more recent results, particularly those of 1-3 February, 1965. In the latter period, continuous measurements of electron density were obtained up to altitudes above 4000 km. Between 3000 and 5000 km, the densities varied by about a factor of two throughout the day. At lower heights there was, at times, strong evidence of rapid vertical motion. During the day, temperature equilibrium between the ions and electrons prevailed above about 400 km, but T_e/T_i reached values approaching three at lower heights. Equilibrium appeared to exist at all heights at night. A limited number of measurements of the ionic composition show no evidence of He^+ ions during the day, and the O^+ and H^+ densities become equal at about 900 km. During the night, however, He^+ does appear to be present in significant amounts, and the relative concentration of O^+ drops to 50% at about 700 km.

9701. Farrar, T. C., **Electron paramagnetic resonance and nuclear magnetic resonance as analytical tools,** (Conf. Purification of Materials, New York Academy of Sciences), *Ann. N.Y. Acad. Sci.* **137,** 323-334 (Jan. 1966).

Key words: Analytical tools; electron paramagnetic resonance; nuclear magnetic resonance; paramagnetic resonance; spectroscopy; tools, analytical.

Nuclear magnetic resonance (NMR) spectroscopy is becoming an increasingly important and useful analytical tool. The advantages (such as rapid, non-destructive analysis), disadvantages (such as large sample requirement and low sensitivity), and limitations of high-resolution, broad-line and pulsed NMR techniques as applied to analytical problems are pointed out. Recent developments in instrumentation which have significantly increased the stability and sensitivity of NMR techniques are discussed.

Examples of the use of high-resolution NMR to determine the structure and the purity of samples of the recently-synthesized molecules HBF_2, Si_3BF_2, and Si_3BF_2 are given. The results of a broad-line NMR study to determine the number and the position(s) of the hydrogen atoms in the molecule $Re_3(CO)_{12}H_x$ are presented.

Although paramagnetic species can be detected in concentrations as low as 10^{-11} M, electron paramagnetic resonance (e.p.r.) has been used for quantitative analysis only in a few cases. It is somewhat more useful for qualitative analysis. At this time its prospects for developing into a useful analytical tool seem limited. The reasons for this are briefly discussed.

9702. Farrar, T. C., Ryan, W., Davison, A., Faller, J. W., **Manganese-hydrogen bond distance in $HMn(CO)_5$,** *J. Am. Chem. Soc.* **88,** No. 1, 184 (Jan. 5, 1966).

Key words: Bond distance; broad-line second moment; carbonyl; hydride; hydrogen; manganese; nuclear magnetic resonance; proton.

The second moment of the proton NMR absorption spectrum of a sample of $HMn(CO)_5$ was determined; its value is 26.6±0.6 G^2. This value corresponds to a value of 1.28±0.01 Å for the Mn—H bond distance.

9703. Fatiadi, A. J., **Effects of temperature and of ultraviolet radiation on pyrene adsorbed on garden soil,** *Environ. Sci. Technol.* **1,** No. 7, 570-572 (July 1967).

Key words: Aromatic; hydrocarbons; particulates; photochemical; photooxidation; polycyclic; pyrene; reaction; 1,1′-bipyrene; 1,6- and 1,8-pyrenediones.

The chemical and photochemical changes of pyrene adsorbed on soil have been studied. It was found that pyrene adsorbed on soil and subjected to either heat or ultraviolet radiation underwent self-coupling to 1,1′-bipyrene, apparently by free-radical mechanisms; this product was not found from pyrene adsorbed on a number of other particulates. Also formed in the pyrene—soil reaction were 1,6- and 1,8-pyrenediones, probably by a different reaction-path.

9704. Fatiadi, A. J., **Novel aromatization of inositols in dimethyl sulfoxide—acetic anhydride,** *Chem. Commun.* **9,** 441 (May 10, 1967).

Key words: Acetic anhydride; aromatization; inositol; methyl sulfoxide.

A novel method has been discovered for the aromatization of inositols. The procedure involves treatment of inositols with a mixture of methyl sulfoxide and acetic anhydride.

9705. Fatiadi, A. J., **Preparation of inososes from their phenylhydrazones by use of a cation-exchange resin; separation of certain phenylhydrazones from phenylosazones,** *Carbohydrate Res.* **1,** No. 6, 489-491 (1966).

Key words: Cation-exchange resin; inosose phenylhydrazones; inosose phenylosazones; preparation of inososes from phenylhydrazones; removal of phenylhydrazine residue from phenylosazones.

Cation-exchange resin of the sulfonic-acid type conveniently removes the phenylhydrazine residue from inosose phenylhydrazones. The liberated phenylhydrazone combines with the resin, obviating an extraction process. The yields of inosose are about the same as those obtained by the benzaldehyde exchange reaction.

Inosose phenylosazones are unaffected by the resin, and consequently can be separated from inosose phenylhydrazones.

9706. Fearn, J. E., Brown, D. W., Wall, L. A., **Polymers and telomers of perfluoro-1,4-pentadiene,** *J. Polymer Sci.* **4,** Pt. A-1, 131-140 (Jan. 1966).

Key words: Dechlorination; gamma ray initiation; pentadiene; polymerized; pressure; 3,5,6-trichloro-octafluorohexanoic.

Perfluoro-1,4-pentadiene was prepared from 3,5,6-trichlorooctafluorohexanoic acid by pyrolysis and subsequent dechlorination with zinc in a high-boiling ether. This process also yielded three isomers of chloroheptafluoro-1,4-pentadiene. Polymerization studies showed that the monomer yielded rubbery samples, powdery samples, oils, and at least four dimers. There was also strong evidence that the 1,4-diene is converted into the 1,3-diene under conditions of polymerization.

9707. Fehsenfeld, F. C., Schmeltekopf, A. L., Goldan, P. D., Schiff, H. I., Ferguson, E. E., **Thermal energy ion-neutral reaction rates. I. Some reactions of helium ions,** *J. Chem. Phys.* **44,** No. 11, 4087-4094 (June 1, 1966).

Key words: Helium ions; ion-neutral; ions, helium; reaction rates; thermal energy.

A flowing, steady-state afterglow system has been utilized to measure room-temperature ion-neutral reaction rates. A description of the apparatus and technique is given. Measured rate constants for He^+ reactions with O_2, N_2, CO, NO, and CO_2 are reported, as well as upper limits for the reactions of He^+ with H_2, Ne, and Ar, and an estimate for the reaction of He_2^+ with Ne and N_2.

The reactions of He^+ with O_2, N_2, CO, NO, and CO_2 are all rapid, the rate constants all being $\approx 10^{-9}$ cm^3 sec^{-1}, implying essentially a reaction per collision.

9708. Feldman, A., **Piezo-optical effects in solids by sample rotation,** *Physics Letters* **23,** No. 11, 627-628 (Dec. 1966).

Key words: Modulation technique; optical; piezo-optical; semiconductor; silicon; strontium titanate.

The differential absorption and reflection coefficients of uniaxially stressed Si and $SrTiO_3$ were determined by rotating the samples in a linearly polarized light beam.

9709. Fetters, L. J., Pummer, W. J., Wall, L. A., **Monomer-polymer equilibria of deuterated α-methylstyrenes,** *J. Polymer Sci.* Pt. A-1, **4,** No. 12, 3003-3011 (Dec. 1966).

Key words: Anionic polymerization; heats and entropies of the polymerizations of deuterated α-methylstyrenes.

The equilibria between α-trideuteromethyl-β,β-dideuterostyrene, α-methyl-2,3,4,5,6-pentadeuterostyrene, and perdeutero-α-methylstyrene and their respective polymeric anions in tetrahydrofuran have been investigated between 253 and 308 °K. The heat and entropy changes were both increased by deuteration of the alkyl group. Qualitatively the effect observed appears best explained by the premise that a lowering of steric repulsions occurs with deuterium and hence the effective volume for deuterium is less than that for hydrogen.

9710. Fey, L., Barnes, J. A., Allan, D. W., **An analysis of low information rate time control unit,** *Proc. 20th Annual Symp. Frequency Control, Atlantic City, New Jersey, April 19-21, 1966,* pp. 629-635 (1966).

Key words: Flicker noise; meteor burst; multi-loop servo; oscillator correction; time synchronization; VLF propagation.

Computer simulation has been used to study the feasibility of producing a synchronized time station requiring minimum attention to operate.

The device simulated consists of a multiloop servo system to correct the output phase of a quartz crystal and to simultaneously compensate for the linear frequency drift common to these oscillators. Upon the occurrence of occasional phase comparison, such as propagated from VLF transmission during the time of day when propagation conditions are most stable, the servo incorporates a resulting phase correction and establishes a new linear frequency drift compensation rate based on the past history of the oscillator—allowing extrapolation of the phase of the reference signal until the next phase comparison occurs. This in effect results in a remote, phase locked system operating automatically with an intermittant reference.

The effect on such a system of flicker noise modulation, the characteristic type of noise associated with quartz crystal oscillators in the domain of interest is treated, along with servo system time constant considerations.

The use of such a system is discussed in relation to applications such as unmanned standard time and frequency stations, meteor burst synchronization, and the operation of atomic time scales with intermittant frequency calibrations. From available data, one anticipates a synchronization precision of 1 microsecond at stations as remote as 1,500 kilometers using the meteor burst technique. The system would be both low in initial cost and in operation.

9711. Fey, L., Looney, C. H., **A dual frequency VLF timing system,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 190-195 (Dec. 1966).

Key words: Multiple VLF transmissions; portable clock; standard time broadcasts; VLF propagation; worldwide clock synchronization.

The use of high precision portable clocks and radio signals is discussed in relation to synchronization of remotely located clocks. The demonstrated inherent phase stability, approximately two μs rms, of very low frequency (VLF) propagation and its low attenuation rate with distance, have led to various approaches to exploit these virtues in timing applications. The system considered here employs two carrier frequencies with timing information contained in their difference frequency to permit indentification of a specific cycle of one of the carrier frequencies. Such a system makes stringent demands on phase stabilities of the transmitted signals and of the receiving system as well as that of the propagation medium itself.

The present system, whose development has been supported jointly by NBS and NASA, makes use of NBS radio station WWVL at Fort Collins, Colorado. Receivers are of the standard VLF phase tracking servo type. A special signal generator is used in conjunction with the local clock to simulate the transmitted signal in order to relate the local time scale to that at the transmitter.

One of the carrier frequencies is maintained at 20 kHz. With a second frequency (500 Hz removed from this frequency), carrier cycle identification was achieved on about 90 percent of the days for over a month on the path from Fort Collins, Colorado, to Greenbelt, Maryland. Since January 4, 1966, the difference frequency has been 100 Hz, with somewhat more fluctuation in results. However, lower precision is required for the initial synchronization. The results of averaging to improve this performance will be discussed.

9712. Fitzgerrell, R. G., **Swept-frequency antenna gain measurements,** *IEEE Trans. Ant. Prop.* **AP-14,** No. 2, 173-178 (Mar. 1966).

Key words: Antenna gain; frequency measurement; standard antenna; swept-frequency.

This paper presents a method of making a swept-frequency antenna gain measurement which yields a result based upon the known frequency of a standard antenna. This antenna consists of a 295-mm length of X-band waveguide with a cover flange on one end. It is an inexpensive and very satisfactory gain standard. The error analysis, which gives the accuracy of the resulting gain figure, consists of evaluating the conjugate mismatch losses at the antenna feed point or junction. This method of measuring gain is shown to yield useful gain data from an antenna test range that is not free of reflections. Gain vs. frequency curves are given for the standard gain antenna and a test antenna, having estimated accuracies of at least 0.27 dB and 1.00 dB, respectively.

9713. Flynn, J. H., Wall, L. A., **A quick direct method for the determination of activation energy from thermogravimetric data,** *Polymer Letters* **4B,** No. 5, 323-328 (May 1966).

Key words: Activation energy; applied kinetic analysis; determination of kinetic parameters; non-isothermal kinetics; thermogravimetric variation of heating rates.

A quick simple method for determining energy of activation from thermogravimetric weight-loss vs. temperature data at two or more constant heating rates is presented. The activation energy is accurately obtained from the slope of a logarithm heating rate vs. reciprocal absolute temperature plot at constant degree of conversion. The independence of activation energy from degree of conversion and temperature may be tested by determining it at various values of constant weight loss.

9714. Flynn, T. M., **Liquid hydrogen engineering instrumentation,** (Proc. Intern. Inst. Refrigeration, June 9-11, 1965), *Book, Liquid Hydrogen,* pp. 295-338 (Paris, France 1965).

Key words: Cryogenic liquid; engineering and instrumentation; hydrogen; liquid hydrogen; liquid level; measurement of pressure.

Prudent liquid hydrogen engineering requires the measurement of both extensive and intensive properties of the cryogenic liquid. Transducers are required for liquid level (quantity), both point and continuous systems, and mass rate systems. In addition, there must be transducers of pressure, temperature, density, and occasionally, quality. This paper discusses some of the devices and practices currently used for the measurement of pressure, temperature, flow rate, and liquid level in liquid hydrogen systems.

9715. Flynn, T. M., Timmerhaus, K. D., **Superconducting devices,** (Proc. Inst. Refrigeration, Comm 1, Boulder, Colo., June 15-17, 1966, Annexe 1966-5), *Book, Liquid Helium Technology,* pp. 23-29 (Paris, France 1967).

Key words: Bearings; bolometer; electron microscope; helium; hydrogen; level gauging; liquid level; magnet; motor; pump; rectifier; solenoid; superconductivity; switch; temperature; thermometer.

Superconductors may be treated as engineering materials having three unusual properties: (1) a transition occurs between two different states which depends upon external parameters, (2) zero resistivity is exhibited in one state, and (3) perfect diamagnetism is exhibited.

This paper views superconductors in this way, as engineering materials, and examines applications of these properties. Examples include applications of superconductors to thermometry, bolometry, level gauging, rectifiers, magnets (briefly), bearings, motors, electron microscope lenses, and a helium pump.

9716. Forman, R. A., **Nuclear magnetic resonance of nitrogen-14 in potassium azide,** *J. Chem. Phys.* **45,** No. 4, 1118-1123 (Aug. 1966).

Key words: Azides; nitrogen; nuclear magnetic resonance; nuclear quadrupole.

The nuclear magnetic resonance of ^{14}N split by large quadrupole interactions has been observed in single crystals of potassium azide (KN_3). The observed spectrum at arbitrary orientation consists of eight resonance lines, which can be decomposed into two groups of four lines each. The resonances in each group are of the same apparent intensity, and one group is twice as intense as the other. The quadrupole coupling constants and asymmetry parameters of the two inequivalent nitrogens have been obtained from a rotation study. For the end nitrogen $e^2qQ/h = 1.79\pm0.03$ MHz with $\eta = 0.04\pm0.02$. For the central nitrogen $e^2qQ/h = 1.028\pm0.03$ MHz with $\eta = 0.03\pm0.02$. Unsuccessful attempts were also made to observe the pure quadrupole resonance of the end nitrogens.

9717. Forman, R. A., Kahn, A. H., **Line shapes due to anisotropic interactions in magnetic resonance experiments,** *J. Chem. Phys.* **45,** No. 12, 4586-4588 (Dec. 1966).

Key words: Anisotropic interactions; computer calculations; line shapes; magnetic resonance.

Magnetic resonance line shapes resulting from anisotropic interactions of the form $a_p(3\cos^2\theta - 1)$ have been calculated. Typical shapes are displayed. Of particular importance is the presence of a reasonably strong resonance peak occurring in the absorption derivative at the position of the step ($\theta = 0°$) in the absorption curve.

9718. Forman, R. A., McKneely, T., **A cooling system for a laboratory magnet,** *Appl. Spectry.* **20,** 189 (May-June 1966).

Key words: Closed water system; magnetic field stability; NMR; temperature fluctuation.

The cooling system is described for use with a 5 kW magnet system which enables one to obtain high electrical and thermal stability.

9719. Foster, D. E., **Chemical admixtures,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **169A,** Significance of Tests of Concrete and Concrete Making Materials, 356-564 (1966).

Key words: Accelerating concrete admixtures; concrete admixtures; set-retarding; water-retarding.

A description of the water-reducing, set-retarding, and accelerating concrete admixtures commonly used in the United States is given, together with their effects on freshly mixed and hardened concrete. The problems encountered in writing specifications for these products are discussed from the standpoint of the tests required, and the statistical problems involved in comparing treated with untreated concrete.

9720. Fowler, B. O., Moreno, E. C., Brown, W. E., **Infrared spectra of hydroxyapatite, octacalcium phosphate and pyrolyzed octacalcium phosphate,** *Arch. Oral Biol.* **11,** 477-492 (May 1966).

Key words: Infrared spectra of calcium phosphate; pyrolyzed octacalcium phosphate.

Infrared spectra of hydroxyapatite, octacalcium phosphate, and pyrolyzed octacalcium phosphate were studied in the range 4,000 to 400 cm^{-1}, and probable band assignments are given. Unreported bands were found for both octacalcium phosphate (13 bands) and hydroxyapatite (5 bands); the hydroxyapatite band at 631 cm^{-1} was reassigned to the librational mode of the hydroxyl group.

The pyrolysis reactions of octacalcium phosphate were studied by IR absorption, weight loss, and pyrophosphate analysis. The major products between 325 and 600 °C were hydroxyapatite and $\beta-Ca_2P_2O_7$ and $\beta-Ca_3(PO_4)_2$. Simple dehydration was continuous from 50 to about 400 °C. Formation of $\beta-Ca_2P_2O_7$, instead of $\gamma-Ca_2P_2O_7$, was detected at a lower temperature (325 °C) than has been reported. The maximum amount of pyrophosphate formed, about 40% at 500 °C, was intermediate between the amounts predicted by reactions postulated in other studies. From 700 to 900 °C, the pyrophosphate content approximated the expected values.

9721. Fowler, H. A., Erginsoy, C., **Is proton channeling a diffraction process?** *Physics Letters* **24A,** No. 7, 390-391 (Mar. 27, 1967).

Key words: Channeling; diffraction; energy loss; protons; stopping power.

Some stopping-power limitations are suggested on a dynamical-diffraction model of proton channeling at 1-5 MeV.

9722. Fowler, H. A., Marton, L. L., **Widths of Kikuchi lines in germanium,** *J. Appl. Phys.* **38,** No. 4, 1735-1738 (Mar. 15, 1967).

Key words: Cross-section; electron diffraction; electron scattering; germanium; Kikuchi lines.

Transmission Kikuchi patterns at 80 keV from wedges of germanium have been measured with high angular resolution. Linewidths are compared with the Fourier potential calculated from a simple coherent-elastic-amplitude model. Germanium shows a higher experimental curve of scattering amplitude per unit cell volume than silicon, as may be expected from its greater atomic scattering potential. Suppressed contrast is found for the (111) reflection; this is interpreted as an overlap between the halves of the line-pair or band.

9723. Frederikse, H. P. R., Hosler, W. R., Thurber, W. R., **Experimental evidence concerning the conduction band of $SrTiO_3$,** (Proc. Intern. Conf. Physics of Semiconductors, Kyoto, Japan, Sept. 8-13, 1966), *J. Phys. Soc. Japan* **Suppl. 21,** 32-36 (1966).

Key words: Band structure; effective mass; electronic transport properties; semiconductor; strontium titanate.

Experimental information about the conduction band of semiconducting $SrTiO_3$ is compared with the calculated band structure. Measurements of transport properties, magnetic susceptibility and plasma frequency yield rather high average effective masses. Low-field magnetoresistance as well as piezoresistance experiments have been performed on $SrTiO_3$. Although some disagreement remains, the weight of the evidence is in favor of a many-valley structure of the lowest conduction band as predicted by theory.

9724. Frederikse, H. P. R., Hosler, W. R., Thurber, W. R., **Magnetoresistance of semiconducting $SrTiO_3$,** *Phys. Rev.* **143,** No. 2, 648-651 (Mar. 1966).

Key words: Energy band structure; magnetoresistance; semiconductor; strontium titanate.

The magnetoresistance of reduced and doped $SrTiO_3$ was measured at 4.2 °K in fields up to 8000 Oe. The effect was studied for directions of primary current and magnetic field along the major crystalline axes. Results are in agreement with the theoretical prediction of 3 (or 6) energy minima on the $\langle 100 \rangle$ axes. Assuming an isotropic collision time, the effective-mass ratio is either 4.0 or 0.34.

9725. Frederikse, H. P. R., Hosler, W. R., Thurber, W. R., Babiskin, J., Siebenmann, P. G., **Shubnikov—de Haas effect in $SrTiO_3$,** *Phys. Rev.* **158,** No. 3, 775-778 (June 15, 1967).

Key words: Band structure; high magnetic field; oscillatory magnetoresistance; Shubnikov—de Haas effect; strontium titanate.

The magnetoresistance of semiconducting $SrTiO_3$ has been investigated in high magnetic fields (up to 150 kOe). In the temperature range 1.4 to 2.1 °K, for fields or more than 50 kOe, well-developed Shubnikov—de Haas-type oscillations have been observed. The data support a conduction band consisting of spheroids along the $\langle 100 \rangle$ crystalline axes, having 3 minima at the points X_3. The periods of oscillation as well as the temperature dependence of the amplitude and the magnetic field saturation lead to the following values for the transverse and longitudinal effective masses: $m_t = 1.5 m_0 \pm 15\%$; $m_l = 6.0 m_0 \pm 30\%$.

9726. Frederikse, H. P. R., Schooley, J. F., Thurber, W. R., Pfeiffer, E., Hosler, W. R., **Superconductivity in ceramic, mixed titanates,** *Phys. Rev. Letters* **16,** No. 13, 579-581 (Mar. 28, 1966).

Key words: Ceramic; ferroelectric; mixed compounds; semiconductors; superconductivity; titanates.

Superconductivity has been observed in slightly reduced, ceramic samples of $(Ba_xSr_{1-x})TiO_3$ and $(Ca_ySr_{1-y})TiO_3$ for $x \leqq 0.10$ and $y \leqq 0.3$. Some of the insulating compounds are ferroelectrics; reduced specimens are semiconductors. The superconducting transition temperatures reach higher values (0.55 °K) than that of reduced $SrTiO_3$. A connection with the high static dielectric constants of the (unreduced) titanates is suggested.

9727. French, J. L., **Discussion of the paper "Flow in culverts and related design philosophies,"** *J. Hydraulics Div. Am. Soc. Civil Eng.* **93,** No. Hy 1, 85-91 (Jan. 1967).

Key words: Culverts; hood inlets; hydraulics; tapered inlets.

An evaluation is made of certain conclusions advanced in a paper by Fred W. Blaisdell. The paper, entitled "Flow In Culverts And Related Design Philosophies" appeared in the Journal of the Hydraulics Division, American Society of Civil Engineers, March 1966. The present paper will form a discussion of Mr. Blaisdell's paper and will appear in a subsequent issue of the same publication.

The present discussion of Mr. Blaisdell's paper illustrates the use of tapered inlets in the design of culverts. The use of a minimum performance curve in the design of culverts is concluded to be acceptable, notwithstanding certain reservations advanced by Mr. Blaisdell. The concept of "balanced design" as applied to culverts is discussed in terms of the assessment of the risks of hydraulic overloading to the various component parts of the structure and it is concluded that the design rate of flow for the culvert and a structure or channel immediately downstream of the culvert need not be identical. And finally it was suggested that the experimental data so far presented have not demonstrated beyond reasonable question that the performance assigned to the hood inlet is applicable at prototype size as well as at model size.

9728. Frenkel, L., Kryder, S. J., Maryott, A. A., **Debye relaxation in symmetric-top-foreign-gas mixtures; temperature dependence of collision cross sections,** *J. Chem. Phys.* **44,** No. 7, 2610-2619 (Apr. 1, 1966).

Key words: Collision cross sections; Debye relaxation; foreign-gas mixtures; gas mixtures; relaxation-rate parameters.

The Debye relaxation spectra of three symmetric-top gases CH_3Cl, CHF_3, and SO_2F_2, in the pure state and in dilute mixtures with the foreign gases, He, H_2, D_2, Ar, N_2, CH_4, CO_2, and C_3F_8, were obtained over the temperature range −20° to 145 °C at a frequency of 1220 MHz. Relaxation-rate parameters and the corresponding collision cross sections are derived. The cross sections vary with the absolute temperature as T^{-m}, where the value of m ranges from 0.3 to 0.9 for the different systems. The cross sections are considered from a classical kinetic viewpoint and an empirical relation is obtained which accurately relates the dielectric cross section to the effective viscosity cross section (or the corresponding Lennard-Jones parameters), the internal-to-orbital-angular-momentum ratio, and one additional parameter related in some way to the shape (prolateness or oblateness) of the top. Deviations in the shape of these spectra from the simple Debye form, which are attributable to a distribution of relaxation rates, are examined in some detail and correlated with the effective collision number.

9729. Frenkiel, F. N., Klebanoff, P. S., **Higher-order correlations in a turbulent field,** *Phys. Fluids* **10,** No. 3, 507-520 (Mar. 1967).

Key words: Acoustic noise; air or water flow; atmospheric and oceanographic turbulence; boundary layer turbulence; higher-order correlations; physical origin; random processes of physical origin; turbulent field.

Higher-order time-correlations and the associated skewnesses and flatnesses were measured in a turbulent field downstream of a grid using high-speed computing techniques. The results were obtained using samples of 160 020 digitized data recorded at time intervals of 1/12 800 sec during time periods of approximately 12.5 sec. Comparison is made between the measured correlations and the higher-order correlation curves corresponding to a Gaussian probability density distribution of turbulent velocities. The departures from Gaussianity are shown, and non-Gaussian probability distributions are proposed which correspond considerably better to experimental reality. Several relations between correlation coefficients of different orders are obtained for the non-Gaussian probability distributions and confirmed by comparison with the measured correlations, skewnesses, and flatnesses.

9730. Frenkiel, F. N., Klebanoff, P. S., **Space-time correlations in turbulence,** (Proc. Symp. Dynamics of Fluids and Plasma, University of Maryland, College Park, Md., Oct. 7-9, 1965), *Book, Dynamics of Fluids and Plasma,* Ed. S. Pai et al., pp. 257-274 (Academic Press Inc., New York, N.Y., 1966).

Key words: Computer; correlations: even-order, odd-order, space-time; hot-wire anemometer; Taylor's approximation; turbulence; wind tunnel.

Space-time correlations of the component of turbulent velocities along the direction of mean velocity were measured in a turbulent field downstream of a grid using high-speed computing techniques. These results provide new information in that the space-time evaluation is carried out to much higher orders than had previously been measured. Space-time correlations of even order up to the eighth, and of odd order up to the fifth are presented. The applicability of Taylor's space-time approximation, i.e. the concept of a frozen pattern of turbulence moving with the mean velocity, to these higher order correlations is examined. The higher even-order correlations are compared with the results obtained from the second-order correlations assuming a Gaussian distribution for the turbulent velocities, and the different behavior of the various odd-order correlations is demonstrated.

9731. Fuller, E. G., **Photoneutron reactions,** (Proc. Intern. Conf. Study of Nuclear Structure with Neutrons, Antwerp, Belgium, July 14-23, 1965), *Book, Nuclear Structure Study with Neutrons,* Ed. M. Neve de Mevergnies, P. VanAssche, and J. Vervier, pp. 359-375 (North Holland Publ. Co., Amsterdam, The Netherlands, 1966).

Key words: Cross sections; photoneutron angular distributions; photoneutrons; photoneutron spectra.

The papers on Photoneutron Reactions submitted to the International Conference on the Study of Nuclear Structure with Neutrons are discussed in the context of a general review of this field.

9732. Garfinkel, S. B., Baerg, A. P., Zigman, P. E., **Certificates of radioactivity standards,** Report of the Subcommittee on the Use of Radioactivity Standards, *Natl. Acad. Sci.-Natl. Res. Council,* pp. 1-11 (Washington, D.C., Dec. 1966).

Key words: Certificates; combination of errors; commercial standards; measurements; precision; radioactivity standards; standards accuracy.

Recommendations for certificates of standards of radioactivity are presented. It is hoped that commercial producers of such standards in the United States of America will use these recommendations in the preparation of certificates which they supply with their standards.

9733. Garfinkel, S. B., Hutchinson, J. M. R., **The standardization of Co^{57},** *Intern. J. Appl. Radiation Isotopes* **17,** No. 10, 587-593 (Oct. 1966).

Key words: Cobalt-57; coincidence counting; radioactivity standardization.

A new method is described for standardizing radioactive cobalt-57 for total disintegration rate. Systematic errors due to maximum uncertainties in the decay scheme are estimated to be less than 0.6%.

9734. Garvin, D., Rosenstock, H. M., **Two National Bureau of Standards data centers—chemical kinetics and mass spectrometry,** *J. Chem. Doc.* 7, No. 1, 31-34 (Feb. 1967).

Key words: Chemical kinetics; information retrieval; mass spectrometry.

Two current information retrieval centers, one for chemical kinetics, the other for mass spectrometry are described. The methods and philosophies of operation of these programs are compared. The role of specialized information systems in promoting data evaluation, the evaluation of their usefulness as sources for reference material, the choice of techniques, and possibilities for intercenter coordination are discussed.

9735. Geil, G. W., **Some effects of notch geometry on tensile behavior of annealed type 310 stainless steel,** *J. Mater.* **1,** No. 3, 583-608 (Sept. 1966).

Key words: Fracture; initial cracking; multiaxial stresses; notch geometry; 310 stainless steel; stress concentrations; tensile deformation; workhardening.

A study was made of the influence of notch geometry (angle, depth and root radius) on the tensile deformation and fracture characteristics of circumferentially notched cylindrical tensile specimens of annealed 310 stainless steel at ambient temperatures. Specimens with a root radius of 0.05 inch or less and theoretical stress concentration factors of 1.6 or greater, regardless of notch angle or depth, exhibited cracking at small plastic strains. These strains were generally much smaller than the strains at maximum load. The cracking slowly increased in depth in a discontinuous manner with increase in applied stress and extension of the specimen until a condition of plastic instability was reached, resulting in a final rapid fracture of the specimen. Notched specimens with a root radius of 0.10 inch or greater, and theoretical stress concentration factors less than 1.6 did not exhibit any cracking at the root of the notch prior to the final rapid fracture.

9736. Geist, J., Kneissl, G. J., Weidner, V. R., **High purity powdered CsI as a high reflectance infrared diffuser,** *Appl. Opt.* **6,** No. 7, 1280-1281 (July 1967).

Key words: Body scatterer; cesium diode; diffuse reflector; powdered iodide; sulfur.

The spectral reflectance of powdered CsI is compared with that of flowers of sulfur between 2.5μm and 20μm. The experimental procedure is described and room temperature data are presented. The reflectance of ultra pure powdered CsI was found to be appreciably higher than that of the flowers of sulfur beyond 7μm.

9737. Geltman, S., Takayanagai, K., **Excitation of molecular rotation by slow electrons II,** *Phys. Rev.* **143,** No. 1, 25-30 (Mar. 1966).

Key words: Electrons; electron spin; modular rotation; nonvanishing electron spin; rotational excitation; slow electrons.

A previous study is here extended to consider the effects on rotational excitation of the nonvanishing electronic spin of O_2 and the short range static fields of the H_2, N_2, and O_2 molecules. The spin effect is found to be negligible, while the effect of short range interactions can be quite large in certain energy regions. This permits a qualitative explanation of the heretofore unexplained ratio of the observed electron relaxation rates in oxygen and nitrogen.

9738. Goebel, D. G., **Generalized integrating-sphere theory,** *Appl. Opt.* **6,** No. 1, 125-128 (Jan. 1967).

Key words: Absolute reflectance techniques; general equation; hemispherical reflectance measurements; integrating-sphere theory.

A general equation is developed for the efficiency of an integrating sphere with a nonuniform coating. The only assumptions are that the interior is a perfect sphere and that all areas reflect perfectly diffusely. Three special cases of the general equation are examined for the basic applications of integrating spheres as mixing mechanisms in hemispherical reflectance measurements and in absolute reflectance techniques.

9739. Gerstenberg, H., O'Connell, J. S., **Three-body photodisintegration of He^3,** *Phys. Rev.* **144,** No. 3, 834-838 (Apr. 22, 1966).

Key words: Bremsstrahlung; cross section; cryostat; helium-3; helium-4; neutrons; photodisintegration.

The $He^3(\gamma,n)2p$ cross section has been measured in 1-MeV steps from threshold to 30 MeV using the National Bureau of Standards betatron and a He^4 cryostat to produce a 40-cm^3 liquid-He^3 target. The measured cross section shows a broad peak between 14 and 20 MeV with a maximum cross section at about 0.90 mb. The cross section and bremsstrahlung-weighted cross section integrated up to 28 MeV give 12.1±10% MeV mb and 0.68±10% mb, respectively. Theoretical calculations of the three-body photodisintegration cross section overestimate the experimental cross section by factors of 3 to 10.

9740. Giarratano, P. J., Smith, R. V., **Comparative study of forced convection boiling heat transfer correlations for cryogenic fluids,** (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Texas, Aug. 23-25, 1965), *Book, Advances in Cryogenic Engineering* **11,** 492-506 (Plenum Press Inc., New York, N.Y., 1966).

Key words: Boiling; cryogenic; film; forced convection; hydrogen; nitrogen; nucleate.

This study compares predictive reliability of several common forced convection boiling heat transfer correlations using available cryogenic experimental data. A statistical method is used to compare the correlations and results indicate that none of the proposed predictive methods fall in a very respectable range of reliability and, furthermore, for design purposes, the simpler correlations seem to compare favorably with the more complex approaches.

9741. Gillilland, K. E., Cook, H. D., Mielenz, K. D., Stephens, R. B., **Use of a laser for length measurement by fringe counting,** *Metrologia* **2,** No. 3, 95-98 (July 1966).

Key words: Automatic fringe counting interferometer; fringe counting; interferometer; laser for length measurement; length measurement.

The use of a 633-nm He-Ne laser of normal neon isotopic abundance as a light source for an automatic fringe counting interferometer was found to improve the counting precision and extend the usefulness of the interferometer to the full one meter limit of its carriage travel.

A 91-mm length was measured in terms of Hg^{198} and laser fringes. From the fringe counts obtained and the wavelength of the Hg^{198} line, the laser vacuum wavelength was measured to be 632.991 46 nm with a standard error of 1.1×10^{-7}. With the laser wavelength so determined, each decimeter interval of a one meter line standard was measured by counting laser fringes. All measured decimeter interval lengths agreed with the assigned values within the mutual limits of uncertainty, the largest discrepancy being less than 0.5 um.

The result obtained for the total length of the line standard agreed with the assigned length of the line standard to 7 parts in 10^8, which is well within the mutual limits of uncertainty.

This method is being applied to routine calibration of line standards using a stabilized isotopic He-Ne laser.

9742. Glaser, E., Rosenblatt, D., Wood, M. K., **The design of a Federal statistical data center,** *Am. Stat.* **21,** No. 1, 12-20 (Feb. 1967).

Key words: Automatic data processing equipment; disaggregation; Federal statistical system; inherent computability; matching; probability master samples; propagation of error computations; statistical standards.

This paper treats the principle underlying the design of a Federal statistical data center intended to provide a better integrated information network for use by Government, industry, and the research community in an age of large-scale computers.

9743. Glass, S. J., Chappell, W. R., **The interaction of radiation with charged particles. II. Dispersion relation for transverse modes,** *Il Nuovo Cimento* **38,** No. 1, 79-88 (Mar. 1966).

Key words: Charged particles; dispersion relation; equation of motion; radiation; transverse excitation.

Quasiphotons are introduced and an equation of motion method is used to obtain a dispersion relation for transverse excitations for a system of electrons interacting with radiation.

9744. Goebel, D. G., Caldwell, B. P., Hammond, H. K. III, **Use of an auxiliary sphere with a spectrophotometer to obtain absolute reflectance,** *J. Opt. Soc. Am.* **56,** No. 6, 783-788 (June 1966).

Key words: Absolute; reflectance; spectral.

Reflectance measurements that are made on a scale that is not relative to an arbitrary standard are often called "absolute" measurements. The method presented here uses an auxiliary sphere with a double-beam integrating-sphere spectrophotometer to make measurements on an absolute basis. The basic requirements are: (1) The auxiliary sphere must be uniformly coated with a highly-reflecting, highly-diffusing material. (2) A flat plate must be coated in an identical manner to provide a measure of the coating reflectance. (3) The interior-surface area of the sphere and the area of the entrance port must be measured.

The theory of the method is discussed and an error analysis is made. Reflectance data are reported for specimens of smoked MgO and pressed powders of MgO and $BaSO_4$.

The precision of repeatability has been evaluated from measurements of a Vitrolite-reference standard. More than a dozen measurements at each of eight wavelengths made over a 3-year period exhibited a standard deviation of 0.003 for the spectral reflectance.

9745. Goldberg, K., **Hadamard matrices of order cube plus one,** *Proc. Am. Math. Soc.* **17,** No. 3, 744-746 (June 1966).

Key words: Block designs; Hadamard matrices; incidence matrices.

If H is an Hadamard matrix of order h, with the property that $H+H^T = 2I$, then there exists an Hadamard matrix of order $(h-1)^3+1$ with the same property.

9746. Goldman, D. T., **Reactor physics in the resonance and thermal regions,** *J. Franklin Inst.* **283,** No. 5, 437-438 (May 1967).

Key words: Absorption; neutron; reactor; resonance; thermalization.

A review of papers presented at a topic conference of the American Nuclear Society.

9747. Goldman, D. T., **The calculation of nuclear cross-sections by the optical model,** (Proc. Intern. Atomic Energy Agency Conf. Nuclear Data for Reactors, Vienna, Austria, 1966), *Book, Nuclear Data for Reactors* **1,** 339-364 (1967).

Key words: Calculations; cross-section; neutron; nuclear cross-sections; nucleus; optical model scattering.

It is well recognized that there will always be limitations to the amount and certainty of microscopic nuclear cross-section data which are available for direct input into reactor design calculations. Therefore, scattering models for the interaction between incident nucleons and the target nucleus have been proposed and used to obtain appropriated values of necessary cross-sections, both where experimental data are lacking and to differentiate between conflicting data. The generic term for such computations is conveniently "optical model calculations" wherein the two-body internucleon potential is replaced by effective nuclear potential.

This paper presents a systematic derivation of nuclear cross-sections beginning with the interaction between an incident particle and the target nucleons. The replacement of the exact potential by an effective potential results, to first order, in the ordinary time-independent Schrödinger equation. This equation, including a complex and spin-orbit potential is solved for the resultant wave function. By writing the wave function in its scattering solution form, it is possible to compute the shape elastic cross-section and the polarization directly in Legendre moment expansions. The compound nucleus cross-section, as given originally by the statistical model of Hauser and Feshbach, arises naturally by examining the total wave function. By using the entire solution, including the complete interaction potential, it is possible to generalize these calculations to include the effect of non-spherical potentials and to derive the distorted wave Born approximation. The equations derived in this manner have been used in writing ABACUS-1 and OPTIC, two widely utilized optical model programmes developed by colleagues and the author at Knolls Atomic Power Laboratory. The results obtained from calculations with suitably adjusted potential parameters, have provided confidence for further use of these optical model techniques in providing cross-section information.

9748. Gorden, R., Jr., Ausloos, P., **Gas-phase photolysis and radiolysis of methane. Formation of hydrogen and ethylene,** *J. Chem. Phys.* **46,** No. 12, 4823-4834 (June 15, 1967).

Key words: Free radical reactions; ion-molecule reactions; photolysis; radiolysis.

The photolysis of CH_4 and of CH_4-CD_4 mixtures has been investigated at 1236 Å (10.0 eV) and at 1048-67 Å (11.6−11.8 eV). The excited methane molecule dissociates to form H_2, H, CH_3, CH_2, CH, and probably also C. The CH and CH_2 radicals insert into methane to form internally excited C_2H_5 and C_2H_6 species, respectively. Below one atmosphere, all C_2H_5 radicals decompose to form C_2H_4, while the ethane molecules are partially stabilized. The relative quantum yield of CH increases about threefold when the wavelength is reduced from 1236 Å to 1048-67 Å. On the basis of an isotopic analysis of the hydrogen produced in the photolysis of CD_4-H_2S mixtures, it is concluded that at 1236 Å, D-atoms constitute at least 65% of the "molecular" deuterium yield.

In the radiolysis, ethylene is largely, although not exclusively formed by the insertion of CH into methane. It is demonstrated that addition of small concentrations of an unsaturated hydrocarbon to methane profoundly affects the ion-molecule reaction mechanism and, therefore, does not lead to a dependable value of the "initial" ethylene yield as suggested in earlier studies. Upon application of an electrical field, the production of CH and CH_2 is augmented in the saturation current region. The importance of the latter two radicals in the direct and rare-gas-sensitized radiolysis is examined briefly. The formation of hydrogen in the radiolysis will be discussed on the basis of new information derived from CD_4-H_2S experiments. The production of hydrogen in the radiolysis of $Xe-CH_4-CD_4-NO$ mixtures has also been reexamined in view of a recent study in which it was asserted that all of the hydrogen in such a mixture is due to the unimolecular decomposition process

$$CH_4 \rightarrow CH_2 + H_2.$$

Our data disagree with this view and actually demonstrate that CH and CH_2 play a minor role in the xenon-sensitized radiolysis of methane.

9749. Gorden, R., Jr., Doepker, R., Ausloos, P., **Photoionization of propylene at 1236 Å reactions of $C_3D_6^+$ with added alkanes,** *J. Chem. Phys.* **44,** No. 10, 3733-3740 (May 1966).

Key words: H_2^--transfer reactions; hydrocarbons; ion-molecule reaction; photoionization; photolysis; propylene.

$C_3H_6-C_3D_6-O_2$ mixtures have been irradiated at 1236 Å (10 eV) in the presence and absence of an applied electrical field with the purpose of obtaining information about the ion-molecule reaction mechanism. On the basis of a number of observations, it was calculated that the product, propane, can be ascribed to the reaction $C_{3m}H_{6m}{}^+ + C_3H_6 \rightarrow C_{3m}H_{6m-2}{}^+ + C_3H_8$, ($m>2$). When alkanes ($RH_2$) whose ionization energy is less than 10 eV are added to $C_3D_6-O_2$ mixtures, the following H_2^--transfer reaction occurs: $C_3D_6^+ + RH_2 \rightarrow CD_3CDHCD_2H + R^+$. Relative rates of the reaction of $C_3D_6^+$ with various alkanes have been determined and compare favorably with values obtained in a recent radiolytic study in which cyclopentane-d_1 was used as a source of $C_3D_6^+$ ions.

The optimum experimental conditions, under which meaningful saturation ion currents can be obtained in the photoionization apparatus, are described. On the basis of measurements of the saturation ion current in NO and propylene at 1236 Å, values of 0.197 and 0.208 were obtained for the photoionization efficiencies of C_3H_6 and C_3D_6, respectively. The latter measurements made it possible to express the products in the number of molecules formed per ion pair as well as in the number of molecules formed per quantum absorbed.

9750. Gordon, G. S., **A new service by NBS. An aid in making the Bureau's technical resources available to private standards organizations, manufacturers, and government agencies,** *Proc. 15th Annual Meeting Standards Engineering Society, Atlantic City, N.J., Sept. 14, 1966,* pp. 73-75 (1966).

Key words: Focal point; OESLA established at NBS; standards-making bodies.

The Office of Engineering Standards Liaison and Analysis was established as a focal point for assistance to standards-making bodies. Its functions will be to catalyze, strengthen existing institutions, identify new areas of technical activity in the standards field, assist the internal technical engineering standards activities at NBS in reaching maximum effectiveness, and build bridges of communication between NBS and both government and non-government groups in national and international standardization. The LaQue Committee in 1965 recognized the need for developing a national standards effort by tying together the efforts of several hundred standards-making organizations and developing the concept of the USA Standards Institute, and recommended expansion of the Bureau's cooperation with industry and USASI in making technical experts available to serve on committees and as delegates to international ISO, IEC, and COPANT meetings.

9751. Gordy, L. H., Harman, G., **The use of semiconductors for the study of boiling heat transfer to low temperature liquids,** *Cryogenics* **7,** 89-92 (Apr. 1, 1967).

Key words: Cryogenic heat transfer; measurements; semiconductors.

It is shown that semiconductors, such as silicon and germanium, can be advantageously used to study boiling heat transfer from solids to low temperature liquids. Measurements can be made quickly and automatically. Widely different types of resistance vs. temperature characteristics can be obtained from these materials and such characteristics can influence the nature of the nucleate to film-boiling transition. Because these materials have large positive temperature coefficients of resistance, the transitions are thermally self-regulating. All heat flux data obtained from such samples lie within normal experimental values.

9752. Gornick, F., Ross, G. S., Frolen, L. J., **Crystal nucleation in polyethylene: The droplet experiment,** *J. Polymer Sci.* Pt. C, **18,** 79-91 (1967).

Key words: Crystallization; homogeneous nucleation; kinetics; microscopy; polyethylene; surface free energy.

The droplet technique was utilized to obtain estimates of the isothermal rate of homogeneous crystal nucleation in highly supercooled melts of unfractionated linear polyethylene. In a typical experiment a cell containing a suspension of several hundred micron-size spherical droplets of the polymer was placed on a microscope hot stage and quenched from a temperature well above the melting point of polyethylene to the desired crystallization temperature. When viewed between crossed polarizers, the droplets were initially invisible but, upon freezing, they appeared as visible birefringent spheres. The time dependence of the process was followed by time-lapse photography. Half times ($\tau 1/2$) for the freezing of those droplets remaining unfrozen by the time the crystallization temperature was attained were thus obtained at a series of undercoolings and related to the desired nucleation rate constant I(nuclei-cm^{-3}-sec^{-1}) by the equation $I = ln2/\tau l/2v$, where v is the droplet volume.

The temperature dependence of I, as obtained by the above procedure, was analyzed in accord with current theories of homogeneous nucleation of chain-folded polymer crystals. From this analysis, an estimate, 14,960 ergs^3 cm^{-6} was made of the quantity ($\sigma^2\sigma_e$), where σ and σ_e are respectively the lateral and end-surface free energies of the crystal.

9753. Grabner, L. H., **Oscillatory photoconductivity and luminescence in $SrTiO_3$,** (Proc. Cairo Solid Sate Conf. American University, Cairo, Egypt, Sept. 3-8, 1966), *Book, Interaction of Radiation with Solids,* Ed. A. Bishay, pp. 155-160 (Plenum Press Inc., New York, N.Y., 1967).

Key words: Electric field quenching; luminescence; negative resistivity; photoconductivity; strontium titanate.

Photocurrents and luminescence in $SrTiO_3$ oscillate at low temperatures (~4 °K) at a threshold of about 100 volts/cm. Voltage-current curves show negative differential resistance in the region of oscillation. We suggest that these effects are due to the field ionization, into the valence band, of a hole trapped 1 eV from the valence band. The hole is ionized by the local field (~10^6 V/cm) which differs from the externally applied field of 10^2 V/cm because of the high dielectric constant of $SrTiO_3$ (~10^4) at low temperatures.

9754. Gray, J. E., Bussey, H. E., **Instrumentation and measurements,** *Book, 1965 Digest of Literature on Dielectrics* **29,** Chapt. I, pp. 1-25 (Publ. 1461, Nat. Acad. Sci.-Natl. Res. Council, Washington, D.C., 1967).

Key words: Dielectric breakdown; dielectric constant; dielectric standards; electrical insulation; instrumentation; measurement; permittivity.

A classified bibliography of abstracts from the literature of instrumentation and measurement applicable to the study of dielectric materials has been prepared for publication as the first chapter of the Digest of Literature on Dielectrics for 1965.

9755. Green, M. S., **Lectures on critical phenomena,** (Proc. Summer School of Theoretical Physics, Cargese, Corsica, Summer 1964), *Book, Cargese Lectures in Theoretical Physics & Statistical Mechanics,* Ed. B. Jancovici, pp. 59-88 (Gordon and Breach Publ., New York, N.Y., 1964).

Key words: Critical phenomena in liquid vapor systems; liquid vapor systems; statistical mechanics; thermodynamics of phase changes.

Some speculative ideas on the theory of critical phenomena in liquid vapor systems are presented. As a background for these fundamental maximum principles of statistical mechanics, thermodynamics of phase changes in the activity temperature plane and sequence of Legendre transformations are discussed. It is suggested that critical phenomena will be simpler when expressed in term distribution functions rather than the potentials and that the critical points correspond to the existence of the zero eigenvalue of the derivative matrix of the transport from potentials of average force to potentials.

9756. Green, M. S., Garcia-Colin, L. S., Chaos, F., **The Chapman-Enskog solution of the generalized Boltzmann equation,** *Physica* **32,** 450 (1966).

Key words: BBGKY hierarchy; Bogolyubov's functional assumption; Chapman-Enskog method; dense gases; transport properties.

The generalization of the Chapman-Enskog method is applied to systems of equations which are obtained when Bogolyubov's functional assumption is introduced into the BBGKY hierarchy. A system of inhomogeneous equations is derived from the solution of which the transport coefficients may be determined.

The kernel of these equations is shown to have different left and right eigenfunctions with zero eigenvalues. The method, while dependent on the Bogolyubov assumption, is independent of the assumption of a power series expansion for the transport coefficients.

9757. Green, M. S., Vincentini-Missoni, M., Sengers, J. M. H. L., **Scaling-law equation of state for gases in the critical region,** *Phys. Rev. Letters* **18,** No. 25, 1113-1117 (June 19, 1967).

Key words: Compressibility; critical exponents; critical isotherm; critical region; density gradients; equation of state; gases; gravity effect; scaling law.

The Widom-Kadanoff scaling-law equation of state has been confirmed for a variety of gases in a range of ±50% of the critical density and within a few percent above and below the critical temperature. Using a new procedure motivated by the scaling law the exponent δ describing the shape of the critical isotherm was found to be close to 5 while the compressiblity exponents γ and γ' were found to be both equal to about 1.4.

9758. Greenberg, L., **On a theory of Ahlfors and conjugate subgroups of Kleinian groups,** *Am. J. Math.* **LXXXIX,** No. 1, 56-68 (Jan. 1967).

Key words: Conjugate subgroups; Fuchsian group; Hilbert nullstallensatz; Kleinian group; parabolic triangle group; prime ideal; region of discontinuity.

A gap in a theorem of L. Ahlfors is filled and a generalization of the problem is studied.

9759. Greenberg, L., **Fundamental polyhedra for Kleinian groups,** *Ann. Math.* **84,** No. 3, 433-441 (Nov. 1966).

Key words: Euler characteristic; fundamental polyhedron; hyperbolic space; Kleinian group; limit set; region of discontinuity.

The following theorem is proved: Let Γ be a Kleinian group whose limit set contains at least two points. If Γ has a fundamental polyhedron (in hyperbolic 3-space) with a finite number of sides, then the region of discontinuity in the complex plane cannot be connected and simply connected. From this, it follows that there exist finitely generated Kleinian groups which have no finite-sided fundamental polyhedron. This is in surprising contrast to the case of Fuchsian groups.

9760. Greenberg, L., **Fundamental polygons for Fuchsian groups,** *J. Anal. Math.* **18,** 99-105 (1967).

Key words: F-regular region; Fuchsian group; fundamental polygon; horocyclic region; hypercyclic region; simple fundamental polygon.

It is proved that a certain class of fundamental polygons for finitely generated Fuchsian groups are finite-sided. This is already known for convex polygons. However, this paper gives a much shorter proof for a wider class of polygons.

9761. Greene, F. M., **Field-strength standards and measurements (30 Hz to 1000 MHz),** *Proc. IEEE* **55,** No. 6, 970-981 (June 1967).

Key words: Calibration of field-strength meters; electric-field-strength standards; magnetic-field-strength standards; near-zone electric-field-strength standards; standard-antenna calibration method; standard-field calibration method.

A description is given of the various CW field-strength standards and associated measurement instrumentation and techniques developed over the past twenty-five or thirty years at the National Bureau of Standards. These are used for the calibration of both commercial and military field-strength meters in various frequency bands of the overall range from 30 Hz to 1000 MHz. The techniques used are applicable only for evaluating the strength of steady-state, ac fields varying sinusoidally in time, and are not intended for use in broadband applications of any kind.

Two principal types of field-strength standards and a prototype near-zone field-strength meter are described. These are as follows:

(a) *Magnetic-Field-Strength Standards* used over the frequency range 30 Hz to 30 MHz for the calibration of CW field-strength meters employing small-loop receiving antennas;

(b) *Electric-Field-Strength Standards* used over the frequency range 30 to 1000 MHz for the calibration of CW field-strength meters employing half-wavelength self-resonant dipole receiving antennas; and

(c) *Near-Zone Electric-Field-Strength Meter and Interim Field-Strength Standards* used over the frequency range 150 kHz to 30 MHz for the evaluation of hazards of high-level electromagnetic radiation to ordnance devices and other uses.

9762. Haber, S., **A functional inequality,** *Proc. Am. Math. Soc.* **73,** No. 10, 1103-1104 (Dec. 1966).

Key words: Functional equations; inequalities; inverse functions; real functions.

It is shown that if f is a continuous increasing function then $f(x) \cdot f^{-1}(x) > (1-\epsilon)x^2$, for some sets of values of x.

9763. Haigh, P. J., Forman, R. A., Frisch, R. C., **Nuclear magnetic resonance of ^{7}Li and ^{1}H in solid lithium imide, lithium amide, and lithium nitride,** *J. Chem. Phys.* **45,** No. 3, 812-816 (1966).

Key words: Ammonia analogues; hydrogen; lithium; nuclear magnetic resonance; resonance.

Nuclear magnetic resonance lines of ^{7}Li nuclei have been observed in solid, polycrystalline samples of $LiNH_2$, Li_2NH, and Li_3N. Proton resonance lines have also been observed in the first two samples. In $LiNH_2$ there is a splitting of the resonance line due to first order quadrupole effects which indicates a coupling constant of 119±2 kHz (estimated limit to maximum error) at room temperature. In Li_2NH no quadrupole effects are seen which is in agreement with the fact that the lithium nuclei in this compound are situated in sites of cubic symmetry. In Li_3N both first and second order quadrupole effects have been observed simultaneously. From these data coupling constants for Li_3N

have been found to be 296±4 kHz and 200±10 kHz at room temperature. An unexplained line was also observed at low magnetic fields for this compound. These effects were found to vary with temperature and with the purity of the sample.

9764. Hall, J. L., Morey, W. W., **Optical heterodyne measurement of neon laser's millimeter wave difference frequency,** *Appl. Phys. Letters* **10,** No. 5 152-155 (Mar. 1, 1967).

Key words: Frequency-millimeter wave difference; heterodyne measurement; millimeter wave difference frequency; neon laser's millimeter wave difference frequency; optical heterodyne measurement.

We report detection and measurement of the millimeter wave difference frequency between two near laser lines at 1.152 μ. The two spectral transitions, separated by 2.26 Å, oscillate in pure neon in a single laser device, producing about 150 μW total power in several longitudinal modes. The many resulting 51.3-kmc beat frequencies have been studied by optical heterodyne techniques. A type of diode has been found which has enough microwave sensitivity *and* enough optical sensitivity to combine the optical detector and the microwave heterodyne functions in a single element. The preliminary value for the difference in frequency between the $2S_2|\rightarrow|2P_4$ and $2S_4\rightarrow 2P_7$ transitions in neon at 150 mtorr is (51,360±150) Mc. This value is not in agreement with the value calculated from NBS Circular 467, Vol. I of Sitterly's *Atomic Energy Levels*.

9765. Hall, M. B., Larsen, N. T., Little, W. E., **Combination RF radiation and fluid pressure seal,** *Proc. IEEE* **54,** No. 11, 1585-1586 (Nov. 1966).

Key words: Electrical measurements; fluid pressure seal; pressed woven metal; radiofrequency; waveguide joints; woven metal.

Radiation leakage by extraneous paths from sources to detectors frequently limits the dynamic range of precision electrical measurements in the radio-frequency range. Elimination of leakage paths becomes more difficult with increasing frequency. Correct use of gaskets made of pressed woven metal eliminates measurable leakage but does not insure a low, stable reflection from waveguide joints. Furthermore, commercially available woven-metal gaskets require special grooved flanges. Lead washers suppress leakage sufficiently for many purposes when freshly inserted between waveguide flanges, but their effectiveness decreases with time, particularly if they are removed and reinserted. A commercial (recent) gasket material consisting of silver powder embedded in vinyl polymer has proved to be very effective, at least when fresh. A recent publication describes RF leakage tests on a number of gaskets of different designs and materials.

A new type of microwave gasket for use, for example, between waveguide flanges has been developed at the NBS Boulder Laboratories. It is convenient, requiring only moderate pressure, and may be reused. The new gasket can be made thin, and hence, light. It provides simultaneously a microwave radiation and a fluid pressure seal, and the reflection it introduces can be made small. It is expected that variations of the materials of construction will provide for various other combinations of desirable properties.

9766. Hamer, W. J., **Electrochemistry,** *Encyclopedia of Physics*, Ed. R. M. Besancon, pp. 200-203 (Reinhold Publ. Corp., New York, N.Y., 1966).

Key words: Batteries; conductivity; electrolysis; electrophoretic separation; Faraday; ionization.

This article deals with the scientific discipline known as electrochemistry and the development of the field from the time of Alessandro Volta to the present. *Topics covered include:* Voltaic couples, electromotive series of the elements, electrolysis, electrolytic and electronic conductors, electrolytic solutions, ionization, the Debye-Hückel theory of interionic attraction, Faraday's laws of electrolysis and the Farady constant, and electrochemical thermodynamics. The article concludes with a listing of the applications of electrochemistry. These include electrochemical analysis; electrochemical synthesis of dyestuffs, fertilizers, plastics, insecticides; electrophoretic separation of proteins in biology and medicine, in corrosion, and in the development of storage batteries and dry cells.

9767. Hanley, H. J. M., **Comparison of the Lennard-Jones, exp-6, and Kihara potential functions from viscosity data of dilute argon,** *J. Chem. Phys.* **44,** No. 11, 4219-4222 (June 1966).

Key words: Argon; kinetic theory; phase studies; potential functions; special functions; thermodynamics; transport properties.

Experimental viscosity coefficients of argon are used to illustrate how the variation of the parameters of the Lennard-Jones, exp-6, and Kihara functions effect the correlation of the Chapman-Enskog transport theory with experimental data. By rationalizing the choice of the parameters, better correlations are possible than obtained by previous workers and it is shown that the Kihara function gave the best results.

9768. Harari, H., Horn, D., Kugler, M., Lipkin, H. J., Meshkov, S., **W spin for any spin,** *Phys. Rev.* **146,** No. 4, 1052-1057 (June 1966).

Key words: Arbitrary spin state; basic spin; linear combinations; ordinary spin states; spin states; W spin.

The general "W spin" properties of an arbitrary spin state constructed from any number of basic spin 1/2-objects are discussed in detail. Explicit formulae for expressing the eigenstates of W^{-2} as linear combinations of ordinary spin states are given and some properties of the transformation matrices are discussed.

9769. Harrach, R. J., **Radiation-field-dependent frequency shifts of atomic beam resonances,** *J. Appl. Phys.* **38,** No. 4, 1808-1819 (Mar. 15, 1967).

Key words: Atomic beam; cesium beam; frequency shifts; frequency standards; radiation field.

Radiation-field-dependent frequency shifts arising in atomic beam spectroscopy are treated theoretically and experimentally. Shifts due to fundamental and unavoidable interactions between the radiation field and the atoms comprising the beam are distinguished from those due to various "apparatus effects." Precise measurements of frequency shifts are made for a cesium beam experiencing Ramsey-type excitation. For the magnetic field-sensitive transitions $(F,M_F)=(4,\pm 1)\leftrightarrow(3,\pm 1)$, the magnitude of the shifts is about 1 part in 10^{10} of the resonance frequency value, per milliwatt variation of input power to the radiation field. The shifts vary with input intensity in a nonmonotonic fashion and are shown to result from nonuniformity in the static magnetic *c*-field of the apparatus. Much smaller shifts of about 5 parts in 10^{13} per milliwatt are observed for the magnetic-field-insensitive transition $(F,M_F)=(4,0)\leftrightarrow(3,0)$. The major features of these shifts are shown to arise from spectral impurities in the radiation exciting the transition and a small phase difference between the pair of separated radiation fields. The bearing these results have on evaluating the accuracy an atomic beam frequency standard is discussed.

9770. Harrach, R. J., **Some accuracy limiting effects in an atomic beam frequency standard,** *Proc. 20th Annual Symp. Frequency Control, Atlantic City, N.J., Apr. 19-21, 1966*, pp. 424-435 (1966).

Key words: Accuracy; cesium beam; frequency shifts; frequency standard.

The accurate resonance frequency of the transition $(F,M_F)=(4,0)\leftrightarrow(3,0)$ in the ground state of cesium-133 is expressed in the form of an operational equation for an atomic beam spectrometer. Emphasized are the terms in this equation which correct for the beam direction dependence and radiation field dependence of measured resonance frequencies: $1/2[\nu_{res_i}(P_l)+\nu_{res_j}(P_l)]-1/2(S_i+S_j)P_l$, where i and j refer to opposite beam directions through the apparatus, P_l is the microwave power exciting the transition, and S_i and S_j are rates of linear frequency shift. The results of a detailed theoretical analysis are given which specify the contributions to these terms by various apparatus and fundamental shift-inducing effects.

This approach to accuracy specification is applied to the United States frequency standard, a National Bureau of Standards atomic beam machine designated NBS III, through a set of experiments using an atomic hydrogen maser as a highly stable reference frequency source. The corrections determined are -3.2×10^{-12} for beam direction dependence, -2.2×10^{-12} for power dependence and $+0.4 \times 10^{-12}$ for second-order Doppler shift. The uncertainties in these corrections and contributions from other sources give a present 1σ estimate of accuracy capability of $\pm1.1 \times 10^{-12}$ for NBS III. This figure should be reducible by one order of magnitude through efforts to eliminate systematic errors in the measurements of ν_{res_i} and ν_{res_j}.

9771. Harris, F. K., Cooter, I. L., Dunfee, B. L., Harris, W. P., Hermach, F. L., Peterson, C., **Electrical standards and measurements,** *Electro. Technol.* **97,** 53-70 (Jan. 1967).

Key words: Absolute measurements; electrical reference standards; electrical units; precise electrical measurements.

The basis of the electrical units and their derivation for the mechanical units is briefly reviewed. Methods used by the Electricity Division of the National Bureau of Standards for the establishment of measurement reference standards are discussed together with the techniques employed in extending the range of measurement from the reference standard to higher and lower values.

9772. Harris, W. P., **A new ultra-low frequency bridge for dielectric measurements,** *1966 Annual Report Conf. Electrical Insulation and Dielectric Phenomena, National Academy of Sciences-National Research Council, Mt. Pocono, Pa., 1966,* pp. 72-74 (1967).

Key words: Bridge; dielectric measurements; dielectrics; electrical measurements; low frequency; measurements, dielectric; measurements, electrical; ultra-low frequency.

9773. Harris, W. P., **Apparent negative impedances and their effect on three-terminal dielectric loss measurements,** *(1965 Annual Report Conf. Electrical Insulation), Natl. Acad. Sci.-Natl. Res. Council Publ. 1356,* pp. 83-86 (Natl. Acad. Sci.-Natl. Res. Council, Washington, D.C., 1966).

Key words: Dielectric losses; dielectric materials; dielectric measurements; errors; low-loss; negative impedances; negative losses.

Tee networks consisting of "stray" impedances can cause "errors" in the conductance and capacitance of three-terminal capacitance measurements. In particular, a tee with two capacitive arms and a resistance leg to ground can introduce a negative component of conductance. Therefore, a three-terminal capacitor can appear to have zero or negative losses. A measurement of the dielectric loss of a material can indicate a negative loss unless steps are taken to eliminate by careful cell design this source of error. A component of negative loss can arise from the coaxial cables connecting the cell or capacitor to the bridge. This error can be reduced by the use of coaxial chokes or by a feedback circuit.

9774. Hayward, E., **Some aspects of the photodisintegration of light nuclei,** *Proc. Intern. School of Physics "Enrico Fermi", Course* **XXXVI,** Ed. C. Bloch, July-Aug. 1965, Monastero, Italy, pp. 559-565 (Academic Press, Inc., London, England, 1966).

Key words: Intermediate structure; isotopic spin; photodisintegration.

The photonuclear giant resonance is discussed from the point of view of isotopic spin mixing and intermediate structure.

9775. Heidemann, H. G. M., Kuyatt, C. E., Chamberlain, G. E., **Inelastic electron scattering from H_2,** *J. Chem. Phys.* **44,** No. 2, 440-441 (Jan. 1966).

Key words: Electrons; energy-loss spectra; inelastic electron scattering.

Energy-loss spectra have been measured for 13.7- to 50.7-eV electrons in H_2. For incident energies below about 16 eV, energy-loss peaks are observed due to either or both of the $a\ {}^3\Sigma_g^+$ and $c\ {}^3\Pi_u$ states of H_2. The excitation cross section of the $v=0$ and $v=1$ vibrational levels to the $\beta\ {}^1\Sigma_u^+$ state show sharp and large resonances, corresponding in energy with resonances in the total scattering. The absolute electron energy scale in H_2 was recalibrated to an estimated accuracy of 0.1 eV.

9776. Heidemann, H. G. M., Kuyatt, C. E., Chamberlain, G. E., **Resonances in the elastic and inelastic electron scattering from N_2,** *J. Chem. Phys.* **44,** No. 1, 355-358 (Jan. 1, 1966).

Key words: Doppler broadening; electronic excitation; low energy elastic electron scattering; low energy inelastic electron scattering; Lyman-Birge-Hopfield bands; metastable states; molecular nitrogen; negative ions; nitrogen window; resonances; vibrational excitation.

A sharp and isolated resonance of the "helium window" type has been discovered in electron transmission measurements in N_2 at 11.48±0.05 eV (believed accurate to within 0.05 eV). Additional resonance structure is observed at 11.75 and 11.87 eV. The $E\ {}^3\Sigma_g^+$ state is coincident in energy with the 11.87 eV structure and is found to exhibit an excitation probability sharply peaked near threshold. The series of resonances previously known to exist between 1.8 and 3.5 eV as a consequence of an N_2^- state with vibrational structure, has been studied with improved resolution and by different procedures.

9777. Heinrich, K. F. J., **Electron probe microanalysis,** *Book, Experimental Methods of Materials Research. Advances in Materials Research,* pp. 145-162 (John Wiley and Sons Inc., New York, N.Y., 1967).

Key words: Characteristics of probe analysis; electron microanalysis; electron probe microanalysis; microanalysis, electron probe; probe.

This paper introduces the reader into the principles and techniques of electron probe microanalysis. After a brief description of the instrument, the characteristics of probe analysis, such as range of elements, spatial resolution, sensitivity, and conditions necessary for the specimen, are discussed. The corrections to be applied in quantitative analysis are enumerated and explained. Several signal evaluation systems, particularly for scanning microprobe analysis, are described, including the use of signals other than x-rays. The fields of application are briefly indicated.

9778. Heinrich, K. F. J., **Identification to inclusions with the electron probe microanalyzer,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **393** (Jan. 1966).

Key words: Electron probe microanalysis; microanalyzer; particle size.

Direct identification of the components of inclusions and precipitates can be performed with the aid of the electron probe microanalyzer. Although the method is restrictive as to minimum particle size, range of detectable elements, and attainable accuracy, satisfactory characterization of the inclusions is generally possible. Special techniques applicable to inclusions and precipitates and recent applications are discussed.

9779. Henderson, M. B., **Introductory remarks at the symposium on problems of small information groups,** (Div. Chem. Lit. Symp., Problems of Small Information Groups, 151st National Meeting Am. Chem. Soc., Pittsburgh, Pa., Mar. 25, 1966), *J. Chem. Doc.* **6,** 143 (Aug. 1966).

Key words: Chemical literature; documentation services; remarks; small information groups.

The Symposium on Problems of Small Information Groups, presented before the Division of Chemical Literature, ACS, on March 25, 1966, addressed itself to the problems of information groups with three or fewer professionals on the staff. Possible solutions to some of the problems of such groups were presented, as for example, problems of physical storage, distribution, and evaluation of information systems, and cooperation in the establishment and operation of information networks.

9780. Henig, S., **A proposal for a supplement to the patent system,** *Design News* **21,** No. 1, 84-89 (Jan. 5, 1966).

Key words: Anti-trust violations; better products; copiers; developer-producer's; dormant patents; higher productivity; improvements; industrial stimulus; industrial trade associations; "limit right"; material/product/process improvements; non-inventions; quasi-property; right to royalties; supplementary system; traditional property-rights; unrestricted copying; useful service.

It is postulated that the patent system is inadequate as an industrial stimulus toward both higher productivity and better products. The need is indicated for a supplementary system applicable to improvements which may be non-inventions. A proposal, using a quasi-property concept termed "limit right", describes a system which specifies: a developer-producer's right to royalties from copiers of material/product/process improvements when the latter are put into useful service; unrestricted copying of such improvements so as to exclude other traditional property rights; a means of encouraging the use of industrial trade associations to collect, distribute, and adjudicate royalties. A projection of practice under the system shows that it would be largely self-regulating through each industry's trade association. Contrasted with the patent system, the proposal is shown to be *directly* inductive toward the end of bringing benefits of improved manufacture and produce to the marketplace, and non-inductive to anti-trust violations. An optional measure of superseding property-rights in the area of dormant patents is directed at hastening development effort for these.

9781. Henry, R. J. W., Lipsky, L., **Multichannel photoionization of atomic systems,** *Phys. Rev.* **153,** No. 1, 51-56 (Jan. 1967).

Key words: Close-coupling; core relaxation; multi-channel; neon; photoionization; standing waves; 2p shell.

Expressions for multi-channel photoionization are obtained with the dipole approximation assuming LS coupling, which, while including the effects of coupling between channels, give separate contributions for each channel. The explicit form of the cross sections for atomic systems with configurations $1s^22s^22p^4$ is obtained assuming superpositions of determinantal wave functions (Hartree-Fock) for initial and final states. The effects of core relaxation are considered. The formalism is applied to the photoionization of neon with the result that coupling between channels and core relation have a larger effect on the individual channel cross sections than on the total cross section. Both effects tend to bring the dipole velocity and length forms of the cross section into closer agreement with each other, but improvement is appreciable only near threshold.

9782. Hermach, F. L., Williams, E. S., **Thermal converters for audio-frequency voltage measurements of high accuracy,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 260-268 (Dec. 1966).

Key words: Audio-frequency; comparator; standards; thermal convectors; thermoelements; transfer standards; voltage comparator; voltage measurements.

The ac-dc differences of a reference group of thermoelements have been evaluated at audio frequencies to a few ppm at currents from 5 to 20 mA. A technique for comparing the ac-dc differences of two thermoelements with an uncertainty of about 2 ppm has been developed. Two 5 mA thermoelements are used with a plug-in set of resistors of computable reactances to form thermal voltage converters for voltage measurements. With this same technique adjacent ranges of these converters can be compared to step up from 0.5 to 500 V to better than 10 ppm.

9783. Hermach, F. L., **Thermal converters used as transfer standards for the measurement of alternating current and voltage,** *Proc. 11^e Session Comite Con. d'Electricite, May 10-12, 1965*, pp. 83-88 (Gauthier-Villars, Paris, France, 1965).

Key words: ac-dc transfer standards; alternating current and voltage; thermal converters; transfer standards.

This report to the Advisory Committee outlines recent progress at NBS in the development of ac-dc transfer standards (comparators) for measurements of alternating current and voltage with 20 ppm accuracy or better at audio frequencies. Electrothermic transfer standards of the thermocouple type offer good prospects of meeting this goal. Their ac-dc differences appear to be very stable. The standards can be read with high precision and are rugged and portable. Furthermore, they can readily be intercompared for ac-dc difference, to step up and down the current and voltage scale with a precision of a few ppm. They are thus worthy of consideration for international comparisons of the accuracy of alternating current and voltage measurements.

9784. Herron, J. T., **Mass spectrometric study of the reactions of O atoms with NO and NO_2,** *Erratum, J. Chem. Phys.* **44,** No. 9, 3645 (May 1966).

Key words: Atoms; mass spectrometer; O atoms; spectrometric study.

9785. Heydemann, P. L. M., **The Bi I-II transition pressure measured with a dead weight piston gage,** *J. Appl. Phys.* **38,** No. 6, 2640-2644 (May 1967).

Key words: Bismuth; free piston gage; high pressure; polymorphic phase transition; transition pressure; volume change.

A dead weight piston gage was used to determine the Bismuth I-II transition pressure and the volume change at the transition. The transition pressure for one sample, believed to contain less than .001% impurities, was found to be 25,306±60 (estimated uncertainty) bars. With another sample, of substantially less purity and of larger grain size, a transition pressure of 25,500±60 bars was measured. The average relative volume change was .035.

9786. Hoeve, C. A. J., **Adsorption isotherms for polymer chains adsorbed from Θ solvents,** *J. Chem. Phys.* **44,** No. 4, 1505-1509 (Feb. 15, 1966).

Key words: Adsorption; chain; concentration; interface; isotherm; polymer; polystyrene; segment; Θ solvent.

In the case of interacting polymer chains near the interface, the first layer at the interface corresponding to the thickness of segments, is treated as a polymer solution to which the Flory-Huggins theory is applied. Interaction in other layers is assumed to be absent for Θ solvents. On minimizing the free energy, adsorption isotherms are calculated. The amount of adsorbed polymer increases without limit and the fraction of segments in the first layer decreases to zero with increase in molecular weight and solution concentration. The root-mean-square distance of segments from the interface is also calculated and is found to vary approximately proportional to the square root of the molecular weight, in good agreement with experiment.

9787. Hoffman, J. D., **Dielectric relaxation in molecular crystals: Multiple site models,** *Book, Molecular Relaxation Processes, Chemical Society Spec. Publ. No.* **20,** pp. 47-60 (The Chemical Society and Academic Press, Inc., New York, N.Y., 1966).

Key words: Dielectric relaxation; long chain molecule; molecular crystals; multiple site model; potential barrier to rotation; relaxation times.

The multiple site model of dielectric relaxation in molecular crystals is reviewed. In this model, a dipolar molecule, which is incorporated in a crystal lattice, may orient into one of several equilibrium positions upon rotation about a single axis in an anisotropic crystalline field. The equilibrium sites are mapped out by a 360° rotation of the dipolar molecule in the crystalline lattice assuming that the interaction of the dipole with its neighbors is a Lennard-Jones potential or a volume overlap potential. From this calculation it is seen that each accessible equilibrium site is separated from its neighboring site by a potential barrier to rotation. Differential equations, which describe the rate at which dipoles leave and enter a site as a function of the elementary transition probabilities over the potential barrier, are set up. The solutions to these equations give decay functions $\psi_\beta = \exp[-f_\beta(\alpha)t]$ where $f_\beta(\alpha)$ is the reciprocal of the relaxation time of the β mode and is a general function of the transition probabilities of all neighboring pairs of sites. If there are five equilibrium sites then there will be five modes or relaxation times of which one will be trivial (equilibrium).

The model is used to describe the dielectric relaxation of long chain ketone molecules in a urea lattice and relaxation in other long chain paraffin-like crystalline substances.

9788. Hornbeck, G. A., **Optical methods of temperature measurement,** *Appl. Opt. Lead Article* **5,** No. 2, 179 (Feb. 1966).

Key words: Boltzmann; Draper; Jeans; Kirchoff; optical; Planck; pyrometry; radiance; Rayleigh; Stefan; temperature; Wien.

The history of the laws of thermal radiation is briefly reviewed, and the theoretical relations basic to some of the optical methods of temperature measurement are given. Comments on a number of optical methods are presented, as well as a selected reference with each method where more detail is available. In conclusion, several problems, in areas of uncertainty in the field optical methods of temperature measurement, are suggested in the belief that a solution to these problems will greatly enhance the technical value of this field.

9789. Howard, R. E., **Random-walk method for calculating correlation factors: Tracer diffusion by di-vacancy and impurity-vacancy pairs in cubic crystals,** *Phys. Rev.* **144,** No. 2, 650-651 (Apr. 15, 1966).

Key words: Calculations; correlation factors; di-vacancy and impurity-vacancy pairs; random walk; tracer diffusion.

The random-walk technique is extended in a way that allows correlation factors to be calculated in all cases where principle axes for diffusion can be found. The results are applicable both to tracer and to impurity diffusion. Explicit calculations are given of correlation factors for the diffusion of tracers by bound impurity-vacancy pairs in fcc metals and NaCl-type ionic crystals, and by bound di-vacancy pairs in NaCl-type ionic crystals, CsCl-type ionic crystals, and fcc metals. Appropriate modifications for the "isotope effect" are made for the case of impurity-vacancy pairs.

9790. Huber, M. G., Danos, M., Weber, H. J., Greiner, W., **Collective treatment of the giant resonances in spherical nuclei,** *Phys. Rev.* **155,** No. 4, 1073-1084 (Mar. 1967).

Key words: Cross section; dipole-quadrupole interaction; giant resonances.

In a collective treatment the energies of the giant resonances are given by the boundary conditions at the nuclear surface which is subject to vibration in spherical nuclei. Therefore, a coupling between these two collective motions is consistently present. Its general form is given by angular momentum and parity conservation, the coupling constants being completely determined within the hydrodynamical model.

In the present treatment the influence of the surface vibrations on the total photon absorption cross section has been calculated. It turned out that in most of the spherical nuclei this interaction leads to a pronounced structure in the cross section. The agreement with the experiments in medium heavy nuclei is striking; many of the experimental characteristics are reproduced by the present calculations. In some nuclei, however, there are indications of single particle excitations which are not yet contained in this work.

9791. Hudson, G. E., **Some characteristics of commonly used time scales,** *Proc. IEEE* **55,** No. 6, 815-821 (June 1967).

Key words: Broadcast time signals; standard frequency and time signals; time; time and frequency standards; time scales.

Various examples of ideally defined time scales are given. Realizations of these scales occur with the construction and maintenance of various clocks, and in the broadcast dissemination of the scale information. Atomic and universal time scales disseminated via standard frequency and time-signal broadcasts are compared. There is a discussion of some studies of the associated problems suggested by the International Radio Consultative Committee (CCIR).

9792. Hudson, P. A., **Measurement of RF and baseband pulse quantities,** *Proc. IEEE* **55,** No. 6, 851-855 (June 1967).

Key words: Measurement; peak pulse power; pulse modulation; RF power.

This paper is a survey of the principal methods developed during the past twenty years for the measurement of RF peak pulse power. The basic principles involved for each method are described together with accuracies attainable under normal operating conditions. General techniques for pulse power measurement and precautions to be observed are also given.

9793. Hughes, A. N., Scheer, M. D., Klein, R., **The reaction between $O(^3P)$ and condensed olefins below 100 °K,** *J. Phys. Chem.* **70,** No. 3, 798-805 (Mar. 1966).

Key words: Low temperature chemistry; olefins; oxidation; oxygen atom.

The addition of oxygen atoms to condensed simple olefins has been studied in the 77 to 90 °K temperature range. The ground state O(^{3}P) atoms were generated in the gas by dissociation of O_2 on rhenium or tungsten surfaces heated to 2300 °K.

At 90 °K and oxygen pressures below 40 millitorr, the major products were found to be the unfragmented epoxides and carbonyls. Above 50 millitorr ozonides and oxygenated products characteristic of rupture at the double bond were observed. Above 100 millitorr only the ozonides and its fragments were produced. At 77 °K, the ozonolysis reaction occurred at much lower oxygen pressures. Comparison of these results with those obtained in the gas phase at 300 °K indicates that the low temperature environment efficiently removes the excess energy from the excited biradical formed in the primary act of O atom addition to the double bond. In all cases studied, fragmentation was less extensive than in the comparable gas phase process.

9794. Hunt, C. M., **Nitrogen sorption measurements and surface areas of hardened cement pastes,** (Highway Research Board Symp. Structure of Portland Cement Paste, Washington, D.C., Jan. 1965), *Highway Research Board Special Report* **90,** 112-122 (1966).

Key words: Cement pastes; nitrogen sorption; pastes; water cement.

Surface area by nitrogen adsorption and also nonevaporable water were determined on hardened cement pastes of four water cement ratios, ranging from 0.251 to 0.501, and four ages, ranging from 1 day to 180 days.

Water-cement ratio made very little difference in the surface area of hardened pastes at 1-day but with pastes at later ages, evidence suggests that surface area may reach a limiting value which is a function of the original water-cement ratio. The ratio of surface area by nitrogen adsorption to nonevaporable water was not constant but increased with increasing hydration in paste of water-cement ratio 0.501 and changed very little or even decreased slightly in paste of water-cement ratio 0.251.

The degree of subdivision of the paste during drying exerted a significant effect on the measured surface area except for specimens of high water-cement ratio measured early in the hydration process. In most cases pastes which were dried as cylinders, 1/2-inch in diameter and 1/2-inch long, had lower surface areas than specimens of the same pastes which were crushed to smaller particle sizes below 1 mm before drying. The sorption isotherm and calculated pore size distribution of a paste after different drying treatment were also determined.

9795. Huntley, L. E., Jones, R. N., **Impedance of lumped circuits,** *Proc. IEEE* **55,** No. 6, 900-911 (June 1967).

Key words: Capacitance; inductance; impedance and admittance; measurement; radio frequency; resistance; standards; state of the art.

This paper is a tutorial presentation dealing with two and three terminal lumped parameter impedance measurements at radio frequencies. Included is a very brief historical discussion with particular emphasis upon more important recent developments such as precision coaxial connectors and coaxial air line standards. The relationship of impedance standards to standards of length and time is shown together with a discussion of instruments and measurement techniques in current use. Special attention is given to particular areas of measurement difficulty. Also included is a presentation of the state of the art wherein commercial instrumentation is compared with best practices from the standpoint of accuracy. The paper concludes with comments and recommendations for improving measurement and measurement agreement.

9796. Huntoon, R. D., **Status of the National Standards for physical measurement,** *Science* **150,** No. 3693, 169-178 (Oct. 8, 1965).

Key words: Ampere; candela; current; degree Kelvin; International System of Units; kilogram; length; luminous intensity; mass; meter; metric system; second; standards for physical measurement; temperature; time.

This article outlines various stages of sophistication in the development of a measurement system, from a "unit-standard" system to a consistent system in which standards are tied to atomic and molecular properties in an independently reproducible way. The present stage of development of our measurement system is discussed in this context, and predictions are made regarding its future development.

9797. Huntoon, R. D., **The basis of our measurement system,** *Phys. Teacher* **4,** No. 3, 113-120 (Mar. 1966).

Key words: Degree Kelvin; kilogram; measurement system; meter; physical constant; second; standard; unit.

This article outlines various stages of sophistication in the development of a measurement system, from a "unit-standard" system to a consistent system in which standards are tied to atomic and molecular properties in an independently reproducible way. The present stage of development of our measurement system is discussed in this context, and predictions are made regarding its future development.

9798. Hust, J. G., Stewart, R. B., **Thermodynamic property computations for systems analysis,** *ASHRAE J.* **8,** No. 2, 64-68 (Feb. 1966).

Key words: Calculated properties; entropy of gases, saturated fluids, and liquids; equations of state; systems analysis; thermodynamic property computations.

Methods for calculating thermodynamic properties from equations of state and zero pressure properties are reviewed. The calculation of entropy of gases, saturated fluids, and liquids is considered in detail. Particular attention is given to the determination of the two phase boundary and thermodynamic consistency of the calculated properties.

A method of iterative solution for implicit variables and its application to thermodynamic calculations are discussed. In addition methods of least squares are considered. Normal equations resulting from the usual minimization procedure are compared with corresponding equations of the constrained least squares problem. Discussion is also included on a technique for fitting related thermodynamic data simultaneously.

9799. Hutchinson, J. M. R., **Alpha-gamma angular correlations in three heavy odd-*A* nuclides,** *Phys. Rev.* **157,** No. 4, 1093-1098 (May 1967).

Key words: Alpha particles; americium-243; angular correlations; neptunium-237; partial wave branching; uranium-233.

Angular correlations between alpha particles and gamma rays have been measured in liquid sources of three separate nuclides, americium-243, uranium-233, and neptunium-237. The angular-correlation functions were experimentally determined for five transitions, and the relative angular-momentum mixing ratios for these transitions were deduced. The mixing ratios of $L=2$ and 0 agree with theory, but the $L = 4$ and 2 mixing ratios are somewhat higher than predicted. Upper limits of the half-lives of 99-keV and 45-keV states in Th^{229} were measured, respectively, as 0.8×10^{-9} and 1.2×10^{-9} sec. From a comparison of the attenuated angular correlation in Am^{243}, and a previously measured angular correlation in Am^{241}, it is deduced that an extranuclear interaction occurs whose time duration is less than 1.2×10^{-9} sec.

9800. Hutchinson, J. M. R., Walker, D. H., **A simple and accurate method of calibration by photopeak efficiencies,** *Intern. J. Appl. Radiation Isotopes* **18,** No. 1, 86-89 (Jan. 1967).

Key words: Accurate method of calibration; gamma-ray photopeak efficiency; photopeak efficiency curve.

The gamma-ray photopeak efficiency curve for a 3″ x 3″ NaI(Tl) crystal is presented assuming the peak distribution to be a gaussian shape. A simple and accurate method for determining gamma-ray emission rate is discussed. A small, but systematic discrepancy, between present and past photopeak efficiency curves, is noted. Using this method, the number of 0.908 MeV gamma rays per disintegration of yttrium-88 was found to be 0.936±0.013.

9801. Hyman, A., Perloff, A., Mauer, F., Block, S., **The crystal structure of sodium tetraborate,** *Acta. Cryst.* **22,** No. 6, 815-821 (June 1967).

Key words: Crystal structure; sodium tetraborate; symbolic addition; x-ray.

Single crystals of sodium tetraborate, $Na_2O.4B_2O_3$, have been synthesized and studied. The structure has been determined using the method of symbolic addition. The space group is $P2_1/a$ with unit cell dimensions: a = 6.507±0.001 (estimated uncertainty), b = 17.796±0.002, c = 8.377±0.001, and $\beta = 96°34' \pm 2'$; Z = 4. The structure consists of two infinite, independent, and interlinking boron-oxygen networks, each containing alternating single and double rings. The sodium atoms serve to hold the networks together through coordination with oxygen atoms.

9802. Inscoe, M. N., **Losses due to adsorption during filtration of aqueous solutions of polycyclic, aromatic hydrocarbons,** *Nature* **211,** No. 5053, 1083-1085 (Sept. 3, 1966).

Key words: Aqueous solutions; filter media; filtration phenanthrene; hydrocarbons; polycyclic aromatic hydrocarbons.

During filtration, phenanthrene and other hydrocarbons are adsorbed from aqueous solutions by various filter media. Losses are particularly pronounced when membrane filters are used.

9803. Isbell, H. S., Fatiadi, A. J., **Phenylhydrazono-phenylazo tautomerism. Part I.** ***xylo*-4,5,6-trihydroxy-2-oxo-1,3-bis(phenylhydrazono)cyclohexane and 4-oxo-1-phenyl-5-phenylazo-2-pyridazine derivatives,** *Carbohydrate Res.* **2,** No. 2, 204-215 (June 1966).

Key words: Absorption spectra of pyridazine derivatives; cyclic polyhydroxy ketones; inositol, triketo-; nuclear magnetic resonance of pyridazine derivatives; phenylhydrazono-phenylazo tautomerism; pyridazine derivatives; *xylo*-trihydroxycyclohexenediolic acid preparation of bis-phenylhydrazon of-; *xylo*-4,5,6-trihydroxy-2-oxo-1,3-bis(phenylhydrazono)cyclohexane.

The positions of the phenylhydrazono groups in xylo-4,5,6-trihydroxy-oxo-1,3-bis(phenylhydrazono)cyclohexane were established by degradation of the compound with sodium metaperiodate and identification of the reaction product. The dialdehyde initially formed by periodate oxidation (but not isolated) cyclized to 4-oxo-1-phenyl-5-phenylazo-3-pyridazinecarboxaldehyde, which gave a crystalline methyl hemiacetal, an oxime, a semicarbazone, and, by oxidation, the corresponding monocarboxylic acid and sodium salt. Upon treatment with phenylhydrazine at 50°, the carboxaldehyde gave a red crystalline phenylhydrazone which, with phenylhydrazine at 130° gave a product that appears to be 4-oxo-1-phenyl-5-(phenylhydrazo)-3-pyridazine-carboxaldehyde phenylhydrazone.

The reactions provide a route to a series of new pyridazine derivatives which may prove valuable for the synthesis of unusual compounds for biological and medical research.

9804. Ives, L. K., Ruff, A. W., Jr., **Extended dislocation nodes in a silver-tin alloy,** *J. Appl. Phys.* **37,** No. 4, 1831-1837 (Mar. 15, 1967).

Key words: Alloys; dislocation; dislocation nodes; stacking faults; transmission electron microscopy.

A study of dislocation nodes formed in silver-tin solid solution alloys has been conducted using the technique of transmission electron microscopy. In alloys of 6 and 8 at. % Sn, both extrinsic and intrinsic stacking faults were observed at three-fold dislocation nodes. Burgers vector data obtained from diffraction contrast studies were in agreement with predictions based on geometric considerations. From a qualitative comparison of the node extensions, the extrinsic fault energy was found to be at least twice the intrinsic fault energy. Both fault energies were observed to decrease with increasing solute concentration. At many of the nodes containing extrinsic faults, the dislocation curvature was small or negative; at the intrinsically faulted nodes, positive curvatures were always observed. It is believed that the dislocation constrictions or cross-linking dislocations required at the extrinsically faulted nodes were responsible for this difference. Motion under stress of the extrinsically faulted nodes was observed, consistent with the coplanar Burgers vector geometry. The general occurrence of both types of faults in low stacking fault energy FCC materials is predicted.

9805. James, T. C., **Exact vibrational matrix elements for molecular hydrogen and the intensity of the quadrupole rotation-vibration spectrum,** *Astrophys. J.* **146,** No. 2, 572-580 (Nov. 1966).

Key words: Hydrogen; intensity; quadropole spectrum; rotation-vibration interaction; vibrational matrix elements.

Accurate vibrational overlap integrals and matrix elements of $\xi = (r\&re)/re$, ξ^2, and ξ^3 have been calculated for lines in the 1 – 0, 2 – 0, 3 – 0, and 4 – 0 rotation-vibration bands of molecular hydrogen. The affect of rotation-vibration interaction has been considered and values are given for Q, S, and some O branch lines. The calculations were carried out using a computer program written by R. N. Zare. These results are used to analyze the intensity measurements in the quadrupole rotation-vibration spectrum which have been made by Rank and his associates. The possibility of predicting the intensity of the 4 – 0 band, and of using the 2 – 0, and the 3 – 0 bands for rotational temperature measurements is discussed.

9806. Jennings, D. A., **Calorimetric measurement of pulsed laser output energy,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 161-164 (Dec. 1966).

Key words: Calorimetric measurement; laser, pulsed; output energy; pulsed laser.

There are several methods by which one may measure the energy output of the pulsed laser. However, the technique which seems to be most promising as far as accuracy and precision are concerned is the calorimetric method. We have designed, built, and calibrated calorimeters for measuring the output energy of the pulsed ruby laser (6943 Å). The heart of the calorimeter is a small absorption cell containing an aqueous solution of $CuSO_4$. The temperature of the absorption cell, as measured by a thermocouple, indicates the energy absorbed by the calorimeter. The calorimeter was calibrated in two different ways: 1) the known heat capacity of the absorption cell and thermocouple sensitivity calibration gives a calorimeter calibration, which agrees within 0.3 percent of 2) an electrical energy substitution calibration which is obtained via a heater wire contained in the absorption cell solution. A method has been devised by which two calorimeters may be intercompared. Calorimeters which we have built and calibrated agree with each other to about 0.7 percent. This specific calorimeter has been designed to measure energies up to 30 J and will take peak powers of up to 200 MW/cm². .

9807. Jensen, M. W., **Quantity control—a tool of industry, and arm of government,** *Proc. Annual Conf. Soc. Advancement of Food Service Research, Washington, D.C., Apr. 18, 1966.*

Key words: Measures; product quality; standards; weights.

Weights and Measures regulatory control in the United States is discussed; the role of the National Bureau of Standards and of the States is explored. The program of NBS in voluntary product standardization also is briefly discussed.

9808. Jensen, M. W., **Thoughts on weights and measures,** *Soap and Chemical Specialties* **VLII,** No. 4, 99 (Apr. 1966).

Key words: NBS authority; package control; State authority; weights and measures.

The regulatory control of weighing and measuring in commerce is a function of the States and their political subdivisions and is carried on under the universally acknowledged "police powers" of the States. The National Bureau of Standards is the principal technical resource for the States in this field. Specifically, the Bureau provides assistance to the States and to affected segments of industry and business in the areas of physical standards, testing equipment, test methods, administrative procedures, and technical training.

Operating through the National Conference on Weights and Measures, and directly with the individual states, the Office of Weights and Measures of the Bureau is the prime mover toward nationwide uniformity in weights and measures laws, regulations, and control methods.

Recently, concentration in the weights and measures field has been on package labeling and on package net content. Model laws, model regulations and control procedures have been developed and are widely utilized.

9809. Jesch, R. L., Jickiling, R. M., **Impedance measurements in coaxial waveguide systems,** *Proc. IEEE* **55,** No. 6, 912-923 (June 1967).

Key words: Air lines; coaxial; impedance; measurements; standards; transmission line; waveguide.

This article is a tutorial review of impedance measurements and standards in coaxial waveguide systems propagating a TEM wave. It describes the development of coaxial air lines as impedance standards, reviews representative measurement methods, and discusses the errors and measurement techniques of the slotted line in detail. A list of selected references to pertinent literature is included.

9810. Johannesen, R. B., Farrar, T. C., Brinckman, F. E., Coyle, T. D., **Nuclear magnetic resonance studies of inorganic fluorides. I. High-resolution ^{19}F spectra of Si_2F_6 and $(SiF_3)_2O$,** *J. Chem. Phys.* **44,** No. 3, 962-964 (Feb. 1, 1966).

Key words: Chemical shifts; fluorine; fluorsilanes; nuclear magnetic resonance; silicon; spin coupling constants.

Fluorine nmr spectra of hexafluorodisilane and hexafluorodisiloxane have been recorded and analyzed. The $^{19}F-^{19}F$ and $^{29}Si-^{19}F$ spin coupling constants were obtained from the satellite spectra arising from the ^{29}Si-substituted molecules present in natural abundance. The "near" and "far" $^{29}Si-^{19}F$ coupling constants in Si_2F_6 were found to be of opposite sign.

9811. Johnson, D. P., Hutton, U. O., **Discussion of ASME paper 60-WA-333, November 30, 1960,** Chapter in *High Pressure Measurement,* A. A. Giardini and E. C. Lloyd, eds., pp. 350-351 (Butterworth, Inc., London, England, 1963).

Key words: Calibration; fixed point; freezing pressure; manganin gage; mercury; pressure standards.

The various determinations of the freezing pressure of mercury at 0 °C and the use of this manometric fixed point in the calibration of manganin wire pressure gages is reviewed. After Bridgman's measurements, published in 1912, of the freezing pressure of mercury (7640 kg/cm^2 at 0 °C) no determinations were made for 40 years. Five determinations have been made in the decade between 1952 and 1962. These fall in the range between 7714 and 7723 kg/cm^2 or 7565 to 7574 bars.

9812. Johnston, R. G., Canfield, L. R., Madden, R. P., **Reflective scattering from substrates and evaporated films in the far ultraviolet,** *Appl. Opt.* **6,** 715 (Apr. 1967).

Key words: Far ultraviolet; optical polishing; scattering; substrates; surface roughness; thin films.

Measurements of radiation reflectively scattered from mirror surfaces have been made at the wavelengths 1216 Å and 584 Å. Several glass and fused silica substrates with differing degrees of surface roughness have been studied, as well as evaporated films of aluminum and gold as a function of film thickness. A relatively small area detector was scanned in angle about the sample, and the detected energy integrated over the scattering angle. The results indicate that fused silica can be polished to a smoother surface than glass, that a smooth substrate surface is significantly advantageous in obtaining evaporated films having surfaces with low scatter, and that gold films are considerably smoother than aluminum films of equal thickness.

9813. Jones, E., Lee, D., Edelman, S., **Improved transfer standard for vibration pickups,** *J. Acoust. Soc. Am.* **41,** No. 2, 354-357 (Feb. 1967).

Key words: Accelerometer; axial motion; ceramic; comparison calibration; transfer standard; transverse motion; vibration pickups.

This paper describes a vibration transfer standard designed to provide comparison calibrations of pickups with minimum degradation. Features of the design are the use of a ceramic housing of a stiff, light, glossy material, provision of a means for evaluating the quality of the motion by the use of three integral accelerometers oriented parallel to the nominal direction of motion, and design of the geometry to minimize differences in motion between the pickup being calibrated and the standard. The useful frequency range is 10 to 10,000 Hz.

9814. Jones, M. C., Nagamoto, T. T., Brennan, J. A., **Heat transfer to a subliming solid-vapor mixture of hydrogen below its triple point,** *AIChE J.* **12,** No. 4, 790-795 (July 1966).

Key words: Cryogenics; dimensional analysis; heat transfer; hydrogen; low pressure; solid-vapor; tube; two-phase flow.

Heat transfer coefficients have been measured over a range of Reynolds numbers for a solid-vapor mixture of parahydrogen discharging through a heated brass tube below the triple point pressure. A simple empirical correlation is given which is shown by dimensional analysis to account for most of the system variables.

9815. Jones, R. N., Huntley, L. E., **Precision coaxial connectors in lumped parameter immittance measurement,** *IEEE Trans. Instr. Meas.* **15,** No. 4, 375-380 (Dec. 1966).

Key words: Coaxial; connectors; immittance; lumped-parameter; measurement; precision; radio frequency.

Amid the concern surrounding the design and application of precision coaxial connectors for use in precise electrical measurements there is one area which has received very little attention. This has to do with the application of such connectors to measurements in the lumped-parameter region. This paper points out the significant sources of error in lumped-parameter measurements which are attributable to connector uncertainties and shows how they can be greatly reduced through the application of precision coaxial connectors. Where these connectors are utilized in lumped-parameter immittance measurements, extensions of frequency, magnitude and accuracy are realized. Specific examples are discussed.

9816. Jordan, J. E., Amdur, I., **Almost "head-on" collisions in the scattering of fast argon atoms by hydrogen isotopes,** *J. Chem. Phys.* **46,** No. 10, 4145-4146 (May 1967).

Key words: Hydrogen; intermolecular potential; molecular beam.

A significant difference between the measured elastic cross sections for argon atoms scattered by H_2 from those of argon scattered by D_2 is reported. Measurements in the same apparatus of helium beams scattered by H_2 and D_2 show that there is no significant difference in the interaction potential for H_2 and D_2. The measured difference is a verification of a theoretical prediction that scattering at small impact parameters can reduce the measured cross section when the mass of the beam atom is much larger than the target atom. The difference in cross sections for $Ar-D_2$ and $Ar-H_2$ can be used to obtain potential energies involved in collisions at very small interaction distances.

9817. Judd, D. B., **Color appearance,** *Proc. Intern. Color Comm., Lucerne, Switzerland, 1965,* **1,** 27-51 (Mar. 1966).

Key words: Ambient-light color; color; color appearance; color-matching; normal and abnormal vision.

Summaries of the researches that have formed the basis of predicting color appearance are given as follows: color-matching functions for normal and abnormal vision, simultaneous and successive contrast, von Kries coefficient law of chromatic adaptation, and perceptual separation of object color and ambient-light color. In addition, prediction of the color appearance of non-flat objects is discussed; and the approach to empirical formulas for hue, lightness, and saturation of objection-color perceptions developed in 1940 is described and the shortcomings of the formulas are discussed. Finally, the evidence for the "crispening' effect in lightness perception discovered by Takasaki is presented and discussed.

9818. Judd, D. B., **Color designation and specification,** *Encyclopedia of Industrial Analysis* **1,** 315 (1966).

Key words: Color; colorimetry; vision.

Tristimulus colorimetry is summarized from basic assumptions to the 1931 CIE standard observer and the 1964 CIE supplementary observer and coordinate system for large-field colorimetry. Three types of tristimulus colorimetry (visual, photoelectric, spectrophotometric) are described including operating procedures, methods of reducing the data, and a summary of applications. A similar treatment is given of approximate colorimetry by systematic collections of color standards (Munsell, Ostwald, Maerz & Paul dictionary) including determination of the ISCC-NBS color designation. Definitions of radiometric, photometric, and colorimetric terms used are given in the form of a glossary.

9819. Judd, D. B., **Fundamental studies of color vision from 1860 to 1960,** *Proc. Natl. Acad. Sci.* **55,** No. 6, 1313-1330 (June 1966).

Key words: Chromatic adaptation; color blindness; color-matching functions; color vision; deuteranopia; opponent-colors theory; protanopia; three-components theory of color vision; tritanopia.

The color-matching functions determined since Maxwell's time (1860) have been reduced to the primaries previously (1807) proposed by Young, and the modern determinations are shown to be in good agreement. The principal theories of color vision are summarized under the headings: three-components (Young, Helmholtz, Konig), opponent-colors (Hering), two-stage theories (von Kries-Schrodinger, and Hurvich-Jameson), and three-stage theories (Muller, Adams). The results of quantifying these theories by appeal to modern determinations of color-matching functions is shown. For example, by the Young theory, predictions of the spectral absorptance of three retinal photo-pigments are derived, and from the Helmholtz-Konig theories, the responses of three types of retinal receptors responsible for color vision are derived. The various experimentally determined relations between the three principal forms of partial color-blindness and normal color vision are inter-compared and checked against the various theories, and a brief review of the results of studies of chromatic adaptation (von Kries coefficient law; Stiles two-color increment thresholds) and their theoretical implications is given.

9820. Judd, D. B., **Interval scales, ratio scales, and additive scales for the sizes of differences perceived between members of a geodesic series of colors,** *J. Opt. Soc. Am.* **57,** No. 3, 380-386 (Mar. 1967).

Key words: Additive scales; color geodesics; color scales; geodesics; interval scales; ratio scales; scales; scaling.

From larger-smaller judgments of color differences, compared visually two at a time, the perceived sizes may be evaluated on an interval scale. Given numbers B so evaluated, and such that B is linearly connected to some power p, less than one, of the physical measure D (such as distance on any chromaticity diagram) of the differences, the additive constant K_{br} such that the numbers $B+K_{br}$ are expressed on a ratio scale, may be found from judgments of ratios of sizes of pairs of color differences. To evaluate p, it is sufficient to observe the three differences, 12, 23, and 13 among three colors forming a geodesic series, and chosen so that B_{12} is not much different from B_{23}. The scale formed by the numbers $(B+K_{br})^{1/p}$ is additive if the D-scale is additive. A close approximation may be found without determining K_{br} or p. This approximation is based on the empirical discovery that the additivity condition:

$$(B_{12}+K_{bd})^{1/p}+(B_{23}+K_{bd})^{1/p}=(B_{13}+K_{bd})^{1/p},$$

though it implies that K_{bd} depends strongly on p, is satisfied about equally well by any choice of p. It is sufficient, therefore, to derive the additive scale by setting $p=1$, and computing K_{bd} as $B_{13}-B_{12}-B_{23}$.

9821. Judd, D. B., **Progress report for OSA committee on uniform color scales,** *Proc. Intern. Color Comm., Lucerne, Switzerland, 1965,* **1,** 399-407 (Mar. 1966).

Key words: Color chips; color scales; painted color chips; rhombohedral lattice-sampling method; uniform color scales.

This committee, organized in 1947, has been engaged since 1955 in experiments intended to result in the production of several hundreds of painted color chips that would sample the paint gamut as uniformly as possible by the regular rhombohedral lattice-sampling method. The first experiment (1956) determined a locus of chromaticity points on the CIE (x,y)-diagram for colors of Munsell value 6/ perceived as having the same saturation (departure from gray). The second experiment (1957) determined 40 chromaticity points on this locus equally spaced in hue. The third experiment (1961) determined chromaticness spacing near grays of Munsell 3/, 6/, and 8/. The latest experiment is a preparation of 43 chips intended to give a uniform triangular sampling at Munsell 6/, and a check of the spacing uniformity by 70 observers each making judgments of "larger" or "smaller" for 142 of the pairs of differences among the 43 chips. Some tentative conclusions are presented.

9822. Judd, D. B., **Reflectance spectrophotometry,** *Encyclopedia of Industrial Chemical Analysis* **3,** 376-392 (John Wiley and Sons, Inc., New York, N.Y., 1966).

Key words: Color; color matches; light-diffusing specimens; reflectance spectrophotometry; spectrophotometry.

Five commercially available spectrophotometers adapted to the measurement of light-diffusing specimens are described. The use of these instruments for qualitative and quantitative analysis of such specimens by means of the Kubelka-Munk model is presented together with the methods for formulating colorants required to produce both nonmetameric and metameric color matches.

9823. Judd, D. B., **Terms, definitions, and symbols in reflectometry,** *J. Opt. Soc. Am.* **57,** No. 4, 445-452 (Apr. 1967).

Key words: Definitions in reflectometry; photometry; radiometry; reflectance; symbols in reflectometry; terms in reflectometry.

Angular conditions of incidence are described as hemispherical, conical, or directional; the same adjectives are used to describe the angular conditions of collection. This classification of angular conditions leads to nine kinds of reflectance; symbols for them are proposed in which 2π, g, and θ_0, ϕ_0 refer to hemispherical, conical, and directional incidence, 2π, g', and θ_r, ϕ_r refer to the corresponding kinds of collection. Use of the perfectly reflecting mirror and of the perfectly reflecting diffuser as reference standards in reflectometry is discussed. Three of the nine reflectance ratios, specimen to perfect diffuser, in which the collection is directional have already been named radiance [luminance] factor. It is proposed to differentiate them by angular condition of incidence. It is also proposed to name the other six ratios: reflectance factor qualified by the same adjectives identifying the type of incidence and collection as are used for reflectance. The interrelationships of these 18 concepts are shown both by formulas for computing one from another and by diagrams indicating the process (integration, summation, averaging, equality, reflectance of perfect diffuser, and reciprocity) by which values of one concept may be computed from those of another.

9824. Judd, D. B., **Progress report for OSA committee on uniform color scales,** *Die Farbe* **14,** 287-295 (1965).

Key words: Color chips; color scales; painted color chips; uniform color scales.

This committee, organized in 1947, has been engaged since 1955 in experiments intended to result in the production of several hundreds of painted color chips that would sample the paint gamut as uniformly as possible by the regular rhombohedral lattice-sampling method. The first experiment (1956) determined a locus of chromaticity points on the CIE (x,y)-diagram for colors of Munsell value 6/ perceived as having the same saturation (departure from gray). The second experiment (1957) determined 40 chromaticity points on this locus equally spaced in hue. The third experiment (1961) determined chromaticness spacing near grays of Munsell 3/, 6/, and 8/. The latest experiment is a preparation of 43 chips intended to give a uniform triangular sampling at Munsell 6/, and a check of the spacing uniformity by 70 observers each making judgments of "larger" or "smaller" for 142 of the pairs of differences among the 43 chips. Some tentative conclusions are presented.

9825. Kaeser, R. S., Ambler, E., Schooley, J. F., **Vibrating coil magnetometer for use at very low temperatures,** (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Texas, Aug. 23-25, 1965), Chapter in *Advances in Cryogenic Engineering* **11,** 694-698 (Plenum Press, Inc., New York, N.Y., 1966); *Rev. Sci. Instr.* **37,** No. 2, 173-175 (Feb. 1966).

Key words: Cryogenic; demagnetization; instrumentation; magnetic moment; magnetization; magnetometer; vibrating coil.

A vibrating coil type magnetometer is described for measuring magnetization curves of small specimens in the magnetic cooling range of temperature. For a 3 mm diameter sphere the sensitivity of magnetic moment measurements is 10^{-6} emu. At this sensitivity the amplitude of vibration is 0.5 mm, and at 0.3 °K the extra heat influx into the sample thereby introduced is less than 10 erg/min. Examples of magnetization curves are shown.

9826. Kamas, G., Morgan, A. H., Jespersen, J. L., **Preliminary results of some new measurements of phase velocity at VLF,** *Radio Science* **1,** No. 12, 1409-1410 (Dec. 1966).

Key words: Ionosphere; phase velocity; VLF.

A new measurement of the phase velocity of VLF radio waves is described. The measured value of the phase velocity at 18.6 kc/s, for distances greater than 2400 kilometers from the transmitter, was -0.0021 ± 0.0006 in the form $v_p/c-1$. For both 18.6 and 20.0 kc/s, at distances less than 2400 kilometers, the phase velocity varied with distance from the transmitter.

9827. Kanagy, J. R., **Physical and performance properties of leather,** Chapter 64 in *The Chemistry and Technology of Leather* 4, 369-416 (Reinhold Publ. Corp., New York, N.Y., 1965).

Key words: Fiber structure; hide; insulator leather; mechanical properties; physical properties; stability.

This Chapter gives an outline of the properties of leather including both strength and mechanical properties such as compressibility and flexing. In addition its value as an insulator and its stability to temperature and atmospheric conditions are discussed. The nature of the hide is described with regard to fiber structure and chemical composition in order to give a better understanding of its properties and indicate how it might be modified. The information should be useful in developing further uses for leather and to stimulate further research in the study of its properties.

9828. Kasuya, T., Lide, D. R., Jr., **Measurements on the molecular nitrogen pulsed laser,** *Appl. Opt.* **6,** No. 1, 69-80 (Jan. 1967).

Key words: Accurate wavelength measurements; laser; molecular nitrogen pulsed laser; nitrogen molecule; nitrogen pulsed laser; pulsed laser emission; rotational band spectrum.

Accurate wavelength measurements of the pulsed laser emission from the nitrogen molecule have been made. About one hundred new stimulated emission lines which belong to the first and second positive systems were obtained and identified as to rotational quantum number. The relative intensities of the laser lines in the rotational band spectrum are analyzed. Some characteristics of the oscillations, including the recovery time after the laser pulse, are discussed.

9829. Keegan, H. J., Weidner, V., **Infrared reflectance of frost,** *J. Opt. Soc. Am. Letter* **56,** No. 4, 523-524 (Apr. 1966).

Key words: Carbon dioxide; frost; infrared; spectral reflectance; water.

The infrared reflectance spectra of water frost and of two forms of solid carbon dioxide ("frost" and crushed commercial "dry ice"), were obtained over the spectral range 4000 to 450 cm^{-1} on a high-resolution spectrophotometer with a reflectance attachment.

9830. Keenan, R. G., Marcus, J. M., DeVoe, J. R., **Simultaneous determination of copper and zinc in human lung tissue by**

neutron activation analysis, *Am. Ind. Hygiene Assoc. J.* **27,** 128-134 (Mar.-Apr. 1966).

Key words: Biosyntheses; catalysis in biosyntheses; copper; human lung tissue; lung tissue; neutron-activation analysis.

Certain trace elements including copper and zinc are constituents of numerous enzymes and function as essential catalysts in biosyntheses. The expanded interest in these substances has supplied a demand for microanalytical techniques of increased sensitivity, accuracy and precision if meaningful conclusions are to be derived from the analytical data. This paper shows that good precision may be realized in the activation analysis of complex biological specimens with only a few one-step chemical separations.

The nuclear reactions Cu^{63} (n,γ) Cu^{64} (12.8h) and Zn^{68} (n,γ) Zn^{69m} (13.8h) were used for the analysis. The samples were irradiated in a thermal neutron flux of 10^{13} n/cm^2/sec. The copper was extracted as the acetylacetonate into chloroform from an acetate system buffered at a pH of 4.75. The remaining aqueous phase was extracted with chloroform to remove most of the acetylacetone dissolved in the aqueous phase. The zinc was extracted as the dithizonate into chloroform and was back-extracted into 1% HCl for counting. Careful internal standardization was used for correction of results for variation in chemical yields.

Applications of the method to the simultaneous determination of copper and zinc in lung samples provided values of the same order of magnitude as those reported by Tipton and Cook for U.S. adults using emission-spectrographic procedures which were between 7 and 10 ppm for copper and 40 and 70 ppm for zinc. Comparison of the precision of this method with that of emission spectroscopy indicates that this activation technique has at least three times better precision.

9831. Keffer, C., Mighell, A., Mauer, F., Swanson, H., Block, S., **The crystal structure of twinned low-temperature lithium phosphate,** *Inorg. Chem.* **6,** No. 1, 119-125 (June 1967).

Key words: Crystal structure; differential thermal analysis; lithium; lithium phosphate; twinning.

It is shown that lithium phosphate (Li_3PO_4) prepared by precipitation from an aqueous solution differs from the form that has been described in the literature. When heated it transforms irreversibly at 502±5° to the familiar form. The low-temperature orm crystallizes in space group $Pmn2_1$ with $a_0 = 6.1150 \pm 0.0010$ Å, $b_0 = 5.2394 \pm 0.0011$ Å, and $c_0 = 4.8554 \pm 0.0010$ Å; $Z = 2$. It exhibits merohedral twinning with the twin plane normal to the z axis. The multiplicity of the predominant image is 0.75. All atoms are tetrahedrally coordinated. The final reliability index is 0.054.

9832. Keller, R. A., Dolby, L. J., **Rate constants and the mechanism for the transfer of triplet excitation energy,** *J. Am. Chem. Soc.* **89,** 2768-2770 (May 1967).

Key words: Energy transfer; fluorescence; phosphorescence; triplet states.

The intramolecular transfer of triplet excitation between chromophors held approximately 15 Å apart by rigid steroid bridge was measured for the two molecules shown below. The acceptor in both cases is the naphthalene chromophor. The rate constant for transfer is 25 sec.$^{-1}$ for I and 0.04 sec.$^{-1}$ for II. The 1000 fold difference in these rate constants is paralleled by the 1000 fold difference in the triplet state lifetime for the two donor chromophors. The transfer mechanism indicated by these results involves spin-orbital coupling to the singlet system in the donor chromophor combined with dipole-dipole coupling between the singlet systems of the two chromophors and spin-orbital coupling back to the triplet system in the acceptor chromophor. In both cases the transfer of singlet excitation energy was more complete than the transfer of triplet excitation energy.

9833. Kelly, F. J., **An equation for the local thermal emissivity at the vertex of a diffuse conical or V-groove cavity,** *Appl. Opt.* **5,** 925-927 (June 1966).

Key words: Diffuse conical or V-groove cavity; emissivity, vertex of a diffuse conical or V-groove cavity; equation, apparent local emissivity; vertex of a diffuse conical or V-groove cavity; V-groove cavity.

An exact, closed-form expression is derived for the apparent local emissivity at the vertex of a diffuse conical or V-groove cavity. This expression is obtained by a substitution into an approximate equation for the apparent local emissivity of a point within a cavity of any shape. The exact expression depends only on the emissivity of the cavity wall material and the angle factor between the point at the cavity vertex and the cavity opening. Agreement is very good between the values predicted by the expression and those obtained from a numerical solution of the integral equation characteristic of a diffuse conical cavity.

9834. Kerns, D. M., Grandy, W. T., **Perturbation theorems for waveguide junction, with applications,** *IEEE Trans. Microwave Theory Tech.* **MIT-14,** No. 12, 85-92 (Feb. 1966).

Key words: Compensation theorems; immittance-matrix elements; perturbation theorems; waveguide junctions.

Perturbation or "compensation" theorems are derived for waveguide junctions. These express changes in immittance-matrix elements, due to changes in the junction, in terms of integrals over products of changed and unchanged basis-fields associated with the junction and its adjoint. Media involved are required only to be linear.

Applications are made to half-round obstacles in rectangular waveguide, to finite conductivity in the obstacle problem, and to the junction of rectangular with filleted waveguide. It is observed that the common expedient of approximating perturbed fields by unperturbed ones does not always lead to correct lowest-order results.

9835. Kerper, M. J., Scuderi, T. G., **Mechanical properties of chemically strengthened glasses at high temperatures,** *J. Am. Ceram. Soc.* **49,** No. 11, 613-618 (Nov. 1966).

Key words: Chemically strengthened glass; elevated temperature; glass; strength; Young's modulus.

Young's modulus, shear modulus, and modulus of rupture of two chemically strengthened glasses were determined at elevated temperatures. The results showed that the Young's modulus and shear modulus decrease with increasing temperature with a sharp inflection present slightly above room temperature.

The modulus of rupture is not affected by short exposure to temperatures up to 260 °C, but drops appreciably when exposed to temperatures above 204 °C for 200 hours or more.

Measurement of deflection at room temperature showed the two chemically strengthened glasses to exhibit about five times as much delayed elasticity as did thermally tempered soda-lime-silica glass.

9836. Kerper, M. J., Scuderi, T. G., **Modulus of rupture of glass below room temperature,** *Am. Ceram. Soc. Bull.* **45,** No. 9, 782-783 (Sept. 1966).

Key words: Glass; low temperature; strength.

The modulus of rupture of seven different commercial glasses was determined at 0 °F (−17.8 °C) and −50 °F (−45.6 °C). The results showed that for all glasses and for all conditions of temper the modulus of rupture increased as the temperature decreased.

9837. Kerper, M. J., Scuderi, T. G., **Relation of fracture stress to the fracture pattern for glass rods of various diameters,** *Am. Ceram. Soc. Bull.* **45,** No. 12, 1065-1066 (Dec. 7, 1966).

Key words: Fracture; fracture pattern; glass; mirror-size; strength.

Five different size glass rods ranging in diameter from 0.16 inch to 1.5 inch were broken and the relationship between the fracture stress and fracture pattern determined. The results showed that the size of the rod affected the fracture stress but did not affect the relationship between the size of the smooth, or "mirror" part of the fracture face and fracture stress.

9838. Kessler, H. K., **Cooler for semiconductor light emitters, laser and photodetectors,** *Rev. Sci. Instr.* **37,** 517-518 (Apr. 1966).

Key words: Cryogenic cooler; light emitters; mode switching; photo detectors; semiconductor lasers.

A device for cooling lasers and radiation detectors by means of a jet of gas permits control of the temperature of the laser or detector over a wide range of temperatures not normally accessible by cryogenic cooling techniques.

9839. Kessler, K. G., **Some experiments with Zeeman shifted levels,** (Proc. Zeeman Centennial Conf., Amsterdam, The Netherlands, Sept. 9-11, 1965), *Physica* **33,** 29-46 (1967).

Key words: Atomic beams; double resonance; isotope shifts; Lande *g*-factor; mercury hyperfine structure; Zeeman filter.

A review of some applications of the Zeeman effect to studies of the resonance line of mercury. Techniques discussed include Zeeman scanning of an atomic beam, double resonance, level crossing and the Zeeman filter. Examples are drawn in large part from the work of Dr. Bitter's group at MIT and of the author and his colleagues at NBS. Fundamental data obtained in these studies include the hyperfine structure, isotope shifts and Zeeman splitting, in both naturally occurring and short-lived isotopes, the Lande *g*-factor and the lifetime of the $^3P_1{}^0$ states.

9840. Kidnay, A. J., Hiza, M. J., **High pressure adsorption isotherms of neon, hydrogen, and helium at 76 °K,** (Proc. 1966 Conf., Boulder, Colo., June 13-15, 1966), Chapter in *Advances in Cryogenic Engineering* **12,** 730-740 (Plenum Press, Inc., New York, N.Y., 1967).

Key words: Adsorption potential; charcoal; helium; high-pressure physical adsorption; hydrogen; low temperature; neon; zeolite.

A desorption technique was used to measure the physical adsorption isotherms of hydrogen and helium on a synthetic zeolite and of hydrogen, helium, and neon on an activated cocoanut shell charcoal at 76 °K in the pressure range of 1 to 95 atmospheres.

The Polanyi adsorption potential theory, as modified by Dubinin, was used in an attempt to obtain a general correlation of these isotherms. The results, while not completely general, should allow the prediction of the high pressure isotherms of neon, hydrogen, and helium at any temperature with an accuracy sufficient for most engineering calculations.

9841. Kidnay, A. J., Hiza, M. J., **The low temperature removal of small quantities of nitrogen or methane from hydrogen gas by physical adsorption on a synthetic zeolite,** *AIChE J.* **12,** No. 1, 58-63 (Jan. 1966).

Key words: Hydrogen gas; low temperature; methane; nitrogen; physical adsorption; synthetic zeolite; zeolite.

A flow system was used to measure the physical adsorption isotherms of two mixtures of nitrogen and hydrogen and two mixtures of methane and hydrogen on a synthetic zeolite. The measurements were made at liquid nitrogen temperature and at pressures of 4 to 85 atm. Static systems were used to measure the pure component isotherms of nitrogen, methane, and hydrogen at the same temperature and over the appropriate pressure ranges.

Although many different methods have been proposed for using pure component adsorption isotherms to predict the mixture isotherm, the only method giving quantitative agreement with the data of this study is the empirical "adsorption enhancement factor."

In addition to the adsorption isotherms, the concentration-time or break-through curves of the mixtures were measured at flow rates ranging from 40 to 300 lb.(hr.)-ft.^{2}. The method proposed by Eagleton and Bliss was used to correlate these curves.

9842. Kidnay, A. J., Meyers, A. L., **A simplified method for the prediction of multicomponent adsorption equilibria from single gas isotherms,** *AIChE J.* **12,** No. 5, 981-986 (Sept. 1966).

Key words: Adsorption; adsorption azeotropes; ideal adsorbed solution; multicomponent adsorption equilibria; spreading pressure.

The ideal adsorbed solution theory of Myers and Prausnitz provides an accurate and thermodynamically consistent method for predicting multicomponent adsorption equilibria. The major difficulty in the application of this theory lies in the calculation of the spreading pressure curves for the pure adsorbates. The purpose of this article is to show that in many cases of practical interest, the spreading pressure calculations may be greatly simplified or altogether eliminated with little or no loss in the accuracy of the calculations. The problem of adsorption azeotropy is also briefly discussed.

9843. Kieffer, L. J., Dunn, G. H., **Electron impact ionization cross section data for atoms, atomic ions, and diatomic molecules: I. Experimental data,** *Rev. Mod. Phys.* **38,** No. 1, 1-33 (Jan. 1966).

Key words: Absolute cross sections; critical review; electron impact; multiply charged ions; relative cross sections.

This review includes a compilation and critical evaluation of absolute cross sections for ionization of atoms and diatomic molecules by electron impact. Experimental techniques used for ionization are surveyed. Selected relative cross sections for production of multiply charged ions and a brief discussion of relative cross section data near threshold are presented. Absolute limits are not set on the size of probable systematic errors in the various experiments.

9844. Kieffer, L. J., Van Brunt, R. J., **Energetic ions from N_2 produced by electron impact,** *J. Chem. Phys.* **46,** No. 7, 2728-2734 (Apr. 1967).

Key words: Angular distributions; appearance potentials; electron impact; energetic ions; energy distributions; N_2.

Energy distributions, appearance potentials, and angular distributions of N^+ ions produced by electron impact on N_2 have een observed. The energy distribution and appearance potential of the N^{++} ions from electron impact on N_2 were also observed. The data are interpreted to give the abundance of the "zero energy" N^+ and the N^{++} ions. The appearance potential data for the "zero energy" N^+ ions disagree with previous measurements, and a possible interpretation indicates that the conclusion of previous investigators that no excited ions are produced may not be valid.

9845. King, R. C., Armstrong, G. T., **A study of the heat of formation of oxygen difluoride,** Proc. 5th Meeting of ICRPG, Working Group on Thermochemistry 1, 69, *CPIA Publ.* **146** (May 1967).

Key words: Calorimetry, fluorine flame; fluorine, reaction with hydrogen; hydrofluoric acid, heat of formation; hydrogen, reactions with fluorine, oxygen difluoride and oxygen; oxygen, reaction with hydrogen; oxygen difluoride, heat of formation; oxygen difluoride, reaction with hydrogen.

The enthalpies of the reactions below ΔH°_{303} were determined in a flow calorimeter operated at one atm. pressure, to be respectively, in kcal mol^{-1}, -227.52 (0.16), -153.38 (0.06), and -68.28 (0.03). The numbers in parentheses are the standard deviations of the means for 13, 5, and 6 experiments, respectively. The enthalpy of formation of $OF_2(g)$, ΔH°_{f298},

$$OF_2(g) + 2H_2(g) + 99H_2O(l) = 2[HF \cdot 5OH_2O](l)$$

$$F_2(g) + H_2(g) + 100H_2O(l) = 2[HF \cdot 5OH_2O](l)$$

$$1/2\ O_2(g) + H_2(g) = H_2O(l)$$

$$F_2(g) + 1/2\ O_2(g) = OF_2(g)$$

was calculated from the measured enthalpy changes to be $+5.86$ kcal mol^{-1}. The average bond energy $E(O-F)$ in the gaseous molecule of OF_2 was calculated to be 45.72 kcal mol^{-1}. The results of the second reaction are compared with other recently derived data on HF(aq).

9846. Kirchoff, W. H., **The microwave spectrum and dipole moment of pyrazole,** *J. Am. Chem. Soc.* **89,** No. 6, 1312-1316 (Mar. 1967).

Key words: Dipole moment; gas phase pyrazole; microwave spectrum; pyrazole; rotational constants.

The microwave spectrum of pyrazole in the region 8000 Mc/s to 35000 Mc/s has been assigned. The rotational constants are A = 9618.92±0.14 Mc/s, B = 9412.59±0.13 Mc/s and C = 4755.88±0.11 Mc/s. The dipole moment $\mu = 2.214 \pm 0.015$ D was calculated from the Stark effect of the $0_{0,0} \rightarrow 1_{0,1}$ and $0_{0,0} \rightarrow 1_{1,1}$ transitions but only after the perturbation treatment had been extended to fourth order. The indicated uncertainties are three times the standard errors obtained from the least squares fit. The interpretation of the data shows that in the gas phase pyrazole is a planar molecule with no in-plane symmetry axis.

9847. Klebanoff, P. S., **The effect of a two-dimensional roughness element on boundary layer transition,** (Proc. Eleventh Intern. Congress Applied Mechanics, Munich, Germany, 1964), Chapter in *Applied Mechanics,* H. Gortler, ed., pp. 803-805 (Springer-Verlag, Berlin, Germany, 1966).

Key words: Hot-wire anemometry; instability; laminar boundary layer; roughness; transition.

This paper is in the nature of a summary of the results obtained from an experimental investigation of the effect of a two-dimensional roughness element on boundary layer transition. The method of investigation and the main results obtained are described. It is revealed that the basic mechanism by which a two-dimensional roughness element induces earlier transition from laminar to turbulent flow in boundary layers is by the destablizing influence of the distorted flow in the immediate downstream vicinity of the roughness.

9848. Klein, F. S., Herron, J. T., **Erratum: Mass spectrometric study of the reactions of O atoms with NO and NO_2,** *J. Chem. Phys.* **44,** No. 9, 3645-3646 (May 1, 1966).

Key words: Kinetics; nitric oxide; nitrogen dioxide; oxygen; oxygen atoms; rate constants.

In an earlier paper (*J. Chem. Phys.*) the reactions of O atoms with O_2, NO, and NO_2 were discussed in terms of the general mechanism

$$O + XO \underset{B}{\overset{A}{\rightleftharpoons}} [OXO]^* + M \xrightarrow{C} XO_2 + M$$

$$\xrightarrow{D} X + O_2$$

$$\xrightarrow{E} XO_2 + h\nu$$

In derived rate constants k_B and k_D for the NO_2 reaction were anomalously low due to an arithmetic error on our part and the use of a misquoted rate constant from the literature. The values have now been corrected.

9849. Klose, J. Z., **Atomic lifetimes in neon I,** *Phys. Rev.* **141,** No. 1, 181-186 (Jan. 1966).

Key words: Delayed coincidence; lifetimes, atomic; neon; spectra, atomic.

Mean lives of a number of electronically excited atomic levels in Ne I have been determined using a method of delayed coincidence. Following a detailed description of the experimental procedure, the measured values of the mean lives of the $2p_1$ through $2p_9$, $3p_1$, $3p_{10}$, and $4d'_1$ (Paschen notation) levels in neutral neon are given. These lifetimes, determined from transitions with associated wavelengths extending from ≈ 3400 Å to ≈ 6400 Å, ranged in value from ≈ 14 nsec (10^{-9} sec) to ≈ 500 nsec. The lifetimes were estimated to contain possible systematic errors varying from 5 to 20 percent and are presented in comparison with corresponding results of other workers.

9850. Klose, J. Z., **Mean lives of atomic levels excited by electron impulse,** *Proc. Intern. Conf. Electronic Excitation of an Atomic Vapor--Applicable to Spectroscopy, Grenoble, France, May 23-26, 1966* (Centre Natl. de la Recherche Scientifique, Paris, France, 1967).

Key words: Atomic levels; electron impulse; mean lives; slow electrons.

The life-time of the atomic levels of rare gases is measured by the recording of the de-excitation of levels reached by the impulses of slow electrons, by means of the technique of delayed coincidence. The order of length of the life-times measured is 15 to 30 ns. (He, Ne, Ar).

9851. Knight, B. L., Timmerhaus, K. D., Flynn, T. M., **A superconducting liquid-level sensor for slush hydrogen use,** (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Texas, Aug. 23-25, 1965), Chapter in *Advances in Cryogenic Engineering* **11,** 218-222 (Plenum Press, Inc., New York, N.Y., 1966).

Key words: Liquefied gases, liquid level gages; liquid level gages, hydrogen; liquid rocket propellants; performance (engineering); sensors; superconductors.

A system of three superconducting niobium stannide liquid-level sensors was constructed and tested in triple-point liquid hydrogen. Tests indicated that the sensors were capable of detecting, in a linear fashion, the liquid level of the system over a range of about 60% of the total sensor length. One of the sensors was shown to be capable of detecting a liquid-level change on the order of 0.2 mm. Sensitivity of the sensors was investigated and was shown to be a function of the current applied to the sensors as well as a function of several physical characteristics of the sensors themselves. A heat balance was used to obtain an approximation to the measurement error of the sensors.

9852. Koch, H. W., **Electron beams: National Bureau of Standards and the new technology,** *Science* **156,** No. 3773, 321-328 (Apr. 1967).

Key words: Electrons; nuclear physics; particle accelerators; radiation measurement standards; radiation power; radiation processing; x rays.

High-energy electron beams can now be generated with radiation powers of hundreds of kilowatts and can be measured with energy resolutions of several parts in 10^4. The importance of this new technology to science, industry, and the public is related to the measurement research and services of the National Bureau of Standards.

9853. Koch, H. W., Eisenhower, E. H., **Radioactivity criteria for radiation processing of foods,** Chapter 7 in *Radiation Preservation of Foods,* pp. 87-108 (Advances in Chemistry Series **65,** Am. Chem. Soc., Washington, D.C., 1967).

Key words: Detection; induced radioactivity; maximum permissible concentrations; photonuclear reactions; processing; radiation; threshold energies.

The high-dose-level processing of foods by high-energy electrons and x rays can induce measurable radioactivity in foods. Such radioactivity might, but fortunately need not, present a food wholesomeness problem. The amount of induced radioactivity can be controlled and limited so as to be non-measurable by limiting the maximum energy of the radiation to 10 MeV. Therefore, non-measurability is one useful criterion. Another criterion may be developed from considerations of the maximum permissible concentration of radioactivity in foods and of the deliberate or chance nature of the occurrence of the activity. The bases of the various criteria and of possible future developments are detailed by a consideration of the characteristics of photonuclear radioactivities, the detection methods and capabilities, the influence of production parameters, and the maximum permissible concentrations.

9854. Kokoszka, G. F., Allen, H. C., Jr., Gordon, G., **Magnetic and optical spectra of two dimeric copper-chloride pyridine-*n*-oxide complexes,** *J. Chem. Phys.* **46,** 3013 (Apr. 1967).

Key words: Copper chloride-pyridine-*n*-oxide; exchange coupled; magnetic spectra; optical spectra; triplet state.

The electron paramagnetic resonance spectra and the optical absorption spectra of dichlorobispyridine-*n*-oxide copper(II) $[(C_5H_5NO)_2CuCl_3]$ and dichloromonoaquopyridine-*n*-oxide copper(II) $[C_5H_5NOCuCl \cdot H_2O]$ have been observed at room temperature. The magnetic resonance studies were carried out at both X-band and K-band frequencies. The observed spectra could be fit to an $S = 1$ spin Hamiltonian. The direction of the maximum zero field splitting did not correspond to the principal z axis of the g tensor. For the $(C_5H_5NO)_2CuCl_2$ the angle between these two directions was about 23° and for the $C_5H_5NOCuCl \cdot H_2O$ the angle was about 27°. A study of the intensity of the E.P.R. signal as a function of temperature indicated that the triplet state was about 550 cm^{-1} above the single ground state for the $(C_5H_5NO)_2CuCl_2$ and about 885 cm^{-1} above the singlet state for the other complex. The optical spectra for both examples revealed two bands in the 8000- to 15,000-cm^{-1} region and a higher energy transition at about 22,000 cm^{-1}.

9855. Kokoszka, G. F., Allen, H. C., Jr., Gordon, G., **The electron paramagnetic resonance spectrum of tetrakis-t-butoxyvanadium (IV),** *Inorg. Chem.* **5,** No. 1, 91-93 (Jan. 1966).

Key words: Electron paramagnetic spectrum; paramagnetic resonance spectrum; tetrakis-t-butoxyvanadium.

The electron paramagnetic resonance spectrum of tetrakis-t-butoxyvanadium (IV), $[V(OR)_4]$, has been measured in the temperature range of 30° to −196 °C. The measurements were made on pure $V(OR)_4$, 1-2% $V(OR)_4$ in $Ti(OR_4)$ and 1-2% $V(OR)_4$ in CS_2. The spectrum was essentially the same in all the samples. At 30 °C $\langle g \rangle = 1.964$ and $\langle a \rangle = 0.0064$ cm^{-1} while at −196 °C in the solid the magnetic parameters are $g\| = 1.940$, $gN = 1.984$, $A\| = 0.0125$ cm^{-1} and $A = 0.0086$ cm^{-1}. These parameters are interpreted in terms of the molecular orbital-theory and the model due to Murao is used to account for the low value of the effective spin-orbit coupling constant, 156 cm^{-1}.

9856. Kokoszka, G. F., Reimann, C. W., Allen, H. C., Jr., **The optical and magnetic spectra of copper-doped dichloro(1,10-phenanthroline) zinc,** *J. Phys. Chem.* **71,** No. 1, 121-126 (Jan. 1967).

Key words: Dichloro(1,10-phenanthroline) copper; dichloro(1,10-phenanthroline) zinc; d-d transition; electron spin resonance spectrum; polarized optical spectrum.

The optical and magnetic spectra of copper-doped dichloro(1,10-phenanthroline) zinc have been observed. In this complex the cupric ion is a distorted tetrahedral environment which is not common for this ion. Two d-d transitions were observed at 11,630 and 13,800 cm^{-1}. The parameters in the spin Hamiltonian are found to be $g_z = 2.297 \pm 0.002$, $g_x = 2.058 \pm 0.002$, $g_y = 2.062 \pm 0.002$, $A_z = 4 \times 10^{-4}$ cm^{-1}, $A_x = 9 \pm 4 \times 10^{-4}$ cm^{-1} and $A_y = 9 \pm 4 \times 10^{-4}$ cm^{-1}. From the ligand superhyperfine structure it is found that hybridization on the nitrogen is sp^2 and that the bonding orbital on the chlorine is essentially pure p. From the copper hyperfine structure it is found that there is very little admixture of the 4p functions in the ground state. The indicated uncertainties are due to the uncertainty of the alignment of the crystal in the applied magnetic field and are maximum estimated values.

9857. Kostkowski, H. J., **Optical, pyrometry,** *Encyclopedia of Physics,* R. Besaucon, ed., pp. 563-564 (Reinhold Publ. Corp., New York, N.Y., Jan. 1966).

Key words: Optical pyrometry; pyrometry; radiation thermometry; temperature measurement.

A typical visual optical pyrometer, a method of calibrating it from basic principles and the estimated accuracy of such a calibration are outlined. Spectral emissivity and brightness temperature are defined, and other type radiation pyrometers are briefly discussed.

9858. Kopec, C. S., **Measurement of gears,** Chapter 15 in *Handbook of Industrial Metrology,* pp. 424-450 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Analytical inspection; composite inspection; gears; index; involute; lead; metrology; process control.

This chapter contains 26 pages of information on gear measuring methods, practices and basic definitions. The data presented cover only those practices and inspection methods which are recognized and accepted throughout the gear industry as being reliable. The methods described provide measurements which are accurate and repeatable to a degree compatible with the specified quality. Experienced personnel, using calibrated instruments in a suitable environment, are required.

Process control is the method by which gear accuracy is maintained through control of manufacturing equipment, methods, and processes. When analytical inspection of gear elements is required, methods are described for measuring the following tooth elements: runout, pitch, profile, lead, backlash, tooth thickness, and composite method of gear inspection.

9859. Krasnansky, V. J., Parker, M. S., Florin, R. E., **The effect of gamma irradiation on a polyamide,** *J. Phys. Chem.* **70,** No. 1, 40-46 (Jan. 1966).

Key words: Diffusion-controlled reaction; electron spin resonance; irradiation; kinetics of intermediates; polyamide; radical.

Electron spin resonance and optical spectroscopy were used to study the kinetics of intermediates produced by the irradiation of a polyamide MXD-6. This polymer derived from meta xylylene diamine and adipic acid showed remarkable stability to irradiation in previous studies. Experienced personnel, using calibrated instruments in a suitable environment, are required. It is concluded that the colored intermediate is a radical species, whose molar extinction coefficient is $\sim 10^5$ at 3000 Å.

At temperatures above 85 °C the decay of the active species measured by both methods tends to become second order after an initial rapid decay. This complex decay rate during the initial period was attributed to radicals having a very high decay rate or a diffusion controlled bimolecular reaction of pairs. The derived activation energy for diffusion was 19 to 29 kcal/mole.

9860. Kruger, J., **Use of ellipsometry in the study of corrosion,** *Corrosion* **22,** No. 4, 88-97 (Apr. 1966).

Key words: Corrosion; ellipsometry; film thickness; surface measurement techniques.

Ellipsometry by determining the change in the state of polarization (ellipticity) of polarized light reflected from a metal surface bearing a thin film enables one to measure the thickness of this film and its optical properties. Because corrosion processes are strongly affected by the presence of thin films, ellipsometry is an especially valuable tool in corrosion research because it allows one to observe film formation, dissolution, or property changes while these phenomena are actually occurring on a metal surface immersed in any transparent environment. Experimentally the use of ellipsometry mainly requires an experimental cell that allows one to reflect light from the corroding or passive metal surface under study. Thus it does not interfere with other techniques, such as, for example ultra-high vacuum surface preparation or potentiostatic studies, allowing them to be carried out simultaneously along with ellipsometric measurements.

Some of the experimental complications that must be considered in applying ellipsometry to corrosion studies are surface roughening, changes in the optical properties of the solution, non-uniformity of films, effect of light on the corrosion process, and phase changes in the corrosion product films.

The following specific examples serve as a small sampling of the many ways in which ellipsometry may be applied to corrosion studies: (1) The determination of the nature and rate of growth of passive films on iron in inorganic inhibitor solutions. (2) The separation of the different stages in the early growth process of films formed by potentiostatic anodic polarization on iron in neutral solutions. (3) The determination of the point in the corrosion of copper when a new phase begins to form in the corrosion product film.

9861. Ku, H. H., **Statistical concepts in metrology,** Chapter 2 in *Handbook of Industrial Metrology,* pp. 20-54 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Industrial metrology, measurement process; statistical analysis; statistical concepts.

These two sections of the chapter, statistical concepts of a measurement process and statistical analysis of measurement data, are part of the text book *Handbook of Industrial Metrology* sponsored by the American Society of Tool and Manufacturing Engineers.

Beginning with the differentiation between arithmetic and measurement numbers, the properties of the latter are developed and described, leading to a discussion of precision and accuracy at the end of the first section.

A basic kit of tools for the comparison and manipulation of means and variances are given in the second section, including a collection of propagation of error formulas. The use of control chart techniques for monitoring stability is emphasized. Examples are given using actual calibration data of NBS.

Selected references are given for topics introduced but not treated in detail.

9862. Kuczkowski, R. L., Lide, D. R., Jr., **Microwave spectrum, structure, dipole moment, and barrier to internal rotation of phosphorus trifluoride-borane,** *J. Chem. Phys.* **46,** No. 1, 357-365 (Jan. 1967).

Key words: Barrier; coriolis; dipole moment; microwave spectrum; phosphorus trifluoride-borane; structure.

The microwave spectrum of several isotopic species of phosphorus trifluoride-borane ($F_3P^{11}BH_3$) has been measured and the following structural parameters determined: d(BH) = 1.207±0.006 Å; d(FF) = 1.538±0.008 Å; d(FB) = 1.836±0.012 Å; angle HBH = 115°04′±1°; angle FPF = 99°50′±1°. The dipole moment 0 was evaluated from Stark splitting as 1.06 ± 0.02 D.

The vibrational satellite spectrum associated with the excited ν_{12} (E) and ν_6 (A_2) states for $F_3P^{11}BH_3$ was found to be strongly perturbed and was fitted to the theory for a first order coriolis interaction. The analysis of this perturbation and the measurement of the ν_{12} fundamental in the infrared spectrum permitted the inactive torsional fundamental ν_6 to be determined as 197±5 cm^{-1}. This leads to a potential barrier to internal rotation of 3240 ± 150 cal/mol.

The enthalpy of dissociation for the reaction $2F_3HBH_3 \geqslant 2PF_3 + B_2H_6$ (298°) was determined as 10.99 kcal/mol. The experimental results are compared to those found for other related compounds. The indicated uncertainties represent maximum error believed to be possible.

9863. Kuczkowski, R. L., Lide, D. R., Jr., Krisher, L. C., **Microwave spectra of alkali hydroxides: Evidence for linearity of CsOH and KOH,** *J. Chem. Phys.* **44,** No. 8, 3131-3132 (Apr. 15, 1966).

Key words: Alkali hydroxides; CsOH; KOH; microwave spectra.

The microwave spectra of CsOH and KOH have been observed. Both molecules show a spectrum characteristic of a linear molecule.The K—O and Cs—O distances are found to be 2.18 and 2.40 Å, respectively.

9864. Kuehner, E. C., Leslie, R. T., **Sublimation,** *Encyclopedia of Industrial Chemical Analysis* **3,** 572-584 (John Wiley & Sons, New York, N.Y., 1966).

Key words: Analogous to distillation; analysis-sublimation; condensation temperatures; solid substance; sublimation; sublimators.

Sublimation is considered analogous to distillation and their advantages are compared. Methods of sublimation and types of sublimators are discussed. A section on sublimation analysis is included in which characteristics of a solid substance, such as condensation temperatures, are applied to the identification and quantitative analysis of material.

9865. Kulin, G., **Wind effect on pre-existing waves,** Chapter 16 in *Proc. 1965 ASCE Conf. Coastal Engineering, Santa Barbara, Calif., Oct. 1965,* pp. 369-389 (Am. Soc. Civil Engrs., 1966).

Key words: Water waves; wave damping; waves, wind stress on; wind setup; wind-wave interaction; wind waves.

Wind action on pre-existing waves is examined experimentally in a wind-wave channel, in which the pre-existing waves are generated mechanically by a paddle at the windward end of the channel. Air is blown over these waves, in the direction of wave travel, at velocities up to about 30 feet per second, with the formation of wind-generated waves essentially suppressed by addition of a wetting agent to the water. Wind shear forces on these regular wavy surfaces are deduced for a variety of wave geometries.

9866. Kupiec, C.,Muehlhause, C. O., **NBSR converter tube,** *Trans. Am. Nucl. Soc.* **9,** No. 2, 582-583 (Nov. 1966).

Key words: Converter tube; fast neutron; NBSR; pile reactivity; radiation effects; radioactive; Research Reactor; thermal neutron.

There are plans to incorporate a high-power-density fast-neutron converter tube in the National Bureau of Standards 10-MW Research Reactor, the NBSR. The purpose of such a facility would be for radiation effects studies where the flux is free from a thermal-neutron component. A converter of this type would allow the experimenter to irradiate relatively large samples without allowing them to become excessively radioactive or appreciably perturb pile reactivity.

9867. Kurss, H., **Analysis of multimode experimental data,** *IEEE Trans. Ant. Prop.* **AP-14,** No. 3, 401-402 (May 1966).

Key words: Analysis; determinants: experimental data; multimode; nonlinear parameters; rms error.

An approach for minimizing the rms error in approximating a given function by prescribed sum involving variable parameters is solved as follows: First the nonlinear parameters are determined so as to minimize a certain ratio of two determinants. Then the linear parameters are determined as the solution of a system of linear equations.

9868. Kusuda, T., Achenbach, P. R., **Coincident summer weather characteristics of six selected cities in the United States,** (Proc. Symp. Weather. Toronto, Canada, June 27-29, 1966), *ASHRAE J.* **8,** No. 11, 34-42 (1966).

Key words: Coincident summer weather characteristics: fallout shelter; thermal environment; ventilation requirements.

Survival criteria rather than comfort criteria are often used for designing the ventilation and air-conditioning equipment for fallout shelters for economic reasons. Consequently, the choice of design weather conditions assumes unusual importance. Coincident diurnal values of dry-bulb temperature, dewpoint temperature, and solar radiation were obtained from U.S. Weather Bureau records for the hottest day, hottest week, most humid day, and most humid week each year for a 10-year period for six cities. It was shown that the diurnal pattern of coincident dry-bulb and wet-bulb temperatures during extremely hot and humid periods could not be derived directly from the currently available handbook data reporting percentile levels of temperature for total summer hours. A harmonic analysis of these data was made so that coincident cyclic values of several parameters could be introduced into digital or analog computer studies of the thermal environment of a shelter. Three different sets of design psychrometric data for the ventilating air were used to study the effect of coincident climatic data in repetitive diurnal cycles on the environment of two sizes of fallout shelters.

9869. Kusuda, T., Achenbach, P. R., **Outdoor air psychrometric criteria for summer ventilation of protective shelters,** *ASHRAE Trans.* **71,** Pt. 1, 76-87 (Jan. 25-28, 1965).

Key words: Coincident dry- and wet-bulb temperature; fallout shelter ventilation; thermal environment.

A forced ventilation system using outdoor air, powered either manually or by emergency power sources, often provides six cities. the best combination of reliability and economy for protective shelters where outdoor conditions and occupancy characteristics are not extreme. In above-ground shelters, an assumption that the ventilating air must remove all of the sensible and latent heat released inside the shelter is a reasonably good design criterion in most cases. This report analyzes the relation between ventilation rate, heat release inside the shelter, and outdoor and shelter psychrometric conditions based on this assumption. The ventilation rates required to maintain an effective temperature of 85 in the shelter for various selected outdoor design criteria are calculated for the cities of Houston, Phoenix, and Minneapolis. It is shown that none of the published non-coincident dry-bulb and wet-bulb temperature criteria expressed on a percentile basis are adequate for calculating ventilation rates on an equal-risk basis for various climates. A method for calculating ventilation adequacy factors that is applicable to any city for which suitable outdoor coincident dry-bulb and wet-bulb temperature data are available is described and illustrated.

9870. Kusuda, T., Achenbach, P. R., **Earth temperature and thermal diffusivity at selected stations in the United States,** *ASHRAE Trans.* **71,** Pt. 1, 61-75 (Jan. 25-28 1965).

Key words: Amplitude; earth temperature; earth temperature phase shift: thermal diffusivity: underground installations.

To provide information related to the heat transfer in underground installations, 63 sets of data showing annual variations of monthly average earth temperatures at various depths throughout the 48 contiguous states of the United States of America have been compiled and analyzed for the Office of Civil Defense. These data have been used to compute the annual average amplitude and phase angle of the earth temperature by a least-squares method. Thermal diffusivities of earth computed from the observed temperature data by both the amplitude method and phase lag method were compared for selected earth temperature stations. The earth temperature characteristics were also compared with those of air and ground water temperatures.

9871. Kuyatt, C. E., Simpson, J. A., **Electron monochromator design,** *Rev. Sci. Instr.* **38,** No. 1, 103-111 (Jan. 1967).

Key words: Anomalous energy spreads; electron beams; electron optical limitations; high-resolution electron monochromator; space charge; spherical deflectors.

A study has been made of all the known factors which limit the performance of high-resolution (0.07 to 0.01 eV FWHM) monochromators. These limiting factors have been incorporated into design equations for the optimum (maximum current ouput) monochromator. The conclusions are tested by performance measurements on a prototype instrument. The results require the introduction into the design equation of a new limiting factor, an anomalous energy spread in dense electron beams, which is empirically determined.

9872. Kuyatt, C. E., Simpson, J. A., Mielczarek, S. R., **Resonances in electron scattering from H_2, HD, and D_2,** *J. Chem. Phys.* **44,** No. 2, 437-439 (Jan. 15, 1966).

Key words: Absolute electron energy scale; D_2, D_2^-; electron scattering resonances; HD, HD^-; H_2, H_2^-; vibrational constants of H_2^-.

Resonances in the transmission of electrons through H_2, HD, and D_2 have been studied for electrons of energy 11 to 13 eV. In H_2 and HD pairs of resonances were observed, indicating that there exist two electronic states of H_2^- and HD^-, each with well developed vibrational structure. In D_2 only one series of resonances is observed. The single series is attributed to the overlap of two states of D_2^- because of a smaller vibrational separation. The absolute energy scale for the resonances has been recalibrated to an estimated accuracy of 0.1 eV.

9873. Lafferty, W. J., Lide, D. R., Jr., **Microwave spectrum of excited vibrational states of FCN,** *J. Mol. Spectry.* **23,** No. 1, 94-96 (May 1967).

Key words: Fermi resonance; infrared spectrum; microwave spectrum; rotational constants; unperturbed vibrational frequencies; vibrational spectrum.

The microwave and infrared spectra of FCN are reported. The band centers of ν_2^1 and ν_1 have been obtained from resolved infrared bands. The band center for $2\nu_2^0$ has been obtained from both a "hot band" Q branch and, less accurately, by direct observation of the unresolved band. The rotational constants of all Σ vibrational states up to *ca.* 2100 cm^{-1}, and several π and Δ states have been obtained from the microwave spectrum. Combination of the microwave and infrared work permits correction for the Fermi resonance between ν_1 and $2\nu_2^0$. Unperturbed vibrational frequencies for $2\nu_2^0$ and ν_1 are reported. The value of the Fermi resonance matrix element is $35.2_8 \pm 0.4$ cm^{-1}.

9874. Lance, H. W., **The national measurement systems of various countries,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 397-403 (Dec. 1966).

Key words: Measurement system; national standards laboratories; precision electromagnetic measurements; standards laboratories.

This paper is a summary of an informal panel discussion which formed one session of the 1966 Conference on Precision Electromagnetic Measurements. In contrast to the other sessions, this one was concerned primarily with broad management problems rather than with detailed technical matters. The members of the panel, from nine different countries, had been asked to consider the measurement system of their country, their national standards laboratory (or its equivalent), and the scientific and technical program of the laboratory. Although time limitations prevented a thorough discussion, many worthwhile facts and opinions emerged.

9875. Landgrebe, A. R., Gills, T. E., DeVoe, J. R., **Application of radiometric techniques to quantitative paper chromatography of iron, copper, manganese, and cobalt,** *Anal. Chem.* **38,** No. 9, 1265-1266 (Aug. 1966).

Key words: Analysis; Co; Cu; Fe; Mn; NBS Standard Reference Material 671; nickel oxide; paper chromatography; radiometric methods.

A radioactive reagent was used for the quantitative determination of iron, copper, manganese, and cobalt after separating them by paper chromatography. The method has been applied to the analysis of a sample of nickel oxide (NBS Standard Reference Material No. 671). With this method which is operable at the μg/ml level, values of 0.37, 0.19, 0.14, and 0.32 percent for Fe, Cu, Mn, and Co respectively were found and the relative standard deviation of a single determination for Fe, Cu, Mn, and Co were 7.1, 6.8, 3.8, and 4.1 percent. Comparison of these results with those of other analytical techniques were made.

9876. Landgrebe, A. R., McClendon, L. DeVoe, J. R., **A determination of trace amounts of iron and cobalt in the same sample by substoichiometric radioisotopic dilution analysis,** (Proc. 1964 Winter Meeting American Nuclear Society, San Francisco, Calif., Nov. 30-Dec. 3, 1964), *Trans. Am. Nucl. Soc.* 7, No. 2, 337-338 (1964).

Key words: Analysis; cobalt; Dowex 50-X8; EDTA; iron; nickel oxide; radioisotopic dilution; standard reference material.

A method of analysis for iron and cobalt was developed for the concentration range of 10^{-3} to 10^{-8} M. The method involves using a limiting amount of EDTA to complex iron or cobalt. The noncomplexed ions were removed from solution with a cationic exchanger (Dowex 50-X8) leaving a constant amount of cobalt or iron EDTA complex in solution. Trace amounts of naturally occurring cobalt and iron were determined with good sensitivity as long as radioisotopes of high specific activity were used. NBS standard reference material (671, 672, and 673) of nickel oxide were also analyzed for iron and cobalt.

9877. Larsen, S. Y., Witte, K., Kilpatrick, J. E., **On the quantum mechanical pair-correlation function of ^{4}He gas at low temperatures,** *J. Chem. Phys.* **44,** No. 1, 213-220 (Jan. 1, 1966).

Key words: Loww temperature; pair-correlation; quantum-mechanical.

The density independent part of the direct and exchange correlation functions for He^4, using the deBoer and Michels Lennard Jones potential, have been calculated at 2°, 1°, .1 °K. The necessary wave functions were obtained by numerical integration of the Schrodinger equation. The peak of the direct correlation function is much less than its classical value and occurs at a slightly larger radius. The tail (large *r*) agrees very well with the form given by the Wigner-Kirkwood expansion. The exchange correlationn function which represents the entire effect of the spin and statistics of the system vanishes very rapidly with increasing temperatures.

9878. Laufer, A. H., McNesby, J. R., **The chain decomposition of propane initiated by vacuum ultraviolet photolysis,** *J. Phys. Chem.* **70,** 4094-4096 (1966).

Key words: Photolysis; propane chain decomposition; vacuum ultraviolet.

Mixtures of propane and propane-d_8 were photolyzed at 1470 Å from 25-320 °C. Isotopic compositions of the hydrogen and methane products were determined. While the methane is predominantly CH_4 and CD_4 at room temperature, the chain decomposition of *n*-propyl with the consequent formation of isotopically mixed methanes became increasingly important as the temperature was raised. The chain length was found to vary from 0.07 at room temperature to a lower limit of 7.9 at 320 °C.

9879. LaVilla, R. E., Deslattes, R. D., **K-absorption fine structure of sulfur in gaseous SF_6,** *J. Chem. Phys.* **44,** No. 12, 4399-4400 (June 15, 1966).

Key words: Absorption; fine structure; K-edge; molecular gas; SF_6, sulfur; x-ray.

Measurements are reported on the K-absorption fine structure of sulfur in gaseous SF_6. The results differ qualitatively from previous measurements on molecular gases of lower coordination. Comparison is also made with preliminary results on H_2S.

9880. Layer, H. P., Deslattes, R. D., **A simple nonscanning camera for x-ray diffraction contrast topography,** *J. Appl. Phys.* **37,** No. 9, 3631-3632 (Sept. 1966).

Key words: Camera; diffraction; dislocation; topography; x-ray.

A new x-ray topographical camera has been developed that is applicable to both Laue and Bragg geometries for normal and anomalous transmission, that results in a significant reduction of experimental complexity along with quite acceptable exposure times.

9881. Leaderman, H., **Viscoelastic behavior,** *Encyclopedic Dictionary of Physics* **7,** 633-634 (Pergamon Press, Inc., London, England, 1962).

Key words: Linear viscoelastic behavior; relaxation times; retardation times.

A brief summary of the mathematical description of mechanical properties of materials which show linear viscoelastic behavior.

9882. Lee, R. D., **Calibration of the NBS photoelectric pyrometer of 1961,** *Proc. Comite Consultatif de Thermometrie, 7th Session, Paris, France, Sept. 24-25, 1964,* pp. 74-78 (July 10, 1966).

Key words: Calibration, NBS photoelectric pyrometer of 1961; International Practical Temperature Scale; NBS photoelectric pyrometer; photoelectric pyrometer, NBS; pyrometer, photoelectric, NBS.

Factors affecting the reproducibility of the NBS Photoelectric Pyrometer are listed, and progress in reducing these factors are described. A calibration to realize the International Practical Temperature Scale (IPTS) above 1063 °C to 1256 °C is described. At present, the estimated uncertainty in realizing the IPTS is about 0.1 °C at 1063 °C, 0.2 °C at 1256 °C, and is predicted to be 0.8 °C at 2400 °C.

9883. Lehner, J., **Representations of discrete groups,** *Proc. Symp. Pure Mathematics, California Institute of Technology, Pasadena, Calif., Nov. 21-22, 1963, Chapter VIII, Theory of Numbers,* pp. 203-208 (Am. Math. Soc., Providence, R.I., 1965).

Key words: Abstract groups; discrete groups; discrete matrix subgroup; F-groups; matrix subgroup.

It is shown that certain properties of a class of finitely generated abstract groups known as F-groups are preserved when the F-group is imbedded in SL(2, reals) as a discrete matrix subgroup. Thus the abstract structure of the F-group determines to a certain extent the topological properties of the matrix group.

9884. Leslie, R. T., **Distillation as a tool for purification of research quantities of material,** *Ann. N.Y. Acad. Sci.* **137,** 19-29 (Jan. 20, 1966).

Key words: Distillation; material; purification of research quantities of materials; research quantities.

Distillation can increase the purity of nearly any "real" vaporizable mixture if sufficient effort is made. The method is invaluable for purifying relatively small quantities of material for research purposes.

The selection of the proper still column for a particular problem can be based on a knowledge of the characteristics of a few basic types of columns. Some operating procedures which favor good results can be outlined in a general way, but testing of stills by the operator using mixtures whose behaviors can be predicted under various conditions is recommended.

Some possibilities for the improvement of still columns are suggested.

9885. Leslie, R. T., Kuehner, E. C., **Distillation analysis,** *Encyclopedia of Chemistry,* p. 344 (Reinhold Publ. Corp., New York, N.Y., 1966).

Key words: Analysis; concentration; distillation; separation.

Mixtures of volatile materials, either liquid or solid, can be analyzed by information obtained by vaporization at constant pressure or at constant temperature. Miniature and micromethods can be used when necessary. Distillation under carefully prescribed conditions is often useful for control purposes. Gas-liquid chromatography has some advantage for precise analysis. Preseparation or preconcentration of trace constituents by distillation, combined with other methods of analysis, is often useful.

9886. Lester, W., Krauss, M., **Some aspects of the coulomb hole of the ground state of H_3^+,** *J. Chem. Phys.* **44,** No. 1, 207-212 (Jan. 1966).

Key words: Electronic structure; H_3^+; molecular quantum mechanics.

The Coulomb hole for the linear and equilateral configurations of the ground state of H_3^+ is calculated using a Gaussian basis set. A modification of the method of Coulson and Neilson which determines the distribution function, $f(r_{12})$, instead of the distribution function of the interelectronic distance $f(r_{12})$ was used. Curves of $f(r_{12})$ and the Coulomb hole function are plotted for selected orientations of the electron-pair to the nuclear arrangements. The method allows a graphic presentation of the dependence of the size of the Coulomb hole on the nuclear geometry of the polyatomic system.

9887. Levin, E. M., **Liquid immiscibility in the rare earth oxide-boric oxide systems,** *Phys. Chem. Glasses* **7,** No. 3, 90-93 (June 1966).

Key words: Boric oxide; liquid immiscibility; phase equilibria; rare earth oxides.

Three experimental methods were used to determine the composition of the modifier-rich liquids in the following binary sytems with B_2O_3: La_2O_3, Nd_2O_3, Sm_2O_3, Eu_2O_3, Gd_2O_3, Dy_2O_3, Y_2O_3, Ho_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, Lu_2O_3, Sc_2O_3. With decreasing ionic radius (increasing atomic number), the extent of immiscibility increased from 21.5% for the La_2O_3 system to 34.0 mol% for the Sc_2O_3 system. With the exception of the La_2O_3 and the Nd_2O_3 systems temperatures of the monotectics increased monotonically from 1136° for Sm_2O_3 to 1526 °C for Sc_2O_3. Index of refraction of the quenched modifier-rich liquid was a maximum (1.732) for Eu_2O_3. Competing ionic field strengths between the glass-forming and modifier cations with oxygen govern the existence of immiscibility. Structural considerations governing the number of oxygens associated per modifier cation determine the extent of immiscibility.

9888. Levin, I. W., Abramowitz, S., **Force fields for group IV tetrafluorides and group V trifluorides,** *J. Chem. Phys.* **44,** No. 7, 2562-2567 (Apr. 1, 1966).

Key words: Coriolis constants; force fields; Group IV tetrafluorides; Group V trifluorides; vibration-rotation band contours.

The Coriolis zeta constants of the degenerate modes of SiF_4, GeF_4, NF_3, PF_3, and AsF_3 were obtained from infrared band contour measurements. These Coriolis coupling data provided the necessary constraints for determining unique force fields for the F_2 and E symmetry species of the XF_4 and XF_3 molecules, respectively. In an attempt to limit the force field for the A_1 species of the XF_3 molecules, the rotational distortion constants, D_J and D_{JK}, were calculated for a range of values of F_{12}, with the E species force constants in this calculation remaining fixed from the zeta constant data.

9889. Lichtenstein, S., **Corrosion's many faces,** *Southern Eng.* **85,** No. 1, 44-47 (Jan. 1967).

Key words: Basic and applied research; economics of corrosion; industrial design; materials protection; structural failure.

Corrosion is discussed as a technological and economic "disease" eating away at metals and materials, depleting natural resources, and causing injury and death where accidents and explosions result from weakening of structures. Dollar estimates of costs to the nation and the Federal Government are given. Anticorrosion work of the National Bureau of Standards' Institute for Materials Research is described and highlights of a half-century of achievement are noted. Corrosion control is linked to progress in nuclear power, oceanography, water desalination, military operations, space and supersonic transport, health, safety, and conservation.

9890. Lichtenstein, S., **NBS hunts for better ways to control corrosion,** *Mater. Eng.* **65,** No. 5, 21-23 (May 1967).

Key words: Corrosion; ellipsometry; field-electron emission microscopy; low-energy diffraction; NBS corrosion section; passivity; ultra-high vacua.

NBS contributions to a mosaic of evidence on the nature of corrosion processes are described, including thin-film and passivity studies under ultra-clean conditions, underground studies, polarization and cathodic protection, galvanic effects, and stress and atmospheric corrosion in marine environments.

9891. Lide, D. R., Jr., **Correction of some erroneous calculations of the Einstein A coefficient for the 18 cm transition of OH,** *Nature* **213,** No. 5077, 694-695 (Feb. 18, 1967).

Key words: Einstein A coefficient; hydroxyl; radical; transition probability.

The Einstein A coefficient for the 18 cm A doublet transition of OH is calculated to be $8.53 . 10^{-11} \mathrm{sec}^{-1}$. It is shown that previous values of A are incorrect.

9892. Lide, D. R., Jr., **Interpretation of the far infrared laser oscillation in ammonia,** *Physics Letters* **24A,** No. 11, 599-600 (May 1967).

Key words: Ammonia; infrared; inversion; laser; molecular; spectrum.

The interpretation of the laser emission spectrum of ammonia in the far infrared is considered. The P branch of the $v_2 = 3'' - 2''$ transition is shown to coincide closely with the observed laser spectrum. However, only the low K transitions are observed. Possible reasons for the absence of the expected strong $K = 3$ lines are discussed.

9893. Lide, D. R., Jr., **Microwave spectroscopy,** *Encyclopedia of Industrial Chemical Analysis* **2,** 600-611 (John Wiley & Sons, Inc., New York, N.Y., 1966).

Key words: Chemical analysis; microwave spectroscopy; microwave studies; molecular structure; rotational spectra; spectra, rotational; spectroscopy, microwave.

The experimental techniques used in microwave spectroscopy are described. A brief outline of the theory of rotational spectra is given. The information on molecular structure which can be obtained from microwave studies is discussed. Some comments are made on the use of microwave spectroscopy in chemical analysis.

9894. Lide, D. R., Jr., **Microwave studies of rotational isomerism,** *Trans. Am. Crystallographic Assn.* **2,** 106-116 (1966).

Key words: Butadiene; isomerism; microwave spectroscopy; propionaldehyde; rotational; structure.

The application of microwave spectroscopy to the study of rotational isomerism is reviewed. Molecules of the butadiene type are found to exist predominantly in the planar *trans* form; no spectra from other isomers have been detected. Normal propyl compounds show both *trans* and *gauche* isomers at room temperature. Two isomers are also found in propionaldehyde and related compounds. Conclusions regarding structure and stability of rotational isomers are discussed.

9895. Lide, D. R., Jr., Kuczkowski, R. L., **Structure of the alkali hydroxides. I. Microwave spectrum of gaseous CsOH,** *J. Chem. Phys.* **46,** No. 12, 4768-4774 (June 1967).

Key words: Cesium hydroxide; dipole moment; high temperature; microwave; molecular structure; spectrum; vibration.

The microwave spectra of gaseous CsOH and CsOD have been studied in a high-temperature spectrometer. The spectrum indicates a linear or near-linear molecule with a large-amplitude, low-frequency bending vibration. A large number of excited states involving the bending mode and the Cs–O stretching mode have been identified. The rotational constant B_v shows an unusual variation as the bending mode is excited; the cause is not yet understood. The Cs–O bond length is found to be 2.40 ± 0.01 Å and the O–H distance is probably about 0.97 Å. The electric dipole moment is 7.1 ± 0.5 D. Relative intensity measurements indicate a Cs–O stretching frequency of about 400 cm^{-1} and a bending frequency in the neighborhood of 300 cm^{-1}. All of the evidence supports a highly ionic cesium–oxygen bond.

9896. Linnig, F. J., Parks, E. J., Stiehler, R. D., **Effect of certain crystalline substances on physical properties of elastomers. I. Stress-strain behavior,** *Rubber Chem. Technol.* **39,** No. 4, Pt. 1, 1041-1052 (Sept. 1966).

Key words: Anisotropic; β-naphthyl group; glass transition temperature; phenyl β-naphthylamine; physical forces; reinforcement; reversible; rubber vulcanizates; stiffening.

Some crystalline organic compounds containing a β-naphthyl group have been found under certain conditions to produce a pronounced stiffening of rubber vulcanizates. When these materials are removed by extraction, the reinforcing effect vanishes. Reinforcement by the most effective of the materials examined, phenyl β-naphthylamine, is obtained with vulcanizates made from various elastomers and vulcanizing agents, and is essentially independent of the state of cure. In some instances about 5 percent PBNA produces the same stiffness as 30-40% carbon black but the stiffness is markedly reduced by flexing. Less than 3 percent crystalline PBNA may produce an isotropic Young's modulus of about 20 $\mathrm{kg/cm^2}$ at room temperature. At higher concentrations of PBNA, anisotropic effects are observed. The temperature coefficient of Young's modulus is negative analogous to that for vulcanizates containing carbon black. The addition of PBNA to a rubber vulcanizate does not affect significantly the glass-transition temperature.

The reversible nature of reinforcement with PBNA indicates a physical mechanism. However, the effect is not in accord with existing physical theories of reinforcement. This work strongly suggests that profound reinforcement can result from physical forces alone.

9897. Lipkin, H. J., Meshkov, S., **Spin independence, W-spin, parity and SU(6) symmetry,** *Phys. Rev.* **143,** No. 4, 1269-1274 (Mar. 25, 1966).

Key words: Collinearity; lorentz invariance; W-spin.

The assumption of strict spin independence of strong interactions between elementary particles forbids all three meson and meson-baryon-baryon couplings, such as $\rho\pi\pi$, $NN\pi$, and $N^*N\pi$. It is shown that these catastrophies may be avoided, even in the nonrelativistic limit, by adopting a modified definition of spin-independence, i.e., W-spin independence. A nonrelativistic definition of W-spin is obtained which requires only a trivial change to yield the relativistic description. The consequences of the assumption of W-spin independence are explored.

9898. Lipkin, L. E., Watt, W. C., Kirsch, R. A., **The analysis, synthesis and description of biological images,** *Ann. N.Y. Acad. Sci.* **128,** No. 3, 984-1012 (Jan. 31, 1966).

Key words: Biological images; cell analysis; image display; pattern recognition; syntax.

There may be distinguished two approaches to characterizing the properties of biological images: the statistical approach traditionally used for mechanized image-processing, and the articular approach generally used among biologists. We discuss both approaches, but focus attention on the second, for we hold that an articular approach allows the expression of much that is effectively impossible to express in the form of numerical measurements; and we know of no inherent reason why a computer cannot deal with information of a nonquantitative nature.

The articulation of biological images necessarily takes place on two fronts: the imposition of an articular structure on the image itself; and the expression of this construal in English sentences. We will study both kinds of articulation, and we will suggest how they may be brought together, in the form of linked pictorial and linguistic *grammars*. The computer system which this paper envisions will be able to analyze a presented image with respect to a pictorial grammar, and to formulate and accept descriptions of that image, in English sentences, with respect to a linguistic grammar. It will be able to present pictorial instances of English descriptions, and in other ways to respond to English directives.

9899. Loebenstein, W. V., **Surface studies of natural and synthetic bone mineral and teeth,** (Proc. 2d Workshop, Adhesive Restorative Dental Materials, Univ. of Virginia, Charlottesville, Va., Dec. 8-9, 1965), Chapter IV in *Adhesive Restorative Dental Materials, Surface measurements--synthesis and evaluation of dental adhesives,* pp. 213-223 (Dept. of Health, Education, and Welfare, Washington, D.C., 1966).

Key words: Adsorption; anorganic bone mineral and dentin; bone; calcium phosphate; hydroxyapatite; octacalcium phosphate; pore size distribution; pore volume; surface area; surface chemistry; teeth.

Low temperature nitrogen adsorption measurements have been performed using dentin and bone as well as synthetic calcium phosphate preparations. Surface areas ranging from about 1-1/2 to nearly 150 $m^2 \cdot g^{-1}$ have been found. Pore size distribution calculated from the isotherm data shows promise of being a valuable and sensitive tool for aiding in the comparison of crystallographic forms and for detection of subtle changes in structure not measurable by other means presently in use. The pore structure of bone mineral in the range 20-30 Å appears to be entirely independent of the collagen matrix.

9900. Loftus, T. P., Weaver, J. T., Petree, B., **Effect of humidity on ionization measurements using cavity and free-air chambers,** *Radiology* **86,** No. 1, 149 (Jan. 1966).

Key words: Cavity and free-air chambers; free-air chambers; humidity on ionization measurements; ionization measurements.

Measurements are described that show the effect of humidity on the measurement of gamma radiation with cavity ionization chambers. It is found that the chamber current does not vary by more than 0.06 percent as the relative humidity is changed by more than 50 percent. A calculation, based on the assumption that the air and its moisture produce ionization independently, predicts a decrease of about 0.4 percent for the measurement in moist air. The discrepancy is believed to be connected with the value used for the average energy required to produce an ion pair in moist air.

Similar results were obtained with free-air chamber exposed to 60 kVcp x rays. A current increase of only 0.03 percent was observed when the relative humidity was changed from 48 to 13 percent, although the calculated increase is 0.3 percent.

9901. Logan, H. L., McBee, M. J., Bechtoldt, C. J., Sanderson, B. T., Ugiansky, G. M., **Chemical and physical mechanism of salt stress-corrosion cracking in the titanium 8-1-1 alloy,** (Proc. Stress Corrosion Cracking Symp., Seattle, Wash., Nov. 1965), *Am. Soc. Testing Mater. Spec. Tech. Publ.* **397,** pp. 215-229 (1966).

Key words: Corrosion products; high temperature corrosion; preoxidation; salt stress corrosion; solid state reactions; stress-corrosion cracking; titanium 8-1-1 alloy.

The mechanism of salt stress-corrosion cracking of the Ti-8-1-1 alloy was investigated. Specially designed specimens coated with NaCl or $NaCl + MgCl_2 \cdot 6H_2O$ and stressed to 75 percent of their yield strength at 750 °F failed in as short a time as 18 hours. Gaseous oxygen and NaCl or oxidation at 750 °F prior to coating the specimen with NaCl were required to produce cracking. X-ray diffraction studies indicated that anatase, rutile and unidentified corrosion products were formed as a result of the reaction of NaCl and oxygen with the alloy.

9902. Logan, H. L., **The stress corrosion of metals,** *Book,* 306 pp. (John Wiley & Sons, Inc., New York, N.Y., Nov. 1966).

Key words: Aluminum alloys; copper alloys; magnesium alloys; nickel alloys; steels; stress corrosion; stress corrosion failures; testing techniques.

This is the first volume in English in which a single author has brought together previously published material on this subject. In 306 pages, the work covers a broad study of stress corrosion phenomena in alloy systems and correlates the information with today's theories on the mechanism of stress corrosion cracking.

Separate chapters deal with stress corrosion cracking in low carbon steels, high strength steels for aerospace, various stainless steels, and copper, aluminum, nickel, magnesium titanium, and miscellaneous precious metal alloys. In each chapter, techniques are discussed for eliminating stress corrosion. Methods of identifying failures as well as analyzing the failures are set forth in an additional chapter. The final feature of the book provides methods of evaluating the resistance of metals to stress corrosion.

9903. Logan, H. L., Yolken, H. T., **The role of hydrogen in the stress-corrosion cracking of low carbon steel in a nitrate solution,** *Proc. 2d Intern. Congress Metallic Corrosion, New York, N.Y., Mar. 1963,* p. 109 (Natl. Assoc. Corrosion Engr., Houston, Texas, 1966).

Key words: Corrosion; embrittlement; hydrogen; steel; stress-corrosion cracking.

The relative susceptibilities of four low carbon steels (0.20 percent carbon) to failure by hydrogen embrittlement and nitrate stress corrosion were compared (notched specimens being used in each case). The susceptibilities to failure, paths of attack, and rates of crack propagation were different in the two processes. Failure, once cracking was initiated, was much more rapid by hydrogen embrittlement than in nitrate stress corrosion cracking but was slow compared to brittle fracture. Diffusion of hydrogen into the steel was at least 50 times greater in hydrogen embrittlement than in nitrate stress cracking.

9904. Lonie, M., **Voluntary product standards—what they mean to the consumer,** *J. Home Econ.* **58,** No. 1, 22 (Jan. 1966).

Key words: Procedure; products; quality; standards.

The principal purpose of the talk is to emphasize the character of the contribution made by the National Bureau of Standards in the development of commercial standards and simplified practice recommendations, technically and editorially, and how this benefits the consumer.

It emphasizes how the widened exposure to the standards both in and out of the Bureau tends to raise the quality level of commodities covered. It cites examples to show that the "consumer" is not always the "ultimate" consumer. It stresses the point that standards developed according to the procedures of the Bureau are better standards than they would otherwise be.

9905. Lovell, W. S., **Molecular and ionic interactions in dielectrics,** Chapter III in *1965 Digest of Literature on Dielectrics* **29,** 81-198 (National Academy of Sciences—National Research Council, Washington, D.C., 1966).

Key words: Dielectric constant; dielectric polarization and refraction; dielectric relaxation; dipole moments; electrical conductance of liquids and solutions; internal rotation; molecular interactions; pressure broadening.

A survey is given of the 1965 literature treating molecular interactions, pressure broadening, dielectric polarization and refraction, dielectric constant, dipole moments, dielectric relaxation, internal rotation, and electrical conductance of liquids and solutions.

9906. Lyon, H. W., Waterstrat, R. M., Paffenbarger, G. C., **Soft tissue response to implants of gallium alloys and silver amalgam alloys,** *J. Am. Dental Assoc.* **72,** No. 3, 659-664 (Mar. 1966).

Key words: Amalgam alloys; gallium alloys; gold-gallium alloys; silver-amalgam control specimens; soft tissue.

Twenty implants of gold-gallium alloys and 20 silver-amalgam controls were placed subcutaneously in ten NMRI-D strain rats for six months. Silver amalgam control specimens elicited a mild, innocuous response. In contrast, gold-gallium alloy implants not only caused a severe foreign body response (fibrosis) from the host tissues but also fragmented and partially disintegrated. These results were exactly similar to those obtained in a previous experiment wherein palladium-gallium alloy implants were subjected to identical procedures. Disintegration of the experimental alloys was probably due to corrosion of the $AuGa_2$ phase rather than an electrolytic reaction between this phase and the gold.

9907. McCamy, C. S., **Photographic standardization and research at the National Bureau of Standards,** *Appl. Opt.* **6,** No. 1, 27-30 (Jan. 1967).

Key words: Densitometry, NBS; photography; standardization.

The Photographic Research Section of NBS provides physical standards of measurement and calibration services, cooperates with national and international standardizing organizations, and conducts research related directly to the utilization of photographic materials and processes. Standardization and research in sensitometry, standard light sources, emulsion making, preservation of photographs, precise densitometry, and image evaluation have spanned a half century.

9908. McClintock, M., Jennings, O. A., Mizushima, M., **Light scattering from time-dependent molecular orientations at Raman frequencies in liquids,** *Bull. Am. Phys. Soc., Series II,* **12,** No. 5, 711 (May 1967).

Key words: Benzene; carbon tetrachloride; Raman scattering.

The profiles of several Raman lines arising from nontotally symmetric molecular vibrations in liquid benzene and carbon tetrachloride have been measured using 4880 Å radiation from an argon ion laser as a source of illumination. These profiles have been analyzed on the assumption that scattering occurs from time-dependent molecular reorientations of small angle in the liquid, analogous to those producing depolarized scattering at the Rayleigh line. On this basis, the half width at half maximum of the 606 cm^{-1} Raman line in benzene was found to be 3.3 cm^{-1}, and the half width of the "orientation" line underlying this Raman line was found to be 24.3 cm^{-1}. The rotational relaxation time calculated for the v_{18} vibrationally excited molecule is therefore 1.38×10^{-12} seconds. This is short compared with a period of rotation and supports the assumption of rotational Brownian motion. It is also shorter than the rotational relaxation time for the molecule in the ground vibrational state, and indicates that there is weaker rotational coupling between molecules in the ground state than between vibrationally excited molecules and those in the ground state. The depolarization ratios of the Raman and the orientation components of the 606 cm^{-1} line for linearly polarized incident light were found to be 0.748 and 0.749 respectively, in agreement with the theoretically predicted 0.750.

9909. McLaughlin, W. L., **Microscopic visualization of dose distributions,** *Intern. J. Appl. Radiation Isotopes* **17,** 85-96 (1966).

Key words: Dose distribution; dyes; electron beams; energy transfer; films; gamma radiation; high resolution; molecular excitations; radiation chemistry; radiation processing.

Colorless cyanides of triphenylmethane dyes when suitably activated can be made into films that become deeply colored upon irradiation with short-wave ultraviolet and ionizing radiations, but are not sensitive to near ultraviolet radiation or visible light. The response range for x rays, γ-rays, and electrons is approximately 10^5 to 10^8 rads. Experiments show that, because of their stability, low energy dependence, and high spatial resolution, these solid systems have excellent potential for visual inspection off high-level dose distributions on a microscopic scale. Since molecular excitations due to low-energy secondaries are most important to the over-all radiation effects, the relatively large sensitivity of such dye systems expected in the intermediate and far ultraviolet may represent an advantage in dosimetry.

9910. McNesby, J. R., **Vacuum-ultraviolet photolysis of parafin hydrocarbons,** Chapter 2 in *Chemical and Biological Actions of Radiation,* **IX,** 39-67 (Masson and Co., Editors and Publ., Paris, France, 1966).

Key words: Carbenes; hydrocarbons; photochemistry; ultraviolet.

The vacuum ultraviolet photolysis of some simple hydrocarbons is reviewed in detail with regard to its relationship to the chemistry of excited carbenes. Various sources of carbenes are reviewed and the relationships between the observed chemistry for the various sources are examined and generalized.

9911. McNish, A. G., **The international system of units,** *Am. Soc. Quality Control Annual 1965 Tech. Conf. Trans. Industrial Quality Control* **22,** No. 9, 465-469 (Mar. 1966).

Key words: Customary units for length; engineering calculations; International System of units; length; system of units; units of length.

The International System of units is advantageous in engineering calculations because of its completeness and simplicity. No difficulty is experienced in its application in the United States, although it is inconsistent with our customary units for length, mass, and temperature.

9912. McNish, A. G., **The nature of measurement,** Chapter 1 in *Handbook of Industrial Metrology,* pp. 2-12 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Accuracy; measurement principles; precision.

General principles for measurement. Accuracy and precision are discussed.

9913. McNish, A. G., **Reply by A. G. McNish,** *Phys. Today* **19,** No. 4, 15-16 (Apr. 1966).

Key words: Metric system; physical constants; SI; units.

In response to a criticism of units used in a previous article "New Values for the Physical Constants," it is pointed out that dimensional procedures are highly arbitrary and require only that they be consistent.

9914. Macedo, P. B., Capps, W., Litovitz, T. A., **Two-state model for the free volume of vitreous B_2O_3,** *J. Chem. Phys.* **44,** No. 9, 3357-3364 (May 1, 1966).

Key words: Free volume; structure of B_2O_3; two-state model.

New data on the density of B_2O_3 from 25 °C to 320 °C are given. A two-state equation of state for the volume is presented which fits the volume data from 350 °C to 1400 °C. A specific structure for the two states is suggested and shown to be consistent with Raman data. Below 350 °C and at high pressures the data indicated that the two-state expressions for free volume still hold but the volume of the close-packed structure becomes temperature and pressure dependent.

The viscosity of B_2O_3 from the glass transition up to 1400 °C and at high pressure is consistent with the equation of state and the Hybrid equation of Macedo and Litovitz. The viscosity values above 1400 °C indicate a break-up of the two-state structures and the beginning of multi-state behavior which results in a temperature dependent activation energy. The onset of this effect causes the "apparent" activation energy to increase above 1400 °C.

9915. Madden, R. P., Codling, K., **Autoionization spectra of the noble gases,** (Proc. Symp. Atomic Interactions and Space Physics, Goddard Space Flight Center, Greenbelt, Md., Aug. 10-11, 1966), Chapter in *Autoionization Astrophysical Theoretical and Laboratory Experimental Aspects,* pp. 129-151 (Mono Book Corp., Baltimore, Md., 1966).

Key words: Autoionization; far ultraviolet absorption spectra; He through Xe; one and two electron excitation; resonance profiles; synchrotron light source; 20-180 eV.

The absorption spectra of the noble gases He through Xe have been studied extensively in the region 20-180 eV (600-70 Å), utilizing as a background source the pure continuum radiated by the orbiting electrons in the NBS 180 MeV electron synchrotron. Discrete structures, or resonances, have been observed in the photoionization continua of each of these gases. These resonances are due to the existence of autoionizing states of the neutral atoms lying at energies, in general, well above their first ionization limits. The structures have been classified into two types of transitions; on the one hand, one-electron excitation involving either an outer-shell, sub-shell or inner-shell electron, on the other, involving the excitation of any two electrons simultaneously, such that the energy required was appropriate for the present region of observation.

9916. Madey, T. E., Yates, J. T., Jr., **Kinetics of desorption of the beta-nitrogen states chemisorbed on tungsten,** *J. Chem. Phys.* **44,** No. 4, 1675-1684 (Feb. 15, 1966).

Key words: Adsorption; binding states; chemisorption; desorption; kinetics; nitrogen; tungsten.

The kinetics of desorption of the strongly chemisorbed β_1 and β_2 nitrogen states on tungsten have been studied. Independent techniques of isotopic mixing and flash-filament desorption have been employed. The rate of production of $^{14}N^{15}N(g)$ from $^{14}N_2(g)$ and $^{15}N_2(g)$ in a steady state flow experiment is completely accounted for by the kinetically determined rate of desorption from the chemisorbed layer. β_1-nitrogen appears to desorb by first order kinetics. β_2-nitrogen desorbs in a complex manner with higher order kinetics. The apparent β_2 desorption order decreases markedly as temperature increases. A superposition of two or more unresolved substates in the β_2 state is postulated. The temperature variation of desorption order can be accounted for by a lack of achievement of equilibrium between the spatially-separate β_2 substates during desorption at scan rates of 12.5 °K/sec or greater.

Above 1500 °K, where the steady state coverage of nitrogen is very low, a sticking coefficient of less than 0.02 has been measured. The sticking coefficient is nearly constant in the range 1500-1700 °K and over a 25-fold pressure range.

9917. Mahler, R. J., **Angular dependence of the one-phonon-nuclear quadrupole interactions,** *J. Phys. Chem. Solids* **27,** 871-879 (1966).

Key words: Angular dependence; phonon-nuclear quadrupole interaction.

The angular dependence of the $\Delta m = \pm 1$ and $\Delta m = \pm 2$ nuclear quadrupole interactions is developed in a crystal with T_d symmetry assuming a lattice potential $V = f(r)$ and that the phonons have a definite wave number and polarization. The results can be used to explain experiments involving the interaction of a nuclear spin system with externally added phonons.

9918. Mahler, R. J., Daniel, A. C., Parrish, P. T., **Observation of two intrinsic nuclear relaxation rates in antiferromagnetic $KMnF_3$,** *Phys. Rev. Letters* **19,** No. 2, 85-87 (July 10, 1967).

Key words: Antiferromagnetism; magnon-Raman process; nuclear magnetic resonance; relaxation time; spin echo technique; temperature dependence.

F^{19} nuclear spin-lattice relaxation (T_1) measurements are reported in two samples of $KMnF_3$ over the temperature range 1.35 °K to 22 °K and with zero external magnetic field. The high temperature relaxation rate ($1/T_1$) exhibits a T^7 temperature dependence in one sample and a T^5 in the other. At the low temperatures both samples are characterized by an approximate $\exp(\alpha/T)$ dependence.

9919. Maki, A. G., **Measurement of the direct ι-doublet transitions in carbonyl sulfide,** *J. Mol. Spectry.* **23,** No. 1, 110-111 (May 1967).

Key words: Carbonyl sulfide; energy levels; ι-doublet transitions; microwave spectra; molecular structure; OCS; spectra; spectroscopy.

Microwave measurements are given for the $\Delta J = 0$, ι-doublet transitions in $^{16}O^{12}C^{32}S$. Accurate values of the ι-doubling constants are given and compared with previous, less accurate values.

9920. Maki, A. G., Forneris, R., **Infrared and Raman spectra of some trihalide ions: ICl_2^-, IBr_2^-, I_3^-, I_2Br^-, and $BrICl^-$,** *Spectrochim. Acta* **23A,** 867-880 (1967).

Key words: Force constants; infrared spectrum; Raman spectrum; trihalide ions.

The Raman spectrum and infrared absorption spectrum have been studied for a number of trihalide compounds. All three fundamental vibrations were located for each trihalide ion and the force constants are given. Differences in the spectra as the cation is changed are attributed to differences in the anion structures and/or differences in the crystal lattice which result in differing selection rules and force constants. The force constants are interpreted as indicating that the bottom of the potential well for the central atom of the trihalide ions is unusually flat. In agreement with previous observations the stretching force constants were found to have a value about half that of the corresponding halogen or interhalogen molecules.

9921. Mandel, J., Lashof, T. W., **Processing of numerical test data,** Chapter 2 in *Testing of Polymers,* J. V. Schmitz, ed., **2,** 33-82 (Interscience Publ., New York, N.Y., 1966).

Key words: Data processing; design of experiments; performance tests; polymers, analysis of test data in statistical analysis; test data, analysis; test methods, comparison of; homogeneity, tests of.

After a general introduction in which basic statistical concepts are discussed, the chapter proceeds with a brief treatment of statistical methods of experiment design for performance tests, for tests of homogeneity of materials, and for interlaboratory studies of test methods. Statistical methods of data analysis are also discussed. The chapter ends with a section on the presentation of data and a bibliography.

9922. Mandel, J., Kanagy, J. R., **Sampling of leather for physical and chemical examination,** Chapter 50 in *The Chemistry and Technology of Leather* 4, 223-242 (Reinhold Publ. Corp., New York, N.Y., 1965).

Key words: Acceptance sampling; letter; quality control; sampling; statistics; test variability.

A presentation of some general principles of sampling, with application to the sampling of leather.

The topics discussed in this chapter include: (1) General statistical principles of sampling: effect of sample size and of lot size; (2) Formulas for the determination of sample size; (3) The selection of a sampling location on a leather side; (4) Tables of the variability of physical and chemical tests between locations and between hides; (5) Acceptance sampling; and (6) A survey of the literature.

9923. Mangum, B. W., Colwell, J. H., **Low-temperature heat capacity of $NdCl_3$ and $PrCl_3$,** *J. Appl. Phys.* **38,** No. 3, 1468-1469 (Mar. 1, 1967).

Key words: Heat capacity; magnetic entropy; magnetic susceptibility; $NdCl_3$ (neodymium trichloride); $PrCl_3$ (praeseodymium trichloride); temperature measurement.

Heat capacities of $PrCl_3$ and $NdCl_3$ have been measured between 0.3 °K and 4 °K. The dominant feature of the heat capacity curves is a broad anomaly indicating a region of extensive short-range magnetic ordering. The anomaly in $NdCl_3$ has a maximum at 0.47 °K and fits closely that of a linear Ising chain model. In addition, two small peaks appear at the same temperatures as the sharp spikes found in the magnetic susceptibility. $PrCl_3$ has a sharp peak in the heat capacity at 0.4 °K which is presumably associated with long-range ordering. The broad anomaly in $PrCl_3$ has a maximum at 0.8 °K. The magnetic entropy change for the temperature region of the measurements is approximately 80% of R $\log_e 2$ for both salts.

9924. Mangum, B. W., Hudson, R. P. **Spin-lattice relaxation in some rare-earth trichlorides,** *J. Chem. Phys.* **44,** No. 2, 704-713 (Jan. 15, 1966).

Key words: Ce^{3+}, Nd^{3+}, Sm^{3+}, Ho^{3+}, and Er^{3+}; electron-lattice interaction; $LaCl_3$; pulsed microwave; rare-earth; relaxation; spin-lattice; trichlorides.

Studies of *spin-lattice relaxation* of the ions Ce^{3+}, Nd^{3+}, Sm^{3+}, Ho^{3+}, and Er^{3+} present in low concentrations (0.2 to 2 percent) in the host lattice of $LaCl_3$ have been made in the liquid helium region by the pulsed-microwave method. The variation of the relaxation time, τ, with temperature permits separation of the contributions to the relaxation from the two-phonon (resonant and non-resonant) and single phonon processes.

The substances studied are not "well-behaved;" features such as non-exponential decays and variability of the derived values for the splitting between the ground and first excited levels are discussed. Some of the ions exhibit a significant variation of τ with concentration and Nd^{3+} shows an interestingly large anisotropy of τ in the Raman process.

9925. Mann, D. B., Ludtke, P. R., Sindt, C. F., Chelton, D. B., **Liquid-solid mixtures of hydrogen near the triple points,** (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Texas, Aug. 23-25, 1965), Chapter in *Advances in Cryogenic Engineering* **11,** 207-217 (Plenum Press, Inc., New York, N.Y., 1966).

Key words: Cryogenic; crystallization; freezing; growth; hydrogen; liquid-solid phase; melting; nucleation; particle size; production; rate.

Properties and characteristics of liquid-solid mixtures of hydrogen are discussed, including production methods, solid particle size distribution, aging effects, and terminal velocities of the solid particles in the liquid melts. The equipment and techniques for observation and measurements are described.

The equipment developed and the results described are part of an effort to determine techniques and parameters pertinent to the study of production, storage and pipe line transport of this upgraded fuel.

9926. Mann, D. B., Sindt, C. F., Ludtke, P. R., Chelton, D. B., **Slush hydrogen characteristics,** *Proc. Conf. Long-Term Cryo-Propellant Storage in Space, National Aeronautics and Space Administration, Huntsville, Ala., Oct. 12-13, 1966.*

Key words: Cryogenic; fluid transport; freezing; hydrogen-liquid solid; production.

The utilization of slush hydrogen as an upgraded fuel is dependent upon knowledge of its physical and transport properties and characteristics. A NASA-sponsored program designed to acquire this information is in progress.

Experimental measurements of solid particle size distribution, aging effects and terminal velocities of the solid particles in the liquid melt have been completed. Transport characteristics have been predicted using these measured parameters. These predictions are currently being submitted to experimental verification.

Two 100 gallon dewars connected by 75 feet of vacuum-insulated transfer line comprise the experimental flow loop. Pressure sensing transducers and visual observation through glass ports allow acquisition of transport data over a broad range of flow rates.

Handling and investigative techniques such as dewar-to-dewar transfer, straining of the solids through wire mesh screen, and vertical temperature profiles of the settled mixture are presented in the context of a continuing experimental and analytical research program.

9927. Mann, D. E., Calder, G. V., Seshadri, K. S., White, D., Linevsky, M. J., **Geometry and vibrational spectra of the alkaline-earth dihalides. I. MgF_2,** *J. Chem. Phys.* **46,** No. 3, 1138-1143 (Feb. 1967).

Key words: Assignment; frequency; geometry; infrared; matrix; MgF, $Mg^{24}F_2$, $Mg^{26}F_2$.

The infrared spectra of vaporized MgF_2 isolated at liquid hydrogen temperatures in both argon and krypton matrices are reported. Six major regions of absorption have been found vis. 240, 450, 477, 483, 740 and 840 cm^{-1}. On the basis of corresponding matrix spectra of $Mg^{n}F_2$, $Mg^{26}F_2$ and a 1:1 mixture of $Mg^{n}F_2-Mg^{26}F_2$, it is possible to demonstrate unequivocally that the 240, 477, 740 and 840 cm^{-1} absorptions are due to molecular species containing one magnesium atom. The 450 and 483 cm^{-1} features are clearly attributable to polymeric species. From the magnitude of the measured isotope shifts the 740 cm^{-1} and 477, 240 and 840 cm^{-1} absorptions have been assigned to MgF and ν_1, ν_2, ν_3 of MgF_2 respectively. The observation of ν_1 shows that MgF_2 is bent. The higher resolution and precise frequency measurement employed in this work have been used to calculate the apex angle. This lies in the range 145 to 160° the most probable value being 150°.

9928. Manning, J. R., **Diffusion and the Kirkendall shift in binary alloys,** *Acta Met.* **15,** 817-826 (May 1967).

Key words: Binary alloys; diffusion; diffusion coefficients; Kirkendall shift; thermodynamic equations for diffusion; vacancies.

In alloys, the directions of successive vacancy jumps are correlated to one another. This tends to reduce the net vacancy flux in a Kirkendall shift experiment. The magnitude of the vacancy flux, including correlation effects, is calculated assuming that vacancies are not bound to any particular atoms and that fluctuations in average local composition can be ignored. New equations for the intrinsic diffusion coefficients, Kirkendall shift, and interdiffusion coefficient in binary alloys are obtained. The Kirkendall shift and interdiffusion coefficient given by these equations are larger than those predicted by Darken, but smaller than those obtained when vacancy correlations are neglected. The appearance of cross terms and additional diagonal terms in the general thermodynamic equations is discussed.

9929. Margoshes, M., **Recent advances in excitation of atomic spectra,** *Proc. XII Intern. Spectroscopy Colloquium, Exeter, England,* pp. 26-42 (Hilger and Watts, London, England, 1965).

Key words: Atomic properties; atomic spectra; chemical analysis; chemiluminescent and fuel-rich flames; controlled atmospheres; plasma jet.

Some recent developments are reviewed in methods of exciting atomic spectra for chemical analysis and the measurement of atomic properties. Among the subjects included are the plasma jet, arc and spark discharges in controlled atmospheres, chemiluminescent and fuel-rich flames, and wall-stabilized arcs. The present knowledge of the characteristics of excitation sources is briefly considered, and a summary is given of calculations of detection limits by flame photometry and atomic absorption spectrometry.

9930. Marshak, H., Richardson, A. C. B., Tamura, T., **Total cross section for 14-MeV neutrons using aligned ^{165}Ho nuclei,** *Phys. Rev. Letters* **16,** No. 5, 194-197 (Jan. 31, 1966).

Key words: Deformed nucleus; ^{165}Ho; neutron cross section; nuclear orientation.

The effect of nuclear deformation on the total cross section of ^{165}Ho has been measured using 14-MeV neutrons and an aligned target. The aligned ^{165}Ho target was obtained by cooling a metal single crystal to 0.33 °K using the NBS ^{3}He refrigerator. A finely collimated beam of 14-MeV neutrons was obtained by careful collimation of the alpha particle produced in the reaction $^3H(d,T)^4He$ and by detecting it in coincidence with its associated neutron. The NBS 2 MV Van de Graaff was used to provide a 1 μÅ, 300 keV deuteron beam. The results were successfully explained using an adiabatic coupled-channel calculation and the Optical Model potential. The data do not agree with the predictions of the Black Nucleus Model as we would expect since the wave length of a 14-MeV neutron is only equal to the radius of the holmium nucleus.

9931. Marton, L., **Correction of spherical aberration of axially symmetrical magnetic lenses,** *Rev. Sci. Instr.* **38,** No. 1, 130-131 (Jan. 1967).

Key words Diamagnetic corrective element; electron lens; spherical aberration.

It is pointed out that in a magnetic lens of rotational symmetry, correction of the spherical aberration is possible by abandoning paraxial image formation and introducing a diamagnetic corrective element on the axis.

9932. Marton, L., **Progress in electron physics during the last 20 years,** *Proc. Third Czechoslovak Conf. Electronics and Vacuum Physics, Prague, Czechoslovakia, Sept. 23, 1965,* pp. 17-25 (Czechoslovak Academy of Sciences, Prague, Czechoslovakia, 1967).

Key words: Electron physics; history.

Review of progress in electron physics with a short introduction covering pre-war period. Emphasis is laid on the developments of the post-war years with the conclusion that although the greatest accomplishments of electron physics were in the pre-war years, the last 20 years have seen very notable progress in the understanding of the nature and of the interactions of the electron.

9933. Maryott, A. A., Kryder, S. J., **Microwave line shape and the inversion spectrum of ND_3 and ND_3-argon mixtures,** *J. Chem. Phys.* **46,** No. 7, 2856-2857 (Apr. 1967).

Key words: Argon mixtures; inversion spectrum; line shape; microwave absorption; ND_3; pressure broadening.

The microwave loss index associated with the inversion spectrum of ND_3 has been measured at 1600 MHz for pure ND_3 over the pressure range 0.02 to 3 atmos. and for dilute mixtures of ND_3 in argon up to 25 atmos. These results confirm in detail Ben-Reuven's line shape relation.

9934. Marzetta, L. A., **Simple contact type temperature controller,** *Rev. Sci. Instr.* **37,** No. 6, 789 (June 1966).

Key words: Mercury-toluene thermometer; temperature controller.

A simple, low cost temperature controller is described. The circuit has two independent current paths: one provides an On-Off control current, and the other a preselected current for the background heat. With the stated components, 250 watts of heater power can be controlled. For applications such as laboratory liquid baths, 1/1000 °C stability is possible.

9935. Mather, J., **Invariance of the homology of a lattice,** *Proc. Am. Math. Soc.* **17,** No. 5, 1120-1124 (Oct. 1966).

Key words: Combinatorics; homology; lattice.

Rota, Kan, Peterson, and Whitehead have developed a homology theory for finite lattices which *a priori* depends upon the choice of a cross-cut of the lattice. It is shown here that the different cross-cuts of a lattice lead to simplicial complexes which have the same homotopy type and are therefore homology equivalent.

9936. Melmed, A. J., Klein, R., **Field-ion microscopy of ruthenium at 77 °K,** *J. Less-Common Metals* **10,** 225-228 (1966).

Key words: Atomic resolution; electropolishing of ruthenium; field evaporation; field-ion microscopy; heat of sublimation; ruthenium; surface structure.

Ruthenium, recently available in wire form, has been used to obtain a field-ion micrograph. A pattern with good image stability using helium as the imaging gas, has been obtained with the tip at 77 °K. From this, the most recent value of 6.79 eV for the heat of sublimation of ruthenium, rather than the previously used value of 5.52 eV is supported as being correct.

9937. Mendlowitz, H., **Calculated line strengths for the transition array for d^2s-d^2p: Application to Ni II,** *Astrophys. J.* **143,** No. 2, 573-590 (Feb. 1966).

Key words: d^2s+d^2p; intermediate coupling; *LS* coupling; Ni II; relative line strengths.

Transition arrays for the square root of the strengths of the transitions relative to a radial integral parameter are presented for $d^2s \rightarrow d^2p$ ($d^8s \rightarrow d^8p$) in *LS* coupling. The relative strengths in Ni II for the transitions between the configurations $3d^84s \rightarrow 3d^84p$ are calculated in intermediate coupling and are compared with earlier calculations by Gruzdev (1962) and with experiments of Bell, Paquette, and Wise (1965).

9938. Meshkov, S., **SU$_3$ reaction predictions and symmetry breaking,** Elementary Particles Conf., Institute for Theoretical Physics, University of Colorado, Summer 1964, *Lectures Theoret. Phys.* **VII B,** 36-50 (1965).

Key words: Octet symmetry breaking; Q plots; reaction cross section; strong interactions; sum rules; super-resonance; U-spin equalities.

An information and useful way to examine the role of unitary symmetry in strong interactions is to consider the predictions that can be made about reaction cross sections and to correlate them with experiment. When compared at the same Q value, the sum rules seem to fit the data without symmetry breaking. However, we find that predictions of pure SU$_3$ invariance are badly violated for "U-spin equalities." The inclusion of octet symmetry breaking is sufficient to explain this violation. In addition, the Q plots of the reactions involved suggest the possibility of super-resonances.

9939. Meshkov, S., Yodh, G. B., **SU(3) reaction inequalities at high energies,** *Phys. Rev. Letters* **18,** No. 12, 474-481 (Mar. 1967).

Key words: High energy differences; Q-plot inequalities; SU(3) reactions.

SU(3) reaction inequalities which had been thought to be violated are re-examined and found to agree with experiment at high energy. The comparison is made for both integrated and forward amplitudes. The apparent validity of SU(3) puts limits on the high energy behavior of the amplitude differences $|M(K^-p \rightarrow K^-p) - M(\pi^-p \rightarrow \pi^-p)|$ and $|M(K^+p \rightarrow K^+p) - M(\pi^+p \rightarrow \pi^+p)|$.

9940. Mielenz, K. D., **On the diffraction profiles of spectrograph slits of finite width,** *Optik* **25,** No. 3, 138-139 (May 17, 1967).

Key words: Diffraction; partial coherence; spectrograph slit.

In an earlier paper, the author presented a measured curve of line intensity vs. slit width, for the case of partially coherent spectrograph slit illumination. The result of a theroretical calculation is now presented which supports the experimental curve.

9941. Mielenz, K. D., **Spectroscope slit images in partially coherent light,** *J. Opt. Soc. Am.* **57,** No. 1, 66-74 (Jan. 1967).

Key words: Diffraction; luminosity; optimal performance; partial coherence slit illumination; resolution; spectroscopic slit.

The apparatus function of prism or grating spectroscopes with finite slits is derived for the general case of partially coherent illumination of the slit. Numerical results are presented for the border cases of coherent and incoherent slit illumination, as well as for full and partial illumination of the spectroscope aperture.

The dependence of line intensity and line width on slit width, as well as the optimum slit width, are determined for each of these cases. It is shown that the performance of the spectroscope reaches an optimum when the aperture is at least fully illuminated.

9942. Mielenz, K. D., Stephens, R. B., Gillilland, K. E., Nefflen, K. F., **Measurement of absolute wavelength stability of lasers,** *J. Opt. Soc. Am.* **56,** No. 2, 156-162 (Feb. 1966).

Key words: Fringe; interferometer; laser; optical; photoelectric; precision; scanning; stability; standard; wavelength.

A technique was devised to measure the absolute wavelength stability of a gas laser by direct interferometric comparison with a mercury 198 standard lamp. The apparatus used is described; its limits of precision are discussed.

The wavelength fluctuations of a free-running, unstabilized helium-neon laser were measured and found to be of the magnitude (several parts in 10^7) due to thermal and mechanical instabilities of the laser cavity.

Manual control of the laser was seen to yield a wavelength constancy (a few parts of 10^8) comparable to the limits of accuracy of interferometric standard sources.

9943. Mighell, A. D., Perloff, A., Block, S., **The crystal structure of the high temperature form of barium borate, BaO·B$_2$O$_3$,** *Acta Cryst.* **20,** Part 6, 819-823 (June 1966).

Key words: BaO·B$_2$O$_3$; barium borate; borate; crystal; structure; x-ray.

The crystal structure of the high temperature form of BaO·B$_2$O$_3$ (M.P. = 1095 ± 5 °C) was determined by conventional three-dimensional Patterson and electron-density syntheses. The heavy atom was used to establish the initial phases. BaO·B$_2$O$_3$ crystallizes in the rhombohedral space group R3c with 18 formula units per hexagonal cell. Unit-cell dimensions, referred to hexagonal axes, are a = b = 7.2351, c = 39.192 Å. Least-squares refinement with 498 independent reflections yielded a reliability index of 5.7%, based on the observed data only. The anion in the structure is nearly planar $(B_3O_6)^{-3}$ group constructed of three BO$_3$-triangles each of which shares two of the three corners. The structure contains two crystallographically distinct barium atoms located in positions having point symmetry 32 and 3. About the barium in the 32 symmetry position the oxygens are arranged in a trigonal prism. About the barium which lies in the 3 symmetry position the oxygen coordination is 9-fold.

9944. Miller, C. E., Flynn, T. M., **On the problem of measuring transient temperature in cryogenic fluids,** *ISA Trans.* **6,** No. 2, 133-138 (Apr.-May-June 1967).

Key words: Cryogenic; instrumentation; measurement; metrology; response time; sensor; temperature; thermometer; time constant.

The complex and frequently unpredictable energy exchange mechanisms that govern the dynamic behavior of cryogenic sensors makes the measurement of transient temperatures extremely difficult. Without suitable models by which to predict and evaluate sensor performance, considerable measurement errors can and do occur. The intent of this paper is simply to delineate in detail those factors which give rise to this situation. The validity of using notions based on the performance of the "ideal" thermometer for characterizing the cryogenic case is also discussed.

9945. Miller, C. E., Flynn, T. M., Grady, T. K., Waugh, J. S., **Nuclear spin relaxation in liquid hydrogen,** *Physica* **32,** No. 2, 244-251 (Feb. 1966).

Key words: Cryogenic; liquid hydrogen; nuclear magnetic resonance; nuclear relaxation.

The proton longitudinal relaxation time, T_1, has been measured in dilute liquid solutions of *ortho*hydrogen in *para*hydrogen over a range of temperature and compostion.

Below 1.75% orthohydrogen the temperature dependence of T_1 observed at higher concentration is reversed. This fact is interpreted in terms of an anisotropic intermolecular force which is of longer range for *ortho-ortho* than for *ortho-para* pairs, in keeping with previous interpretations of T_1 in the gaseous state.

9946. Miller, C. K. S., Daywitt, W. C., Arthur, M. G., **Noise standards, measurements, and receiver noise definitions,** *Proc. IEEE* **55,** No. 6, 865-875 (June 1967).

Key words: Error analysis; noise factor; noise source; noise temperature; radiometer.

This paper covers four topics; (1) basic principles of noise measurement, (2) the switching radiometer, (3) a survey of noise sources, and (4) concepts of noise factor and noise temperature. The first section presents basic formulas used in analyzing radiometers. The second discusses the switching radiometer briefly tracing its development and useage in the standards field. The third section surveys the development of hot and cold thermal noise sources, noise diodes, and gas-discharge noise generators. The last section presents and discusses the basic definitions of receiver noise performance.

9947. Milligan, D. E., Jacox, M. E., **Matrix isolation study of the infrared and ultraviolet spectra of the free radical CNN,** *J. Chem. Phys.* **44,** No. 8, 2850-2856 (Apr. 15, 1966).

Key words: Carbon suboxide photolysis; C atom reactions; C atom sources; CNN free radical; cyanogen azide photolysis; force constants; infrared spectrum; matrix isolation; NCN free radical; thermodynamic properties; ultraviolet spectrum.

Features appearing at 393, 1241, and 2847 cm^{-1} after photolysis of matrix-isolated cyanogen azide with 2100-2800 Å radiation are shown to exhibit parallel behavior. Isotopic data are consistent with the assignment of these three features as fundamentals of the free radical CNN, produced by the reaction of carbon atoms with molecular nitrogen. Ultraviolet absorptions at 4189 and 3964 Å can also be assigned to CNN. The force constants and thermodynamic properties of CNN have been derived. The carbon-nitrogen bond is found to have approximately triple bond character, and the nitrogen-nitrogen bond approximately double bond character.

9948. Moore, C. E., **A report on the International Conference on Spectroscopy, Bombay, India, Jan. 9-18, 1967,** *Appl. Opt.* **6,** No. 5, 836, 849, 850.

Key words: Indian Conference on Spectroscopy; International Conference on Spectroscopy; molecular spectroscopy.

The First International Conference on Spectroscopy was held in Bombay, India, January 9-18, 1967. Three International Unions, Astronomy, Physics, and Chemistry, supported the Organizing Committee in arranging for the Conference. Some 200 scientists from 13 countries attended. There were 30 invited papers and more than 100 contributed papers in all. Most of them dealt with molecular spectroscopy, but a few touched on interstellar spectra, solar spectroscopy in the x-ray region and laser spectroscopy.

9949. Moore, C. E., **Annual report on spectroscopy,** *Astron J.* **71,** No. 9, 796-797 (Nov. 1966).

Key words: Atomic spectra; rare-earth spectra; solar spectrum; transition probabilities.

This report is furnished annually to the Astronomical Journal in order to present to astrophysicists the spectroscopic work that they are particularly interested in. It is published with the Observatory Reports and provides a brief summary of activity at the National Bureau of Standards.

9950. Moore, C. E., **Future spectroscopy for late-type stars,** Chapter in *Proc. Colloquium on Late-Type Stars, June 13-17, 1966, Trieste, Italy,* Margherita Hack, ed., pp. 15-24 (Osservatorio Astronomico di Trieste, Italy).

Key words: Atomic spectra; molecular spectra; rare-earth spectra; reference data programs; solar spectra; spectra of late-type stars; sun-spot spectra.

The subject is reviewed with the idea of the application of spectroscopy to work on abundances. Two main topics are discussed: the general characteristics of the observed stellar spectra and the available data on laboratory spectra needed to identify the stellar lines. The impact of the developments in space technology has greatly expanded the observed range of stellar spectra. This is handled by regions, the ultraviolet, the visible, and the infrared. More laboratory programs are needed to meet present needs for data on both atomic and molecular spectra. The existing programs are discussed. Encouraging progress on the analyses of selected rare-earth spectra is reported. These promise to be of great astrophysical interest.

9951. Moore, C. E., **Transactions of the triple commission for spectroscopy, Subcommittee D,** *J. Opt. Soc. Am.* **55,** No. 6, 745 (1965).

Key words: Atomic spectra; rare-earth spectra; transition probabilities; triple commission for spectroscopy; ultraviolet atomic spectra.

The present report has been prepared with the idea of emphasizing the astrophysical needs for data on atomic spectra. It is to be given at a meeting of the Triple Commission for Spectroscopy, being held in Copenhagen on August 19, 1965. The meeting is arranged in connection with the 8th European Congress on Molecular Spectroscopy, Aug. 14-20, 1965. The author is one of two members representing the International Astronomical Union on the Triple Commission, which in turn encompasses representatives from the IAU, IUPAP, and IUPAC.

9952. Moore-Sitterly, C. E., **Commission on fundamental spectroscopic data,** (Proc. 12th General Assembly of the I.A.U., Hamburg, Germany, Aug. 26, 1964), *Trans. Intern. Astron. Union* **XIIB,** 173-185 (1966).

Key words: Standard wavelengths; transition probabilities of spectral lines; wavelength standards.

The proceedings of the meeting of Commission 14 are discussed. Current progress in the work on standards of wavelengths and transition probabilities are discussed. Also discussed are the future needs in spectroscopy.

9953. Moore-Sitterly, C. E., **Molecules in the sun,** Chapter in *Proc. Symp. Sun Spots Honoring Galileo, Florence, Italy, Sept. 9-12, 1964,* G. Richini, ed., pp. 181-185 (G. Barbera, ed., Florence, Italy, 1966).

Key words: Molecules; spectroscopy; sun-molecules.

Molecules in the sun presented at a symposium, September 9-12, 1964 in Florence, Italy, honoring Galileo.

9954. Morgan, A. H., **Distribution of standard frequency and time signals,** *Proc. IEEE* **55,** No. 6, 827-836 (June 1967).

Key words: Portable clocks; satellite timing; standard frequency; standard frequency broadcasts; time signals.

This paper reviews the present methods of distributing standard frequency and time signals (SFTS), which include the use of high frequency, low frequency, and very low frequency radio signals, portable clocks, satellites, and RF cables and lines. The range of accuracies attained with most of these systems are included along with an indication of the sources of error. Information is also included on the accuracy of signals generated by frequency dividers and multipliers.

Details regarding the techniques, the propagation media, and the equipment used in the distribution systems described are not included. Also, the generation of the signals is not discussed.

9955. Morris, E. E., Spencer, L. V., **The small-angle limit for twice-scattered rays from a point-isotropic source,** *Nucl. Sci. Eng.* **27,** No. 2, 485-488 (Feb. 1967).

Key words: Angular distribution; gamma radiation; logarithmic divergences; point isotropic; small-angle limit; twice-scattered.

The small-angle limit of the twice-scattered flux from a point-isotropic, monoenergetic source of gamma radiation is calculated. Importance is attached to this limit because of a logarithmic divergence of the angular distribution of the twice-scattered flux. Comments intended to facilitate the application to neutrons are given at the end.

9956. Mosburg, E. R., Jr., **Nonlinear diffusion with recombination in an electron beam excited plasma,** *Phys. Fluids* **9,** No. 4, 824-826 (Apr. 1966).

Key words: Collisional-radiative recombination; electron beam; electron density; light density; nonlinear diffusion; plasma; radial distribution; recombination mechanisms.

The radial distributions of electron density and light intensity are calculated from the nonlinear diffusion equations with a recombination term added. Two-body and three-body recombination mechanisms are considered in addition to the intermediate case of collisional-radiative recombination.

9957. Mountain, R. D., **A note on thermal expansion coefficients of rare gas solids,** *J. Phys. Chem. Solids* **28,** 1071-1073 (Dec. 29, 1966).

Key words: Corresponding states; lattice vibration spectrum; solid argon; solid krypton; solid xenon; thermal expansion coefficient.

Recent measurements of the thermal expansion coefficient of solid argon, krypton and xenon are shown to violate the law of corresponding states. The failure of the law of corresponding states is related to the different ways the lattice vibration spectra of these crystals change as pressure is applied to the lattice.

9958. Mountain, R. D., **Interpretation of Brillouin spectra,** *J. Chem. Phys.* **44,** No. 2, 832-833 (Jan. 15, 1966).

Key words: Brillouin scattering; carbon disulfide-light scattering; intensity of scattered light; light scattering liquids; thermal relaxation density fluctuations in liquids.

When a fluid consists of molecules having internal degrees of freedom weakly coupled to the translational degrees of freedom of the fluid (phonons), it is not correct to refer to the phonons as isotropic fluctuations in the density. This is relevant to the interpretation of Brillouin scattered light in terms of the properties of the scattering fluid. law of corresponding states. An approximate expression for the ratio of the intensity of the unshifted component to that of the Brillouin components is presented and applied to CS_2.

9959. Mountain, R. D., **Spectral distribution of scattered light in a simple fluid,** *Rev. Mod. Phys.* **38,** No. 1, 205-214 (Jan. 1966).

Key words: Brillouin scattering; carbon dioxide-light scattering; critical point; density fluctuations in fluids; Landau-Placzek intensity ratio; negative dispersion; non-local hydrodynamics; thermal diffusivity.

The spectral distribution of light scattered by density fluctuations in a dense, monoatomic, one-component fluid is calculated from the time dependence of the density fluctuations predicted by the linearized, hydrodynamic equations of irreversible thermodynamics.

The results of Landau and Placzek are verified and a procedure for deriving correction terms is discussed with the dispersion in the velocity of thermal sound waves obtained as an illustration. Particular attention is paid to the critical region. The properties of carbon dioxide are used to estimate the spectral distribution of critical opalescence. A comparison is made between light-scattering and sound-propagation experiments. Space dispersion near the cirtical point in the pressure and thermal conductivity is examined briefly. Finally, some of the experimental problems involved in measuring the spectral distribution of the scattered light are discussed.

9960. Mountain, R. D., Zwanzig, R., **Shear relaxation times of simple fluids,** *J. Chem. Phys.* **44,** No. 7, 277-279 (Apr. 1966).

Key words: Argon; bulk viscosity; shear relaxation time; shear viscosity; simple fluid; time correlation function.

This article presents a calculation of shear relaxation times of monatomic fluids covering both the liquid and dense gas phases. The times, which are not experimentally accessible at present, are calculated using low frequency viscosity data and theoretical estimates of the high frequency elastic moduli which were produced earlier by the authors. Numerical values of the relaxation times at various temperatures and densities are presented graphically. Except at very low densities, the times are on the order of 10^{-13} sec.

9961. Myers, V., **Scattering of cold neutrons in ammonium carbonate, ammonium citrate, and ammonium acetate,** *J. Chem. Phys.* **46,** No. 10, 4034-4035 (May 1967).

Key words: Ammonium compounds; cold neutron scattering; torsional and translational vibrations.

Neutron energy gain spectra have been measured in $(NH_4)_2CO_3$, $(NH_4)_2HC_6H_5O_7$, and $NH_4C_2H_3O_2$ at 20 °C using the Brookhaven slow chopper facility. Each spectrum exhibits two peaks that are characteristic of optical modes. The spectra of ammonium carbonate and ammonium citrate are similar to those of the body centered cubic lattice phase of the ammonium halides in which the ammonium ion has torsional and translational optical vibrations.

9962. Nahman, N. S., **The measurement of baseband pulse risetimes of less than 10^{-9} seconds,** *Proc. IEEE* **55,** No. 6, 855-864 (June 1967).

Key words: Baseband pulse rise-times; basic instrumentation system; fractional nanosecond pulse rise-times; oscillographic systems; pulse comparison techniques; pulse rise-times.

This is a review paper dealing with the measurement of fractional nanosecond pulse rise time in which the following subjects are discussed: oscillographic systems, pulse comparison techniques, a basic instrumentation system, and the distortion of pulses by transmission lines. Extensive references are provided. Included in the discussion is a delineation of equivalent time oscillographic sampling systems and a classification into three sampling categories: sequential, random, and multiple. Also considered are single transient oscillographic systems employing either traveling wave deflection structure cathode ray tubes or multiple sampling methods. In order to clearly present the rise time limitations caused by TEM transmission lines, attention is given to the distortion incurred by pulses upon passing through such lines. Some suggestions and predictions relating to future work are presented.

9963. Newton, C. J., Ruff, A. W., **X-ray diffraction measurement of stacking faults in alpha silver-tin alloys,** *J. Appl. Phys.* **37,** No. 10, 3860-3868 (Sept. 1966).

Key words: Dislocations; electron microscopy; silver-tin alloys; stacking faults; x-ray diffraction.

Stacking fault probabilities and dislocation densities were studied by means of x-ray diffraction and transmission electron microscopy in both filed and compressed bulk specimens from a series of dilute silver alloys. In the filed samples the observed stacking fault probabilities increased smoothly from 3×10^{-3} for pure silver to 66×10^{-3} for 10.3 at.% tin. The compressed bulk specimens led to values of 6×10^{-3} and 95×10^{-3} respectively. Direct determinations of the dislocation densities were made in the bulk specimens (1 to 5×10^{11} cm^{-2}) leading to computed values for the stacking fault energy in the range 2 to 6 ergs/cm^{-2}, with a slight dip for pure silver. Values for the dislocation density in the filed samples were also calculated. The effect of directed residual stresses measured on the bulk specimens was shown to be negligible with respect to the low angle diffraction line shifts attributed to faulting.

9964. Nimeroff, I., **Comparison of uncertainty ellipses calculated from two spectrophotometric colorimetry methods by an automatic-computer program,** *J. Opt. Soc. Am.* **56,** No. 2, 230-237 (Feb. 1966).

Key words: Automatic-computer program; colorimetry; computer program; ellipses; photometric colorimetry; spectrometric colorimetry.

The parameters and equations for calculating uncertainty of chromaticity coordinates in spectrophotometric tristimulus colorimetry have already been derived for the 10°-field standard-observer system. From the variability data for eleven optical filters obtained from two methods of spectrophotometric tristimulus colorimetry, standard-observer-system method and actual-observer method, two sets of chromaticity uncertainty ellipses are derived and intercompared. The similarity between corresponding ellipses of these two sets of ellipses leads to the conclusion that the system-derived uncertainty ellipses, based on the variances and covariances of the spectral tristimulus values of the large-field standard-observer system, can be used to estimate observer-derived chromaticity-uncertainty ellipses.

The equations which are the basis of the automatic-computer program and with which to compute uncertainty ellipses are given to aid anyone who wishes to arrange such a program in his laboratory. The fixed combinations of the spectral tristimulus values and of their variances and covariances can be readily prepared by researchers who may wish to use desk calculators to compute uncertainty ellipses for actual-observer data or for standard-observer data, respectively.

9965. Nimeroff, I., **The variability of color measurement,** *Color Eng.* **5,** No. 2, 24-29 (Mar.-Apr. 1966).

Key words: Colorimetry; propagation of errors; uncertainty in chromaticity coordinates; uncertainty in spectral tristimulus values; uncertainty in spectrophotometric data; uncertainty in spectroradiometric data; uniform chromaticity spacing; variability.

Because all the components in the equations for computing chromaticity coordinates in spectrophotometric colorimetry are measured, these components are subject to measurement uncertainty. The problem of determining the chromaticity uncertainty can be treated most simply by the application of the theory of propagation of errors in a computed result. The ellipse is chosen as the most convenient closed plane curve by which to represent the area of uncertainty in the chromaticity diagram with which the true chromaticity point can be expected to lie a specified fraction of the time. The theory has been applied to determining chromaticity uncertainty resulting separately from uncertainties in spectral irradiance of a source, spectral emittance of objects and spectral response of normal human observers. In actual practice the effects of these uncertainties should be computed coincidently. On the basis of experience it is suggested that a complete standard observer system, consisting of means, variances, and covariances of the spectral tristimulus values, in xyz and uvw coordinates, be recommended by Commission Internationale de l'Eclairage (CIE) for use in color measurement.

9966. Ninham, B. W., Powell, C. J., Swanson, N., **Plasmon damping metals,** *Phys. Rev.* **145,** No. 1, 209-217 (May 6, 1966).

Key words: Aluminum; characteristic electron energy loss half-width; corrected theory; metals; plasmon damping.

A report is given of a theoretical and experimental investigation into the degree of plasmon damping in metals as a function of momentum transfer. A previous theoretical result by DuBois is corrected and extended by taking into account polarization effects. Measurements are reported of the change in half-width $\Delta E_{1/2}$ of the dispersed $\approx$ 15 eV aluminum plasmon energy loss peak, excited by 20 keV electrons, as a function of electron scattering angle θ. The results can be expressed in the form $\Delta E_{1/2} = A + B\,\theta^2 + C\theta^4$, and there is good agreement between the values of B and C obtained from the revised theory and those found experimentally.

9967. Nossal, R. J., **Validity of the convolution approximation for the Van Hove G(r,t) function,** *Phys. Rev.* **143,** No. 1, 74-77 (Mar. 4, 1966).

Key words: Convolution approximation; Van Hove G(r,t).

The validity of the convolution approximation is examined by expanding the spatial Fourier transform of both the true and approximate G(r,t) in powers of the density. By comparing the expansions it is seen that, for small and intermediate k values, terms which are retained in the approximation are comparable to terms which are neglected. Also, since for large k an ideal gas calculation of G(r,t) is sufficient, it is concluded that there is no value of k for which an unmodified convolution approximation can be meaningfully applied.

9968. Nossal, R. J., Zwanzig, R., **Approximate eigenvalues of the Liouville operator in classical variables,** *Phys. Rev.* **157,** No. 1, 120-126 (May 5, 1967).

Key words: Eigenfunctions; hydrodynamic variables; irreversible processes; Liouville operator; many-body systems.

A variational solution of the Liouville Equation is used to obtain collective coordinates for simple classical fluids. Comparison is made with macroscopic analogs determined from relevant hydrodynamic equations. Approximate eigenfunctions of the Liouville operator, when constructed from linear combinations of the spatial fourier transforms (fluctuations) of the mass, momentum, and energy density operators for the fluid, are found appropriate to low frequency disturbances. When time derivatives of fluctuations are included among trial functions the variational procedure provides fluid state counterparts of usual solid state phonons.

9969. Ohashi, M., Paffenbarger, G. C., **Melting, flow and thermal expansion characteristics of some dental and commercial waxes,** *J. Am. Dental Assoc.* **72,** No. 5, 1141-1150 (May 1966).

Key words: Flow; melting; thermal expansion; waxes.

The literature on pertinent properties of waxes that may be suitable in dental impression materials is meager. To provide more data, the melting point and range (ASTM D 87-57), some flow characteristics (ADA Specification No. 4), and the linear thermal expansion (ADA Specification No. 4) were determined on 66 dental and commercial waxes. Instead of plotting the time-temperature curve the more sensitive temperature-rate cooling curve was employed. These curves were useful in identifying waxes and variations among lots or batches. The arrests in the curves were as high as 141 °C and as low as 41 °C. Supercooling was observed in six instances. The flow of wax cylinders (6 mm high) under a 2,000-gram load at 30, 37, 40, and 45 °C had a variable relationship with melting points. The coefficients of linear thermal expansion ranged from $1{,}000 \times 10^{-6}$/°C (25-30 °C) to as low as 110×10^{-6}/°C (25-30 °C).

9970. Ohashi, M., Woelfel, J. B., Paffenbarger, G. C., **Pressures exerted on complete dentures during swallowing,** *J. Am. Dental Assoc.* **73,** No. 3, 625-630 (Sept. 1966).

Key words: Brinell indentation used to measure force; clinical; measuring area dentures; swallowing pressure on dentures; variation in pressure.

The projected areas of the tissue-bearing surfaces of dentures were determined by making tracings on tared pieces of cellulose acetate sheets. The upper dentures of 21 patients had projected areas ranging from 22.8 to 36.6 cm^2 (3.5 to 5.7 in^2), the lower dentures from 14.5 to 24.4 cm^2 (2.2 to 3.8 in^2). The areas of the upper dentures were from 1.2 to 1.9 times the area of the lower dentures. The forces exerted on complete dentures during swallowing were measured by a Brinell indentation method employed in a modified "Coble Intra-Oral Balancer." Forces ranged on the average from 1.5 to 15.8 kg (3.3 to 34.8 lb). The pressure on the upper dentures ranged on the average from 0.06 to 0.56 kg/cm^2 (0.85 to 8.0 lb/in^2; for the lower dentures, 0.09 to 0.80 kg/cm^2 (1.3 to 11.4 lb/in^2).

9971. Okabe, H., **Photochemical studies by means of a field ion mass spectrometer,** *Z. Naturforsch.* **21a,** 135 (1966).

Key words: Field low mass spectrometry; hydrazine; photodissociation; propene; 1-butene.

A mass spectrometric investigation was carried out on the direct photolyses of propene, 1-butene, and hydrazine at 1849 Å with a field ion source in a flow system. Comparisons were made with Pt tip and wire emitters. It was found that, without illumination, mass spectra obtained with the wire were accompanied by a number of fragment peaks amounting to almost 1 percent. Since these peaks interfere with those produced photochemically, the tip emitter was used mostly for the photochemical studies although it gave 100 times less current and was less stable. The photochemical products formed at a gas pressure of 10 μ by a low-pressure mercury lamp were detected after approximately 10 m sec. The three main peaks observed in the propene photolysis were at masses 27, 28, and 56, indicating the processes:

$$C_3H_6 + h\nu \rightarrow C_2H_3 + CH_3,\ C_3H_6 + h\nu \rightarrow C_2H_4 + CH_2,\ CH_2 + C_3H_6 + C_4H_8.$$

The photolysis of 1-butene gave four main peaks at masses 40, 41, 42, and 70, suggesting steps, $C_4H_8 + h\nu \rightarrow C_3H_4 + (H + CH_3)$ or CH_4, $C_4H_8 + h\nu \rightarrow C_3H_5 + CH_3$, $C_4H_8 + h\nu \rightarrow C_3H_6 + CH_2$, $CH_2 + C_4H_8 \rightarrow C_5H_{10}$.

The only peak found with the photolysis of hydrazine was at mass 17, indicating the step, $N_2H_4 + h\nu \rightarrow NH_3 + NH$.

The possibility of forming these products by secondary processes is discussed.

9972. Ondrejka, A. R., **Peak pulse voltage measurement (baseband pulses),** *Proc.* IEEE **55,** No. 6, 882-885 (June 1967).

Key words: Oscilloscope; peak voltage; pulse; sampling; slideback; standard.

Several methods are presently being used for the measurement of pulse voltage. Oscilloscopes are particularly useful because they provide information concerning the shape of the pulse, besides a measure of the peak voltage. Besides the oscilloscope, several peak voltmeter circuits are mentioned. These include pulse stretching, sampling, and the slideback method. A standard pulse generator is described which provides a calibrated pulse voltage suitable for voltmeter calibration and other uses.

9973. Ormsby, W. C., Bolz, L. A., **Microtexture and composition of reaction products in the system kaolin-lime-water,** *J. Am. Ceram. Soc.* **49,** No. 7, 364-366 (July 1966).

Key words: Calcium silicate hydrates; composition; electron diffraction; electron microscopy; kaolin-lime-water; micro- texture.

Textural and compositional features of reaction products in the kaolin-lime-water system were examined by electron microscopy and electron diffraction. Electron micrographs of replicas of fracture surfaces of compacted mixtures and transmission electron micrographs of powdered compacts showed considerable attack of kaolinite particles by hydrated lime and indicated the formation of significant amounts of calcium silicate hydrate phases. Electron diffraction of reaction products confirmed the presence of calcium silicate hydrates. The presence of these hydrates is undoubtedly responsible for the stabilizing effects of lime which have previously been reported in the literature.

9974. Oser, H. J., Editor and Translator, **Functional analysis and numerical mathematics,** *Book by L. Collatz,* Academic Press Inc., New York, N.Y. 1966.

Key words: Approximation theories; functional analysis; Hilbert and Banach spaces; iterative methods; numerical analysis; operators.

This book was written primarily for graduate students in mathematics and physics, this book highlights the dramatic changes which have occurred in numerical mathematics during the past twenty years. The increased use of electronic computers and the tendency to develop more abstract methods are the primary factors in these rapid advances.

The text is mainly concerned with those parts of functional analysis which have proven useful for numerical applications including Hilbert space theory, Banach spaces, metric spaces and pseudometric spaces, the theory of Frechet derivatives, and topological fixed-point theorems. Problems concerning iterative methods, differential and integral equations, and approximation theory are used to illustrate the applications.

9975. Otto, E. M., **Equilibrium pressures of oxygen over oxides of lead at various temperatures,** *J. Electrochem. Soc.* **113,** No. 6, 525-527 (June 1966).

Key words: Dissociation; entropy; equilibrium; heat of reaction; intermediate oxides; irreversibility; lead oxides; oxygen pressures; thermogravimetry.

PbO_2 apparently requires four stages of decomposition to reach PbO. Based on thermogravimetric studies the intermediate products appear to be $5PbO_2 \cdot 4PbO$, $4PbO_2 \cdot 5PbO$ and Pb_3O_4. Though the first three stages seem irreversible, they too come to a steady state in decomposition, but no recombination takes place. $\Delta H°$ and $\Delta S°$ values have been calculated for the four stages.

9976. Paabo, M., Bates, R. G., Robinson, R. A., **Dissociation of acetic acid-d_3 in aqueous solution and related isotope effects from 0 to 50°,** *J. Phys. Chem.* **70,** 540-543 (1966).

Key words: Acetic acid-d_3; dissociation constant; isotope effects; thermodynamics of dissociation; weak acids.

The dissociation constant of acetic acid-d_3 CD_3COOH) in ordinary water (H_2O) has been determined by e.m.f. methods at 11 temperatures from 0 to 50 °C. From the variation of the dissociation constant with temperature the changes of enthalpy, entropy, and heat capacity for the dissociation process have also been derived and compared with similar data for ordinary proto-acetic acid in aqueous solution. The pK of the deuterioacetic acid is from 0.012 to 0.016 unit greater than that of the protoacid, and the temperature (22.9 °C) at which the dissociation constant passes through a maximum is only slightly higher than the corresponding temperature (22.4 °C) found earlier for the protoacid. Moreover, the changes of enthalpy, entropy, and heat capacity accompanying the dissociation of the two acids at room temperature do not appear to differ by an amount significantly greater than the combined errors of the two determinations.

9977. Paabo, M., Bates, R. G., Robinson, R. A., **Dissociation of ammonium ion in methanol-water solvents,** *J. Phys. Chem.* **70,** No. 1, 247-251 (1966).

Key words: Acid-base; ammonia; ammonium; buffer solutions; dissociation constant; electrolytes; ionization; methanol; nonaqueous; solvent effects.

The acidic dissociation constant of ammonium ion in five methanol-water solvents at 25 °C has been determined from measurements of the electromotive force of cells with hydrogen and silver-silver chloride electrodes. The solvents studied contained 10, 20, 33.4, 50, and 70% methanol by weight. The pK_a of ammonium ion follows the same general course as that of other cation acids studied previously, decreasing initially as methanol is added to the aqueous solvent and passing initially through a minimum at a solvent composition in the vicinity of 70 wt. % methanol. The results are interpreted in terms of combined electrostatic effects and a solvent "basicity effect." Values of pa^*_H for equimolal ammonia-ammonium chloride buffer solutions in the methanol-water solvents are given.

9978. Paffenbarger, G. C., Stanford, J. W., Kumpula, M. P., Sweeney, W. T., **Guide to dental materials, 1966-1967,** *Am. Dental Assoc.* **3d ed.,** 188 pages (Chicago, Ill., 1966).

Key words: American Dental Association; casting; ceramic materials; certified products; dental; instruments; materials; metals; polymers; specifications standards.

The seventh edition of this booklet covers all changes made in the *Guide to Dental Materials* since the sixth edition which was published in March 1964. Also included are changes in the List of Certified Dental Materials and the bibliography of dental research at the National Bureau of Standards since the sixth edition.

9979. Page, C. H., **The mathematical representation of physical entities,** *IEEE Trans. Educ.* **E10,** No. 2, 70-74 (June 1967).

Key words: Abstract unit; angle; dimensional analysis; measurement unit; numeric; quantity calculus; quantity equation.

Mathematics comprises abstract operations upon abstract elements. For the application of mathematics to the sciences, we must not only know the rules for manipulating symbols, but must also define the correspondences between the mathematical abstractions and the concepts to which application is made.

Certain basic postulates about physical observables yield the structure of their mathematical representation. An understanding of this structure yields an understanding of measure equations, quantity equations, measurement units, abstract units, and the mathematical nature of dimensional analysis. Writing equations in a dimensionally homogeneous form is often convenient, but not necessary; sometimes an inhomogeneous formulation is more useful.

9980. Parker, K., Goldman, D. T., Wallin, L., **Neutron cross section evaluations—past, present, and future,** (Proc. Intern. Atomic Energy Conf., Reactors, Vienna, Austria, 1966), Chapter in *Nuclear Data for Reactors* **II,** 293 (1967).

Key words: Compilation; cross section; evaluation; neutron; nuclear reactions.

A listing in computer output of all known neutron cross sections evaluations performed throughout the world is given.

9981. Parker, R. L., **Report on International Conference on Crystal Growth (ICCG),** (Proc. Intern. Conf. Crystal Growth, Boston, Mass., Dec. 1966), *Phys. Today* **19,** No. 12, 109-111 (Dec. 1966).

Key words: Crystal; crystal growth; ICCG, Report 1966; International Conference (ICCG).

An International Conference on Crystal Growth (ICCG) took place June 20-24, 1966 in Boston. The purpose of the Conference was to further the science and art of crystal growth by providing a forum for reporting and discussing recent original research in this field. The present report gives a brief summary of certain of the technical subjects dealt with at the Conference.

9982. Parrish, P. T., Daniel, A. C., Mahler, R. J., **F^{19} relaxation in AFM $KMnF_3$,** *Bull. Am. Phys. Soc. Series II,* **12,** No. 3, 284 (Mar. 1967).

Key words: Antiferromagnetism; low temperature; magnon Raman process; spin lattice relaxation time.

The T_1 of F^{19} nuclei located at one of the two possible sites in antiferromagnetic $KMnF_3$ has been measured as a function of temperature through the range of 22° to 1.3 °K in zero external magnetic field. In the 22° to 12 °K range, the relaxation rate followed a T^7 dependence corresponding to a relaxation time of 1.8 msec at 22 °K and 60 msec at 12 °K. This temperature variation of the relaxation rate is characteristic of a magnon Raman-process with a non-exponential magnon density variation due to phonon-magnon interactions. The preliminary data indicates a distinct, much slower fall off of T_1 below 12 °K, with the minimum value of T_1 being 510 msec at 1.3 °K. The corresponding temperature dependence of the relaxation rate is an apparent exponential which is slower than that expected for a two or three-magnon process below T_{AE}.

9983. Payne, B.. F., **Absolute calibration of vibration generators with time-sharing computer as integral part of system,** *Shock Vibration Bull.* **36,** Part 6, 183-194 (Feb. 1967).

Key words: Accelerometers; calibration; shakers; time-shared computers; vibration standard.

Improved shakers with a simplified ceramic moving element and a reference accelerometer now permit reciprocity calibration over a wider frequency range from 10 Hz to 5000 Hz. This paper describes present NBS shaker calibration procedure, using a time-sharing computer, in which magnitude and phase lag measurements are made. Calibrations to 10 kHz are planned.

A teletypewriter gives access to a central commercial computer which can accept commands and data from punched paper tape or from the keyboard. The data may be recorded from digital measuring instruments by a special coupling system. Data reduction is rapid and permits errors to be corrected quickly. The combined use of the computer and the digital data recording system cuts the calibration time to about one-fourth the time required by previous methods. Monitoring the quality of motion of the shaker through the use of the computer makes possible improved accuracy of the calibration process. As an example, a calibration of one of the improved shakers is presented.

9984. Perloff, A., Block, S., **The crystal structure of the strontium and lead tetraborates, $SrO{\cdot}2B_2O_3$ and $PbO{\cdot}2B_2O_3$,** *Acta Cryst.* **20,** Part 2, 274-279 (Feb. 1966).

Key words: Borate; crystal structure; strontium and lead tetraborates.

$SrO \cdot 2B_2O_3$ and $PbO \cdot 2B_2O_3$ are isostructural. These compounds crystallize in the orthorhombic system, $P2_1nm$, with two formula units in a cell of dimensions $a = 4.237$, $b = 4.431$, $c = 10.706$ Å for $SrO \cdot 2B_2O_3$ and $a = 4.244$, $b = 4.457$, $c = 10.840$ Å for $PbO \cdot 2B_2O_3$. A detailed structure analysis was carried out for the Sr compound only.

The structure was solved by conventional Patterson and electron density syntheses utilizing the heavy atom to establish the initial phases. Least squares refinement on three-dimensional data yielded a final R-factor of 7.1 percent.

The results reveal an unusual type of borate framework. All boron atoms are tetrahedrally coordinated. The unusual feature is the occurrence of an oxygen atom common to three tetrahedra.

Although the tetrahedra form a three-dimensional network by corner sharing the borate network gives the appearance of a layer-like structure because there are comparatively few links in the *c* direction. The layers can be described in terms of chains (parallel to *a*) of six membered rings having B–O edges in common. These chains are joined by non-ring oxygens to form layers which are parallel to the *a b* plane.

The Sr coordination is not clearly defined. There are nine nearest neighbor oxygens at distances ranging from 2.52-2.84 Å. There are six more oxygens at 3.04-3.20 Å which could conceivably be considered as part of the Sr coordination sphere.

9985. Persson, K. B., Uhlenbrock, D. A., Johnson, E. G., **Cyclotron harmonic emission from the abnormal negative glow plasma,** *Bull. Am. Phys. Soc., Series II,* **12,** No. 5, 756 (May 1967).

Key words: Cyclotron harmonic radiation; electron beam; magnetic field; plasma.

Experimental evidence indicates that our observed cyclotron harmonic radiation is strong parallel with the magnetic field and that it is directly or indirectly associated with the plasma maintaining electron beam. The search for mechanisms accounting for these facts lead to the following model. The secondary electron generated in an ionization process produces a helical space charge wave packet in the dense back ground plasma. When this packet is generated in a uniform back ground plasma it can be shown that the electron cyclotron harmonics radiate essentially only perpendicular to the magnetic field. Strong radiation parallel with the magnetic field at the harmonic frequencies is generated when the packet is produced in a spatially non-uniform plasma with the dimensions of the non-uniformity comparable to the relevant cyclotron radius. The spatial non-uniformities are produced by the beam electrons forming "density tracks" in the plasma and/or by cathode non-uniformities.

9986. Peterson, R. L., **Short-range order in the Weiss molecular field approximation,** *Bull. Am. Phys. Soc., Series II,* **12,** No. 4, 502 (Apr. 1967).

Key words: Magnetism; molecular field theory; short-range order.

The Weiss molecular field theory (WMFT) of ferromagnetism, as commonly used, has the well-known defect that the short-range order and heat capacity vanish in zero applied field and temperatures above Curie's point. We here point out that the same use of the WMFT also gives an isentropic susceptibility equal to zero at all fields and temperatures, and two different results for the isothermal susceptibility, depending upon which of two direct methods of calculation are used. These difficulties are all traced to the use of the assumption that different spins are uncorrelated. We argue that this assumption is not consistent within the framework of the WMFT, and show that the molecular field assumption by itself provides a measure of the spin correlations. The assumption that only nearest neighbor spins are correlated is shown to be consistent at high temperature and to yield the correct high-temperature expression for the short-range order and heat capacity. Thus we argue that when correctly used, the WMFT does not possess the gross defects usually attributed to it. The discussion applies also to antiferromagnetism.

9987. Peterson, R. L., **Formal theory of nonlinear response,** *Rev. Mod. Phys.* **39,** No. 1, 69-77 (Jan. 1967).

Key words: Isothermal susceptibility; nonlinear response theory; nonlinear transport theory; response functions; transport coefficients.

This paper presents the derivation of formal, exact expressions for "generalized response coefficients," quantities which characterize the response of a system to conservative forces of arbitrary strength and time dependence. The development avoids all expansions of the response in powers of the driving forces. The generalized response coefficients thus provide the basis for calculations of nonlinear effects in those situations for which expansions in powers of the forces are not suitable. It is shown how the linear and higher order response functions obtained first by Kubo can be obtained in a relatively more simple way. The expressions corresponding to static forces are considered in some detail. Generalized response coefficients are also derived for systems in equilibrium; the lowest order of these is just the isothermal susceptibility, as usually defined.

9988. Peyser, P. Stromberg, R. R., **Conformation of adsorbed polystyrene measured by attenuated total reflection in the ultraviolet region,** *J. Phys. Chem.* **71,** No. 7, 2066-2074 (June 1967).

Key words: Adsorption of polymers; attenuated total reflection; conformation of adsorbed polymer molecules; frustrated total reflection; index of refraction in ultraviolet region; polymer adsorption; refractive index in ultraviolet region; total reflection; ultraviolet spectrophotometry.

Attenuated total reflection (ATR) in the ultraviolet region was used to measure the extension and concentration of an adsorbed layer of polystyrene. The polystyrene was adsorbed on a quartz surface from cyclohexane solution at the theta temperature. The ATR prism, which allowed 15 to 16 reflections, was constructed from synthetic crystalline quartz. It was designed to be placed in a spectrophotometer without the need of additional optical components. The measured adsorbed polymer "extension" agreed reasonably well with similar ellipsometric measurements on nearly the same system. The study reported here was restricted to the use of an adsorbed layer that could be treated as a homogeneous film. The possible use of the method to determine the concentration distribution of adsorbed segments normal to the surface is discussed. Measurements in the ultraviolet region of the refractive indices of the polymer solutions and of the benzene-methanol and toluene-methanol solutions that were used to test the method are also described.

9989. Piccirelli, R. A., **Some properties of the long-time values of the probability densities for moderately dense gases,** *J. Math. Phys.* **7,** 922 (1966).

Key words: Long-time values; moderately dense gases; probability densities.

It has been argued that for sufficiently large times the *n*-particle probability densities of a moderately dense, simple gas become time-independent functionals of the one-particle probability densities. Proofs are given for several properties of the power series representation of these functionals. In particular, it is shown that the equilibrium value of the *n*-particle functional is identical to the usual equilibrium probability density term by term and that the corresponding generalized Boltzmann collision integral vanishes as it should. The two forms of the functional, one due to Bogoliubov and one due to Green and Cohen, are shown to be formally identical. It is argued that the higher terms of these two series probably diverge *together.*

In the course of the discussion several new properties of the coefficient operators of the power series for the functional are derived. Moreover, an integral equation for the *n*-particle functional is derived which may have solutions not representable as functional power series in the one-particle probability density.

9990. Pitts, J. W., Moore, D. G., **Apparatus for studying the effects of atmospheric pollution and cyclic dew formation on the deterioration of materials,** *Mater. Res. Std.* **6,** No. 7, 328-333 (July 1966).

Key words: Accelerated corrosion; atmospheric corrosion; corrosion mechanisms; humidity cabinet; laboratory corrosion apparatus; photomicrography; reflectometry; sulfur dioxide; thermoelectric heat pump; water vapor condensation.

An apparatus and procedure for simulating atmospheric corrosion are described. The apparatus was used to study qualitatively the kinetics of moisture condensation and evaporation, and the resulting corrosion of a metal surface. The effect of varying time of exposure and amount of contaminant (SO_2) in the atmosphere on the corrosion rate of polished iron is illustrated with photomicrographs. A quantitative rating of the apparent progress of corrosion was made with reflectance measurments.

9991. Placious, R. C., **Dependence of 50 and 100 keV bremsstrahlung on target thickness, atomic number, and geometric factors,** *J. Appl. Phys.* **38,** No. 5, 2030-2038 (Apr. 1967).

Key words: Efficiencies; low energy; Monte Carlo predictions; photon emission angles; thick target bremsstrahlung.

Experimental data have been obtained for the bremsstrahlung spectra produced with 50 and 100 keV electrons incident on different targets. The spectrum per unit solid angle per incident electron is measured for photon emission angles of 30, 70, and 110 degrees, for normal and oblique incidence of the electrons on the targets having atomic numbers of 13, 50, and 79, and for four target thicknesses equal to different fractions of the electron range in the given material. Also, results are given for the bremsstrahlung production efficiencies per unit solid angle at a given emission angle. The experimental results show good agreement with the theoretical predictions of Berger and Seltzer, which are based on thin target bremsstrahlung cross sections and which employ Monte Carlo calculations to account for multiple scattering and energy loss effects.

9992. Pollack, G. L., **Effect of normal-fluid motion on third sound in liquid-helium films,** *Phys. Rev.* **143,** No. 1, 103-109 (Mar. 1966).

Key words: Energy attenuation; helium film; liquid helium; normal fluid viscosity; third sound.

Some theoretical consequences are derived of a proposed viscous force on the normal-fluid component of the He II film. Compared to earlier calculations, in which the normal fluid was assumed to be immobile, this new assumption allows large energy attenuations such as have recently been observed in third sound in He II films and in a wave mode of He II partially clamped in narrow channels. Atkins' three equations describing third sound are modified to take account of energy and entropy transfer associated with normal-fluid motion, and wave modes are obtained which simultaneously satisfy these equations and the normal-fluid equation of motion with a viscous force $-Rv_n$. The four wave variables are: T and T′, respectively, the local fluctuations in film thickness and temperature, v_s, and v_n. Attenuation and velocity of the wave mode corresponding to third sound are calculated at temperatures from 1.2 °K through $T\lambda$ for all values of the dimensionless viscosity coefficient ($R/\omega\rho$). The maximum calculated attenuation varies from 0.47 cm^{-1} at 12 °K to 17.3 cm^{-1} at 2.1 °K; at the lower temperature the observed attenuation is about 2 cm^{-1}. However, the anomalously rapid decrease in velocity of third sound observed by Everitt et al. could not be explained in this manner. Evidence for normal-fluid motion in the film is presented and some feasible experiments for detecting it are described.

9993. Post, M. A., **The determination of bound styrene in insoluble emulsion polymerized styrene-butadiene copolymers,** *J. Appl. Chem.* **17,** No. 7, 203-208 (July 1967).

Key words: Absorbance ratio method; bound styrene; infrared; insoluble styrene-butadiene copolymers; masonry paints.

Bound styrene is determined in insoluble emulsion polymerized styrene-butadiene copolymers by measurement of the 10.3μm/13.2μm absorbance ratio using the baseline method. This ratio is obtained from the infrared spectrogram of the copolymer and the styrene content is determined from a standard curve. The standard curve is constructed from absorbance ratios of 10.3μm/13.2μm derived from the infrared spectrograms of cast films of styrene-butadiene latexes over a range of percentage compositions. Bound sytrene is determined in these latexes by nitration of the isolated and extracted copolymers. Styrene content based on nitration is determined from standard curves relating styrene concentration to spectrophotometric absorbance measurements at wavelengths of 285.0 nm, 273.8 nm, and 265.0 nm. The source of the styrene for these curves is NBS standard rubber No. 1500.

9994. Post, M. A., **The determination of bound styrene in soluble high styrene-butadiene resins,** *J. Paint Technol. Eng. Official Digest* **38,** No. 497, 335-342 (June 1966).

Key words: Absorbance ratio method; bound styrene; infrared; masonry paints; styrene-butadiene resins.

Bound styrene is determined in high styrene-butadiene resins by measurement of the 10.3μ/3.25μ absorbance ratio, using the baseline method. This ratio is obtained from the infrared spectrogram of the purified copolymer, and the percent styrene is read from a standard curve. The standard curve is constructed from absorbance ratios of 10.3μ/3.25μ derived from the infrared spectrograms of accurately weighed mixtures of purified polystyrene and purified polybutadiene. These polymers are isolated from their respective latexes. It is shown that this method is useful for analyzing crude resins as well as purified copolymers.

9995. Powell, R. L., **Thermophysical properties of metals at cryogenic temperatures,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **387,** *Behavior of Materials at Cryogenic Temperatures,* pp. 134-148 (1966).

Key words: Cryogenic temperature; metals; thermophysical properties.

The low temperature thermophysical properties of metals can only be fully understood by utilizing the fundamental concepts of electrons, lattice vibrations, and their interactions. After the introduction, the properties of specific heat and thermal conductivity are each discussed with the emphasis on understanding the various contributions to the total observed effect. Based on the above discussions, temperature dependencies for each property are given for various representative metals and alloys. The importance of inter-relations between the various themophysical properties is also noted. With an understanding of basic concepts, inter-relations, and effects of different contributions, one can often make reasonable estimates for the values of the thermophysical properties of new materials or of known materials with different chemical impurities or mechanical or metallurgical treatments. References are given to several good books, review articles, and compilations of numerical values. Information is also given on sources of specialized or up-to-date bibliographie and data collections.

9996. Power, E. A., **A suggested experiment to measure part of the transverse electromagnetic mass of the electron,** *Proc. Roy. Soc. (London)* **292,** No. 1430, 424-432 (May 31, 1966).

Key words: Atomic beam; electromagnetic; electron; hyperfine; mass; measurement; self-energy.

The changes in self energy of a non-relativistic charged particle are calculated where such changes are due to confinement of the charge within conducting plates. This confinement will alter the mode structure of the virtual photons involved in the transverse self energy calculation: it will lead to a reduction in the number of modes at the *long* wavelength limit and, where the modes have a wavelength comparable to the distance, L, between the plates, the normal integrals over virtual momenta are replaced by sums over the integers describing the modes. It is found that mass changes of 1 part in 10^{10} can be induced by plate separations of the order of a millimeter. It is suggested that such relative mass shifts could be measured by the use of high precision atomic beam techniques, such as those used in "atomic clocks". The atomic beam would be directed between two closely spaced parallel conducting plates (or through long cylindrical tubes) located between the oscillating fields used to excite a transition between the hyperfine-structure levels. The mass change will be reflected in frequency shifts of the hfs separation of the same order as the mass change. With a high precision cesium beam apparatus, such as those at NBS, it should be possible to demonstrate not only that changes do indeed occur but also obtain a quantitative estimate of such effects as a function of the plate separation, L. It is predicted that the frequency shifts should be inversely proportional to L.

9997. Power, E. A., **Zero-point energy and the Lamb shift,** *Am. J. Phys.* **34,** No. 6, 516-518 (June 1966).

Key words: Electron; hydrogen; Lamb shift; self energy.

A suggestion by Feynman that the Lamb shift energy can be obtained from the changes in zero-point energy due to the presence of the atoms involved is work through in detail for the Bethe non-relativistic contribution to the energy shift. The self energy of a free electron is obtained in the same way and is equivalent to the state independent shift due to the $e^2A^2/2mc^2$ term in the normal perturbation methods.

9998. Pruitt, J. S., **Secondary electron trajectories in a Faraday cup magnetic field,** *Nucl. Instr. Methods* **39,** 329 (Feb. 1966).

Key words: Electrons; escape; Faraday; magnetic; orbits; solenoidal.

Orbits of electrons with energies between 10 eV and 1 MeV have been studied in inhomogeneous magnetic fields to choose a deflecting magnet for the capture of secondary electrons generated in the mouth of a Faraday cup. The results show that a solenoidal field abets their escape, but the field of two repelling bar magnets completely stops electrons with energies less than about 1 keV. Additional information relevant to Faraday Cup design is also presented.

9999. Pummer, W. J., Antonucci, J. M., **Aromatic fluorocarbon polymers,** (Proc. 152nd American Chemical Society Meeting, New York, N.Y., Sept. 13, 1966), *Polymer Preprint* **7,** No. 2, 1071-1076 (Sept. 1966).

Key words: Fluorinated styrenes; fluoroaryl polymers; para and meta linked polymers; pendant pentafluorophenyl ring; polyperfluorophenylene ethers; polyperfluorophenylenes; sulfides; vinyl ethers.

Recent synthetic work has led to the preparation of a variety of fluoroaryl polymers. Most of the polymers synthesized are similar in structure to the hydrocarbon analogs except for the fluorine atoms. On this basis, the fluorinated polymers, presented in this paper, will be classified and discussed according to structural features. The first class of polymers contains the polyperfluorophenylenes which will include both the para and meta linked polymers. In the second class, the polymers contain an atom or group of atoms between the fluorinated rings, such as oxygen, sulfur and oxydifluoromethylene groups. Some polymers in this category are the polyperfluorophenylene ethers and sulfides. The final group of polymers contains a pendant pentafluorophenyl ring attached to the main polymer chain such as the various fluorinated styrenes and vinyl ethers.

In all cases, the method of polymerization, physical properties and thermal stability of the polymers will be discussed and whenever possible, comparisons will be made between the fluorinated and hydrocarbon polymers.

10000. Radford, H. E., **Free radical microwave absorption meter,** *Rev. Sci. Instr.* **37,** No. 6, 790-792 (June 1966).

Key words: Free radical; microwave absorption.

This note describes a simple microwave spectrometer which can be used to measure absolute concentrations of free radicals at any point in a conventional gas flow reaction system. The spectrometer displays true absorption line profiles and is sensitive to microwave line depths (peak absorption coefficient X path length) as small as 10^{-5}. The instrument may be assembled from commercially available components, at a cost comparable with that of a good optical monochromator.

10001. Radziemski, L. J., Jr., Andrew, K. L., Kaufman, V., Litzen, U., **Vacuum ultraviolet wavelength standards and improved energy levels in the first spectrum of silicon,** *J. Opt. Soc. Am.* **57,** No. 3, 336-340 (Mar. 1967).

Key words: Energy levels; silicon; spectroscopy; standards; vacuum ultraviolet; wavelength.

Vacuum ultraviolet Si I wavelengths have been recalculated using all available low-pressure-source data. One hundred calculated and forty-one measured wavelengths, all with uncertainties of less than 0.002 Å should be useful as wavelength standards in the region 1560 to 2000 Å. Seventy-seven of the proposed standards were originally calculated by Radziemski and Andrew (*J. Opt. Soc. Am.* **55,** 474 (1965)) and although the two sets of wavelength values agree to within their uncertainties, the new set is more internally consistent. Included also is a complete list of low-pressure-source levels for Si I, which contains new values for 30 odd levels previously determined exclusively from relatively high-pressure (450-740 torr) arc data.

10002. Ramaley, D., Shafer, J. F., **Direct ratio readings from a universal ratio set,** *Instr. Control Systems* **39,** 73-74 (Jan. 1966).

Key words: Direct-reading ratio sets; ratio sets; universal ratio sets.

A method for modifying commercially available universal ratio sets to permit their use as direct-reading ratio sets has been developed. This modification is the outgrowth of a series of seminars held at the National Bureau of Standards, Radio Standards Laboratory, Boulder, Colorado, at which some of the participants were from standards laboratories equipped with universal ratio sets but not with direct-reading ratio sets. A simple scheme was devised whereby a few minor connections to the circuit of a universal ratio set, terminated in external binding posts, make the instrument suitable for use also as a direct-reading ratio set, thus providing the equivalent of two separate instruments in a single set. The direct-reading ratio set is especially well adapted to intercompare resistors closely adjusted to nominal values with a minimum of required computation.

10003. Rasberry, S. D., Scribner, B. F., Margoshes, M., **Characteristics of the laser probe for spectrochemical analysis (a summary),** *Proc. XII Intern. Spectroscopy Colloquium, Exeter, England, 1965,* pp. 336-339 (Hilger & Watts, London, England, 1966).

Key words: Laser probe; spectrochemical analysis.

An extended summary is given of a paper presented at the XII International Spectroscopy Colloquium, Exeter, England, July 12-16, 1965. The paper discusses some practical aspects of the use of the laser probe for spectrochemical analysis of minute samples.

10004. Rasberry, S. D., Scribner, B. F., Margoshes, M., **Laser probe excitation in spectrochemical analysis. I. Characteristics of the source,** *Appl. Opt.* **6,** No. 1, 81-86 (Jan. 1967).

Key words: Analysis; emission; emission spectra; high energy; high power; illuminating system; laser probe; laser vaporization; Q-switched ruby laser; qualitative; spark excitation; spectrochemical.

A laser probe for spectrochemical analysis is described. A high energy laser beam is focused onto a specimen to vaporize a sample from a small area, and the vapor thus formed is further excited by a spark discharge. The characteristics of emission spectra with and without auxiliary spark excitation are compared. Spectrograph illuminating systems for qualitative and quantitative analysis were investigated. Some difficulties were encountered with the laser probe, and modifications were made to the instrument to alleviate some of these problems. Some typical analytical applications are discussed.

10005. Rasberry, S. D., Scribner, B. F., Margoshes, M., **Laser probe excitation in spectrochemical analysis. II. Investigation of quantitative aspects,** *Appl. Opt.* **6,** No. 1, 87-94 (Jan. 1967).

Key words: High energy; high power; laser probe; laser vaporization; photographic emulsion; pit volume; Q-switched ruby laser; quantitative; spark excitation; spectral intensity; spectrochemical analysis.

A study has been made of quantitative analysis by a laser probe with spark excitation of the sample vapor. Random errors come largely from variations in laser energy and from photometric errors. The parameters of the spark circuit affect the line intensities; however, these factors are well controlled. Correlations have been established between the energy of the laser beam, the size of the pit formed, and spectral intensities. Single-spike laser operation has been found to be preferable for most purposes to multiple-spike operation. At present, the coefficients of variation for analysis are 15 to 40 percent.

10006. Reader, J., **Nuclear moments of Pm^{147},** *Phys. Rev.* **141,** No. 3, 1123-1128 (Jan. 1966).

Key words: Electronic structure; energy levels; hollow cathode; hyperfine structure; interferrometer; nuclear moments; optical; promethium 147.

The nuclear magnetic dipole and electric quadrupole moments of Pm^{147} have been derived from an analysis of the optical hyperfine structure of singly ionized Pm^{147}. The hyperfine constants for the $[4f^5\ {}^6H_{5/2}, 6s]_2$ ground state are $A = -\ 10.24 \pm 0.20$ mK; $B = -\ 10.6 \pm 2.6$ mK. By using the known atomic beams data for the $[4f^5 6s^2\ {}^6H_{7/2}]$ state of neutral Pm to subtract out the contribution of the $[4f^5\ {}^6H_{5/2}]$ core to the observed magnetic splitting factor, the splitting factor of the 6*s* electron was found to be $a_{6s} = + 214.2 \pm 4.9$ mK. The nuclear moments deduced from the hyperfine constants are $\mu_I(Pm^{147}) = +2.58 + 0.07$ nm and $Q(Pm^{147}) = +0.74 \pm 0.20$ b.

10007. Rebbert, R. E., Ausloos, P., **Vacuum-ultraviolet photolysis of solid propane at 20° and 77 °K,** *J. Chem. Phys.* **46,** No. 11, 4333-4340 (June 1, 1967).

Key words: Free radicals; photolysis; primary dissociations; propane; solid phase.

The photolysis of $CD_3CH_2CD_3$, $CH_3CD_2CH_3$, and $C_3H_8 - C_3D_8$ mixtures has been investigated at 1470 Å (8.4 eV), 1236 Å (10 eV) and 1048-1067 Å (11.6-11.8 eV) both at 20° and 77 °K. On the basis of the isotopic analysis of the products it is concluded that the following primary fragmentation processes occur:

$$C_3H_8 + h\nu \rightarrow C_3H_7 + H$$

$$\rightarrow + C_3H_6 + H_2$$

$$\rightarrow + C_2H_6 + CH_2$$

$$\rightarrow + C_2H_5 + CH_3$$

$$\rightarrow + C_2H_4 + CH_4$$

Hydrogen, methane, and ethane are mainly formed by elimination processes from a single carbon atom which results in the simultaneous formation of a carbene in each case. In this respect the primary processes occurring in the solid phase are the same as those reported to occur in the gas phase. The elucidation of the primary processes in the condensed phase is facilitated because of the inhibition of secondary decomposition of the internally excited fragments formed in the processes above. On the other hand, the occurrence of geminate disproportionation and combination leads to difficulties in determining the relative quantum yields of the primary processes of the first and fourth listed above. It is noted that the C-H and C-C cleavage reactions in one and four increase in importance when the energy of the incident photon is augmented.

Although propane ions, which have an ionization energy of 11.07 eV in the gas phase must be produced at 1048-1067 Å, no concrete information could be obtained as to the fate of these ions in the solid phase. The data, however, show that decomposition of the superexcited molecules is of major importance at these wavelengths.

10008. Reed, R. P., **The plate-like martensite transformation in Fe-Ni alloys,** *Acta Met.* **15,** No. 8, 1287-1296 (Aug. 1967).

Key words: Fe-Ni alloys; low temperatures; martensite.

The martensite morphological and crystallographic characteristics in Fe, 29-35 w/o Ni alloys have been investigated. Optical microscopy results indicate that as the nickel content increases the martensite plates become less fragmented, internal twinning increases, and the pole normal to the midrib plane swings toward the $(011)\gamma$-$(111)\gamma$ line. Two types of internal twinning have been found in high Ni martensites. The M_s temperatures were determined for this series of alloys and are generally about 20 °C higher than previously thought. Results for the midrib variation with temperature and prestrain are also reported.

10009. Reed, R. P., **Deformation twinning in Ni and fcc Fe-Ni alloys,** *Phil. Mag.* **15,** No. 137, 1051-1055 (May 1967).

Key words: Deformation twinning; Fe-Ni alloys; low temperature; nickel.

Using electron and optical microscopy techniques, deformation twinning has been found in Ni and fcc Fe—Ni alloys at low temperatures (76-4 °K).

10010. Reed, R. P., Breedis, J. F., **Low-temperature phase transformations,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **387,** Behavior of Materials at Cryogenic Temperatures, pp. 60-132 (1966).

Key words: Cryogenics; crystal structure; martensite; metals; phase transformations.

Changes in crystallographic structures can occur solely at low temperatures by a diffusionless, shear-type of transformation to a product structure termed martensite. This paper presents a review of martensitic transformations which occur in ferrous and nonferrous alloys. Specifically, kinetic, structure, and the theoretical approaches to describing diffusionless transformations are treated.

The kinetic characteristics pertinent to this class of transformations include dependence upon temperature, time, applied stress, and chemical composition. The structural aspects of martensitic transformations include their morphology and crystallography. Four general types of martensite transformation morphology have been observed in steels and in nonferrous alloys. With particular reference to steels, the product structures may be morphologically described as either: (1) plates, (2) sheets comprised of martensite crystals or laths, (3) homogeneous sheets, or (4) surface martensite. Theories pertaining to martensitic transformations relate either to the initiation or to the subsequent growth of a product. Theories employing thermodynamic analyses or dislocation models generally are concerned with nucleation, while crystallographic theories attempt to predict the mode of growth and the final orientations of the product. Both approaches are discussed.

Approximately 650 references appear in the extended bibliography which lists almost all articles published in English after 1940, in addition to major articles published in other languages. Tables which attempt to classify articles are also included to simplify research of martensite literature.

10011. Reese, R. M., Rosenstock, H. M., **Photoionization mass spectrometry of NO,** *J. Chem. Phys.* **44,** No. 5, 2007-2009 (Mar. 1, 1966).

Key words: Autoionization; mass spectrometry; nitric oxide; photoionization; Rydberg series.

The photoionization of NO has been studied in the 1360-600 Å range with mass analysis. All autoionization peaks found here below 900 Å have been assigned to diffuse lines observed in absorption by Huber. In the 1130-900 Å range, several new vibrational progressions are deduced.

10012. Reid, G. C., **Physics of the D region at high latitudes,** (Proc. NATO Advanced Study Institute, Finse, Norway, April 1965), Chapter in *Electron Density Profiles in Ionosphere and Exosphere,* J. Frihagen, ed., pp. 17-26 (North Holland Publ. Co., Amsterdam, The Netherlands, 1966).

Key words: D region; electron density profiles; free electrons; high latitudes; photochemical reaction rates.

It is shown that the assumption that collisional detachment of negative ions plays an important part in determining nighttime electron density profiles at high latitudes leads to major contradictions. Multiple-frequency data obtained at twilight during a polar-cap absorption event suggest a quite different view of the nighttime D regions, which is consistent with an almost complete disappearance of free electrons below about 75 km, and an almost complete maintenance of the daytime profile above this level. The lack of change of the upper region between daytime and nighttime conditions can be understood if the negative ions there suffer associative detachment reactions with atomic oxygen, and if the atomic oxygen height distribution is governed by dynamical processes (transport and turbulent mixing) rather than simply by photochemical reaction rates. It is shown that other evidence is consistent with this picture of the nighttime D region at high latitudes.

10013. Richardson, J. M., editor, **U.S.A. National Committee Report, Fifteenth General Assembly, Munich, September 1966: Commission 1, Radio Measurement Methods and Standards, Progress in Radio Measurement Methods and Standards,** *Radio Science* **1,** No. 11, 1333-1342 (Nov. 1966).

Key words: Coaxial connectors; electromagnetic properties of materials; frequency standards; lasers; microwaves; radio measurement methods; radio measurement standards; time standards.

Progress in radio measurement methods and standards within the United States during the Triennium 1963 through 1965 is reviewed for inclusion in the report of the U.S. National Committee of URSI to the 1966 General Assembly. Topics surveyed are high precision atomic frequency standards, high precision quartz frequency standards, scientific aspects of Universal and/or Atomic time and frequency transmissions, standards and measurements at 30 kc/s to 1 Gc/s, standards and measurements at 1 to 300 G c/s, precision coaxial connectors, swept-frequency techniques, measurements of electromagnetic properties of materials, and laser standards and measurements. The topics are treated within the length limitation imposed by USNC/URSI.

10014. Richardson, J. M., **Introduction,** (Proc. 1966 Conf. Precision Electromagnetic Measurements, Boulder, Colo., June 21-23, 1966), *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 138 (Dec. 1966).

Key words: Electromagnetic measurements; functional elements; physical measurements.

It is appropriate, at each biennial Conference on Precision Electromagnetic Measurements, to examine the importance of this series in the scheme of things. Recently we have come to recognize that the field of physical measurements has functional elements and complicated interactions characteristic of a vast system. We may call this complex the system of physical measurement. There is a comparatively small group of people who work at the limits of attainable accuracy in order to keep the system valid and current. There is also a huge number of people who use the system as a means to the ends of science, engineering, manufacturing, trade, and everyday life. This conference exists so that the keepers of the system can communicate their work to each other and also to users of the system. No other conference addresses itself exclusively to the dynamically changing techniques of precision electromagnetic measurement and to how they can be put to use.

10015. Richardson, J. M., **Progress in the distribution of standard time and frequency, 1963 through 1965,** (Proc. XV General Assembly of URSI, Munich, Germany, Sept. 5-15, 1966), Chapter in *Progress in Radio Science 1963-1966,* **Part 1,** pp. 40-62 (International Scientific Radio Union, Munich, Germany, 1966).

Key words: Frequency; portable clocks; standard frequency broadcasts; time; time signals; VLF propagation.

Progress in accurate long distance distribution of standard time and frequency, as reported in the literature from 1963 through 1965, is summarized. Techniques are by VLF, LF, and HF radio propagation, by satellite relay, and by portable clocks. Effects on standard frequency transmissions of variations in VLF propagation with geophysical phenomena are quantitatively understood. VLF and LF transmissions have provided careful, long-term, statistical comparison of remotely located atomic frequency standards. Precision of at least 2 parts in 10^{11} for a 24-hour observation period is possible. The phase of some standard frequency transmitters is routinely steered by VLF from distances up to 5300 km. Global distribution of standard time by VLF to microsecond resolution has been shown feasible. The null beat between two neighboring VLF carriers propagates stably enough to mark a particular VLF cycle, and the beat period can be long enough to enable ordinary time signals to mark a particular null beat. Intercontinental time synchronization by microwave pulses has been accomplished via Telstar and Relay II satellites. Accuracy is set at several microseconds. Portable cesium clocks have served as global transfer standards with degradation of timing accuracy of only about a microsecond per trip. Results by all the above methods are consistent with each other and with stated accuracies of atomic standards involved.

10016. Richmond, J. C., **Effect of surface roughness on emittance of nonmetals,** Chapter in *Thermophysics and Temperature Control of Spacecraft and Entry Vehicles* **18,** 167-172 (Academic Press Inc., New York, N.Y., 1966); *J. Opt. Soc. Am.* **56,** No. 2, 253-254 (Feb. 1966).

Key words: Absorptance; alumina; ceramic; emissivity; emittance; optical; reflectance; roughness; scattering theory.

It has been observed experimentally, both at NBS and elsewhere, that the emittance of polished metals can be markedly increased by roughening the surface, by as much as a factor of 2 or 3. For non-metals and particularly white ceramic materials, on the other hand, the emittance appears to be essentially independent of surface roughness, at least for wavelengths below 7 or 8 microns. This apparent anomaly is explained on the basis of the differences in the optical properties of the two types of materials.

10017. Richmond, J. C., Kneissl, G. J., Kelley, D. L., Kelly, F. J., **Procedures for precise determination of thermal radiation properties,** *Tech. Rept.* **ARML-TR-66-302** (Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, Aug. 1966).

Key words: Emissivity; emittance; high temperature reflectance; infrared reflectance; radiation properties; reflectance; spectral emittance; spectral reflectance; thermal radiation; total emittance.

An error analysis of the shallow cavity technique for measuring total normal emittance of ceramic materials at very high temperatures showed that there was an error due to the translucency of the specimens that was as much as +60 percent for alumina, and a second error due to thermal gradients in the specimen that was on the order of −10 percent. Two new techniques were devised in the hope of greatly reducing the translucency error. Progress was made in developing codes to compute and correct for the thermal gradients present in the specimen. The laser-source integrating sphere reflectometer for measuring reflectance of specimens at very high temperatures was extensively redesigned to eliminate errors due to flux reaching the detector on the first reflection, and to convert the reflectometer from the substitution to the comparison mode. A literature search was made of techniques for measuring thermal radiation properties of solids at temperatures above 2500 °K (4000 °F).

10018. Risley, A. S., Bussey, H. E., **Interpretation of ferromagnetic resonance measurement made in a nonresonant system,** *IEEE Trans. Instr. Meas.* **IM-5,** No. 4, 393-396 (Dec. 1966).

Key words: Cavity resonator model; ferromagnetic resonance measurement; nonresonant system; short circuited waveguide.

The loaded line width, ΔH_m (loaded by the coupling), and the resonator coupling coefficient, β, assuming a cavity resonator model, were measured on ferrimagnetic resonant YIG spheres in a (nonresonant) short circuited waveguide. The coupling was varied over a wide range by changing the angle ϕ between the dc and driving rf magnetic fields. The results showed that the unloaded line width, $\Delta H = \Delta H_m/(1+\beta)$, was essentially constant during changes in coupling. It is therefore tentatively concluded that the cavity resonator model furnishes an accurate model for separating unloaded from loaded line width. Other methods for obtaining ΔH, namely using a matched waveguide, or a pick-up loop, or the usual cavity perturbation method were less satisfactory.

The coupling coefficient was 1.06 times theoretical for widely different sample sizes and all reasonable angles ϕ. It follows that line width can be determined very simply from a simple reflection measurement without measuring the width.

10019. Risley, A. S., Johnson, E. G., Jr., Bussey, H. E., **Polycrystalline spin wave theory of ferromagnetic resonance compared with tilting experiment,** *J. Appl. Phys.* **37,** No. 2, 656-668 (Feb. 1966).

Key words: Ferromagnetic resonance; polycrystalline spin wave; spin wave.

Schlömann's spin wave theory of polycrystalline ferromagnetic resonance has been tested in detail using the tilting method reported earlier. Among the quantities measured were the linewidth ΔH, and the maximum value of the imaginary part of the effective susceptibility $(\chi_m'')^{eff}$. The measurement method is equivalent to measuring asymmetric ($N_x \neq N_y$) ellipsoids and thus, introduces another shape dependence in addition to that due to spin waves. Direct comparison with the symmetric ($N_x = N_y$) form of the theory is inaccurate. A proper comparison can be made in two ways: (1) generalizing the theory to include the $N_x \neq N_y$ case and then using the data directly, (2) transforming the data and then comparing with the $N_x = N_y$ theory. Both comparisons are reported and their equivalence is demonstrated.

It is concluded that Schlömann's theory does not fit the data within the spin wave (SW) manifold. It is suggested that the theory of Sparks may provide a better fit. The difference between coupling models seems to be the basic difference between the two theories. Experimentally and theoretically, ΔH and $(\chi_m'')^{eff}$ are different quantities. The dispersive effects of spin wave coupling are shown to be the cause of the difference between the theoretical ΔH and $(\chi_m'')^{eff}$.

10020. Risley, A. S., Johnson, E. G., Jr., Bussey, H. E., **Erratum: Polycrystalline spin-wave theory of ferromagnetic resonance compared with the tilting experiment,** *J. Appl. Phys.* **37,** No. 9, 3646 (Aug. 1966).

Key words: Dipolar narrowing; ferrites; ferromagnetic resonance relaxation; polycrystals; porosity; spin wave.

A more complete test of Schlömann's spin wave, SW, theory of polycrystalline ferromagnetic resonance, FMR, has been made. This theory is compared with measurements made by the tilting method reported earlier. Among the quantities measured were the line width, ΔH, and the maximum value of the imaginary part of the effective susceptibility, s''_{max}. The measurement method is equivalent to measuring asymmetric ($N_x \neq N_y$) ellipsoids, which introduces another shape dependence in addition to that due to SW's. Direct comparison with the symmetric ($N_x = N_y$) form of the theory is inaccurate. A proper comparison can be made in two ways: (1) generalizing the theory to include the $N_x \neq N_y$ case and then using the data directly, (2) transforming the data and then comparing with the $N_x = N_y$ theory. Both comparisons are reported and their equivalence is demonstrated.

It is concluded that Schlömann's theory does not fit the data within the SW manifold. It is suggested that the theory of Sparks may provide a better fit. The difference between coupling models seems to be the basic difference between the two theories.

Experimentally and theoretically, ΔH and s''_{max} are different quantities. The dispersive effects of SW coupling are shown to be the cause of the difference between the theoretical ΔH and s''_{max}. ΔH does not provide an adequate description of the FMR; s''_{max} is a necessary additional parameter.

10021. Ritter, J. J., Coyle, T. D., **Convenient safety cutoff device for water cooled equipment,** *Rev. Sci. Instr.* **37,** No. 4, 523 (Apr. 1966).

Key words: Cutoff; electric; flow-sensitive switch; safety.

This note describes a device to detect interruptions in the flow of cooling water through laboratory apparatus. A control circuit is provided to deactivate equipment and to shut off water supply to prevent flooding.

10022. Robertson, A. F., **Report on the conference on burns and flame retardant fabrics (Dec. 1966), New York, N.Y.,** *Fire Res. Abstr. Rev.* **9,** No. 2, 119-122 (1967).

Key words: Accidents, clothing fires; clothing, flame resistance; burn injuries, fire-retardant clothing; flame resistance, clothing; retardant treated fabrics.

A summary is presented of subject meeting which was held on 2 and 3 December 1966.

10023. Rosberry, F. W., **The measurement of homogeneity of optical materials in the visible and near infrared,** *Appl. Opt.* **5,** No. 6, 961-966 (June 1966).

Key words: Homogeneity; index gradient; infrared; interferometer; laser; measurement; optical; refractive index; shadowgraph.

A procedure is described for determining the inhomogeneities of a sample of optical material in terms of small changes in index of refraction at discrete points over the measured surface. The method is used in the visible and near infrared regions of the spectrum. A He-Ne gas laser source was used for the infrared measurements. The variation in index was mapped with contour lines enclosing areas of similar index variations. The largest index change in one cm distance was noted and recorded as the maximum gradient per cm. Over 25 different samples of six different materials were examined. The results are presented in a chart indicating the range of maximum index gradients of the samples observed. Data are shown to illustrate the possibility of determining index values to higher precision than the material justifies.

10024. Rosenberg, S. J., **Metals for use in orthopedics,** Chapter in *Orthotics Etcetra,* S. Licht, ed., **9,** 77-94 (E. Licht Publ., New Haven, Conn., 1966).

Key words: Alloys, aluminum; aluminum alloys; magnesium alloys; orthopedics, metals; titanium alloys.

10025. Rosenblatt, D. R., **Aggregation in matrix models of resource flows II. Boolean relation matrix methods,** *Am. Stat.* **21,** No. 3, 32-37 (June 1967).

Key words: Aggregation; automatic theory; Boolean matrices; consolidation; DeMorgan-Pierce-Schroder relation algebra; input-output models; indecomposability; Markov chains; mathematical economics; mathematical logic; primitivity and automatic theory; relation, calculus.

A Boolean relation matrix approach is taken to issues of aggregation in matrix models of resource flows involving substochastic matrices A,B. The following results are shown: (i) an aggregation matrix is many-one and onto: (ii) if B is a consolidation of A with weight matrix regular, then if A is indecomposable (primitive), B is indecomposable (primitive): but, if the weight matrix is singular the preceding conclusions fail; if B is a consolidation of A. $(I-B)^{-1}$ exists if, and only if, for every indecomposable stochastic submatrix A_k of A, the image under the consolidation of every row index of A_k is connected in the associated graph of B to the image of a "nonstochastic row" index of A.

10026. Rosenblatt, J. R., **Comments on presentation by Albert A. Anctil,** (Proc. 11th Conf. Design of Experiments in Army Research Development and Testing, Dover, N.J., Oct. 20-22, 1965), *U.S. Army ARO-D Report* **66-2,** pp. 509-510 (U.S. Army Research Office, Durham, N.C., May 1966).

Key words: Curve-fitting; statistics.

Discussion of a paper entitled "Statistical analysis of tensile strength-hardness relationships in thermochemically treated steels," including remarks on the interpretation of a goodness-of-fit measure for the relationships.

10027. Rosenstock, H. M., **Franck-Condon factors and the mass spectra of small molecules,** (Proc. Intern. Mass Spectrometry Conf., ASTM E-14, The Hydrocarbon Research Group and GAMS, Paris, France, Sept. 1964), *Adv. Mass Spectrometry* **3,** 435-439 (1966).

Key words: Acetylene probability; Franck-Condon factors; photoionization; transition; vibrational.

This paper is not a review paper but is rather a status report of the theory relating to the mass spectra of small molecules and includes, in outline, some recent work carried out at the National Bureau of Standards.

10028. Rossmassler, S. A., **The National Standard Reference Data System program in atomic and molecular properties** (Proc. Symp. Compilations of Data on Chemical and Physical Properties of Substances, 152d National Meeting, Am. Chem. Soc., New York, N.Y., Sept. 12, 1966), *J. Chem. Doc.* **7,** No. 1, 15-18 (Feb. 1967).

Key words: Atomic; compilation; data; data center; molecular; properties.

In general, Atomic and Molecular properties are taken to mean properties primarily characteristic of the individual atoms or molecules rather than of any system or state of aggregation. For operational convenience, the area includes also certain general and fundamental physical constants.

An Advisory Panel listed sixty-three specific properties and gave high priority to twenty-eight of these. The Office of Standard Reference Data is supporting or monitoring sixteen projects which are concerned with fourteen of these high priority topics. Most of the projects are continuing ones. Five of the activities perform data center or information center functions.

In several cases, joint support or cooperative programs have been developed, and we are seeking to extend this type of activity.

To provide reasonable current coverage of the general area, the number of projects should be doubled (high priority topics only) or trebled (high priority plus related moderate priority topics) as rapidly as possible. Projects being initiated in other countries (cf. next paper by R. M. S. Hall) are already assuming some of this burden.

Ten compilations of data and a similar number of bibliographies and secondary publications will have appeared by the end of calendar year 1966.

10029. Row, R. V., **Evidence of long-period acoustic-gravity waves launched into the F region by the Alaskan earthquake of March 28, 1964,** *J. Geophys. Res. Letter* **71,** 343-345 (Jan. 1966).

Key words: Acoustic-gravity waves; Alaskan earthquake; Doppler sounder; F region; ionograms; ionospheric disturbances.

Evidence of disturbances to the ionosphere caused by the Alaskan earthquake of (03:36 U.T.) March 28, 1964 have been published recently by Leonard and Barnes (1965) and Baker and Davies (1965). The data presented by both pairs of authors are shown to be mutually compatible. It is suggested that the large long period disturbance seen on Doppler records at Boulder and vertical sounder ionograms at Boulder and other locations are a manifestation of long period ducted acoustic-gravity waves launched into the ionosphere near the epicenter.

10030. Rubin, R. J., **Brownian motion models,** (Summer Institute on Spectral Theory and Statistical Mechanics, Brookhaven National Laboratory, Upton, L.I., N.Y., July-Aug. 1965), *Brookhaven Natl. Lab. Publ.* **PNL993 (T422),** (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, 1966).

Key words: Brownian motion; momentum autocorrelation function; statistical mechanics.

Two recent investigations of the ensemble average motion of a particle in a harmonically coupled system of particles are outlined and reviewed, namely the investigations of Rubin and Ford, Kac and Mazur.

10031. Rubin, R. J., **Random-walk model of adsorption of a chain-polymer molecule on a long rigid-rod molecule,** *J. Chem. Phys.* **44,** No. 5, 2130-2138 (Mar. 1966).

Key words: Adsorption; chain polymer; critical energy; generating function; lattice model; partition function; random walk.

A lattice model of adsorption of a flexible chain molecule on a rod-like molecule is investigated. The rod-like molecule is represented by the lattice sites on the z-axis of a simple cubic lattice. The sites which are nearest neighbors to the z-axis are adsorbing sites. The dimensionless adsorption energy per momomer unit is $\Theta = \epsilon/kT$. The problem of enumerating polymer chain configurations taking into account the increased probability of occupying adsorbing sites and the zero probability of occupying z-axis sites is formulated and solved as a random walk problem. The average fraction of monomer units in adsorbing sites $f_R(\Theta)$ is computed in the limit in which the number of monomer units in the polymer chain approaches infinity. There is a critical value of the adsorption energy $\Theta c = \ln(6/5)$ such that for $\Theta < \Theta_c$, $f_R(\Theta) = 0$. For $\Theta > \Theta_c$, $f_R(\Theta)$ is an increasing function of Θ with all derivatives equal to zero at $\Theta_c = \ln(6/5)$. In the analogous simple cubic model of adsorption of a polymer chain molecule at a plane solution surface, the same value of the critical energy has been obtained. For $\Theta < \ln(6/5)$ the average fraction of monomer units in adsorbing surface sites is zero, i.e., $f_S(\Theta) = 0$. For $\Theta > \ln(6/5)$, $f_S(\Theta)$ is an increasing function of Θ whose right-hand slope is 25 at $\Theta = \ln(6/5)$.

10032. Rubin, R. J., **Random walk with an excluded origin,** *J. Math. Phys.* **8,** No. 3, 576-581 (Mar. 1967).

Key words: Excluded origin; restricted random walk.

The mean square end-to-end distance R_N^2 is calculated for the subset of all random walk configurations of a D-dimensional simple cubic lattice which do not return to the starting point. Explicit results are obtained in the limit $N \gg 1$ for the one-, two-, and three-dimensional lattices. The values of the first two terms in the asymptotic series for R_N^2 are, respectively, $N+N$, $N+N/\log N$, and $N+.435/N^{-1/2}$.

An unexpected relation is obtained between R_N^2 and S_N, the average number of different lattice sites visited in an N-step random walk on a perfect lattice. It is $R_N^2 = S_N(S_{N+1} - S_N)^1$.

10033. Rubin, S. **Standards for galvanomagnetic devices,** *Solid-State Electron.* **9,** No. 5, 559-566 (May 1966).

Key words: Flux sensitive resistors; galvanomagnetic devices; Hall effect; magneto resistors; photoresistors; standard terminology.

A review is given of the Military Standard and the IEC standard for Hall effect devices. Points of outstanding interest such as linearity definitions are detailed. A review of a proposed standard for magnetoresistive devices is given. Similarities between the two standards are noted as are some of the similarities with standards for other flux sensitive resistors such as thermistors and photoresistors.

10034. Rubin, S., **Standards for galvanomagnetic devices,** (Proc. Committee on Hall Effect Applications, Cambridge, Mass., Nov. 8-9, 1965), Chapter in *Solid State Electronics* **9,** No. 65, 559-566 (Pergamon Press, Inc., New York, N.Y., 1966).

Key words: Galvanomagnetic device; Hall effect device; Hall element; magnetoresistive device; magnetoresistor; standard terminology.

A summary is given of existing and "in-process" standards for Galvanomagnetic devices. Controversial items in the IEC standard for Hall effect devices, 47(Secretariat)196, May 1965, are reviewed, and note is made of USA and Japanese comments on his document. Items in the USA document, 47(USA), September 1965, commenting on 47(Secretariat)196, are reviewed, and particular emphasis is given to items relating to linearity error, particularly as a percent of reading, to residual voltages, and to sensitivity indices.

A summary of items in an "in-process" document for "Standard Definitions and Terminology for Magnetoresistive Devices," is given. The concept of compatibility between definitions for flux and temperature sensitive resistors (i.e., magnetoresistors, thermistors, and photoresistors) is introduced. Some overlapping areas of application are noted. The linear input-output characteristics obtainable from a device which has a square law characteristic is noted and appropriate definitions for both characteristics are introduced.

Copies of four documents dealing with standard terminology and definitions for Hall Effect Devices are included as appendices.

10035. Rubin, S., **Transistorized UHF marginal oscillator and its application for the measurement of the magnetic flux density,** *Proc. IEEE Letter* **53,** No. 9, 1249-1250 (Sept. 1965).

Key words: Density, magnetic flux; flux density; magnetic flux density; marginal oscillator; oscillator, marginal; UHF marginal oscillator.

A transistorized marginal oscillator operating in the UHF region has been used to measure flux density in a Helmholtz coil at 17.5 mT, with an accuracy of better than a part in 10^3. The instrument uses plug-in oscillator modules to simplify frequency changing. The results achieved indicate the feasibility of such a device for measurement of magnetic flux density in the 1 to 50 mT range in industrial environments and with accuracies approaching a part in 10^4.

10036. Ruegg, F. W., Dorsey, W. W., **The flow field of a body-stabilized two-dimensional V-flame,** *Combust. Flame* **10,** No. 1, 1-10 (Dec. 1966).

Key words: Flame field; flame holder calculation; flame simulation; flame speed; flame vorticity; V-flame.

A two-dimensional, V-shaped flame is simulated by a combination of source and sink sheets of fluid in a general stream. Complex variable theory is used to determine the flow field of the simulated flame. Adjustment of the strength of the sink sheet on the interior symmetry flame axis yields a flame speed that is constant within about one percent along the front. Two 22-degree half-angle flames are calculated. In both cases a portion of the flame front near the apex of the flame and the sink are found to be enclosed within a body shaped as a flameholder. Actual flames in the calculated approach fields would generate appreciable vorticity in the flame gas, but the calculated field downstream from the simulated flame is irrotational.

10037. Ruff, A. W., Ives, L. K., **Quench defects formed in a low-stacking fault-energy silver tin alloy,** *J. Appl. Phys.* **37,** No. 8, 3073-3079 (July 1966).

Key words: Dislocation loops; dislocations; electron microscopy; quenching; silver-tin alloy; stacking fault tetrahedra.

A transmission electron microscopy study of defects was conducted in quenched and plastically deformed samples of a silver—8 at. percent tin alloy. After quenching from 750 °C and aging at 200-300 °C, dislocation loops and small faulted defects were found distributed randomly in low numbers. Many examples of aligned rows of clustered defects were observed together with stacking fault growth on existing screw-oriented dislocations. Helical dislocations with visibly extended segments were found which are believed to indicate the process of tetrahedron formation in $\langle 110 \rangle$ rows. A specific mechanism is proposed to explain the observations. Extensive plastic deformation is also observed to produce such features.

10038. Rumfelt, A. Y., Elwell, L. B., **Radio frequency power measurements,** *Proc. IEEE* **55,** No. 6, 837-850 (June 1967).

Key words: Bolometer mount efficiency; mismatch error; power measurement; power meter; substitution error.

The need for improved accuracy in and understanding of all kinds of measurements has come with the recent rapid advances in modern technology. RF power measurement, the subject of this paper, is no exception to this requirement. The basic principles of bolometric, calorimetric, and certain other types of power meters are reviewed. The methods for making accurate RF power measurements are discussed in detail. Emphasis is given to the techniques for eliminating or accounting for the errors due to mismatch, dc or LF substitution, and bolometer mount efficiency.

10039. Rush, J. J., **Cold-neutron study of hindered rotations in solids and liquid methyl chloroform, neopentane and ethane,** *J. Chem. Phys.* **46,** No. 6, 2285-2291 (Mar. 1967).

Key words: Barrier to rotation; cosine potential; globular molecules; hindered rotation; methyl group; molecular reorientation; neutron scattering; neutron spectra; phase transitions; torsional vibrations.

The low-frequency modes of methylchloroform, neopentane, and ethane in their solid and liquid phases have been investigated by the scattering of cold neutrons. The energy-gain spectra for these compounds in their low-temperature solid phases exhibit broad bands peaked at about 52, 50 and 82 cm^{-1} for CH_3CCl_3, $C(CH_3)_4$, and C_2H_6, respectively, which are attributed to whole-molecule librations and translations in the lattice. In the high-temperature phases of the "globular" compounds CH_3CCl_3 and $C(CH_3)_4$, these spectral bands are no longer peaked, but are quite diffuse and blend into a considerably broadened elastic peak. These results show that the phase transitions below the melting points are associated with a change from strongly hindered to quasi-free rotation, in agreement with the results of previous experiments. The barrier to molecular reorientation is estimated to be approximately < 1 kcal/mole in the high-temperature phase of each compound.

Bands are also observed in the CH_3CCl_3 and $C(CH_3)_4$ spectra peaked at about 300 and 286 cm^{-1}, respectively, which are assigned primarily to the torsional oscillations of the methyl groups. These peak positions show no significant change in proceeding from the liquid to the solid phases, indicating little intermolecular contribution to the forces hindering methyl-group reorientation. One of the liquid ethane spectra exhibits a shoulder around 260 cm^{-1}, which is possibly due to torsional vibrations. Assuming three-fold cosine potentials, with no interaction between methyl groups "average" barriers to rotation of 5.8 and 5.2 kcal/mole are calculated from the torsional peaks for CH_3CCl_3 and $C(CH_3)_4$. The CH_3CCl_3 barrier is considerably higher than the value derived from thermodynamic results for CH_3CCl_3 (and ethane) gas.

10040. Rush, J. J., Ferraro, J. R., **Neutron and infrared spectra of $HCrO_2$ and $DCrO_2$,** *J. Chem. Phys.* **44,** No. 6, 2496-2498 (Mar. 15, 1966).

Key words: Chromous acid; $DCrO_2$; $HCrO_2$; hydrogen bond; infrared spectra; isotope effect; lattice modes; neutron spectra; vibration spectra.

The vibrational spectra of $HCrO_2$ and $DCrO_2$ have been investigated by the energy-gain scattering of cold-neutrons, and by infrared absorption spectra from 4000-30 cm^{-1}. The infrared measurements are in agreement with previous results above 400 cm^{-1}. In addition, no absorptions are observed between 400 and 30 cm^{-1}, a region not covered in previous measurements. These results appear to support previous evidence for asymmetric hydrogen bonds at $DCrO_2$ and essentially symmetric bonds in $HCrO_2$. The neutron spectra exhibit a number of maxima, including a band peaked at about 225 cm^{-1} in $HCrO_2$ (and a less intense peak around 180 cm^{-1} in $DCrO_2$), probably due to low-frequency optic lattice modes. A comparison of the neutron and infrared results appears to raise some uncertainty concerning the assumption of symmetric hydrogen bonds in $HCrO_2$.

10041. Rush, J. J., Hamilton, W., **Free rotation of methyl groups in dimethyltin difluoride,** *Inorg. Chem.* **5,** No. 12, 2238-2239 (Dec. 1966).

Key words: Barrier to rotation; cross-section slope; free rotation; methyl group; neutron wavelength; total neutron cross section.

Total cross sections for long-wavelength neutrons have been measured for polycrystalline $(CH_3)_2SnF_2$. The variation of the scattering cross section per hydrogen atom with neutron wavelength was determined to be 12.0 ± 0.5 barns/Å-H. Comparison of this value with previous results on methyl-substituted compounds and with theoretical calculations leads to the conclusion that the methyl groups in $(CH_3)_2SnF_2$ are rotating almost freely, with a barrier to reorientation of approximately < 0.3 kcal/mole.

10042. Rush, J. J., Connor, D., Carter, R., **Study of D_2O ice as a cold-neutron source,** *Nucl. Sci. Engr.* **25,** No. 4, 383-389 (1966).

> Key words: Cold neutrons; D_2O(ice); (leakage) spectra; neutron; (neutron) flux; (neutron) moderation; (neutron) spectra; neutron temperature; (neutron) thermalization; transport (effects).

The leakage flux from a large cylinder (18 × 18 in.) of D_2O with a beam of pile neutrons incident at its center has been studied at D_2O temperatures from 22° to 293 °K. Intensities through beryllium and graphite filters, as well as indium foil transmissions, have been measured to determine cold-neutron fractions and neutron temperatures for the emerging spectra. The results of these measurements show that large volumes of D_2O ice can be useful as low-temperature moderators in reactors. The percentage of leakage neutrons with $\lambda_n \geqslant 3.95$A is 21 percent at 22 °K, a 20-fold increase over the fraction at 293 °K, and about twice the value at 100 °K. The neutron temperature of the leakage spectrum, calculated from the transmission data assuming a Maxwellian distribution, decreases with moderator temperature, reaching a value of about 75° for D_2O at 22 °K. An abrupt increase in the fraction of cold neutrons is observed at the D_2O freezing point, which is shown to be primarily due to a change in the transport rather than the moderating properties of the D_2O. This result clearly illustrates the fact that any moderator acts as a neutron filter as well as a thermalizing medium, so that the emerging energy distribution is dependent on the variation of the neutron with cross section energy.

10043. Rush, J. J., Taylor, T. I., **Study of low-frequency motions in several ferroelectric salts by the inelastic scattering of cold neutrons,** *Proc. 3d Symp. Inelastic Scattering of Neutrons, Bombay, India, 1965,* **II,** 333 (1965).

> Key words: Ammonium salt; barrier to rotation; ferroelectric; neutron scattering; phase transition; torsional vibrations; vibration spectra.

For $K_4Fe(CN)_6 \cdot 3H_2O$ ($T_c = 249$ °K) scattered spectra were obtained at 121, 175 and 296 °K. The results were quite similar in both the high temperature and ferroelectric phases. A broad band centered at an energy gain 435 ± 40 cm^{-1} (54 ± 5 MeV) is observed at all three temperatures and assigned to the librations of the water molecules. A second broad peak around 165 cm^{-1} is possibly due to the translational motions of the water molecules in the lattice.

The room-temperature spectra for NH_4HSO_4 (T_c at 154 and 270 °K) and $(NH_4)_2SO_4$ ($T_c = 224$ °K) show broad bands peaked at about 260 cm^{-1} and 300 cm^{-1}, respectively, which are primarily due to the torsional motions of the ammonium ions. The NH_4HSO_4 spectrum at 177 °K shows an indication of splitting, with little shift in the center of the band. At 125 °K the spectrum is clearly split, with peaks at 290 ± 25 and 190 ± 16 cm^{-1}. The $(NH_4)_2SO_4$ results at 172 °K also exhibit a split band, with peaks centered at 335 ± 25 and 200 ± 16 cm^{-1}. In both cases the higher-energy peaks are assigned to torsional vibrations. The $(NH_4)_2BeF_4$ spectra also show broad "torsional" bands with several indicated maxima in the 175-290 cm^{-1} range. No great differences were observed in the spectra above and below the ferroelectric transitions for any of the ammonium salts.

The results for all of the compounds studied indicate that the ferroelectric transitions are not related to any large change in the average rotational freedom of the ammonium ions and water molecules. In addition the measurements show that the average barriers to reorientation are relatively small (V_o is approximately < 4 kcal/mole) in every case. The results are compared with total cross-section data and with data obtained by other techniques.

10044. Russell, D. H., Larson, W., **R.F. attenuation,** *Proc. IEEE* **55,** No. 6, 942-959 (June 1967).

> Key words: Attenuation; coaxial; measurements; standards; waveguide.

A tutorial review of r-f attenuation measurement methods and standards is presented.

Accepted and proposed definitions and attenuator models are discussed. Commonly used standards operating from d-c through most waveguide bands are compared with the "ideal" interlaboratory standard. Characteristics of fixed resistive, waveguide below-cutoff and rotary-vane standards are included.

Measurement methods are classified and described including comments concerning convenience and accuracy of various methods, and references are given which cover most of the basic and important research in the field.

10045. Santoro, A., Zocchi, M., **Absorption correction in the Weissenberg methods,** *Acta Cryst.* **22,** 918-919 (June 1967).

> Key words: Absorption correction; Weissenberg methods; x ray.

A procedure is described for calculating the direction cosines of the incident and diffracted beams in a reference system attached to the crystal for the general case of the Weissenberg method.

10046. Santoro, A., Zocchi, M., **Multiple diffraction in the Weissenberg methods,** *Acta Cryst.* **21,** No. 3, 293-297 (Sept. 1966).

> Key words: Crystal structure; diffraction; multiple diffraction; Weissenberg method.

The conditions for multiple diffraction due to symmetry have been derived for the Weissenberg geometry, for the various crystal systems and for the most commonly used rotation axes.

It is shown that the equal-cone method is the most appropriate in intensity measurements.

10047. Saylor, C. P., **Accurate microscopical determination of optical properties on one small crystal,** Chapter in *Advance in Optical and Electron Microscopy,* R. Barer and V. E. Cosslett, eds., **1,** 41-76 (Academic Press, Inc., New York, N.Y., 1966).

> Key words: Crystal; microscopical determination; optical properties; wavelength.

By rotating a crystal about one axis and using phase, double diaphragm, or interference contrast, refractive indices of a typical crystal can be microscopically determined for any wavelength with an error that is not greater than 0.00002. For such accuracy, the diameter of the crystal must be about 20μ or larger. Precautions involve careful orientation, precise matching of index with that of immersion fluid, and correct determination of the refractive index of the fluid.

10048. Schafft, H. A., French, J. C., **A survey of second breakdown,** *IEEE Trans. Electron. Devices* **ED-13,** No. 8-9, 613-618 (Aug.-Sept. 1966).

> Key words: Breakdown; diodes; reliability; second breakdown; thermal instability; transistors.

The existence of a "new high current mode of transistor operation" now generally known as second breakdown, was first reported by Thornton and Simmons in 1958 and was used to explain the mysterious failures that were observed to occur under certain operating conditions. Since then, with the production of higher power and higher frequency transistors, the problems resulting from the existence of second breakdown have proliferated. Interest in the phenomenon has grown concurrently and many papers about second breakdown can be found in the literature. These papers cover a range of interest that extends from theoretical studies of the basic mechanisms involved to interpretations of specifications for transistor operation free of second breakdown. A complete understanding of second breakdown has not yet been achieved and several concepts of second breakdown prevail. The purpose of this paper is to review historically the work that has been reported in order to present a coherent and comprehensive picture of the present status of second breakdown.

10049. Scala, A., Ausloos, P., **Gas phase radiolysis and vacuum ultraviolet photolysis of 2- and 3-pentanone,** *J. Phys. Chem.* **70,** No. 1, 260-269 (Jan. 1966).

Key words: Ion-molecule reactions; ion pair yields; pentanone; photolysis; primary processes; radiolysis.

In the photolysis of 3-pentanone and 2-pentanone at 1470 Å and 1236 Å, the major modes of fragmentation of the electronically excited ketones are as follows:

$$C_2H_5COC_2H_5{}^{*} \rightarrow C_2H_5 + CO + C_2H_4 + H \qquad (1)$$

$$\rightarrow CH_3 + CH_2COC_2H_5 \text{ (or } CH_2CO + C_2H_5\text{)} \qquad (2)$$

$$CH_3COCH_2CH_2CH_3{}^{*} \rightarrow CH_3CO \text{ (or } CH_3 + CO\text{)} + C_2H_4 + CH_3 \qquad (3)$$

$$\rightarrow CH_3CO \text{ (or } CH_3 + CO\text{)} + C_3H_6 + H \qquad (4)$$

On the basis of experiments carried out with $C_2H_5COC_2H_5 - C_2D_5COC_2D_5$ mixtures it can be concluded that "molecular" elimination of methane does also occur to a minor extent. Isotopic analysis of the products formed in the photolysis of $CD_3COCD_2 - CH_2CH_3$ further indicates that the elimination process

$$CD_3COCD_2CH_2CH_3{}^{*} \rightarrow CD_3COCD_2H + C_2H_4 \qquad (5)$$

does take place. but to a lesser extent than at 2537 and 3130 Å.

In the radiolysis neutral excited molecules and ions are produced. When an electrical field is applied during the radiolysis, increased excitation by electron impact occurs. At low field strengths molecules are mainly excited to the first upper singlet and/or triplet state, and decompose in much the same way as reported in the earlier near-ultraviolet photolysis studies. When the field strength is increased the ketone is excited to a higher singlet state and decomposes according to process 1 to 4. Products which are not affected by the application of an electrical field such as C_3H_4 and 1-C_4H_8 can be ascribed to ion molecule reactions. It is proposed that in the radiolysis, transfer of a proton from various fragment ions to the pentanone molecule does occur, and that this is followed by neutralization of the protonated pentanone to yield hydrogen as a product.

10050. Schafft, H. A., French, J. C., **Second breakdown and current distributions in transistors,** *Solid-State Electron.* **9,** No. 7, 681-688 (July 1966).

Key words: Diodes; failure mechanisms; internal current distributions; second breakdown; semiconductors; temperature sensitive phosphors; transistors.

A study of second breakdown in transistors, which included the use of temperature-sensitive phosphors to reveal current distributions, has emphasized how intimately the susceptibility of the transistor to second breakdown is linked to the internal distribution of current or of energy dissipation. The effect of such factors as the base drive and internal structural irregularities on the internal current distribution is described. A better understanding of the role of the base drive in second breakdown was achieved and led to a test which was used to distinguish second breakdown from other low voltage modes that have been recently reported to be different levels of second breakdown.

10051. Schafft, H. A., Schwuttke, G. E., Ruggles, R. L., Jr., **Second breakdown and crystallographic defects in transistors,** *IEEE Trans. Electron. Devices* **ED-13,** No. 11, 738-742 (Nov. 1966).

Key words: Dislocations; failure mechanisms; second breakdown; semiconductors; transistors; x-ray diffraction microscopy.

A study was conducted to determine the effect, on second breakdown in transistors, of some of the crystallographic defects that can develop during handling and fabricating procedures. X-ray diffraction microscopy was used to detect these defects. The susceptibility to second breakdown of about 1500 epitaxial planar silicon transistors diffused on two wafers was measured and the site of the current constriction of second breakdown was registered on most of these transistors. These data were then compared with the x-ray topographs. Any effect of the gross dislocations seen, was masked by other factors, such as surface induced effects, that were not discernible in the x-ray topographs. Evidence was found, however, to indicate that a faulted emitter structure that has been correlated with the emitter diffusion step may be of importance. The heating in the transistor at the second breakdown current constriction site to temperatures above 600 °C and recrystallized laser-induced melt regions smaller than about 30μm in diameter produced no crystallographic changes nor any frozen in strain fields detectable in the x-ray topographs.

10052. Scharf, K., **Exposure rate measurements of x and gamma rays with silicon radiation detectors,** *Health Phys.* **13,** No. 6, 575-586 (June 1967).

Key words: Dosimetry; exposure rate measurements; gamma rays; radiation detection devices; radiation detectors; radiation monitoring; semiconducting devices; silicon; x rays.

The steady-state d.c. current and voltage signals produced by x or gamma rays in silicon radiation detectors used either as photovoltaic cells or photodiodes are shown to be dependent on such circuit parameters as load resistance and bias voltage used in the respective exposure rate measurement. Non-linear exposure rate dependence of radiation-produced signals may result from choosing unsuitable circuit parameters and no singular value of sensitivity or signal per unit exposure rate can be ascribed to an individual detector without specifying the circuit parameters used. Measurements are reported with silicon detectors of the diffused p-n junction type illustrating these performance features, and a measuring method is suggested which makes it possible to measure with high precision the generated photocurrent at zero voltage applied at the detector which is independent of circuit parameters and proportional to exposure rate over a wide range. Measurements using this method are reported of exposure rates ranging up to 10^5 R/hr of 30-kV x rays of 0.09 mm Al HVL, and from approximately 1 R/hr to 30 R/hr of ^{60}Co gamma rays.

10053. Schlemper, E. O., Hamilton, W. C., Rush, J. J., **Structure of cubic ammonium fluosilicate: neutron-diffraction and neutron**

inelastic scattering studies, *J. Chem. Phys.* **44,** No. 6, 2499-2505 (Mar. 15, 1966).

Key words: Ammonium ions; barriers to rotation; crystal structure; disorder; inelastic scattering; neutron diffraction; neutron scattering; $(NH_4)SiF_6$; torsional vibrations.

The motion of the ammonium ion in the cubic phase of $(NH_4)_2SiF_6$ has been investigated by the inelastic scattering of slow neutrons. The prominent feature of the neutron energy gain spectrum is a moderately broad band peaked at 168 ± 8 cm^{-1} with a shoulder at 305 ± 25 cm^{-1} (estimated uncertainties). These are assigned to the 1-0 and 2-0 transitions of a rotational motion of the ammonium ion. A precision refinement of single crystal neutron diffraction data has also been completed. There is a well-defined disorder of the ammonium groups. Although a model with a static three-fold disorder, with each 1/3 hydrogen atom undergoing harmonic vibration gives a very satisfactory fit to the data, such a model is probably unrealistic in view of the fact that the disordered positions are only 0.75 A apart. A more realistic model is one involving an ordered hydrogen atom undergoing thermal motion in a very anharmonic potential well. We propose a model in which the hydrogen atom is relatively free to move over a region of about 1 A^2 by small rotations of the ammonium ion but with a very high barrier toward a reorientation which involves an interchange of two hydrogen atoms. Such a model is an agreement with both the neutron diffraction and the inelastic scattering data.

10054. Schneider, S. J., McDaniel, C. L., **The melting point of Al_2O_3 in vacuum,** *Rev. Hautes Témper. Réfract.* **3,** 351-361 (1966).

Key words: Alumina; dissociation; melting point; vacuum environment.

The National Bureau of Standards has initiated a program to determine, under a variety and proportional to exposure rate over a wide range. of environmental conditions, the melting points of a number of the more refractory metal oxides. The present paper, the first in a series, reports results obtained in an investigation of the melting point of Al_2O_3 (corundum) in vacuum. Equipment has been constructed which will permit the heating of small samples under blackbody conditions to 3000 °C in vacuum or inert atmosphere. The furnace essentially consisted of two concentric covered tungsten crucibles supported by three tungsten rods in the center of a water-cooled, copper, load concentrator. The outer crucible served as the susceptor for induction heating. The inner crucible acted as both the specimen container and the blackbody enclosure for temperature measurements. Theoretical calculations as well as experimental testing indicated that the blackbody-container had an effective emittance of 0.999 at 2000 °C. Temperatures were continuously monitored with a recording photoelectric spectral pyrometer which has a sensitivity of $\pm 0.2°$ at 1063 °C and $\pm 1°$ at 2000 °C. Experiments were conducted on specimens obtained from three different sources of Al_2O_3, each having a purity in excess of 99.9%. The data indicated that the melting point of Al_2O_3 in vacuum ($\sim 6.5 \times 10^{-5}$ torr) is 2051 °C (IPTS). The overall maximum uncertainty of the melting point was estimated to be no greater than ± 4 °C. Precision of the measurements was within ± 1.5 °C.

10055. Schwerdtfeger, W. J., **Cathodic protection of copper in a severely corrosive soil,** *IEEE Trans. Ind. Gen. Appl. IGA*-**3,** No. 1, 66-69 (Jan.-Feb. 1967).

Key words: Cathodic protection; copper; corrosion current; corrosion rate; polarization; potential; soil corrosion.

This paper describes a laboratory procedure used in developing electrical requirements pertinent to the cathodic protection of copper for a given situation. The work was prompted by severe corrosion of copper tubing used underground at a housing development. The soil environment was reported as having a low resistivity (about 200 ohm-cm) and a high concentration of sulfate ion.

Specimens of the same type of copper tubing, one arranged to corrode freely (control) and the other under cathodic protection (cathode), were exposed in the laboratory to a sample of the soil for a period of 130 days.

Polarization data obtained on the control were used to evaluate the cathodic protection simultaneously applied to the cathode. After 130 days, the specimens were removed from the soil and cleaned. The cathode was well protected, the metal loss being less than 3 percent of that on the control which was almost perforated in a few places.

10056. Scott, A. H., **Anomalous conductance behavior in polymers,** (1965 Annual Report Conf. Electrical Insulation), *Natl. Acad. Sci.-Natl. Res. Council Publ.* **1356,** pp. 98-102 (Natl. Acad. Sci.-Natl. Res. Council, Washington, D.C., 1966).

Key words: Anomalous d-c conductance; conductive rubber electrodes; epoxy; polycarbonate; polystyrene; polyvinylbutyl; polyvinylchloride; tinfoil electrodes.

Conductance measurements on polymer materials are found to be affected by discharge currents even though the specimen has not had a voltage applied to it. It is necessary to fully discharge a specimen (sometimes for several days) before a repeatable conductance measurement is obtained. The discharge currents are amplified by the use of conductive rubber electrodes rather than tinfoil electrodes. Conductivities that were obtained with conductive rubber electrodes were lower in all cases than those obtained with tinfoil electrodes.

10057. Scott, A. H., Harris, W. P., **Long-time effects of humidity change on the dielectric properties of certain polymers,** (Proc. 1962 Annual Rept. Conf. Electrical Insulation, Hershey, Pa., Oct. 15-17, 1962), *Natl. Acad. Sci.-Natl. Res. Council Publ.* **1080,** pp. 41-44 (1963).

Key words: Dielectric properties of certain polymers; humidity change; polycarbonate; polyethylene; polystyrene; properties of certain polymers; polymers.

The results of a study of the long-time effects of humidity change on the dielectric properties are given for three materials: polyethylene, polystyrene, and polycarbonate. The polyethyiene and polystyrene specimens were disks about 4 cm in diameter with gold electrodes. Measurements on polycarbonate specimens were made using the air-gap method without contact electrodes. The electrical properties of some specimens were still changing at the end of three years. The results are given in the form of graphs.

10058. Scott, W. W., Jr., Frederick, N. V., **The measurement of current at radio frequencies,** *Proc. IEEE* **55,** No. 6, 886-891 (June 1967).

Key words: Ammeter; calibration; current; electrodynamic; measurement; radio-frequency; standards; thermocouple.

The state of the art of radio-frequency current measurements is reviewed with emphasis on what the authors consider are the most useful current standards. In particular, thermocouple and electrodynamic ammeters are discussed in detail. Reference is made to photoammeters, air thermometer ammeters, and other types of current measuring apparatus, some of which deserve additional development. Extensive referencing is included for the convenience of investigators interested in an intensive review of radio-frequency current measurements.

10059. Selby, M. C., **Voltage measurement at high and microwave frequencies in coaxial systems,** *Proc. IEEE* **55,** No. 6, 877-882 (June 1967).

Key words: High frequency voltages; microwave voltages; standards of rf voltage; voltage measurement.

The progress and up-to-date state of the art in measuring voltages at frequencies to 10 GHz and higher at three accuracy echelons is briefly described. The trend towards higher frequencies in voltmeter design is indicated. Justifications for this trend are listed. Advantages of voltage measurements and standards over computation of voltages from power and impedance measurements are briefly discussed. Some pending development problems are indicated and major steps are proposed to improve the application of voltmeters at frequencies above 30 MHz.

10060. Selby, M. C., **Brief report of the XV URSI General Assembly, Com. I, on the status of international intercomparisons of high frequency and microwave electrical quantities,** (Proc. XV General Assembly of URSI, Munich, Germany, Sept. 5-15, 1966), Chapter in *Progress in Radio Science 1963-1966,* **Pt. 1,** pp. 113-116 (International Scientific Radio Union, Munich, Germany, Sept. 1966).

Key words: International intercomparisons; radio measurements.

A report is given on the intercomparisons completed, in progress, and planned under the auspices of URSI and the CIPM.

10061. Selby, M. C., **International comparison of high frequency electromagnetic quantities,** *Proc. IEEE* **55,** No. 6, 745-747 (June 1967).

Key words: Electrical quantities at high frequencies, measurement of; high frequency electrical measurements; international agreement on electromagnetic measurements.

Activities to establish international agreement on measurements of high frequency electrical quantities have been in progress since 1957 at the initiative of the URSI (International Radio Scientific Union) and the International Committee of Weights and Measures (CIPM). Results accomplished and the overall up-to-date status are presented.

10062. Selby, M. C., **International comparison of measurements at high frequencies,** *IEEE Spectrum* **3,** No. 1, 89-98 (Jan. 1966).

Key words: Electrical quantities; high frequencies; international comparison of measurements; measurements at high frequencies.

The status of international agreement in measuring electrical quantities at frequencies above approximately 30 kHz, as of 1965, is analyzed. An attempt is made to tell (1) why it is necessary to agree internationally on measurements of high frequency electrical quantities, (2) for what specific quantities and related ranges ("measurands") agreement is desirable at present, (3) what has been done in the past towards that end, and (4) what is being planned for the future. Aims and relative responsibilities and authorities of the International Electrotechnical Commission (IEC), of the International Radio Scientific Union (URSI), and of the International Bureau of Weights & Measures (BIPM) are briefly indicated.

10063. Selby, M. C., **Remarks for XV URSI General Assembly Session on progress at $f \leq 1$ GHz,** (Proc. XV General Assembly of URSI, Munich, Germany, Sept. 5-15, 1966), Chapter in *Progress in Radio Science 1963-1966,* **Pt. 1,** pp. 157-162 (International Scientific Radio Union, Munich, Germany, Sept. 1966).

Key words: Measurement of field strength; measurement of pulsed voltage; measurement of rf voltage; measurement of thermal noise.

Several recent NBS contributions in the area of electromagnetic measurement are briefly described, namely, a miniaturized near-zone electric-field probe, a thermal noise comparator, a pulse-peak voltmeter and a special Tee for rf voltage calibrations.

10064. Selby, M. C., **The system of electromagnetic quantities at 30 kHz to 1 GHz,** *Metrologia* **2,** No. 1, 37-45 (Jan. 1966).

Key words: Electromagnetic quantities; frequencies; standards; units.

The system of electromagnetic quantities, units, and standards at frequencies of 30 kHz to approximately 1 GHz is briefly described. Its application at the National Bureau of Standards is used as an example. The system with some likely modifications seems in operation in several technically developed countries and is tentatively suggested for newly developing countries. Basic and derived physical quantities, and conceptual bases of standards and methods of measurement are described. Ranges of accuracies are given and suggestions for extensions of the system and for establishing validity via international comparison are pointed out.

10065. Sengers, J. M. H. L., **Compressibility, gas,** *Encyclopedia of Physics,* R. Besaucon, ed., pp. 118-120 (Reinhold Publ. Corp., New York, N.Y., Jan. 1966).

Key words: Compressibility; compressibility factor; gases; radial distribution function; speed-of-sound.

A definition of compressibility is given. Also a brief discussion is given of experimental methods for determining this quantity, its experimental behavior and an explanation of this behavior in terms of molecular theory. Some references to recent reviews of experimental and theoretical effort are added.

10066. Shafer, A. B., **Hamilton's mixed and angle characteristic functions and diffraction aberration theory,** *J. Opt. Soc. Am.* **57,** No. 5, 630-639 (May 1967).

Key words: Aberration; diffraction; Hamilton's characteristic functions.

The use of Hamilton's mixed and angle characteristic functions in wave and diffraction aberration calculations is theoretically examined. The relation of Hamilton's mixed and angle characteristic functions to the wave aberration function is shown. From this relation a wave aberration function is derived. The mixed and angle characteristic functions as utilized in diffraction theory via the Luneberg-Debye integrals are examined. The mathematical and physical approximations are discussed. The use of the Luneberg-Debye diffraction integrals for image evaluation is examined and some difficulties are pointed out. It is concluded that the above methods are poor approximations to more rigorous methods.

10067. Shapiro, S. L., McClintock, M., Jennings, D. A., **Brillouin scattering in liquids at 4880Å,** *IEEE Quantum Electron.* **QE-2,** No. 5, 89-93 (May 1966).

Key words: Argon ion laser; Brillouin scattering; hypersonic velocity; organic liquids; Rayleigh wings.

An argon ion laser has been used as a source of 4880Å radiation to study Brillouin scattering in liquids. Hypersonic velocities were measured in benzene, carbon disulfide, carbon tetrachloride chloroform, methylene chloride, methylene iodide, toluene, and water at a scattering angle of 89° 45′. The width of the Brillouin line was found to be 0.042 cm^{-1} in toluene and 0.040 cm^{-1} in methylene chloride. Depolarization factors of the

Brillouin lines were measured in carbon disulfide, benzene, and toluene. The structure of the Rayleigh lines and depolarization of the Rayleigh wings were also measured in benzene, carbon disulfide, and toluene. Widths of the Rayleigh wings were approximately 6.8 cm^{-1} in benzene, 7.6 cm^{-1} in carbon disulfide, and 8.5 cm^{-1} in toluene. From measurements of Brillouin scattering intensity, approximate values of the electrostrictive coupling constants of the other seven liquids were calculated relative to those of carbon disulfide.

10068. Sharnoff, M., Reimann, C. W., **Charge-transfer spectrum of the tetrachlorocuprate ion,** *J. Chem. Phys.* **46,** No. 7, 2634-2640 (Apr. 1, 1967).

Key words: Band assignments; charge transfer spectra; Cs_2CuCl_4; $Cs_2ZnCl_4(Cu)$; tetrachlorocuprate ion; single crystals.

The polarized ultraviolet absorption spectra of the tetrahedral $CuCl_4^=$ ion oriented in single crystals of Cs_2CuCl_4 or Cs_2ZnCl_4 have been observed. The spectral bands are identified by means of an analysis which takes into account the observed variations with lattice of the band intensities and positions and which allows for the effects upon the spectra of terms of rhombic symmetry known to be present in the ionic Hamiltonian. The resulting band assignments are significantly different from those of Ferguson. Salient differences between the Cs_2CuCl_4 observed spectra and those reported by Ferguson are noted and tentatively explained.

10069. Shields, W. R., **The evolution of the accuracy of isotopic analysis by thermal ionization from 2% to 0.2%,** (Proc. Symp. Nuclear Materials Management, IAEA, Vienna, Austria, Aug. 30-Sept. 3, 1965), Chapter in *Nuclear Materials Management,* pp. 737-746 (Intern. Atomic Energy Agency, Vienna, Austria, Feb. 1966).

Key words: Isotopes; precise analysis; thermal ionization; uranium.

A detailed study of the parameters that affect the precision, both internal and external, of an isotopic analysis has been made. The magnitude of the effects of some of these parameters on the analysis of transuranic elements is shown.

The product of this research is a table of the best estimates of the isotopic compositions of sixteen uranium isotope standards distributed by the National Bureau of Standards. The current level of analytical proof of these values is given along with a discussion of the work (in progress) that is necessary to change the analytical precision statements to accuracy statements.

10070. Shoub, H., Gross, D., **Doors as barriers to fire and smoke,** *Proc. Symp. Fire Testing, Lancaster, Pa., June 24-25, 1965,* pp. I-1—I-10 (Armstrong Cork Co., Lancaster, Pa., 1965).

Key words: Doors, dwelling; dwelling unit entrance doors; fire and smoke barriers, dwelling unit entrance doors.

A study was made of means for improving dwelling unit entrance doors as fire and smoke barriers. Existing combustible doors and frames could be modified to enhance their fire resistance, but it did not appear practical to raise them to the level of rated commercial fire door assemblies. Fire retardant paints, except those consisting of heavy, reinforced, intumescent-type coatings, provided little or no increase in fire resistance.

Several modifications of existing doors were not effective in preventing the transmission of smoke. However, controlling the pressure levels on both sides of a door, as by suitable venting, appeared to offer a means of reducing smoke penetration into an area.

It is recommended that current methods of fire tests of doors, and criteria relating to their fire and smoke transmission be improved.

10071. Shumaker, J. B., Jr., Popenoe, C. H., **Experimental transition probabilities for the ArI 4s-4p array,** *J. Opt. Soc. Am.* **57,** No. 1, 8-10 (Jan. 1967).

Key words: Argon; plasma; spectroscopy; transition probability.

Thermal arc measurements of transition probabilities are reported for the entire 4s-4p transition array of argon I. Except for a few very weak lines the experimental values agree closely with the recent intermediate coupling calculations of Garstang and Van Blerkom.

10072. Sicilio, F., Florin, R. E., Wall, L. A., **Kinetics of the hydroxyl radical in aqueous solution,** *J. Phys. Chem.* **70,** No. 1, 47-52 (Jan. 1966).

Key words: Aqueous solutions; electron spin resonance; hydroxyl radicals; kinetics; resonance spectra.

The electron spin resonance spectrum of hydroxyl radical, generated from titanous ion and hydrogen peroxide in a flow system, was studied as a function of flow rate, temperature, and variations in composition of mixture. Two peaks occur, a principal peak at $g = 2.0128$ and a usually minor peak at $g = 2.0114$. The intensity of the minor peak is increased by large concentrations of titanous chloride or sulfate, increased slightly by large concentrations of titanic salts, and lowered by excess sulfuric acid. The minor peak is thought to be the spectrum of hydroxyl associated with titanic ion.

At 20 °C and 28 °C the concentration of hydroxyl shows a maximum as flow rate is varied, while the concentration increases monotonically with increasing flow rate at 58 °C. At low flow rates (time after mixing 0.5 to 4 sec) there appears to be an approach to second-order disappearance with $k = 4.5 \times 10^5$ ℓ/mole sec at 28 °C and an activation energy of 11 kcal. 11 kcal/mole(46kJ/mole).

10073. Simpson, J. A., **The production and use of monoenergetic electron beams,** *Proc. 8th Annual Electron & Laser Beam Symp., Ann Arbor, Mich.,* G. I. Haddad, ed., pp. 437-447 (Apr. 1966).

Key words: Electrons; electron beam; electron energy distributions; space charge.

The generation of dense electron beams of energy half-width below 0.1 eV presents special problems. Among these are generation of tightly collimated beams of very low energy space charge effects in deflectors and anomalous energy spreads. A discussion of one successful attack on these problems will be given together with examples of the uses of such beams in electron optics.

10074. Simpson, J. A., Kuyatt, C. E., Mielczarek, S. R., **Absorption spectrum of SF_6 in the far ultraviolet by electron impact,** *J. Chem. Phys.* **44,** No. 12, 4403-4404 (June 15, 1966).

Key words: Forward inelastic electron scattering; oscillator strength; sulfur hexafluoride; ultraviolet absorption cross section.

Measurements of forward inelastic scattering of 400 eV electrons from SF_6 were made and used to derive relative ultraviolet absorption cross sections. The relative values were normalized to an ultraviolet absorption measurement at 23.00 eV. Agreement with additional u-v measurements at 21.2 and 17.6 eV was excellent. Oscillator strengths for three absorption bands between 10 and 15 eV, as derived from the electron scattering measurements, are in fair agreement with the corresponding values measured by u-v absorption. The total oscillator strength for excitations up to 32 eV is found to be 15.3.

10075. Simson, B. G., Deslattes, R. D., **Kinematic locator for crystal alignment,** *Rev. Sci. Instr.* **37,** No. 3, 300-301 (Mar. 1966).

Key words: Crystal alignment; crystal polishing; kinematic locator; spectrometer alignment.

A kinematic locator with one rotational degree of freedom is described. This device makes possible the transfer of aligned crystals within 2 seconds of arc.

10076. Sligh, J. L., Brenner, A., **Galvanostalametry: A technique for chemical analysis,** *J. Electrochem. Soc.* **114,** No. 5, 461-465 (May 1967).

Key words: Chemical analysis; electrolyte discharge; electro-reducible or -oxidizable; galvanostalametry; hydrogen; oxygen.

A method utilizing a novel technique to designate the endpoint of a diffusion controlled electro-reducible or -oxidizable reaction has shown promising analytical capability. The apparatus consists of a J-shaped, evacuated glass tube in which a column of electrolyte is suspended under tensile stress in the longer limb. One electrode is sealed into the top of the J and the other into the short limb. The formation of a minute amount of gas at the upper electrode by electrolytic discharge of hydrogen or oxygen causes the column of electrolyte to suddenly drop. It has been found that, in the constant-current electrolysis of a suitable supporting electrolyte containing an electroreactive ion, the transition time required for the column to drop is a function of the concentration of the ion. The use of this method as an analytical tool and its relationship to chronopotentiometry are discussed.

10077. Smith, E. L., Bowman, H. S., Weissler, P. G., Cook, R. K., **Bone-air cancellation,** *Bull. Lab. Electroacoustique* **9,** 45-50 (Apr. 1966).

Key words: Air-conduction; audiometry; bone-air cancellation; bone-conduction; hearing; masking; psychoacoustics; threshold.

An experimental study using bone-air cancellation to correlate the sensation levels of the air and bone signals and the occlusion effect of audiometric earphones has been made. Attempts were also made to use cancellation in lieu of masking in bone-conduction threshold determinations.

10078. Smith, G. W., Becker, D. A., Lutz, G. J., Currie, L. A., DeVoe, J. R., **Determination of trace elements in standard reference materials by neutron activation analysis,** *Anal. Chim. Acta* **38,** 333-340 (1967).

Key words: Accuracy; activation; analysis; decay curve resolution; gamma-ray attenuation; geometrical location; neutron; neutron self-shielding; precision; similar gamma-ray energy; Standard Reference Materials; trace.

Neutron activation analysis with its high sensitivity and accuracy in trace analysis, is being used at the NBS for analysis of Standard Reference Materials. Problems affecting precision and accuracy have been encountered and solutions to four problems are discussed. First, the positive bias introduced by induced radioactivity of similar gamma-ray energy was found in the determination of interstitial argon in ultra-pure silicon. A decay curve resolution technique was used to compensate for the error. Secondly, errors due to differences in geometrical location between sample and standard during irradiation were observed. Flux gradients were determined by copper foil flux monitoring to give necessary means of correction. Thirdly, errors are caused by differences in neutron self-shielding between sample and standard during irradiation. An empirical correction method was used and computer program written for calculation. Examples are given. Finally, the problem of gamma-ray attenuation during counting of sample and standard has been explored. A theoretical and experimental study gives the necessary corrections. It is concluded that careful study is vital to assure accurate analyses by neutron activation analysis on trace elements in complex matrices such as many Standard Reference Materials.

10079. Smith, J. C., **Wave propagation in a three-element linear spring and dashpot model filament,** *J. Appl. Phys.* **37,** No. 4, 1697-1704 (Mar. 15, 1966).

Key words: Dashpot model filament; filaments; linear model; model filament; wave propagation.

Mathematical expressions are derived for the particle velocity, stress, and strain distributions in the wave that results when a semi-infinite viscoelastic filament is subjected at one end to constant velocity tensile impact. The equations governing the stress-strain-time behavior of the filament are assumed to be those for a linear model consisting of a spring coupled in parallel with a spring and dashpot in series. These equations are so formulated that by changing a single parameter either the spring branch or spring and dashpot branch can be made to dominate. The general solution, and special solutions describing the behavior at the wave front and at the point of impact are derived. Approximate solutions for rough calculations are also given. The application of these solutions in the interpretation of experimental data is discussed.

10080. Smith, W. W., Gallagher, A. C., **Radiation lifetime of the first $^2P_{3/2}$ state of ionized calcium and magnesium by the Hanle effect,** *Phys. Rev.* **145,** No. 1, 26-35 (May 6, 1966).

Key words: $Ca^+4^2P_{3/2}$ state; collisional depolarization; Hanle effect; $Mg^+3^2P_{3/2}$ state; radiative lifetime.

The lifetimes of the $Ca^+4^2P_{3/2}$ state and $Mg^+3^2P_{3/2}$ state have been measured by the Hanle-effect method with optical excitation from the ground states of the ions. The lifetimes are, respectively, $6.72 \pm 0.20 \times 10^{-9}$ sec. and $3.67 \pm 0.18 \times 10^{-9}$ sec. The ions were produced by introducing traces of calcium or magnesium into an argon discharge. Alignment depolarization cross sections, σ, were obtained for the collisional depolarization of the following states of calcium and magnesium due to collisions with argon.

$$\sigma(\text{Ca}4^1P_1 \text{ state}) = 1.9 \pm 0.3 \times 10^{-14}\ \text{cm}^2$$

$$\sigma(\text{Mg}3^1P_1 \text{ state}) = 1.9 \pm 0.3 \times 10^{-14}\ \text{cm}^2$$

$$\sigma(\text{Ca}^+4^2P_{3/2} \text{ state}) = 1.4 \pm 0.2 \times 10^{-14}\ \text{cm}^2$$

$$\sigma(\text{Mg}^+3^2P_{3/2} \text{ state}) = 1.3 \pm 0.25 \times 10^{-14}\ \text{cm}^2.$$

10081. Spangenberg, W. G., Rowland, W. R., Mease, N. E., **Measurements in a turbulent boundary layer maintained in a nearly separating condition,** (Proc. Symp. Fluid Mechanics of Internal Flow, General Motors Research Labs., Warren, Mich., 1965), Chapter in *Fluid Mechanics of Internal Flow,* Gino Sovarn, ed., pp. 110-151 (Elsevier Publ. Co., Amsterdam, The Netherlands, 1967).

Key words: Adverse pressure; boundary layer; near-separating flow; skin friction near-zero; turbulence; turbulent boundary layer.

A turbulent boundary layer on a smooth, flat wall was investigated where the pressure was increasing with increasing distance downstream such as to maintain the boundary layer in the condition of near separation. The investigation was conducted with air flowing in a channel having the boundary-layer wall as the bottom. The width was sufficient to permit realization of two-dimensional boundary-layer flow. Venting and sloping incorporated in the upper wall provided the control of pressure gradient by progressively decreasing the velocity within the duct with increasing distance downstream. The maximum free-stream velocity was always about 84 ft per sec. The depth was sufficient to realize a free stream above the boundary layer except at the farther downstream positions where the boundary-layer flow itself reached the upper wall and escaped through the vents. Measurements of turbulence as well as of mean flow are made in order to reveal more of the mechanics of such flows than hitherto known. Measurements of turbulence were made with hot-wire instrumentation, and these comprised turbulence intensity, transverse integral scale, and turbulent shearing stress. Mean velocities were measured both with the hot-wire anemometer and total-head tube. Skin friction was estimated from mean-velocity profiles. Results were obtained for two slightly different pressure distributions, one yielding a closer approach to separation and vanishing skin friction than the other.

10082. Sparks, L. L., Powell, R. L. **Cryogenic thermocouple thermometry,** *Meas. Data* **1,** No. 2, 82-90 (Mar.-Apr. 1967).

Key words: Cryogenics; thermocouples; thermometry.

Commercially available low-temperature thermocouple wire from all major U.S. manufacturers has been exhaustively tested to determine the inhomogeneity and interchangeability characteristics of the wire. Spot calibrations between liquid-helium and liquid-nitrogen temperatures, and between liquid-nitrogen and ice temperatures, show that the NBS interim low-temperature tables are sufficient for most engineering and scientific requirements. Preliminary work on several gold-iron alloys indicates that these alloys will allow more accurate thermoelectric temperature measurement in the liquid/helium-hydrogen temperature range. Research, now well underway, will lead to establishment of standard thermocouple tables for temperatures from liquid helium up to 0 °C for all of the cryogenically useful commercial thermocouple alloys.

10083. Spector, N., **Analysis of the spectrum of neutral erbium (Er I),** *J. Opt. Soc. Am.* **56,** No. 3, 341-349 (Mar. 1966).

Key words: Absorption lines of erbium (Er I); energy levels of erbium (Er I); erbium (Er I), spectrum analyzed.

First results of a continuing analysis of Er I are given: 30 low levels belonging to the odd configurations $4f^{11}5d6s^2$ and $4f^{11}5d6s$, as well as 138 high levels of even parity are assigned J-values. More than 300 absorption lines are classified. The connection of the odd levels to the $4f^{12}6s^2$ configuration is established, using transitions in the infrared. The energy matrices in intermediate coupling for the subconfiguration $f^{11}(^4\mathrm{I})d$ have been calculated and are given. The theoretical formulas were adjusted by a least-squares fit to 19 observed levels designated as $4f^{11}$ $({}^4\mathrm{I}_{7\,1/2}{}^{6}{}_{1/2})$ $5d6s^2$ resulting in new values for 6 electrostatic and 2 spin-orbit interaction parameters. The rms error was 186 cm^{-1}. Calculated percentage compositions in various coupling schemes show the $J_1 = j$ type to be the best for these levels.

10084. Spijkerman, J. J., Ruegg, F. C., DeVoe, J. R., **A standard reference material for Mössbauer spectrometry of iron and its compounds,** *Technical Reports Series* **50,** Applications of the Mössbauer Effect in Chemistry and Solid-State Physics, pp. 254-259 (International Atomic Energy Agency, Vienna, Austria, 1966).

Key words: Iron and its compounds; Mössbauer spectrometry; spectrometry-Mössbauer; standard reference materials.

The rapid development of the Mössbauer effect has resulted in a new spectrometric method for chemical structure analysis. The various sources used in Mössbauer spectroscopy requires a reference material to provide Mössbauer data on a uniform basis. A series of standard reference materials for Mössbauer spectroscopy will be made available from the National Bureau of Standards, U.S.A. The first in this series is a single crystal of disodium pentacyanonitrosylferrate dihydrate, $Na_2[Fe(CN)_5NO]\cdot 2H_2O$. The crystals are supplied by a commercial manufacturer, and calibrated by NBS on a Mössbauer spectrometer, using an optical fringe counting technique. The Mössbauer spectrum of a single crystal absorber, cut along the bc plane, is a well resolved, symmetric doublet. The center of this doublet is defined as the zero reference point for the differential chemical shift, with the containing absorber at 25.0 °C. The absorber crystals supplied will be 1cm × 1cm, with 25.0 $\mathrm{mg/cm^2}$ of natural iron.

10085. Stabler, T. M., **State standards and laboratories,** *Scale J.* **53,** No. 1, 3 (Oct. 1966).

Key words: Calibration and measurement; instruments; length; mass; state measurement centers; state standards.

The program of the Federal Government to supply new standards of mass, length, volume, and instruments to each State is now underway. Ten States have been chosen to receive them beginning January 1966. These States have had to provide suitable laboratories and qualified personnel to perform the calibrations and to promote measurement. The National Bureau of Standards will assist the States in the establishment of the laboratories and in the training of the technologists. The final goal is to have established the State Measurement Center in all 50 States.

10086. Stabler, T. M., **The role of the National Bureau of Standards in the establishment of measurement capability at the state level,** 1966 ISA Conference Proceedings (21st Conf., Oct. 24-27, 1966, New York, N.Y.), *Instr. Soc. Am. Preprint* **16.**1-3-66, pp. 1-3 (Oct. 1966).

Key words: Laboratory; measure; standards; States; training; weights.

The program of the Federal Government to supply new standards and instruments to each State is now underway. Ten States have been chosen to receive certain standards as of this winter. These States have had to provide suitable laboratories and qualified personnel to perform the calibrations and to promote measurement. The National Bureau of Standards will assist the States in the establishment of the laboratories and in the training of the technologists. The final goal is to establish a well-equipped State Measurement Center in each of the 50 States.

10087. Stair, R., **The measurement of solar radiation, with principal emphasis on the ultraviolet component,** *Air Water Pollut. Intern. J.* **10,** 665-688 (1966).

Key words: Solar radiation; stratospheric ozone; ultraviolet solar radiation.

A review is presented covering much of the scientific work of the past half century relating to the measurement of the spectral distribution of radiant energy (in particular in the ultraviolet region) from the sun. Mention is made of those special solar disturbances that are expected to result in large variations of the ultraviolet solar emission as well as the absorbing medium, ozone, which through its turbulence and distribution further affects greatly the spectral distribution of the solar radiation reaching the earth's surface at any locality. Various instrumentations and the standards employed by the different laboratories are discussed in some detail with emphasis placed upon some of their shortcomings and the great lack of accurate solar spectral data, in particular within the ultraviolet region. Finally, new instrumentation offering promise of considerable usefulness in obtaining rapidly more accurate data in this area is described.

10088. Stavroudis, O. N., **Two-mirror systems with spherical reflecting surfaces,** *J. Opt. Soc. Am.* **57,** No. 6, 741-748 (June 1967).

Key words: Cassegrainian systems; collimators; cubic equations; optical design; reflecting systems; third order spherical aberration.

An analysis is made of two-mirror systems consisting of spherical refracting surfaces. Solutions are found for those systems having zero third order spherical aberration. It is shown that no practical solution exists for the configuration resembling the Gregorian telescope. For the configuration resembling the Cassegrainian telescope three one-parameter families of solutions obtain. These are given by

$$c_1 = (q - 1)/2\, t_o \quad t_1 = (t_o - f)/q \quad c_2 = q/2f$$

$$t_o = f\, 27f/32 \sec^2 \theta \quad q = -3[1 + 4 \cos 2/3\, (\theta + \pi r)]^{-1}$$

where c_1 and c_2 are the two curvatures; t_1, the axial separation of the two reflecting surfaces; t_o, the distance from a focus to the corresponding surface; and f, the focal length. The free parameter is θ and $r = 0, 1, -1$.

10089. Stearns, C. O., **Computed performance of moderate size, super-gain, end-fire arrays,** *IEEE Trans. Ant. Prop. AP*-**14,** No. 2, 241-242 (Mar. 1966).

Key words: Antenna arrays; computed performance; endfree antenna arrays; radiation patterns; super-gain antennas.

Using an approach developed by Block, Medhurst, and Pool, numerical calculations were carried out of gains, currents, and radiation patterns, for a series of moderate-size super-gain antennas. These were linear end-fire arrays of equally spaced, parallel, side-by-side, infinitesimal, half-wave dipoles with element spacings of 0.05, 0.10, 0.15, 0.20, 0.25, and 0.30 wavelength for 2 to 17 elements.

A rapid increase in the required precision in current values with an increase in the number of elements sets an upper limit on the number of elements for a given element spacing. For 0.05-wavelength element spacing, the largest number of elements which could be computed using eight-figure precision was 5; while for 0.30-wavelength spacing the performance of a 17-element antenna could be computed. However, these computations can be verified far beyond the practicability of a real antenna.

10090. Stephens, R. E., **Experimental verification of superachromatism,** *J. Opt. Soc. Am.* **56,** No. 2, 213-214 (Feb. 1966).

Key words: Achromatism; superachromatism.

To experimentally verify superachromatism a five-element prism, to deviate a beam of light approximately 30 degrees without dispersion or distortion, has been designed and constructed from three types of Schott glass. When tested on a spectrometer, viewing a narrow slit with a telescope magnification of approximately 30 times, no dispersion could be seen. Pointings on 7 isolated spectrum lines separated by a monochromator show a maximum dispersion of 3 seconds, 1 part in 36,000.

10091. Stokesberry, D. P., **A large signal IGFET dc source follower,** *Proc. IEEE* **54,** No. 1, 66 (Jan. 1966).

Key words: Constant gain; dc source follower; field-effect transistor.

The low transconductance and small dynamic range of an insulated-gate field effect transistor limit its usefulness in dc source follower circuits. This limitation is removed by a modified circuit, which exhibits source follower action while maintaining a constant drain-to-source voltage.

10092. Straus, S., Brown, D. W., **The thermal decomposition of poly-3,3,3-trifluoropropene made at high pressure,** (Proc. 152nd American Chemical Society Meeting, New York, N.Y., Sept. 13, 1966), *Polymer Preprint* **7,** No. 2, 1128-1132 (Sept. 1966).

Key words: High pressure; initiation rate; poly-3,3,3-trifluoropropene; pyrolysis; random component; thermal decomposition; volatilization.

Poly-3,3,3-trifluoropropene prepared by irradiating the monomer at various temperatures and pressure has been pyrolyzed in vacuo in the temperature range 397-432 °C. At 402 °C the pyrolysis rates at 20 percent volatilization vary by a factor of 20 depending on the polymerization conditions. The rate of volatilization decreases smoothly with the fraction volatilized except with the most stable polymer, with which the rate is constant over a considerable portion of the pyrolysis. Molecular weight drops are extremely rapid and the monomer yield is only about 0.3 percent. Dimer and trimer are thought to be formed in yields of 5 and 15 percent respectively. The overall behavior probably results from a mechanism with a large random component but with an initiation rate that depends on the polymerization conditions and the extent of pyrolysis.

10093. Streever, R. L., Uriano, G. A., **Nuclear-resonance spin-echo study of ^{61}Ni hyperfine fields in ferromagnetic Ni-Al, Ni-V, and Ni-Cr systems,** *Phys. Rev.* **149,** No. 1, 295-301 (Sept. 9, 1966).

Key words: Hyperfine-field and atomic-moment; Ni-Al; Ni-Cr; Ni-V; nuclear magnetic resonance.

The nuclear-magnetic-resonance line shapes of ^{61}Ni have been studied in ferromagnetic Ni rich Ni-Al, Ni-V and Ni-Cr powders by plotting the spin-echo amplitude as a function of frequency across the inhomogeneously broadened resonance lines. The measurements were made at 4.2 °K in alloys containing concentrations of up to 12.3 at.% Al, 5.5% V and 5.3% Cr. In all three systems, the average hyperfine fields decreased approximately linearly with increasing solute concentration. A general discussion of the relationship between the average hyperfine field and the atomic moments is presented. The major contribution to the hyperfine field is believed due to the moment on the parent atom with a smaller contribution from moments on neighboring atoms via conduction electron polarization. The detailed structure of the resonance spectra is analyzed. It is found that the magnetic disturbances are spatially more widespread in the Ni-Al and Ni-V systems than in the Ni-Cr system. The Ni-Cr system in turn has a more delocalized behavior than the Ni-Co system previously studied. The results in the Ni-V and Ni-Cr system are consistent with results obtained by Collins and Low using neutron scattering techniques.

10094. Strobridge, T. R., Chelton, D. B., **Size and power requirements of 4.2 °K refrigerators,** (Proc. 1966 Conf., Boulder, Colo., June 13-15, 1966), Chapter in *Advances in Cryogenic Engineering* **12,** 576-584 (Plenum Press, Inc., New York, N.Y., 1967).

Key words: Cyclic refrigerators; physical characteristics; refrigerators.

A survey to determine the physical characteristics of 4.2 °K cyclic refrigerators is presented. Although the data acquired through the survey show considerable scatter, the expected trends can be detected and attempts have been made to establish guides by which the weight, volume, and power requirements for various capacity refrigerators may be estimated. No attempt is made to assess the reliability, the interval of maintenance free operation, or the capital costs.

10095. Stromberg, R. R., **Adsorption of polymers,** Chapter 3 in *Treatise of Adhesives and Adhesion*, **Vol. 1** *Theory*, pp. 68-118 (Marcel Dekkers, Inc., New York, N.Y. 1967).

Key words: Adsorption of polymers; adsorption of polymers review; interface studies; polymer adsorption; polymer adsorption review; review of polymer adsorption; surface studies.

The adsorption of polymers from solution onto solid surfaces is comprehensively reviewed. The theoretical treatments that are described, compared, and evaluated include the diffusion equation approach, a thermodynamic approach, and a direct combinational evaluation of the partition-function approach. This last treatment, together with certain modifications, apparently is the most correct treatment. Much of the experimental effort in polymer adsorption has been directed toward a determination of the extension of the adsorbed molecule normal to the surface. The measurement of this extension by means of ellipsometry, viscosity, and other techniques, is discussed in some detail, with emphasis given to the configuration of the adsorbed molecule. Measurement of the number of attachments to a surface are also included. Other subjects discussed are rates of adsorption and parameters influencing the adsorption isotherm such as molecular weight, solvent, and temperature dependence.

10096. Swanson, N., Powell, C. J., **Inelastic scattering cross sections for 20-keV electrons in Al, Be and polystyrene,** *Phys. Rev.* **145,** No. 1, 195-208 (May 6, 1966).

Key words: Al; Be; cross-sections; electrons; inelastic scattering; polystyrene.

Measurements are reported of the inelastic scattering cross sections associated with the characteristic energy losses of 20-keV electrons transmitted through thin films of Al, Be and polystyrene. These measurements have been made using two techniques which overcome several sources of systematic error in previous measurements.

For materials which have narrow characteristic loss lines (such as Al), it is possible to establish the form of the differential cross section and the generalized oscillator strength for the ≈ 15 eV Al plasmon energy loss for scattering angles between zero and 20 mrad, the cutoff angle. The differential cross section has been used in repeated two-dimensional folding calculations to correct the intensity measurements of the multiple plasmon losses at the larger scattering angles where unambiguous intensity measurements could not be made. For materials which have broad characteristic loss peaks, such as polystyrene, it is not possible to establish the variation of generalized oscillator strength $f(q)$ with momentum transfer q. If it can be assumed that $f(q) \approx f(0)$ for small q, a cross section for a given loss can be obtained from an energy loss spectrum measured at one scattering angle. The cross-section measurement accuracy is improved by a comparison of two energy loss spectra, that of a standard (such as Al) and that of a material of unknown loss cross sections, which have been obtained at zero angle under the same measurement conditions.

10097. Takasaki, H., **An automatic ellipsometer. Automatic polarimetry by means of an ADP polarization modulator III,** *Appl. Opt.* **5,** No. 5, 759-764 (May 1966).

Key words: ADP modulator; automatic ellipsometer; ellipsometer; optics; polarimetry; thin film.

An analytical and experimental study of an automatic ellipsometer is reported. The polarized beam is modulated simultaneously by two ADP cells and the corresponding two signals are separated and are used to adjust polarizer and analyzer settings in any of the four zones. The reproducibility of the setting has been demonstrated to be of the order of .01 degree.

10098. Taylor, J. K., **Measurement of density and specific gravity,** Chapter 81 in *Treatise on Analytical Chemistry, Part 1, Theory and Practice* **7,** I. M. Kolthoff, P. J. Elving, and E. B. Sandell, eds., 4561-4610 (Interscience Publ., New York, N.Y. 1967).

Key words: Density; dilatometry; gases, density measurements; liquids, density measurements; solids, density measurements; specific gravity.

Density is an important and significant property of matter. For pure materials, density values may serve as one means of identification. For binary mixtures, such measurements frequently provide convenient methods for analytical determination of composition. Density values also may be combined with other physical properties such as viscosity or refractive index for analytical or structural determinations. In solid-state chemistry, precise density data on pure materials may provide information of the number of dislocations present in a given specimen.

An extensive literature exists both on methods for measurement of density and on tabulations of measured values for a wide variety of materials. An exhaustive review of this literature is outside the scope of this chapter. In fact, the reader is urged to consult original sources, especially for details of precision methods. Instead, general considerations will be presented here, especially those that might be useful to the practicing analytical chemist.

10099. Thomas, L., Norton, R. B., **Possible importance of internal excitation in ion-molecule reactions in the F region,** *J. Geophys. Res.* **71,** No. 1, 227-230 (Jan. 1, 1966).

Key words: Electron loss rate; electron temperature; F region; internal excitation; ion molecule; ionosphere; magnetic disturbance and aurorae.

The apparent electron loss rate in the *F* region is determined by ion-molecule reactions involving O^+ ions and O_2 or N_2 molecules. The present paper considers whether a dependence of the rate coefficients on internal excitation of the reactants could be important in the ionosphere and examines briefly the excitation and deactivation processes involved. Particular attention is paid to vibrational excitation of N_2 molecules and it is suggested that excitation by electron impact may be important especially during conditions of high electron temperature as might be expected during magnetic disturbances and aurorae.

10100. Tilford, S. G., Simmons, J. D., **Electric quadrupole transition in the $A\,^1\Pi \leftarrow X\,^1\Sigma^+$ system of CO,** *J. Chem. Phys.* **44,** No. 11, 4145-4147 (June 1, 1966).

Key words: Diatomic molecule; electric dipole; electric quadrupole; heteronuclear diatomic molecule.

In the fourth positive system, $A\,^1\Pi \leftarrow X\,^1\Sigma^+$, of CO, electric quadrupole transitions ($\Delta J = 2$) have been observed for the first time in bands of an electric dipole *allowed* transition. This system also represent the first example of an electric quadrupole transition to be observed in a heteronuclear diatomic molecule. The quadrupole transition probability has been determined to be $\approx 1.1 \times 10^3$ sec^{-1}. This value compares well with the value of $\approx 2.0 \times 10^3$ sec^{-1} determined for the quadrupole transition probability of the electric dipole *forbidden* $a\,^1\Pi_g \leftarrow X\,^1\Sigma_g^+$ transition in the isoelectronic N_2 molecule.

10101. Tisone, G. C., Branscomb, L. M., **Detachment of electrons from H^- by electron impact,** *Phys. Rev. Letters* **17,** No. 5, 236-238 (Aug. 1, 1966).

Key words: Cross section; electron beam; electron detachment; electron impact; ionization; negative ion.

10102. Torgesen, J. L., **Purification of single-crystal growth,** *Ann. N.Y. Acad. Sci.* **137,** 30-43 (1966).

Key words: Crystal growth; crystallization; single-crystal growth.

Full exploitation of crystallization's efficiency to purify is realized only as (1) surface-to-volume ratio is minimized; (2) trapping of impurities at intergrain boundaries is avoided; and (3) the process is conducted near equilibrium. These criteria are most nearly satisfied when crystallization is conducted to favor single-crystal growth. Phenomena which limit the attainment of complete purification are (1) formation of solid solutions, substitutional and interstitial; (2) occlusion of impurities at physical lattice defects; and (3) adsorption of impurities with subsequent occlusion through the morphology and kinetics of growth processes.

The distribution coefficient, a measure of purification efficiency, is the ratio of impurity concentration in the crystalline phase to that in the mother phase. It is dependent on diffusion, material transport, and adsorption. Theoretical and experimental evidence point to the conclusion that as crystallization occurs nearer equilibrium, as homogeneity in the fluid phase is more closely approached, the distribution coefficient approaches a limiting value, usually less than 1.

Techniques are described for the growth of single crystals from vapor, from melt (excluding zone refining) and from solution. Examples of attained purities are given. Solution growth is emphasized for advantages gained from lower temperature conditions.

10103. Tryon, M., Horowitz, E., **Rubber and rubber products,** Chapter 59 in *Standard Methods of Chemical Analysis, 6th Edition, IIIB. Instrumental Analysis,* F. J. Welcher, ed., pp. 1664-1763 (D. VanNostrand Co., Inc., Princeton, N.J., 1966).

Key words: Instrumental analysis of rubber; rubber, instrumental analysis.

A compilation of selected methods for analysis of rubber and rubber products by instrumental techniques.

10104. Tsai, D. H., Beckett, C. W., **Shock wave propagation in cubic lattices,** *J. Geophys. Res.* **71,** No. 10, 2601-2608 (May 15, 1966).

Key words: Crystal; cubic lattice; Hooke's law forces; lattice dynamics; Morse potential function; numerical computation; shock compression; shock propogation; shock wave.

We have studied from a lattice dynamics viewpoint the propagation of a strong one-dimensional shock wave in a semi-infinite cubic lattice. Our model included the simple cubic, face-centered and body-centered cubic configurations. The interactions between various neighbors, and different types of interactions, ranging from Hooke's law forces to forces corresponding to Morse type potential functions, were considered. The equations of motion were solved approximately by a numerical method. Our results showed that the computed shock velocity increased with particle velocity approximately in a linear manner, in good qualitative agreement with experimental data. However, the computed stress profile of the shock wave was not steady in time, and this unsteadiness raises some questions on the interpretation of the pressure-volume relationship of the shock compressed lattice.

10105. Tsang, W., **Thermal decomposition of 4,4-dimethylpentene-1 in a single pulse shock tube,** *J. Chem. Phys.* **46,** No. 7, 2817-2822 (Apr. 1, 1967).

Key words: Allyl radicals; allylic resonance energy; single pulse shock tube; t-butyl radicals; thermal decomposition; 1-butene; 1,5 hexadiene; 4-methylpentene-1; 4,4-dimethylpentene-1.

4,4-dimethylpentene-1 has been pyrolyzed in a single pulse shock tube. The initial process is apparently the breaking of the allylic carbon-carbon bond. The rate expression for the reaction,

$$C_4H_9-C_3H_5 \xrightarrow{k} t-C_4H_9\cdot + C_3H_5\cdot$$

has been found to be

$$k = 10^{15.8} \exp(-65{,}500/RT)\sec^{-1}.$$

Assuming no activation energy for the recombination process this leads to a value of 12 kcal for the allylic resonance energy.

10106. Tsang, W., **Thermal decomposition of hexamethylethane, 2,2,3-trimethylbutane and neopentane in a single pulse shock tube,** *J. Chem. Phys.* **44,** No. 11, 4283-4295 (June 1, 1966).

Key words: Bond energies; decomposition; hexamethylethane; isopropyl radical; methyl radicals; neopentane; pyrolysis; shock tubes; *t*-butyl radicals; 2,2,3-trimethylbutane.

Hexamethylethane, 2,2,3-trimethylbutane and neopentane have been pyrolyzed in a single pulse shock tube. The initial steps of the main reactions involve the breaking of carbon-carbon bonds. The rate parameters of the following reactions

$$C_4H_9-C_4H_9 \rightarrow 2\,t-C_4H_9\cdot,$$

$$C_4H_9-C_3H_7 \xrightarrow{k_{II}} t-C_4H_9\cdot + i-C_3H_7\cdot$$

and

$$C_4H_9-CH_3 \xrightarrow{k_{III}} t-C_4H_9\cdot + CH_3\cdot$$

have been found to be

$$k_I = 10^{16.3} \exp(-68{,}500/RT) \sec^{-1},$$

$$k_{II} = 10^{16.2} \exp(-73{,}000/RT) \sec^{-1} \text{ (1100 °K and 4 atm.)}$$

and

$$k_{III} = 10^{16.1} \exp(-78{,}200/RT) \sec^{-1}.$$

10107. Turgel, R. S., **A comparator for thermal AC-DC transfer standards,** (*ISA Proceedings, Proc. 21st Annual ISA Conference and Exhibit, New York, N.Y., Oct. 24-27, 1966*) (ISA Preprint No. 12.3-1-66, Oct. 1966).

Key words: AC; calibration; DC; intercomparison; thermoelement; transfer standard.

Thermal transfer standards play an important role in precision a-c measurements. They are calibrated by intercomparison with standards of known ac-dc difference. A comparator is described that simplifies such routine calibrations. A sequence of null balances in the measuring circuit operates a simple analog computer which indicates the result of the intercomparison directly in parts per million of ac-dc difference.

10108. Vessot, R., Peters, H., Vanier, J., Beehler, R., Halford, D., Harrach, R., Allan, D., Glaze, D., Snider, C., Barnes, J., Cutler, L., Bodily, L., **An intercomparison of hydrogen and cesium frequency standards,** *IEEE Trans. Instr. Meas.* **IM-15,** No. 4, 165-176 (Dec. 1966).

Key words: Atomic clocks; cesium beam; clocks; frequency fluctuations; frequency standards; hydrogen maser; hyperfine separation; maser; noise; standards; time standards; wall shift.

Intercomparisons of average frequency and of frequency stability were made among one Hewlett-Packard 5060A cesium beam, two Varian Associates H-10 atomic hydrogen masers, and the National Bureau of Standards NBS III cesium beam designated as the United States Frequency Standard. Each of the standards displayed a white noise frequency fluctuation behavior with a transition into an approximate flicker of frequency fluctuation behavior for longer time intervals. The rms fractional frequency fluctuation between adjacent samples, $\sigma(\tau, N=2)$, was $6 \times 10^{-11}\tau^{-1/2}$ down to a flicker level of about 3×10^{-13} for the hp 5060A cesium beam ($10^2 \leqslant \tau \leqslant 10^4$s), $1 \times 10^{-11}\tau^{-1/2}$ down to a flicker level of less than 1×10^{-13} for NBS III cesium beam ($10^2 \leqslant \tau \leqslant 10^4$s), and $5 \times 10^{-13}\tau^{-1/2}$ down to a flicker level of about 1×10^{-14} for the H-10 hydrogen masers ($10^0 \leqslant \tau \leqslant 10^4$s). The accuracy capabilities of NBS III and H-10 No. 4 are now 1.1×10^{-12} and 0.47×10^{-12}, respectively (1σ estimate).

A discrepancy of only 1.1 parts in 10^{12} was observed between the average frequencies of the hp 5060A cesium beam and the NBS III cesium beam, with the former being higher in frequency.

In terms of the frequency of the Cs^{133} hyperfine transition ($F=4$, $m_F=0$) $\leftrightarrow$ ($F=3$, $m_F=0$), defined as 9192 631 770.0000 Hertz, the measured frequency of the H^1 hyperfine transition ($F=1$, $m_F=0$) $\leftrightarrow$ ($F=0$, $m_F=0$) was $\nu_H = 1420\,405\,751.7864 \pm 0.0017$ Hertz. This is believed to be the most accurate and precise measurement of any physical quantity.

10109. Vieth, D. L., Yakowitz, H., **Design considerations for a Kossel microdiffraction camera,** *Rev. Sci. Instr.* **37,** No. 2, 206-209 (Feb. 1966).

Key words: Camera design concepts for electron probe microanalyzer; electron probe microanalyzer; Kossel microdiffraction technique.

A Kossel microdiffraction camera has been adapted to the National Bureau of Standards electron probe microanalyzer. Complete design concepts for any Kossel camera are discussed and evaluated. The details of their conversion to the National Bureau of Standards Kossel microdiffraction camera are given. The major concepts adopted were: (1) Transmission camera, (2) Inclusion of microgoniometric capabilities, (3) Film cassette in air rather than vacuum, (4) Variable source to film distance of 6 to 11 cm. Transmission pseudo-Kossel patterns of an aluminum crystal employing Cu radiation are shown to illustrate the capabilities of the camera.

10110. Vinti, J. P., **Effects of a constant force on a Keplerian orbit,** *Proc. Astronomical Union Symp. No. 25, Athens, Greece, Aug. 15-Sept. 3, 1964,* pp. 355-362 (1966).

Key words: Constant force; elliptic orbit; Keplerian orbit.

This paper applies the von Zeipel method to the perturbations by a constant force of a satellite in an elliptic orbit. As expected, the method fails in spherical coordinates but works in parabolic coordinates. The results account for the short-periodic and the first-order secular terms and go far enough to indicate that the long-periodic and the second-order secular terms can be calculated in physically achievable cases. The calculation of the latter effects depends on the resolution into constant and long-periodic terms of the Hamiltonian resulting after short-periodic terms have been eliminated. In contradistinction to the case where the perturbing potential is a zonal harmonic, this resolution requires an infinite Fourier series rather than a trigonometric polynomial. It is feasible whenever the applied force does not lie in the plane of the orbit. When the force is coplanar, however, the orbit eventually intersects the earth, so that there is less interest in following the orbit over a long interval of time.

10111. Vinti, J. P., **The spheroidal method in the theory of the orbit of an artificial satellite,** *Proc. Symp. Celestial Mechanics, Mathematische Forschungsinstitut, Oberwolfach, Germany, Mar. 1964,* pp. 97-111 (1964).

Key words: Artificial satellite; gravitational potential; oblate planet; satellite spherical method.

This paper developed the physical foundations for the formulation of a gravitational potential, in oblate spheroidal coordinates, appropriate for an oblate planet. As applied to the Earth, the adequacy of the model follows from the minuteness of the deviations of the resulting geoid from the true sea-level figure of the Earth. For the motion of an artificial satellite, the potential leads to a solution in quadratures, which is found. Inversion then leads to expressions for the coordinates as functions of time. Finally, von Zeipel's theory gives the perturbations produced by the small effects not represented by the model.

10112. Voth, R. O., Norton, M. T., Wilson, W. A., **A cold moderator refrigerator incorporating a high-speed turbine expander,** (Proc. 1965 Cryogenic Engineering Conf., Rice University, Houston, Texas, Aug. 23-25, 1965), Chapter in *Advances in Cryogenic Engineering* **11,** 126-138 (Plenum Press, Inc., New York, N.Y., 1966).

Key words: Brayton cycle; cold neutron moderator; cryogenic refrigerator; gas bearings; turbine expander.

The thermal cycle and high speed gas bearing supported turbine expander chosen for a 1000 watt refrigerator used in a nuclear research program is described. Results of the refrigerator tests under operational conditions are presented. A bearing analysis extends previous work to include the effect of end leakage on the performance of Sixsmith type gas bearings.

10113. Wachtman, J. B., Jr., Peiser, H. S., **Symmetry conditions on jump rates occurring in relaxation times associated with point defect motion,** *J. Phys. Chem. Solids* **27,** 975 (1966).

Key words: Crystallographic point group; jump rates; point defects; relaxation times; space group; symmetry condition.

Relaxation times for mechanical or dielectric relaxation processes associated with atomic jump frequencies which are all symmetrically equivalent may differ for algebraic reasons but are usually of the same order of magnitude. If two or more symmetrically inequivalent jump rates are necessary for the relaxation process, the relaxation times may differ by orders of magnitude. Symmetry considerations can give the maximum and the minimum number of symmetrically inequivalent jump rates required. The results have been tabulated for the most general type of point defect neighboring a fixed trapping center for the case of complete removal of degeneracy.

10114. Wachtman, J. B., Jr., Spinner, S., Brower, W. S., Fridinger, T., Dickson, R.W., **Internal friction in rutile containing Ni or Cr,** *Phys. Rev.* **148,** No. 2, 811-816 (Aug. 1966).

Key words: Activation energy; internal friction; point defect; reduction; rutile; symmetry conditions.

Rutile containing Ni gives an internal friction peak centered near 50 °C at 2 kHz characterized by $H = 15.3 \pm 2.4$ kcal/mole and $\tau_o = 3 \times 10^{-15 \pm 1.7}$ sec; this peak occurs for tensile stress along [100] or [110]. A peak centered near 200 °C with $H = 21.4 \pm 2.1$ kcal/mole and $\tau_o = 8 \times 10^{-15 \pm 1.0}$ sec occurs for stress along [100] but not for stress along [110]. Rutile containing Cr gives similar peaks characterized by $H = 13.5 \pm 2.4$ kcal/mole and $\tau_o = 2 \times 10^{-14 \pm 1.6}$ sec and by $H = 22.2 \pm 1.5$ kcal/mole and $\tau_o = 4 \times 10^{-15 \pm 0.9}$ sec. Light reduction in vacuum decreases the amplitude of the low temperature peak and enhances the high temperature peak in both cases. Heavy reduction of rutile containing Cr removes both peaks but they reappear upon subsequent reoxidation. The evidence suggests that the motion of interstitial cations is involved and that reduction causes the formation of a compound defect. A tentative interpretation is given in terms of unpaired Ni^{3+} interstitials for the low temperature peak and of interstitial pairs composed of $Ni^{3+} - Ti^{3+}$ for the high temperature peak in Ni-doped specimens; the corresponding peaks in Cr-doped rutile are tentatively interpreted in terms of Ti^{4+} interstitials and of interstitial pairs consisting of $Ti^{4+} - Ti^{3+}$. It is possible to have two charge-compensating Cr^{3+} on adjacent substitutional sites and preserve the last two models.

10115. Waclawski, B. J., Hughey, L. R., Madden, R. P., **Effect of oxygen on the photoelectron yield from tungsten in the vacuum ultraviolet,** *Appl. Phys. Letters* **10,** 305 (1967).

Key words: Oxygen adsorption; photoelectric effect; tungsten; vacuum ultraviolet.

The effect of adsorbed oxygen on the photoelectron yield of bulk polycrystalline tungsten was studied at photon energies of 7.7, 10.2, 11.8, 16.9, and 21.2 eV. Use of ultra-high vacua $\sim 3 \times 10^{-10}$ torr ensured sample cleanliness prior to oxygen exposure. The photoelectron yield decreases with oxygen exposure because of the increase in the electronic work function of the tungsten photocathode. However, at $h\nu = 21.2$ eV, an increase in photoelectron yield with oxygen exposure also appears and is believed to be due to photoelectron emission from the adsorbed oxygen atoms.

10116. Walker, R. F., **Temperature measurement in high temperature chemistry: 1000–3000 °C,** *Rev. Hautes Témper, et Réfract,* **3,** 301-308 (1966).

Key words: High temperature chemistry; international temperature scale; melting points; pyrometry; secondary reference points; temperature measurement.

The uncertainty of temperature measurements is one of the principal causes of error in the measurement of the thermodynamic and kinetic properties of substances above the gold point. In terms of international standards, the ultimate accuracy of temperature measurements depends on the consistency of the International Practical Temperature Scale (IPTS) with the thermodynamic temperature scale. The accuracy achieved in measuring other properties depends on the accuracy of calibration of the temperature measuring instruments in accordance with the IPTS, and on the ability to use the instruments under prescribed physical and chemical conditions. The higher the temperatures, the more difficult it becomes to meet these prescribed conditions.

The present status of the IPTS is reviewed briefly. A summary is given of the precision and accuracy achievable with common temperature measuring instruments. The potential advantages and limitations of newer instruments, such as photoelectric pyrometers, are also indicated. It is concluded that in the field of high temperature chemistry the principal limitation is the inability to use the instruments under ideal conditions. Higher precision and accuracy would be achievable if additional internal checks, such as internationally recognized secondary reference points, were available to the experimentalist. Severe problems of both a chemical and physical nature are, however, attendant on the provision of such reference points, and these are briefly discussed.

10117. Wall, A. C., **The photometry of colored light,** *Illum. Engr.* **62,** No. 4, 239-242 (Apr. 1967).

Key words: Filters; photocells; photometers; photometry; phototubes; spectral correction of phototubes.

The photosensitor of a photometer must be corrected to have a spectral sensitivity as close as possible to the CIE photopic luminous efficiency function. A correction-by-filter technique is described, applicable to photosensitors which are used in the measurement of "colored light," which, in this paper, designates light which has a spectral distribution different from that of the light with which the photometer is calibrated. Three types of photosensitors with their associated auxiliary filters were investigated, as well as one type of barrier-layer cell with an integral filter. The photosensitors were first calibrated by exposing them to illumination from a lamp operating at 2854 °K. Then, to test the adequacy of the spectral correction-by-filter technique, twenty-two 2-by-2-inch squares of colored glass whose luminous transmittance was computed from spectrophotometric data were placed in turn in the light beam and readings proportional to the irradiance incident on each photosensitor were taken. If the spectral correction were perfect, the ratio of the reading obtained with the filtered light to the reading with the unfiltered light would be equal to τ_s, the luminous transmittance of the filter obtained from the spectrophotometric measurements. Factors were calculated to convert the ratios obtained to τ_s for the color-corrected photosensitors and for five types of non-color-corrected photosensitors.

10118. Wall, L. A., **Polymerization of fluoroolefins and related monomers,** (Proc. 152nd American Chemical Society Meeting, New York, N.Y., Sept. 13, 1966), *Polymer Preprint* **7,** No. 2, 1112-1115 (Sept. 1966).

Key words: Fluorine-containing monomers; fluorodienes; fluoroolefins; fluoro monomers; fluoropropylenes; fluorovinyl; free radical; gamma rays; high pressures; ionic catalysts; monomers; perfluorostyrene; phenyl ethers; polymerizations.

Although some fluorine-containing monomers polymerize readily, there are many which have not as yet been polymerized either by free radical or ionic catalysts. In order to investigate the reasons for the somewhat general tendency of these monomers to resist polymerization, we have initiated a systematic study using high pressures and γ-rays to induce polymer formation.

The technique has been successful for many fluoro monomers, fluoropropylenes, fluorodienes, perfluorostyrene and some fluorovinyl phenyl ethers. In a general way, the results suggest in many cases that slow propagation steps, easy transfer processes with monomer or impurities, and in some cases a tendency to thermally dimerize, interfere with the formation of high polymer.

10119. Wall, L. A., Straus, S., Florin, R. E., **Pyrolysis of vinyl and vinylidene fluoride polymers: influence of prior gamma irradiation,** *J. Polymer Sci.* **4A,** No. 2, 349-365 (Feb. 1966).

Key words: Fluoride polymers; gamma irradiation; irradiation, gamma; polymers; quantitative comparisons; vinyl and vinylidene.

Quantitative comparisons were made between the rates of thermal volatilization of several fluoropolymers before and after exposure to γ-radiation. The effects of γ-irradiation on poly(vinyl fluoride) and poly(vinylidene fluoride) were also investigated by swelling and sol-gel ratios. With both polymers as well as with polytrifluoroethylene, crosslinks occur predominantly, though there is an appreciable number of scissions. The rates of volatilization and char formation were enhanced by γ-

radiation, whereas the previously studied polytrifluoroethylene did not produce more char upon irradiation, although radiation did accelerate its volatilization. It is believed that in polytrifluoroethylene the enhanced rates of volatilization occur by a different mechanism than in the case of the vinyl and vinylidene fluoride polymers.

10120. Wall, L. A., Straus, S., Flynn, J. H., McIntyre, D., Simha, R., **The thermal degradation mechanism of polystyrene,** *J. Phys. Chem.* **70,** No. 1, 53-62 (Jan. 1966).

Key words: Computer calculation; intermolecular transfer; molecular weights; polystyrene; pyrolysis; theory of free radical degradation.

New and extensive measurements of (1) the rates of volatilization and (2) the molecular weights as a function of the extent of pyrolysis are reported for various polystyrene samples, in particular, fractions spanning a broad range of molecular weights. The experimental observations are shown to be described quite well by the results of computer calculations based on the theory of free radical degradation and a mechanism involving four elementary reactions—initiation, depropagation, intermolecular transfer, and termination by disproportionation.

10121. Washer, F. E., **Effect of chromatic aberration on the resolving power of photographic objectives,** *J. Opt. Soc. Am.* **57,** No. 5, 625-629 (May 1967).

Key words: Chromatic aberration; critical aperture; relative contrast; resolving power.

An empirical method for the estimation of the probable resolving power of a lens affected by longitudinal chromatic aberration is discussed. Values of the resolving power at a series of values of the f-number are calculated for selected values of longitudinal chromatic aberration, d_c. The variation of resolving power with f-number is presented graphically for selected values of longitudinal chromatic aberration and relative contrast. Indication is given of a critical aperture for which the resolving power is a maximum for a given set of values of chromatic aberration and relative contrast. The variation of relative contrast with resolving power is presented graphically for several values of the f-number for a lens having selected amounts of longitudinal chromatic aberration. A method for predicting the resolving power of a given lens-film combination is also indicated.

10122. Washer, F. E., **Resolving power related to aberration,** *Photogrammetric Eng.* **XXXII,** No. 2, 213-226 (Mar. 1966).

Key words: Aberration, optical; lens resolving power; resolution, optical; resolving power.

An heuristic method which accounts for the discrepancy between measured and theoretical values of resolving power of lenses is presented. The analysis also accounts for the sharp decline in contrast with increasing values of resolving power expressed in lines per mm in the image plane. Analyses are given of the probable effects on resolution and contrast of the fraction of the lens area transmitting image-forming light, longitudinal chromatic aberration, and longitudinal spherical aberration. An example is given that demonstrates change in focus with change in resolving power and shows how it is readily explained on the basis of simple diffraction theory.

10123. Weisman, H. M., **Needs of American Chemical Society members for property data,** *J. Chem. Doc.* **7,** No. 1, 10-14 (Feb. 1967).

Key words: American Chemical Society; chemical and physical properties; compilation; data; NSRDS; Office of Standard Reference Data; questionnaire; survey; users.

In August of 1965 the American Chemical Society, on behalf of the NBS Office of Standard Reference Data, sent a questionnaire to its membership asking for information on their needs for compilations of critically evaluated data. Through this questionnaire, the Office of Standard Reference Data obtained information on the preferences and needs of the chemical profession for data compilations, and equally importantly, located a substantial number of compilation activities of which it was not aware. Further, the Office of Standard Reference Data identified dozens of individuals who are both interested and competent to undertake additional projects. Approximately 16,000 replies were received. Overwhelmingly, response was that present compilations of data satisfy poorly or at best only moderately the requirements of the membership of ACS. The survey identified the properties which ACS workers most often sought in the literature as well as those data compilations most often consulted by respondents. Many worthwhile comments and suggestions were contributed as to approaches taken, compilation priorities and techniques of format and presentation.

10124. White, J. A., **Theory of the magnetic torque anisotropy of the samarium iron garnet,** *Proc. Phys. Soc. (Great Britain)* **90,** 1095-1109 (1967).

Key words: Anisotropy of samarium iron garnet; iron garnet; magnetic torque anisotropy; samarium iron garnet.

It is observed that the anisotropy measured by Pearson above 80 °K varies nearly as T^{-3}. This is the temperature dependence to be expected if the samarium ions in the garnet are subjected to an isotropic exchange field and a crystal Stark field of predominantly cubic symmetry. The magnitude of the anisotropy corresponds to an exchange field $\beta H_{ex}/k = 29$ °K. This is considerably less than the 55 °K which, for an isolated cubic quartet, produces the splittings in Sm^{3+} observed calorimetrically. It is suggested that the exceptionally large exchange splittings at $T = 0$ and apparently large exchange field can be understood as the result of an exchange field of 29 °K combined with (1) partial decoupling of the spin and orbital angular moments by the Stark and exchange fields, (2) restoration by the exchange field of some of the angular momentum quenched by the crystal field, and (3) rhombic anisotropy of the exchange field and crystal field.

10125. Whittaker, J. K., **A zero-crossing discriminator with picosecond time slewing,** *IEEE Trans. Nucl. Sci.* **NS-13,** No. 1, 399-405 (Feb. 1966).

Key words: Discriminator; picosecond; resolution; time-invariant; wide-range; zero-crossing.

A zero-crossing type of discriminator with a very wide dynamic range and a short dead-time is described. When used with a 56 AVP photomultiplier with a linear dynode resistor chain, a light amplitude variation of at least 125:1 may be accommodated. The relative time shift of the output discriminator pulse is then only 200 p.s.

10126. Whittaker, J. K., **A 100 Mc/s 2 out of 3 gate,** *Nucl. Instr. Methods* **45,** No. 1, 138-140 (Nov. 1966).

Key words: Coincidence; direct-coupled; gate; nanosecond; time-of-flight; 2 out of 3; 100 Mc/s.

A direct-coupled gate to determine when any two out of three inputs are present is described. The gate will function up to at least 100 megapulses per second and employs negative logic signals of nominal amplitude—1 volt.

10127. Whittaker, J. K., **A simple current generator,** *Nucl. Instr. Methods* **39,** No 1, 183-184 (Jan. 1966).

Key words: Current; generator; magnetic; stable; transistor; variable.

This letter describes two versions of a simple current generator which may be used to drive low impedance magnetic deflection systems. For this application a high resolution control with good stability is essential and it is necessary to be able to control the current in both directions about zero without switching. The circuits to be described have satisfied these conditions and the two versions have respective output currents of ±40 mA and ± 400 mA.

10128. Wiederhorn, S. M., **Effects of environment on the fracture of glass,** *Proc. RIAS Conf., Baltimore, Md., June 7-8, 1965,* pp. 293-317 (Gordon and Breach, New York, N.Y., 1966).

Key words: Cleavage; corrosion; crack propagation; fracture; glass; static fatigue.

This paper briefly reviews previous work on the topic of delayed fracture of glass, and then presents the results of a new experimental approach to the subject. Using the double-cantilever cleavage technique, it was possible to observe crack motion and to accurately measure crack velocities in glass. The temperature and stress dependence of the crack velocity indicates that the observed fracture is an activated process with an activation energy of 19,500 calories/mole. The existence of a static fatigue limit is inferred from the experimental data. Experimental results will be discussed with reference to current theories of static fatigue.

10129. Weiderhorn, S. M., **Fracture surface energy of soda-lime glass,** (Proc. Conf. Role of Grain Boundaries and Surface in Ceramics, North Carolina State University, Raleigh, N.C., Nov. 16-18, 1964), Chapter in *Materials Science Research* **3,** 503-528 (Plenum Press, Inc., New York, N.Y., 1966).

Key words: Crack propagation; fracture surface energy; glass; soda-lime glass; static fatigue; stress corrosion; surface energy.

The fracture energy of soda-lime glass was measured at temperatures of 77 °K, 195 °K, and 300 °K in various media using the double-cantilever cleavage technique. Values obtained for the fracture energy were 3.20 joules/meter^2 in $N_2(l)$, 3.10 joules/meter^2 in toluene $(l)-CO_2(s)$ and 2.83 joules/meter^2 in dry $N_2(g)$.

During the experiment slow crack motion was always observed prior to catastrophic failure of the specimens. The crack motion was complex, depending on the stress at the crack tip and the concentration of water in the medium surrounding the crack. Experimental results will be discussed with respect to several different mechanisms of crack growth.

10130. Wilcox, R. M., **Exponential operators and parameter differentiation in quantum physics,** *J. Math. Phys.* **8,** No. 4, 962-982 (Apr. 1967).

Key words: Baker-Campbell-Hausdorff formula; density matrix; differential equations; expansions; exponential operators; harmonic oscillator; Lie algebra; normal ordering of operators; operator identities; parameter differentiation; quantum statistics; similarity transformations; Weyl prescription.

Elementary parameter-differentiation techniques are developed to systematically derive a wide variety of operator identities, expansions, and solutions to differential equations of interest to quantum physics. The treatment is largely centered around a general closed formula for the derivative of an exponential operator with respect to a parameter. Derivations are given of the Baker-Campbell-Hausdorff formula and its dual, the Zassenhaus formula. The continuous analogs of these formulas which solve the differential equation $dY(t)/dt = A(t)Y(t)$, the solutions of Magnus and Fer, respectively, are similarly derived in a recursive manner which manifestly displays the general repeated-commutator nature of these expansions and which is quite suitable for computer programming. An expansion recently obtained by Kumar and another new expansion are shown to be derivable from the Fer and Magnus solutions, respectively, in the same way. Useful similarity transformations involving linear combinations of elements of a Lie algebra are obtained. Some cases where the product e^Ae^B can be written as a closed-form single-exponential are considered which generalize results of Sack and of Weiss and Maradudin. Closed-form single-exponential solutions to the differential equation $dY(t)/dt = A(t)Y(t)$ are obtained for two cases and compared with the corresponding multiple-exponential solutions of Wei and Norman. Normal ordering of operators is also treated and derivations, corollaries, or generalization of a number of known results are efficiently obtained. Higher derivatives of exponential and general operators are discussed by means of a formula due to Poincare which is the operator analog of the Cauchy integral formula of complex variable theory. It is shown how results obtained by Aizu for matrix elements and traces of derivatives may be readily derived from the Poincare formula.

Some applications of the results of this paper to quantum statistics and to the Weyl prescription for converting a classical function to a quantum operator are given. A corollary to a theorem of Bloch is obtained which permits one to obtain harmonic-oscillator canonical-ensemble averages of general operators defined by the Weyl prescription. Solutions of the density-matrix equation are also discussed. It is shown that an initially canonical ensemble behaves as though its temperature remains constant with a "canonical distribution" determined by a certain fictitious Hamiltonian.

10131. Wilson, W. K., **NBS to dedicate Gaithersburg facility,** *J. Wash. Acad. Sci.* **56,** No. 7, 165-167 (Oct. 1966).

Key words: National Bureau of Standards, dedication; National Bureau of Standards History; National Bureau of Standards Mission.

General discussion of the plans of the National Bureau of Standards for the dedication of its Gaithersburg, Maryland laboratory complex on November 15, 1966.

10132. Winogradoff, N., Kessler, H. K., **Compensation and band tailing effects in high power room temperature GaAs lasers,** *Solid-State Communications* **5,** 155-158 (Pergamon Press, Ltd., London, England, Jan. 1967).

Key words: Compensation with donors; epitaxial gallium arsenide lasers; laser characteristics.

A reduction in the density of states of a two level system would facilitate the production of an inverted electron population. Such a low density of states system can be produced by the incorporation of shallow donors into p-type material in such concentrations that mergence of the impurity bands with the intrinsic bands result in the formation of "tails" of states at the bottom and top of the intrinsic conduction and valence bands respectively.

The low density of states in these tails results in (1) low room temperature thresholds; (2) negligible time delays between the leading edge of the current pulse and the onset of lasing; and (3) high peak power outputs.

The behaviour of a series of vapour phase epitaxially formed p-n junctions with and without compensation will be discussed and recent achievements in high power outputs with compensated lasers will be described and correlated with field effect experiments the results of which show that the enhanced light output in compensated material is not due to radiative transitions between acceptor and donor impurity centers.

10133. Winogradoff, N. N., Kessler, H. K., **Radiative recombination lifetimes in laser excited silicon,** *Appl. Phys. Letters* **8,** No. 4, 99 (Feb. 1966).

Key words: GaAs laser; laser pulse shapes; lifetime; optical pumping; radiative recombination; ruby laser; silicon; stimulated emission.

At high excitation intensities, the decay lifetime for radiative recombination in a wide range of "long lifetime" silicon samples was found to be $<2 \times 10^{-8}$ seconds. The emission occurred at 1.10μ at room temperature.

Correlation of the non-linear emission with excess photoconductivity suggests stimulated radiative transistions to the light hole band.

The fast decay provides a passive, non-critical attenuator for observing pulse shapes of intense laser flashes.

10134. Wolfe, W. C., **Bonding adhesives and paints to treated concrete,** *CSI Mono.* **9MI,** Construction Specifier, pp. 1-8 (Aug. 1966).

Key words: Asphaltic tile adhesives; cement water-based paints; concrete surfaces; paints; water-based paints.

The object of this investigation was to determine the effect of surface treatment of concrete on the adhesion of paints or asphaltic adhesives for asphalt or vinyl asbestos tile. Qualitative and quantitative tests were performed on treated and untreated concrete specimens. The results of the tests indicated that concrete curing and parting agents, oils, and waxes are more compatible with asphalt cutback than with asphalt emulsion adhesive. The tests did not show any oozing of adhesive between tiles or curling of tiles at the corners.

Cement-water paints adhered poorly to concrete treated with curing agents. Organic coatings adhered well to concrete treated with curing agents based on butadiene-styrene copolymer or chlorinated rubber. Likewise, paints formulated with butadiene-styrene copolymer or chlorinated rubber in hydrocarbon solvents adhered to most curing agents. Paints made up in hydrocarbon solvents were more compatible with curing agents, oils, and waxes than were water-based paints.

10135. Wolfe, W. C., **Testing scouring powder abrasion,** *Detergent Age* **2,** No. 10, 22 (Mar. 1966).

Key words: Abrasives; bathtubs; cleansers; detergents; particle; plastic; plumbing; porcelain; sieve; silica; sinks.

Five leading brands of household scouring powders were examined in order to establish a formulation for testing the abrasion or wear resistance of sanitary plumbing fixtures. A test abrasive of known composition and representative of commercial products was desired.

The products examined all contained sodium dodecylbenzenesulfonate as the detergent, usually chlorine bleach, sometimes bactericide, and about 90 percent by weight of abrasive. The abrasive, in each case, was fine quartz powder, mostly less than 44 microns particle size, but containing some particles between 149 and 250 microns in diameter, which might scratch porcelain enamel or plastic.

10136. Wood, L. A., **Physical constants of different rubbers,** *Polymer Handbook,* J. Brandrup and E. H. Immergut, ed., pp. VI-57–VI-68 (Interscience Publ., Inc., New York, N.Y., 1966).

Key words: Butyl rubber; constants; natural rubber; neoprene; physical constants; polymers; properties; rubbers; styrene-butadiene rubber.

Selected values from the literature are tabulated for about 25 physical constants for natural rubber, styrene-butadiene rubber (SBR), Butyl rubber (IIR), and polychloroprene rubber (CR or Neoprene). This is a requested revision of the table published in the Smithsonian Physical Tables, 9th Edition, 1954.

10137. Wright, J. R., Gray, V. E., **Measurement of photochemical degradation in rigid poly(vinyl chloride) by color reactions with N,N-dimethyl-p-phenylenediamine,** (Proc. Conf. Plastics in Building Structures, London, England, June 14-16, 1965), *Plastics Inst. Trans. J. Suppl.* **1,** 113-118 (June 14, 1966).

Key words: Color reactions; opaque pigments; photodegradation; poly(vinyl chloride); rigid plastic; ultraviolet absorbers.

Rigid poly(vinyl chloride) materials which had been exposed to sunlight and to carbon-arc and xenon-arc radiation were subjected to physical and chemical testing to measure the effects of photodegradation. Opaque pigments and ultraviolet absorbers were found to protect the plastic from photodegradation but heat stabilizers varied greatly in their photostability. The color changes and physical strength changes produced during exposure were not directly related.

10138. Wyckoff, J. M., **Modular software for on-line handling of nuclear data,** *IEEE Trans. Nucl. Sci.* **NS-13,** No. 1, 199 (Feb. 1966).

Key words: Digital computer; experiment; modular; nuclear data; on-line; programs; SDS 920.

Modular programming for the handling of nuclear data on-line with a general purpose digital computer considerably simplifies the programming task. A system called ROMEO implementing this concept has been developed. More than 150 relocatable, self-contained programs of some 30 types have been prepared and used in a nuclear physics experiment using an SDS 920 computer. These programs, falling into the housekeeping, data accumulate, data manipulate and data output categories, are described briefly and their use in the experiment is discussed. About 30 of these programs are loaded concurrently with loading and deleting possible during the experiment.

10139. Yakowitz, H., **Precision of cubic lattice parameter measurements by the Kossel technique,** *Trans. Symp. Electron Probe Analysis, Oct. 12-15, 1964, Washington, D.C., 1964,* pp. 417-438 (John Wiley & Sons, Inc., New York, N.Y., 1966).

Key words: Cubic lattice measurements, precision; Kossel technique for cubic lattice measurements.

The major factors affecting the precision of cubic lattice parameter measurement by means of the Kossel technique are considered. It is shown that three special cases can be solved rigorously for projection distortion effects and that obtaining these cases is not difficult. The fact that a lens ratio method should be employed to reduce measured lengths on the film to lattice parameter values is emphasized. General formulae for the lattice parameter and the geometric sensitivity are presented. Correction and minimization of errors resulting from refractive index effects and temperature variations is indicated to be possible. An example of the determination of the lattice parameter of LiF is given. The sensitivity of the method, expressed the relative standard error of the mean lattice parameter of LiF, is given by

$$\Delta a/a_{Lif} = 2.5_4 \times 10^{-6}.$$

10140. Yee, K. W., Deslattes, R. D., **Transistorized current stabilizer for x-ray tubes with directly heated cathodes,** *Rev. Sci. Instr.* **38,** No. 5, 637-638 (May 1967).

Key words: Controlled impedance; current; emission; regulator; stabilizer; x-ray tube.

An instrument is described which stabilizes the emission current in x-ray tubes with directly heated cathodes. Transistors are used in the amplifier and loading circuits. Emission currents from 20 mA to 1A are maintained constant to within 0.1 percent for periods of about a half-hour.

10141. Young, R. D., **Field emission ultramicrometer,** *Rev. Sci. Instr.* **37,** No. 3, 275-278 (Mar. 1966).

Key words: Contour; displacement; distance; distance-measurement; field emission; instrument; measurement; micrometer; precise; sensitive.

A simple, contact free, ultrasensitive distance and displacement measuring instrument has been investigated. Experiments demonstrate that the instrument is capable of operating at spacings as small as a few hundred angstroms. Calculations indicate that distances of 10^{-3} to 10^{-6} cm and less can be reproduced to within about one part in 10^5. With suitable calibration, distance measurements in the 10^{-3} to 10^{-6} cm range can be expected to have accuracies limited only by available calibration techniques. The instrument would be most useful as a null or differential distance measuring device. It has the unusual property that resolution improves over several orders of magnitude as the null or measurement point is approached. Since the instrument contains no optical or mechanical lever systems, or delicately balanced bridges, it has inherent long term stability. Proposed applications include: (1) measurement of ball and hole diameters (contact free), (2) differential thermal expansion cell, (3) mechanical vibration sensor, (4) surface profile delineator (contact free), and (5) surface contour delineator (contact free).

10142. Yu, H., **The unperturbed dimension temperature coefficients of some fluorine-containing polymers,** (Proc. 152nd American Chemical Society Meeting, New York, N.Y., Sept. 13, 1966), *Polymer Preprint* 7, No. 2, 1143-1145 (Sept. 1966).

Key words: Energy component; fluorine-containing polymers; hydrocarbon chain backbone; unperturbed dimension temperature coefficients.

Thermoelastic measurements on amorphous networks of some fluorine-containing polymers were performed.

10143. Yu, H., Bur, A. J., Fetters, L. J., **Rodlike behavior of poly(n-butyl)isocyanate from dielectric measurements,** *J. Chem. Phys.* **44,** No. 7, 2568-2576 (Apr. 1, 1966).

Key words: Dielectric measurements; dilute benzene solution; polybutylisocyanate; rotary diffusion.

The rotary diffusion of poly(n-butyl)-isocyanate was studied by dielectric dispersion in dilute benzene solution. The correlation between the observed dielectric relaxation time and the molecular weight is interpreted on the basis of a hydrodynamic rod of very large axial ratio.

10144. Zapas, L. J., Craft, T., **Correlation of large longitudinal deformations with different strain histories,** *Rubber Chem. Technol.* **40,** No. 2, 506-516 (Mar. 1967).

Key words: BKZ theory; constant rate of strain; creep; elastic fluid; nonlinear behavior; polyisobutylene; polyvinylchloride; recovery; stress relaxation.

It is shown that the BKZ incompressible elastic fluid theory is in excellent agreement with experimental results obtained in simple extension. From single step stress-relaxation data, the stress-strain response for a number of other simple extension histories are calculated from the theory and are compared with experiments.

10145. Zwanzig, R., **Approximate eigenfunctions of the Liouville operator in classical many-body systems,** *Phys. Rev.* **144.** No. 1, 170-177 (Apr. 1966).

Key words: Classical; collective variables; eigenfunctions; eigenvalues; many-body; spectrum; variational; Vlasov.

A variational criterion is used to find approximate eigenfunctions and eigenvalues of the Liouville operator in classical many-body systems. The trial functions are taken to be sums over molecules of functions depending on the position and momentum of a single molecule. In a harmonic lattice, this approach leads to exact eigenfunctions and eigenvalues. In a fluid, the eigenvalue spectrum is continuous, and the eigenfunctions are related to those found by Van Kampen in his study of the linearized Vlasov equation for a plasma. The time dependence of the fluid current density is found by means of these eigenfunctions and eigenvalues. The results show persistent free particle propagation and damped sound wave propagation, with relative importance depending on the magnitude of the sound velocity.

10146. Zwanzig, R., **Probability and entropy of macroscopic fluctuations,** *Math. Phys.* **7,** No. 8, 1552-1556 (Aug. 1966).

Key words: Entropy: macroscopic fluctuations: thermodynamic force.

A macroscopic fluctuation is a fluctuation of order N in an N particle system. This article contains a calculation of the probability of a macroscopic fluctuation, and its associated entropy, which is asymptotically correct in the limit of large N. Sufficiently small macroscopic fluctuations are shown to obey the same Gaussian distribution law as spontaneous microscopic fluctuations (of order $N^{1/2}$). The modifications necessary to describe large macroscopic fluctuations are found. The entropy of a macroscopic non-equilibrium state is expressed by means of various moments calculated at equilibrium. The non-linear thermodynamic force for a non-equilibrium state far from equilibrium is found. The calculation is based on a cumulant expansion of the characteristic function of the probability distribution, and a stationary phase estimate of its Fourier transform.

10147. Richardson, J. M., **Time standards,** *Encyclopaedic Dictionary of Physics, Supplementary* **1,** 351-355 (Pergamon Press, Inc., New York, N.Y., 1966).

Key words: Time standards; unit of measurement; unit of time.

A unit of measurement for any quantity is usually an abstraction which specifies the idealized concept underlying the realization of the unit. A standard on the other hand is a physical embodiment of the unit. Thus standards may occur at any level of use and accuracy. This paper concerns time standards at the highest level of accuracy and at the most inclusive level of use; namely, at the level at national and international standardization.

10148. Young, T. R., **Linear measurements,** Chapter 3 in *Handbook of Industrial Metrology,* pp. 55-81 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Contours: datum deformation; irregular areas; length; linear measurement; process evaluation; shape.

General principles involved in the measurement of length, size and shape are discussed. The importance of definition and evaluation of the measurement process is shown. Deformation of datum defining size or shape are indicated and engineering concepts useful in determining magnitudes of deformation are reviewed; examples of deformations frequently encountered in linear metrology are shown.

10149. Astin, A. V., **International standardization and expanded world trade,** *Mag. Std.* **37,** No. 7, 191-194 (July 1966).

Key words: International Organization for Standardization; international standards; technology transfer; world trade.

The lack of adequate international standards for goods and services is a significant deterrent to expanded world trade. The technical committees, subcommittees, and working groups of the international standards-making bodies are the heart of the standards-making process. Greater participation by the United States in these activities would be to its advantage. Better communication of information about national and international standards is needed. International standards facilitate the transfer of technology from the most advanced nations to the less advanced.

10149A. Beaty, E. C., Browne, J. C., Dalgarno, A., **Ion mobilities in helium,** *Phys. Rev. Letters* **16,** No. 17, 723-724 (Apr. 1966).

Key words: Helium; ion mobilities; mass analysis; metastable.

10150. Allman, W. P., **A computer simulation model of railroad freight transportation systems,** *Intern. Railway Cong. Assoc. Monthly Bull. Cybernetics and Electronics* **4,** No. 2, 45-57 (Feb. 1967).

Key words: Computer simulation model; network-simulation; railroad freight transportation systems; transportation systems:

A railroad may be viewed as a network of nodes (yards) and links (railroad lines), with time-dependent demands for the movement of freight cars imposed upon it. Incident to car movement are the following key operating policy questions of railroad freight operations: (a) When and where should regularly-scheduled trains run? (b) For each yard, what should the car classification (sorting) policy be? (c) Over each line of a train's route, what cars should be assigned to the train for hauling?

These interdependent questions must be answered simultaneously, and in accordance with overall operating objectives of the railroad enterprise. Policies must be revised periodically when significant changes in demand traffic patterns occur.

The paper describes a simulation model which permits experimentation with various alternative railroads freight operating policies at a total-network level. The model has been constructed with the SIMSCRIPT simulation programming language. Model inputs include time-dependent freight car origin-destination demand data, train routes and schedules, yard sorting and operation policies, and assignments of cars to trains for hauling. Freight cars are sorted at yards, and picked up and dropped off by trains which haul them thru the network. Model outputs include several railroad operation performance measures such as origin-destination transit times, activity volumes, train lengths, delays incurred by cars at yard operations, and operating costs.

10151. Bean, B. L., **A method of producing sturdy specimens of pressed powders for use in x-ray spectrochemical analysis,** *Appl. Spectry.* **20,** No. 3, 191-193 (May-June 1966).

Key words: Powders, compacted or pressed; spectrochemical analysis; x-ray spectrochemical analysis.

Sturdy specimens of compacted or pressed powders may be produced for x-ray spectrochemical analysis as follows: A sleeve with sides about 0.16 cm (1/16 inch) thick and diameter 0.02 cm less than the inside diameter of the mold is placed in the mold. The powder is spread on the lower plunger of the mold. The sleeve is then removed and boric acid poured in the formed peripheral trench and on top of the powder. The specimen is then pressed. A specimen with strong edges and backing is prepared that may be reused many times because the boric acid edges support the pressure of the sample holder instead of the pressed sample powder.

10152. Haber, S., **A modified Monte-Carlo quadrature. II,** *Math. Compt.* **21,** No. 99, 388-397 (July 1967).

Key words: Analysis; integration; mathematics; Monte-Carlo; multiple integration; numerical analysis; numerical integration; quadrature.

A modification of Simple Monte-Carlo quadrature is proposed, which uses very simple forms of stratified sampling and of the "method of antithetic variates." The new procedure is fully automatic, requiring no preliminary analysis of the integrand, and converges somewhat faster than Simple Monte-Carlo. Results of experimental calculations are presented.

10153. Arthur, M. G., Allred, C. M., Cannon, M. K., **A precision noise power comparator,** *IEEE Trans. Instr. Meas.* **IM-4,** 301-305 (Dec. 1964).

Key words: Noise power comparator; power comparator; prototype noise power comparator; radiometers; spectral densities.

This paper describes a prototype noise power comparator based upon a theory given by Allred. Operating at 3 MHz, it is a null-type instrument, the principal components of which are a reference CW voltage generator, a hybrid four-port, a dual-channel amplifier and bandpass filter, and an analog multiplier. Unlike other radiometers, no rapid switching of the noise power or reference voltage is performed.

The instrument can compare noise powers having effective noise temperatures in the range from below liquid nitrogen temperature to greater than 30,000 °K. Two noise generators having known spectral densities are used to calibrate the comparator. The accuracy of comparison is 1 percent at 77 °K and increases to 0.2 percent at 29,000 °K.

10154. Schafer, G. E., **A systems concept of electromagnetic measurements in the U.S.A.,** *Proc. IEEE* **55,** No. 6, 775-778 (June 1967).

Key words: Electromagnetic measurement; National Measurement System; radio standards.

A brief description of a systems concept of the National Measurement System proposed by Dr. R. D. Huntoon, Director, Institute for Basic Standards, is given first. Activities of the Radio Standards Laboratory as a functional element of this system are then described. Some benefits of looking at RSL as an element of this system are given.

10155. Simmons, J. A., Coriell, S. R., Ogburn, F., **Calculation of currents of local galvanic cells,** *J. Electrochem. Soc.* **114,** No. 8, 782-787 (Aug. 1967).

Key words: Corrosion currents; galvanic cells; galvanic currents; Laplace's equation; pitting corrosion.

The current flow for a local electrolyte cell with rectangular anode and cathode is calculated as a function of polarization parameter, electrolyte thickness and conductivity, anode and cathode size, and zero current potential difference. The total current is obtained from the numerical computation (with error analysis) of a series solution of Laplace's equation assuming a linear polarization relation at the electrode-electrolyte interface. For high values of the polarization parameter and sufficiently thick electrolytes an asymptotic formula obtains for the current approximately proportional to the anodic fraction, as was found by Waber et al. However, in general the cell geometry greatly influences the amount of current given by Allred. flow, especially for anode shapes near to linear rather than square. This effect can be greater than an order of magnitude. The calculated results are compared with experimental data obtained by Ogburn and Schlissel and are shown to be in good agreement. Corrosion currents in randomly pitted surfaces may be estimated from the above results.

10156. Stromberg, R. R., Smith, L. E., **Conformation of polystyrene adsorbed on liquid mercury,** *J. Phys. Chem.* **71,** No. 8, 2470-2474 (July 1967).

Key words: Adsorption: adsorption of polymers; conformation of adsorbed polymers; ellipsometry; mercury; polymer adsorption; polystyrene.

Measurement of the extension of polystyrene adsorbed in liquid mercury from cyclohexane near the theta temperature indicates that the molecule is attached at a relatively large number of sites and that the conformation remains constant during most of the adsorption period. In addition, the extension is approximately independent of molecular weight for the range studied (537,000 to 3,300,000). These results are in contrast to previous measurements on polycrystalline metallic surfaces. The behavior may be attributed in part to the large value of the contribution of the London dispersion forces to the surface free energy of mercury as compared to other metals. Other possibilities are also discussed.

10157. Bekkedahl, N., **Crystallization of natural rubber,** *Rubber Chem. Technol.* **40,** No. 3., xxv-xxvii (June 1967).

Key words: Chain folding; contractility; crystallization; dilatometry; heat engine; melting; polymers; rubber; stark rubber.

This review article presents a resume of the research work that has been done at the National Bureau of Standards during the past thirty-five years in the field of crystallization of polymeric materials, with special emphasis on natural rubber. It contains only information on results of research work that has already been published.

10158. Brooke, R. L., Cruz. J. E., **Current distribution and impedance of lossless conductor systems,** *IEEE Trans. Microwave Theory Tech.* **MTT-15,** No. 6, 358-364 (June 1967).

Key words: Characteristic impedance; current distribution; general method; matrix solution; rectangular transmission line; time-domain reflectometer; variable impedance.

A general method for determining the characteristic impedance of lossless, uniform, go and return systems is developed. The current distribution within the system is determined by means of a matrix equation programmed for computer solution. Knowing the current distribution, the inductance per unit length and characteristic impedance are obtained. The results obtained by applying this method to several rectangular coaxial systems are compared with the predictions of an approximate analytic expression. The reflection coefficient of a variable characteristic impedance coaxial line is measured on a "Time Domain Reflectometer" (TDR) and the results are compared with both the matrix method and the approximate analytic expression.

10159. Johnson, D. P., Heydemann, P. L. M., **Dead weight piston gauge for pressures to 26 kilobars,** *Rev. Sci. Instr.* **38,** No. 9, 1294-1300 (Sept. 1967).

Key words: High pressure; piston gauge; pressure measurement; transition pressure.

The design and operation of a dead weight piston gauge for pressures to 26 kilobars is described. The gauge is of the controlled clearance type. The diameter of the gauge piston is 0.2 cm. It is loaded directly with up to 840 kg of weights. A volume of about 1 cm³ is provided inside the gauge for the material under test. The use of this gauge for transition pressure determinations is briefly discussed.

10160. Post, M. A., **Determination of bound styrene in insoluble emulsion polymerised styrene-butadiene copolymers,** *J. Appl. Chem.* **17,** 203-208 (July 1967).

Key words: Absorbence ratio method; bound styrene; infrared; insoluble styrene-butadiene copolymers; masonry paints.

Bound styrene is determined in insoluble emulsion polymerised styrene-butadiene copolymers by measurement of the 10·3 μm/13·2 μm absorbence ratio using the baseline method. This ratio is obtained from the infra-red spectrogram of the copolymer. The styrene content is then determined from a standard curve. The standard curve is constructed from absorbence ratios of 10·3 μm/13·2 μm derived from the infra-red spectrograms of cast films of styrene-butadiene latices over a range of compositions in which the bound styrene has been determined by nitration of the isolated and extracted copolymers. Styrene content based on nitration is determined from standard curves relating styrene concentration to spectrophotometric absorbence measurements at wavelengths of 285·0 nm, 273·8 nm and 265·0 nm. The source of the styrene for these curves is NBS standard rubber No. 1500.

10161. Kieffer, L. J., Dunn, G. H., **Dissociative ionization of H_2 and D_2,** *Phys. Rev.* **158,** No. 1, 61-65 (June 5, 1967).

Key words: Dissociative ionization; energy distributions; Franck-Condon principle; D_2; H_2.

Energy distributions of H^+ (D^+) from dissociative ionization of H_2 (D_2) are reported. Evidence of the $2p\sigma u$ states being the major source of energetic ions is presented. Calculated and measured energy distributions do not agree well. Possible explanations are suggested.

10162. Brown, R. L., **Effects of impurities on the production of oxygen atoms by a microwave discharge,** *J. Phys. Chem.* **71,** No. 8, 2492-2495 (1967).

Key words: Atomic oxygen; catalysis; flow system reactions; kinetic EPR spectroscopy; microwave discharges; reactions of oxygen atoms.

The catalytic effects of impurities on the production of O-atoms in microwave discharges have been studied in a flow system by measuring with EPR methods the concentrations of $O_2(^3\Sigma_g^-)$, $O_2(^1\Delta_g)$, O, and H-atoms as a function of the amounts of H_2O, D_2O, and N_2 added to the O_2 upstream from the discharge. The effects of varying the microwave power to the discharge, the O_2 flow rate, and the total pressure were also examined.

10163. Gniewek, J. J., Moulder, J. C., Kropschot, R. H., **Electrical conductivity of high purity copper,** *Proc. Tenth Intern. Conf. Low Temperature Physics, Moscow, USSR, Aug. 31-Sept. 9, 1966,* pp. 366-370 (Viniti, Moscow, USSR, 1967).

Key words: Copper; electrical conductivity; low temperature; size effect.

The low temperature electrical conductivity of copper single crystals ($R_{273}/R_4 > 30{,}000$) and polycrystalline wire ($R_{273}/R_4 > 10{,}000$) has been measured between 4 °K and 77 °K.

Between 14 and 30 °K the resistance is proportional to T^n where $n = 4.8 \pm 0.1$. Size effects are observed using both eddy current and direct current techniques in samples as large as 2 mm in diameter. Assuming diffuse reflection of the electrons from the surface, direct current size effect measurements give a $\rho_b \ell_b = 0.53 \times 10^{-11} \Omega cm^2$ which is less than the free electron value of $0.66 \times 10^{-11} \Omega cm^2$.

10164. Schofer, R. E., Goodyear, F. F., **Electronic computer applications in urban transportation planning,** (Proc. 22nd Natl. Conf. Association for Computing Machinery, Washington, D.C., Aug. 29-31, 1967), *A.C.M. Publ.* **P-67,** pp. 247-253 (Thompson Book Co., Washington, D.C., July 1967).

Key words: Data processing; systems analysis; transportation planning; urban transportation.

The goal of urban transportation planning is to develop a plan for an efficient, balanced transportation system for an urban area; one which will promote a desirable pattern of human activities. While the process has been standardized to some extent, each study must nevertheless acquire and manage a massive amount of information about the specific region with which it is concerned. This information, together with computer representations of transportation networks and travel patterns, is used to produce estimates of future travel demand and utilization of facilities. Thus, computers play an important role in providing transportation planners with the capability for evaluating a variety of proposed transportation systems in order to recommend allocation of government resources and to guide transportation policy. This paper describes specific computer applications to the process of transportation planning.

10165. Melmed, A. J., **Epitaxial growth of iron on tungsten field emission points,** *Surface Sci.* **7,** No. 3, 478-481 (July 1967).

Key words: Crystal growth; epitaxy; Fe-W alloying; field emission microscopy; vapor deposition.

Iron crystals can be grown from the vapor phase on tungsten field emission points. The crystals tend to nucleate at edges of W (011) planes and grow in the same orientation as the substrate, sometimes with an apparent small parallel displacement. Interdiffusion of W into the growing Fe crystals can occur and evidence for this is presented.

10166. Gruzensky, P. M., **Growth of large sodium chloride crystals from solution for color center studies,** *J. Chem. Phys.* **43,** No. 11, 3807 (Dec. 1, 1965).

Key words: Alkali halides; aqueous; chloride; color centers; conductivity; crystal growth; sodium.

Sodium chloride single crystals with edge dimensions as large as 2.5 cm were grown from aqueous solutions. Solutions were purified by chemical precipitation of trace contaminants and filtration through membrane filters. Crystal defects were apparent in the initial stages of growth, but the outer portions of crystals were free of dislocations. F-band coloration by x rays at room temperature was not linear and the "first stage" was either absent or nearly so. Transition from extrinsic to intrinsic dc conductivity occurred at 350 C with the extrinsic conductivity two orders of magnitude lower than for "pure" melt-grown crystals.

10167. Melmed, A. J., **Helium field-ion microscopy of hexagonal close-packed metals,** (Proc. Symp. The Structure of Surfaces, Durham, N.C., Nov. 1966), *Surface Sci.* **8,** No. 12, 191-205 (July-Aug. 1967).

Key words: Field evaporation; field-ion microscopy; hexagonal close-packed metals; surface structure.

The atomic structure of curved hexagonal close-packed metal surfaces is complicated compared to curved surfaces of body-centered cubic metals. He field-ion microscopy of Ru and Re field-evaporated surfaces discloses apparent differences in the surface structures developed under similar experimental conditions. The effect of temperature and field strength on the structure developed by field-evaporation is analyzed, and the structures of the (100) and (001) plane regions in particular are discussed in relation to their respective field-ion images.

10168. Hamer, W. J., **History of the National Standard of electromotive force,** (Proc. 22nd ISA Conf. and Exhibit, Chicago, Ill., Sept. 11-14, 1967), *ISA Preprint* No. M2-1-MESTIND-67, pp. 1-10 (1967).

Key words: Absolute volt; Gibbs' phase rule; history of volt; legal volt; volt standards.

The history of the National Standard of electromotive force is traced from the meeting of the International Electrical Congress in Chicago in 1893 to the present time. Included are discussions of the transfer of the "volt standard" from its old location in Washington, D.C. to its new location near Gaithersburg, Maryland, of the stability of standard cells, of the application of Gibbs' Phase Rule to standard cells, and the relation between the legal and absolute volts.

10169. Newman, S. B., Young, R. W., **Indentation hardness of the fingernail,** *J. Invest. Dermatol.* **49,** No. 1, 103-105 (Mar. 17, 1967).

Key words: Fingernail; hardness; Knoop indenter.

Indentation hardness using the Knoop indenter has been used as a quantitative criterion in physiological studies of the human nail plate. Data were collected and are presented to show that values reported in the literature are in serious error. A number of parameters affecting Knoop numbers are examined in an effort to determine the source of error.

10170. Halberstadt, M. L., McNesby, J. R., **Insertion of methylene into alkanes,** *J. Am. Chem. Soc.* **89,** No. 14, 3417-3420 (1967).

Key words: 1-butane; insertion; ketene; methane; methylene; n-butane; photolysis; propane.

Ketene was photolyzed in the presence of mixtures of pairs of hydrocarbons with NO added to scavenge alkyl radicals. The relative rates of insertion for methane:primary propane:secondary propane are 0.43:1.0:0.43 and for ethane:primary n-butane:secondary n-butane they are 1.0:1.0:0.88. In the case of isobutane, the relative rates of insertion into primary and tertiary bonds are 1.0:0.13. When effects of recombination of alkyl radicals formed by abstraction of H by CH_2 are eliminated by the NO scavenger, insertion is seen to be essentially indiscriminate. It is suggested that the singlet CH_2 lies not more than about 2.5 kcal above the ground state triplet.

10171. Utech, H. P., **Interpretation of de Grinberg's experiments on lateral surface fringes in sodium chloride,** *Phys. Stat. Sol.* **20,** K41-K43 (1967).

Key words: Bands; crystals; Czochralski; fringes; sodium chloride.

Results of a recent experiment by de Grinberg on lateral surface fringes in sodium chloride are questioned in the light of two alternative theories which the author had apparently overlooked. It is suggested that further experiments be conducted to distinguish between the three possible mechanisms.

10172. Bender, P. L., **Laser measurements of long distances,** *Proc. IEEE* **55,** No. 6, 1039-1045 (June 1967).

Key words: Interferometric measurements; laser measurements; modulated laser beams; radio frequency techniques; range measurements.

The extension of radio frequency techniques to the optical region of the spectrum has made possible many types of measurements which were not feasible before. One area in which important scientific contributions can be expected during the next few years is the use of lasers to measure long distances with high accuracy. Three types of distance measurements which have been discussed in the literature and which are now being investigated actively are: (a) interferometric measurements over distances of up to hundreds of meters through evacuated or sealed-off tubes; (b) measurements with modulated laser beams over distances of perhaps one to fifty kilometers with corrections made for the atmospheric index of refraction along the path; and (c) range measurements to artificial satellites and to the moon using laser radar. Some of the possible geophysical and geodetic applications of such measurements will also be discussed.

10173. Young, T. R., **Linear measurements,** Chapter 3 in *Handbook of Industrial Metrology,* pp. 55-81 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Contours; datum deformation; irregular areas; length; linear measurement; process evaluation; shape.

General principles involved in the measurement of length, size and shape are discussed. The importance of definition and evaluation of the measurement process is shown. Deformation of datum defining size or shape are indicated and engineering concepts useful in determining magnitudes of deformation are reviewed; examples of deformations frequently encountered in linear metrology are shown.

10174. Heck, C. K., Hiza, M. J., **Liquid-vapor equilibrium in the system helium-methane,** *AIChE. J.* **13,** No. 3, 593-599 (May 1967).

Key words: Helium; helium-methane binary system; liquid-vapor equilibrium; low-temperature; methane; phase-equilibrium; solubility of helium in liquid methane.

Liquid and gas phase compositions for the system helium-methane have been measured at 15° intervals from 95° to 185 °K up to 200 atmospheres pressure. Data for these seven isotherms were taken in a gas phase recirculation apparatus using chromatographic analysis. In most regions the phase compositions obtained are thought to be within ±3 percent of the mole fraction of the minor component. The maximum deviation from the enhancement factor curve at the lowest concentration levels was 16 percent. These data are in excellent agreement with most of the very recent data but are in poor agreement with the older data for this system.

10175. Reed, R. P., Mikesell, R., **Low temperature (295-4 °K) mechanical properties of selected copper alloys,** *J. Materials* **2,** No. 2, 370-392 (June 1967).

Key words: Copper; copper alloys; low temperatures; mechanical properties.

Fifteen copper alloys, including brasses, bronzes, and commercially pure coppers were tested to determine their tensile, notch tensile, Youngs modulus, and impact properties. Tests were performed at 295, 195, 76, 20, and 4 °K. It was found that copper alloys, in general, have improved room low temperature properties as compared to room temperature properties. The exception to this result is a cast Ni-Al bronze alloy, which is brittle at low temperatures. In 9 alloys the yield and tensile strengths at 4 °K were less than at 20 °K. A discussion of this strength reduction at low temperatures is presented.

10176. McNish, A. G., **Metrology, essential of space age,** *George Washington University Mag.* **1,** No. 4, 10-14 (1965).

Key words: Education; metrology; standards; units.

Understanding the physical world and the progress of civilization depends upon measurement.

10177. Fry, B. M., **Microprinting fills the bill,** *Business Graphics,* pp. 21-25 (Jan. 1967).

Key words: Clearinghouse for Federal Scientific and Technical Information; microphoto; microprinting; printing; systems.

The Clearinghouse for Federal Scientific and Technical Information, part of NBS, is a focal point for the collection, announcement and sale of copies of unclassified U.S. Government R&D reports released for public sale by the sponsoring Federal agencies. Approximately 50,000 new reports and Government-sponsored translations of foreign technical material are received each year. The article describes Clearinghouse reproduction services as part of the system to meet the demand for over 2,000,000 copies of documents in microfiche and paper copy each year. The Clearinghouse reproduction plant makes use of the latest technology in microphotography, electrostatic copying and offset printing. The article highlights the role of the reproduction plant as a laboratory in testing new equipment and ideas to improve service to customers.

10178. Mosburg, E. R., Jr., Lojko, M. S., **Non-linear diffusion with recombination in electron beam excited plasma,** *Phys. Fluid Res. Notes* **9,** No. 4, 824-826 (Apr. 1966).

Key words: Diffusion; radial distribution; recombination-electron ion and plasma.

The non-linear diffusion equations for an isothermal plasma with a recombination term added are treated for the case of cylindrical geometry and no magnetic field. The radial electron density and light intensity distributions are given for various values of the ratio of the recombination loss rate to diffusion loss rate. The light intensities are computed on the basis of two-body and three-body recombination as well as the intermediate case of collisional-radiative recombination.

10179. Newman, M., **Note on partitions modulo 5,** *Math. Compt.* **21,** No. 99, 481-482 (July 1967).

Key words: Density; partitions; Ramanujan congruences.

It is shown that the density of the integers n such that p(n) is divisible by 5, is strictly greater than 1/5.

10180. Marton, L., Toots, J., **Optical properties of germanium in the far ultraviolet,** *Phys. Rev.* **160,** No. 3, 602-606 (Aug. 15, 1967).

Key words: Characteristic electron energy loss; dielectric constant; far ultraviolet; germanium; optical constants; reflectance.

Reflectance measurements for Ge films evaporated *in situ* are reported for 16 wavelengths between 490 and 1610 Å, corresponding to photon energies of 25.2 and 7.7 eV. Measurements were taken after 3-min exposures to ambient pressures of 5×10^{-7} torr. Reflectance values at a number of angles of incidence were used to compute the optical constants: the refraction index n, the extinction coefficient k, and the real and imaginary parts of the frequency-dependent dielectric constant $\epsilon(\omega)=\epsilon_1$ +e $i\epsilon_2$. Values are also presented for the characteristic electron energy-loss functions, i.e., the volume loss, $-\mathrm{Im}\epsilon^{-1}$, and the surface loss, $-\mathrm{Im}(\epsilon+1)^{-1}$. The quantity $-\mathrm{Im}\epsilon^{-1}$ peaked at 16.1 eV and had a half-width of 3.9 eV. Electron oscillator strengths, summed between 8 and 25 eV, gave a $\hbar\omega_p$ value of 13.7 eV. The present data are in better agreement with the accepted plasma theory than are previous data. Some changes of optical characteristics caused by exposure to ambient pressures and air are presented.

10181. Scheer, M. D., Fine, J., **Positive and negative self-surface ionization of tungsten and rhenium,** *J. Chem. Phys.* **46,** No. 10, 3998-4003 (May 15, 1967).

Key words: Electron affinity; ion sublimation energy; mass spectrometry; positive and negative atomic ions; rhenium; self-surface ionization; tungsten.

The self-surface ionization of tungsten and rhenium has been investigated with a specially designed mass spectrometer. It has been found that both positive and negative singly charged atomic ions sublime from these metal surfaces in the 1900-2600 °K temperature range. The assumption that these processes can be described by a generalized Saha-Langmuir equation has been shown to be valid. The energies required for positive ion sublimation were found to be 12.1 ± 0.2 and 10.7 ± 0.1 eV for tungsten and rhenium, respectively. The negative ion sublimation energy for rhenium was determined as 12.6 ± 0.2 eV and that for tungsten is given by approximately the same value. At 2300 °K, the ratio of positive to negative ions evaporating from these surfaces was found to be about 40 for tungsten and about 20,000 for rhenium. These results are consistent with the following estimates for the electron affinities: $A(W) = 0.5 \pm 0.3$ eV and $A(Re) = 0.3 \pm 0.2$ eV.

10182. Selby, M. C., **Progress in the U.S. on electromagnetic standards and measurements at 30 kHz to 1 GHz, 1963 through 1965,** *IEEE Trans. Instr. Meas.* **IM-16,** No. 2, 172-178 (June 1967).

Key words: Attenuation measurements; field strength measurements; high frequency measurements; impedance measurements; phase measurements; progress in radio measurements; thermal noise measurements; voltage measurements.

A digest of highlights is presented on the most significant U.S. contributions to the measurement of attenuation, impedance, voltage, current, field strength, thermal noise, and phase at 30 kHz to 1 GHz. A total of approximately 30 contributions are digested in this section of the report. The following accomplishments are among them: a super-sensitive detector for a complex-insertion-ratio measurement system having accuracies of about 0.0005 dB/10 dB at 30 MHz; exact equations for mutual and self-inductance of various combinations of filaments, tapes, and bars; a modified Twin-T-Bridge for measuring resistances of 100 to 10,000 ohms to 15 MHz; a set of Q-factor standards for frequencies to 45 MHz based on accumulated data and experience over 5 years; a unique adjustable characteristic-impedance coaxial line measurement of Q's greater than 100,000 of cryogenic circuits at frequencies to 300 MHz; a novel Tee-junction to enable calibrations of voltmeters of any practicable input impedances with VSWR's ranging from 1 to 200, to 1 GHz and higher; a miniaturized dipole-antenna field strength meter, employing a semiconducting plastic transmission line, to measure complex near-zone fields of 0.1 to 1000 volts per meter, from 150 kHz to 30 MHz; a prototype 3-MHz model of precision thermal noise-power comparators for an equivalent noise-temperature range of 75 to 30,000 °K at accuracies of 0.2 to 1 percent.

10183. McCamy, C. S., **Proposed recommended practice for description and selection of conditions for photographing specimens,** *Photo. Sci. Eng.* **10,** No. 4, 185-191 (July-Aug. 1966).

Key words: Appearance; camera description; lighting description; specimen photography.

A "Proposed Recommended Practice for Description and Selection of Conditions for Photographing Specimens" has been prepared for the American Society for Testing and Materials so that the photographic method of recording appearance can be made more reproducible from one laboratory to another, for various specimens, and for a given specimen at different times. The proposal defines terms and symbols and provides a systematic method of describing the arrangement of lights, camera, and subject; the characteristics of the illumination; the nature of the photographic process, and the viewing system. Conditions for photographing certain common forms of specimens are recommended. Conventions for exhibiting and publishing photographs of specimens include an orientation mark and a coordinate system for pictures.

10184. Reed, R. P., **Reply to "Comments on Reed Letter, by H. M. Otte,"** *Acta Met.* **15,** No. 6, 1082-1083 (June 1967).

Key words: Low temperatures; martensite; stacking faults.

This brief reply answers the assertion raised by Otte regarding previously published identification of deformation faulting in Fe-Ni alloys. It asserts that the published results quoted by Otte are not faults, but surface martensite.

10185. Young, D., **Scheduling a vehicle between an origin and a destination to maximize traveler satisfaction,** (Proc. 22nd Natl. Conf. Association for Computing Machinery, Washington, D.C., Aug. 29-31, 1967), *A. C. M. Publ.* **P-67,** pp. 233-245 (Thompson Book Co., Washington, D.C., July 1967).

Key words: Computer algorithm; iterative equation; optimal scheduling; parametric analysis; transportation vehicle; utility functions.

This paper presents an algorithm for scheduling a transportation vehicle on a single-link (origin to destination) network, so as to achieve a high degree of passenger satisfaction. The paper includes an explanation of traveler utility functions, a description of the iterative equation upon which the scheduling calculation is based, and a section on numerical results obtained using the algorithm. The latter section illustrates the role of the computer in performing the parametric analyses important for comprehensive evaluation of alternative transportation facilities.

The paper is extracted from research being done at the Technical Analysis Division of the National Bureau of Standards for the Northeast Corridor Transportation Project. Its contents should not be interpreted as representing policies of the Northeast Corridor Project.

10186. Melmed, A. J., **Surface self-diffusion of nickel and platinum,** *J. Appl. Phys.* **38,** No. 4, 1885-1892 (Mar. 1967).

Key words: Activation energy; field emission microscopy; nickel; platinum; surface-diffusion; surface properties.

The surface rearrangement of nickel and platinum due to (1) an electric field (build-up) and (2) surface tension (annealing) as the net driving force, has been studied by field-electron emission microscopy over the temperature range 510°–750 °K for Ni and 550°–850 °K for Pt. An Arrhenius-type relationship between temperature and time was found in both cases, so that an activation energy could be associated with each process. It is assumed that this is an average activation energy for surface diffusion.

The results of the field build-up experiments gave an activation energy of $Q_f = 19.1 \pm 1.9$ kcal/mole for Ni over the negative field range $(28-38) \times 10^6$ V/cm, and $Q_f = 26.3 \pm 2.6$ kcal/mole for Pt over the negative field range $(27-39) \times 10^6$ V/cm. It was possible to measure the effect of the electric field using a method devised earlier by Bettler and Charbonnier. This gave calculated zero-field activation energies of 20.6 ± 2.1 kcal/mole for Ni and 29.7 ± 3.0 kcal/mole for Pt. The results of the annealing experiments (no electric field) gave an activation energy of $Q_0 = 21.4 \pm 2.1$ kcal/mole for Ni and 29.5 ± 3.0 kcal/mole for Pt. (The foregoing indicated uncertainties are estimated over-all limits of error.) It is concluded from the agreement between the results of the two different types of measurement that either type of measurement (for fcc metals) may be used to determine the same quantity within a 10 percent uncertainty.

10187. McNish, A. G., **The aurora,** *Proc. NATO Advanced Study Institute, Bad Homburg, Germany, July 22-Aug. 2, 1963,* D. S. Bleil, ed., pp. 77-93 (Plenum Press Inc., New York, N.Y., 1964).

Key words: Corpuscular; ionization; magnetosphere; particle flux.

The present state of knowledge regarding the aurora is reviewed.

10188. Altschuler, H. M., **The conference on precision electromagnetic measurements,** *Proc. IEEE* **55,** No. 6, 782 (June 1967).

Key words: Conference; Conference on Precision Electromagnetic Measurements; electromagnetic measurements; measurements; precision measurements.

The character of the biennial Conference on Precision Electromagnetic Measurements (CPEM) is described. The scope of the Conference is compared with that of the special issue of the Proceedings of the IEEE on Measurements. Some of CPEM's history is recounted and its increasing international coverage is noted. It is concluded that the challenge to CPEM grows with the expansion of the fields it covers.

10189. Altschuler, H. M., **The role of the NBS Radio Standards Laboratory,** *Proc. IEEE* **55,** No. 6, 778-781 (June 1967).

Key words: High frequency; measurements; microwave; physical properties; physical quantities; physics; standards; standards laboratory; time and frequency.

This paper describes three major roles played by the NBS Radio Standards Laboratory in the field of electromagnetic measurements. It highlights the primary technical areas of the Laboratory with specific examples of the work involved, and mentions the various services which the Laboratory provides to the nation. It also describes the dynamic character and wide range of research in radio metrology at a national standards laboratory.

10190. Levin, E. M., **The system Y_2O_3-V_2O_5,** *J. Am. Ceram. Soc.* **50,** No. 7, 381-382 (July 1967).

Key words: Phase diagram; V_2O_5; Y_2O_3; yttrium vanadate.

The phase diagram of the system Y_2O_3-V_2O_5 has been determined experimentally, by the "quenching" method. The subsystem YVO_4-V_2O_5 is a simple eutectic one, with a solidus temperature of 672 ± 3 °C. Yttrium vanadate, of industrial importance, melts congruently at 1810 ± 25 °C. The subsystem YVO_4-Y_2O_3 is probably pseudobinary because of oxygen losses from the phases of composition $4Y_2O_3{:}V_2O_5$ and $5Y_2O_3{:}V_2O_5$. The composition $4Y_2O_3{:}V_2O_5$ exists in at least three different phases.

10191. Robertson, A. F., **U.S. Department of Commerce and the flammability of clothing fabric,** *Bull. N.Y. Acad. Med. Second Series* **43,** No. 8, 706-710 (Aug. 1967).

Key words: Clothing; clothing fire accidents; fabric flammability; fabrics; fire casualties.

The National Bureau of Standards has conducted studies of existing and modified test methods for measurement of flammable hazards associated with clothing fabrics. Recently, a cooperative program has been initiated with the Public Health Service to secure burn accident experience records which should yield information on the type of fabrics currently associated with clothing burn injuries. This program is just starting and it will be some years before valid information of the national picture becomes available. To date, however, there appears to be no technical evidence to show that a significant modification of the burn accident experience can be achieved without major changes in the flammable behavior of clothing fabrics. Thus, we hope industry will continue research on and development of permanently-retardant-treated fabrics which will be economically, esthetically, and usefully acceptable to the public. It appears, in spite of the lack of direct evidence, that such fabrics will significantly reduce, but not eliminate, clothing fire injuries.

10192. Chilton, C. J., Conner, J. P., Steele, F. K., **A comparison between solar x-ray emission and VLF sudden phase anomalies,** *Proc. IEEE* **53,** No. 12, 2018-2026 (Dec. 1965).

Key words: VELA satellite; VLF sudden phase anomalies measurements; solar x-ray emission measurements.

Original VLF sudden phase anomaly data obtained during October 1963 are presented for comparison with solar x-ray emission measurements made by VELA satellites during the same period.

10193. Meyer-Arendt, J. R., **A note on the evaluation of interference photographs,** *Acta Histochem.* **22,** 58-61 (1965).

Key words: Interference photographs; photographs; wavefront deformation.

Interference patterns should be evaluated with respect to two parameters, namely the spatial displacement and the contrast of the fringes. The contrast permits the deduction of the degree of wavefront deformation in one of the two bundles brought to interference. A series of representative figures are shown in a plot.

10194. Fatiadi, A. J., **A novel, facile preparation of 1,1′-bipyrene,** *J. Org. Chem.* **32,** 2903 (Sept. 1967).

Key words: Periodate oxidation of pyrene; synthesis of 1,1′-bipyrene.

An improved procedure is described for the synthesis of 1,1′-bipyrene.

10195. Saunders, J. B., **A simple, inexpensive wavefront shearing interferometer,** *Appl. Opt.* **6,** No. 9, 1581-1583 (Sept. 1967).

Key words: Interferometer; prism interferometer; wavefront shearing interferometer.

An efficient wavefront shearing interferometer is easy to produce from two small right-angle prisms. A cube beam divider becomes such an interferometer when two of its faces are aluminized. Any chosen angle of shear is obtained by a simple rotation of one prism relative to the other. Chromatic compensation is achieved by sliding one prism relative to the other along their common face.

10196. Klemperer, W. K., **Angular scattering law for the moon at 6 meter wavelength,** *J. Geophys. Res. Letter* **70,** No. 15, 3798-3800 (Aug. 1965).

Key words: Angular scattering law; meter wavelength; radar echoes; short-pulse.

Short-pulse (100 μsec) radar echoes have been obtained from the moon using the NBS-Instituto Geofisico del Peru 50 Mc/s facility near Lima, Peru. The results of an analysis of the data in terms of the angular scattering law $P(\theta)$ are compared with a recent theory of P. Beckmann (1965). The physical significance of the absence of any marked departure from the smooth $P(\theta)$ curve is pointed out.

10197. Ma, M. T., **Another method of synthesizing nonuniformly spaced antenna arrays,** *Trans. IEEE Ant. Prop.* **AP-13,** No. 5, 833-834 (Sept. 1965).

Key words: Amplitude excitations; antenna arrays; element spacings; nonuniformly spaced antenna arrays; synthesizing nonuniformly spaced antenna arrays.

A formulation for synthesizing an optimum nonuniformly spaced but symmetrical array by adjusting both the amplitude excitations and element spacings is given. This is accomplished by applying Haar's theorem which is known in a branch of mathematics. It is shown that the solution obtained according to the method proposed here is optimum in the senses that, with respect to a chosen set of element spacings, (1) the maximum deviation between the synthesized and desired patterns is minimized, (2) the side lobes can be made equal and their level minimum for a specified beamwidth, (3) the side lobe level and beamwidth are not mutually constrained so that a solution better than the Dolph-Chebyshev array is possible, (4) a minimum number of elements required to synthesize a desired pattern can be determined, and (5) the solution is unique.

10198. Cottony, H. V., **Antennas,** *Encyclopedia of Physics,* R. M. Besancon, ed., pp. 25-28 (Reinhold Publ. Co., New York, N.Y., 1966).

Key words: Antennas; circuits; contiguous electronic circuit; electronic circuit; information energy; terminal impedance.

The functions and properties of antennas are outlined in a 1500 word article for use in an encyclopedia. The presentation is presented from a viewpoint that an antenna is a network designed to facilitate the transfer of information energy from circuits to space and reverse.

The relationship between an antenna and the contiguous electronic circuit is determined and fully described by the terminal impedances of the circuit and antenna. Because of the three-dimensional nature of propagating medium and the nature of electromagnetic wave, the performance of an antenna as a radiator is more complex. For full description, it requires the specifications of its radiation pattern in space, and the polarization of the radiated electromagnetic wave.

Six illustrations of different types of antennas are presented.

10199. Macek, J. H., **Application of the Fock expansion to doubly excited states of the helium atom,** *Phys. Rev.* **160,** No. 1, 170-174 (Aug. 5, 1967).

Key words: Applications; generalizations; helium; hyperspherical coordinates; power series; Schrödinger equation; solution.

A method of integrating the Schrödinger equation developed by Fock for S states of the helium atom is extended to all angular momentum states. The method makes use of an expansion in powers of R and log R, where $R=(r_1^2+r_2^2)$. Some applications and generalizations are explored. The convergence of the series is investigated.

10200. Powell, C. J., **Characteristic energy losses of 8 keV electrons in liquid In-Al and In-Bi alloys,** *Advan. Phys.* **16,** No. 62, 203 (Apr. 1967).

Key words: Characteristic-electron-energy-losses; electronic excitations; In-Al alloys; In-Bi alloys; liquid alloys.

Measurements have been made of the characteristic energy losses of 8 keV electrons in a series of liquid In-Al and In-Bi alloys in order to avoid the confusing effects of phase mixtures present in most similar studies of solid alloy systems. Loss spectra were measured in a reflection-type scattering geometry with total electron scattering angles of 15° and 70°. Two principal energy loss peaks, identified as being due to surface plasmon and to volume plasmon excitation, were found to vary as a function of alloy composition in each system. Deviations from the variaion expected from a simple free-electron model could be interpreted in some cases in terms of an interband electronic transition occurring near the measured volume and surface energy-loss peaks. For bismuth-rich In-Bi alloys and for indium-rich In-Al alloys the transition energy and oscillator strength could be estimated and shown as a function of composition.

10201. Kerns, D. M., **Coping with multiple reflections in precise measurement of the speed of light with a microwave Michelson interferometer,** (Proc. URSI Symp. Electromagnetic Wave Theory, Delft, The Netherlands, September 1965), Chapter in *Electromagnetic Wave Theory,* pp. 245-249 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Interferometer; microwave; multiple reflections; speed of light; waveguide junction.

A microwave version of the Michelson interferometer is currently being used for a precise determination of the speed of light. In preliminary experiments, multiple reflections between the antenna and the movable mirror of the system have been found to produce apparent variations in c, which, if uncorrected, would be an order of magnitude greater than tolerable. This paper establishes a theorem that should enable substantial elimination of errors due to multiple reflections. It is also shown that the four-arm junction in the arrangement—usually visualized as an ideal magic T—need have no special properties and in particular need have none of the ideal properties that distinguish an ideal magic T.

10202. Zare, R. N., Bender, P. L., **Cross section for Na($^2P_{1/2}$, $^2P_{3/2}$) intramultiplet transactions induced by collisions with hydrogen atoms,** *Proc. Am. Phys. Soc. Meeting, Los Angeles* **10,** 1183 (American Physical Society, New York, N.Y., 1965).

Key words: Atom wavefront; hydrogen atoms; inelastic collisions.

The cross sections for the transfer of excitation between the $3^2P_{1/2}$ and $3^2P_{3/2}$ states of sodium induced by inelastic collisions with hydrogen atoms have been calculated using the impact parameter approximation. When two atoms approach each other a quasi-molecule is formed which may be characterized by its spin and projection of its total angular momentum on the molecular axis. For the Na*-H system the electronic wavefunctions are taken to be the antisymmetrized products of the separated atom wavefunctions, from which the $^1\Sigma$, $^3\Sigma$, $^1\Pi$ and $^3\Pi$ energy splittings are determined as a function of internuclear distance. The transition probability for each velocity and impact parameter is found by integrating along the collision trajectory the coupled differential equations arising from the time-dependent Schrödinger equation. Upon averaging overall impact parameters and the distribution in velocities we obtain for the total cross section σ (Na $^2P_{1/2} \rightarrow$ Na $^2P_{3/2}$) 61.8, 58.0 and 55.2 πa_0^2 at $T=5000$, 7500 and 10,000 °K. Corrections to these values still have to be made for deviations from straight-line paths and for the neglect of van der Waals forces, although these are anticipated to be small.

10203. Cushen, W. E., **C. S. Peirce on benefit-cost analysis of scientific activity,** *Operations Res.* **15,** No. 4, 641 (July-Aug. 1967).

Key words: Benefit-cost; history; Peirce; philosophy; pragmatism; research priorities; weights and measures.

A very early paper on benefit-cost analysis of research projects was published in the Appendix to the Coast Survey's Annual Report 1876. A special issue of *Operations Research,* devoted to applications, is reprinting the original article, authored by Charles Sanders Peirce, who is better known as the father of pragmatism in American philosophical circles. The paper by Cushen serves to introduce the reprint and to paint a brief scene for its use and interpretation.

10204. Kerns, D. M., **Definitions of v, i, Z, Y, a, b, Γ, and S,** *Proc. IEEE* **55,** No. 6, 892-900 (June 1967).

Key words: Admittance matrix; impedance concepts; impedance matrix; scattering matrix; waveguide junction; waveguide n-port.

Concepts and conditions underlying the establishment and use of the immittance- and scattering-matrix description of waveguide n-ports are discussed. The discussion is intended to be critical and intensive rather than general. Needed results of electromagnetic (and waveguide) theory are assumed. Emphasis is placed on defining basic quantities needed in the matrix scheme. These include: generalized voltage and current, v and i, for waveguide modes; modal impedance; modal characteristic impedance; the immittance matrices, Z and Y; traveling-wave amplitudes, a and b; the scattering matrix, S; and reflection coefficient, Γ. Theoretical properties of Z, Y, and S are not discussed; applications are indicated but not discussed.

10205. Bowen, R. L., **Development of an adhesive restorative material,** (Proc. 2nd Workshop, Adhesive Restorative Dental Materials, University of Virginia, Charlottesville, Va., Dec. 8-9, 1965), Chapter 4 in *Adhesive Restorative Dental Materials,* No. 2, p. 225 (U.S.) Public Health Service Publ. 1494, Supt. Doc. U.S. Government Printing Office, Washington, D.C., $1.00, 1966).

Key words: Adhesive; bonding; dental material bonding; resin; restorative.

Recent findings, primarily from the literature, are reviewed on the subject of adhesive, restorative, dental materials. One mode of attack on the problem is described. In this, an inorganic-organic composite is used as the restorative material. The inorganic reinforcing fillers serve primarily to reduce the material's thermal expansion. A coupling agent improves the bonding between the phases. Bonding between the organic resin phase and the tooth surface is also improved by a coupling agent (surface-active comonomer).

10206. Robertson, B., **Equations of motion in nonequilibrium statistical mechanics. II. Energy transport,** *Phys. Rev.* **160,** No. 1, 175-183 (Aug. 5, 1967).

Key words: Energy transport; equations of motion; exact flux operator; heat conductivity; heat wave equation; nonequilibrium statistical mechanics.

The exact equations of motion for the space- and time-dependent coordinates of an arbitrary many-body system have been derived previously. These equations are integrodifferential equations whose kernels are generalizations of correlation functions and therefore are related to Green functions. In this paper an exact general expression for a flux operator is used to rewrite the equations. Then they become memory-retaining nonlocal generalizations of the diffusion equation. The formalism is applied to energy transport, and the usual expression for heat conductivity is derived without making the usual assumptions. Finally, a simple function is assumed for the kernel, and the equation then reduces to a well known heat conduction and wave equation.

10207. Weinstock, J., **Equivalence between two formalisms of plasma fluctuations,** *Phys. Fluids* **9,** No. 3, 621-622 (Mar. 1966).

Key words: Auto-correlation function; distribution function; kinetic theory; plasma fluctuation.

It is pointed out that the expression for auto-correlation functions which is given in terms of the two-time distribution function is related by a trivial identity to the expression for auto-correlation functions which is given in terms of the usual distribution function.

10208. Okabe, H., **Excited species and their contribution to NO (β,γ) fluorescence in the photodissociation of N_2O,** *J. Chem. Phys.* **47,** No. 1, 101-109 (July 1, 1967).

Key words: Energy transfer; excited species; fluorescence; gas phase; N_2O; photolysis; vacuum ultraviolet;

The fluorescence intensity and the yield of the NO β bands, originating from photodissociation of N_2O, was measured as a function of wavelength of incident light in the vacuum ultraviolet region. Photon energies required for the occurrence of the fluorescence are far less than the threshold energy to produce $NO(A^2\Sigma^+, B^2\Pi_r)$ directly from N_2O, indicating that the emission is due to secondary processes. The fluorescence intensity curve follows closely the absorption curve of N_2O indicating that excited species responsible for the emission are produced from dissociation of electronically excited N_2O rather than from the direct dissociation to these species. A mechanism of fluorescence is discussed on the basis of the threshold energy above which a specific photochemical process is possible. Reactions responsible for the β emission in the absorption region 1400 to 1550 Å of N_2O are production of $N(^2D)$ and $O(^1S)$ followed by $N(^2D) + N_2O \rightarrow N_2 + NO(B^2\Pi_r)$ and $O(^1S) + N_2O \rightarrow NO + NO(B^2\Pi_r)$. In the region below 1440 Å, $N(^2P)$ and $N_2(B^3\Pi^g, B'^3\Sigma_u^-)$ also can contribute to the emission. When NO was added to N_2O, the fluorescence intensity increased considerably and the emission changed from β to γ bands. Reactions which produce the emission in the absorption region 1400 to 1550 Å are

$$N_2O \underset{\rightarrow}{hv} N_2(A^3\Sigma_u^+) + O(^3P)$$

followed by $N_2(A^3\Sigma_u^+) + NO \rightarrow N_2 + NO(A^2\Sigma^+)$. Below 1350 Å additional excited molecules $N_2(B^3\Pi_g, B'^3\Sigma_u^-)$ can contribute to the emission in similar reactions.

10209. Bridges, J. M., Wiese, W. L., **Experimental determination of transition probabilities and Stark widths of S I and S II lines,** *Phys. Rev.* **159,** No. 1, 31-38 (July 5, 1967).

Key words: Arc; atomic spectroscopy; plasma; Stark broadening; sulfur; transition probability.

Absolute transition probabilities and Stark widths for some prominent multiplets of S I and S II have been determined experimentally. A well-stabilized arc was operated in SO_2 with a small hydrogen admixture. The spectroscopic measurements were performed photoelectrically. Side-on observations were transformed via the Abel inversion to give the radial dependence of the measured quantities. Measurements of the absolute intensity of O I lines and the width of H_β served for the plasma analysis; the results of these measurements together with the application of equilibrium and conservation relations for arc plasmas enabled the determination of the temperature and various particle densities. Mass separation effects are taken into account. The measured Stark widths generally agree well with values calculated from Stark broadening theory; in the case of S II lines the agreement with very recently calculated values is substantially better than that with earlier theoretical data.

10210. Frederikse, H. P. R., Hosler, W. R., **Hall mobility in $SrTiO_3$,** *Phys. Rev.* **161,** No. 3, 822-827 (Sept. 15, 1967).

Key words: Electron mobility; ionized impurity scattering; optical mode scattering; strontium titanate; temperature dependence of mobility.

Electron mobilities in reduced and doped $SrTiO_3$ have been deduced from measurements of conductivity and Hall coefficient between 1 and 1000 °K. Above room temperature scattering by the highest two longitudinal optical modes determines the mobility. Expressions based on intermediate electron-phonon coupling yield good agreement. Below 10 °K ionized impurity scattering is the dominant collision process. Using a screened Coulomb potential, one obtains mobility values of the right order of magitude.

10211. Wallace, M. R., Milliken, L. T., Toner, S. D., **Identification of dyes in paper by extraction and chromatographic analysis,** *TAPPI* **50,** No. 9, 121A-124A (Sept. 1967).

Key words: Chemical analysis; chemical tests; chromatography; dyes.

A chromatographic procedure is described for the determination of a range of direct and acid dyes in dyed paper. It can be used for the identification of individual dyes in complex mixtures on unknown samples, and is simple and inexpensive enough to use in routine quality control and testing of dyes and dyed paper.

R_f values and visual appearances serve immediately to identify most of the paper dyes studied. Comparisons with known references give good estimates of the quantities of each dye present. Individual basic dyes could not be identified by this procedure, but the presence of a basic dye could be detected by ts appearance in the solvent front. In a mixed furnish containing both acidic and basic dyes the acidic dyes could be determined without interference by the basic dyes. R_f values for the principle characteristic bands of 26 dyes are listed.

10212. Fehsenfeld, F. C., Megill, L. R., Droppleman, L. K., **Interpretation of cyclotron resonance line shapes in slightly ionized gases,** *J. Chem. Phys.* **43,** No. 10, 3618-3624 (Nov. 1965).

Key words: Cyclotron resonance line shapes; ionized gases; line shapes; resonance line shapes.

The dependence of cyclotron resonance line shape on the velocity dependence of the collision frequency for three different distribution functions is calculated. Several sets of data for various collision frequency dependency upon energy are calculated. These include, in addition to simple one term power laws, results for four gases using measured collision frequencies. Because the line shape is strongly influenced by the energy dependency of the collision frequency, the calculation of collision frequencies from line width data requires an accurate knowledge of the variation of collision frequency with energy. Moreover, with previously used analyses, large errors in the deduced collision frequency may be caused, for some gases, by the presence of small admixtures of other gases, or ions. The examples which are given to illustrate the above statements indicate that extreme care must be exercised if reliable experimental data are to be obtained.

10213. VanZandt, T. E., **Ionosphere,** *Encyclopedia of Physics,* R. M. Besancon, ed., pp. 348-349 (Reinhold Publ. Co., New York, N.Y., 1966).

Key words: Electron concentration; height range; ionic composition; ionosphere; ionospheric regions.

10214. Klose, J. Z., **Lifetimes of some 4p levels in argon I,** *J. Opt. Soc. Am.* **57,** No. 10, 1242-1244 (Oct. 1967).

Key words: Argon; delayed coincidence; lifetimes, atomic; spectra, atomic.

Mean lives of four electronically excited atomic levels in Ar I have been determined using a method of delayed coincidence. The measured values of the mean lives of the $2p_1$ through $2p_4$ (Paschen notation) levels in neutral argon determined from transitions with associated wavelengths extending from 6677 to 7147 Å are as follows: $2p_1$, 21 ± 2 nanoseconds; $2p_2$, 25 ± 1 nsec; $2p_3$, 26 ± 1 nsec; and $2p_4$, 31 ± 2 nsec. The lifetimes were estimated to contain systematic errors varying from 5 to 15 percent and are presented in comparison with corresponding results of other workers.

10215. Arms, R. J., Hama, F. R., **Localized-induction concept on a curved vortex and motion of an elliptic vortex ring,** *Phys. Fluids* **8,** No. 4, 553-559 (Apr. 1965).

Key words: Curved vortex; elliptic vortex ring; localized-induction; motion of vortex ring; vortex; vortex motion.

The localized-induction concept for the induction effect of a smooth curved vortex on itself is derived. This concept is applicable to the limiting case of a vortex filament of infinitesimal core size and of negligible long-distance effect, and was already successfully utilized in the investigations of the motion and deformation of a curved vortex filament given various initial configurations. Two theorems obtained under this concept are that the arc length of a vortex filament and the projected area of a closed vortex filament are both invariant with respect to time. These theoretical predictions are examined by a numerical analysis of the motion of an initially plane elliptic vortex ring of various eccentricities.

10216. Costrell, L., **Lou Costrell of NBS speaks out on the revolution in instrument packaging,** *IEEE Trans. Nucl. Sci.* **15,** No. 8, 78-84 (Aug. 1967).

Key words: Instrument; interchangeability; modules; nuclear; standard.

The interchangeability problem posed by the advent of modular instrumentation has been alleviated by the development of a Standard Nuclear Module (NIM) system by the AEC Committee on Nuclear Instrument Modules. The Committee held its first meeting in March 1964. The completed specifications were issued in July 1964 and laboratory utilization and industry exhibit of the NIM system began in November 1964. Acceptance by the laboratories and by the nuclear instrument industry has been so rapid and so overwhelming that by September 1966 more than 70 percent of the total modular nuclear instruments produced in the U.S. were in the NIM system. The percentage today is even higher and the impact is world wide. Since all necessary components are available, other fields and other industries can readily adopt the system.

10217. Hermach, F. L., **Low-frequency electrical calibrations at the National Bureau of Standards,** (Proc. 22nd Annual ISA Conf. and Exhibit, Chicago, Ill., Sept. 11-14, 1967), **ISA Preprint** No. M5-1-MESTIND-67 (1967).

Key words: Electrical calibrations; electrical standards; low-frequency calibrations; low-frequency standards.

Charts are presented to show the present range and accuracy of NBS calibrations of standards of resistance, capacitance, inductance, voltage, and current, from direct current through 50 kHz. The chains of measurements by which these and other calibrations are related to the basic NBS standards of voltage and resistance are also shown.

10218. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the reaction of carbon atoms with chlorine. The electronic and vibrational spectra of the free radical CCl_2,** *J. Chem. Phys.* **47,** No. 2, 703-707 (July 15, 1967).

Key words: Carbon atoms; CCl_2 radical; CF_2 radical; chlorine; cyanogen azide; electronic spectrum; infrared spectrum; matrix isolation.

Studies of the photolysis of N_3CN in the presence of Cl_2 in Ar and N_2 matrices at 14 °K provide evidence for the formation of the free radical CCl_2 by the reaction of photolytically produced

C atoms with Cl_2. The two stretching fundamentals of CCl_2 appear at 721 and 748 cm^{-1}. The corresponding fundamentals of $^{13}CCl_2$ have also been observed. When the sample is warmed above about 30 °K, these features disappear, and CCl_4 features grow in intensity, indicating the CCl_2 can react with Cl_2 with little or no activation energy. The valence angle of CCl_2 probably lies between 90° and 110°. A weak band system appearing between 4400 and 5600 Å, with an average band separation of 305 cm^{-1}, may also be attributed to CCl_2. Analogy with the electronic absorption spectrum of CF_2 suggests that CCl_2 possesses a ground singlet state and that this band system arises from a transition between the ground state electronic configuration and the first excited electronic configuration of CCl_2, involving an extensive progression in the upper state bending vibration.

10219. McNish, A. G., **Measurement standards,** *IEEE Student J.* **4,** No. 2, 24-31 (Mar. 1966).

Key words: Length; mass; temperature; time; units of measurement.

All *units of measurement*, including the ampere of current and candela of light intensity—two base units included in the new International System of Units, are ultimately derived from four original prototype units—the meter of *length*, kilogram of *mass*, degree Kelvin of *temperature*, and second of *time*. To make all measurement units more effective tools, the standards that physically embody or define three of the prototypes—length, time, and temperature—have been changed in recent years.

10220. Roberts, J. R., Eckerle, K. L., **Measurements of Stark profiles of C II and Ca II lines,** *Phys. Rev.* **159,** No. 1, 104-107 (July 5, 1967).

Key words: C II; Ca II; experimental; monochromator; profile scans; Stark profiles; T-tube.

An electromagnetic *T* tube was the source of a plasma used to measure line profiles of singly ionized atoms. The profiles of C II lines emitted by a plasma composed of He and Co_2 in the ratio 95:5 were scanned with a monochromator. The profile scans were accomplished by repeated firings of the T tube while advancing the monochromator in wavelength steps. Also measured was the profile of the 3934 Å Ca II resonance line emitted by a plasma composed of He, H_2, and CO_2 in the ratio 20:10:70 with Ca as an impurity. The profile of the 3889 Å He I line was also measured and its halfwidth was used to determine the plasma electron density in the case of the C II lines. Likewise H_α was used to determine the electron density in the case of the Ca II line. The experimental C II and Ca II Stark-profile half-widths were compared with the theoretically calculated values.

10221. Corliss, E. L. R., **Mechanistic aspects of hearing,** *J. Acoust. Soc. Am.* **41,** No. 6, 1500-1516 (June 1967).

Key words: Auditory analysis; auditory perception; communication theory; ear behavior; hearing; mechanistic model of hearing; resolving power of the ear.

The results of a number of apparently diverse experiments on human hearing can be summarized via a simple model. Two mechanisms are required: One element emits unit responses whose number is proportional to the instantaneous amplitude of a sound. The other is a selector mechanism, analogous to a resonant circuit, that integrates the responses. Correspondingly, just two parameters are involved: the threshold of hearing and the "Q" of the selector mechanism. The system of equations representing the model makes it possible to derive the necessary parameters from the results of a number of different types of experiments. The theory of the selector mechanism is based upon a recent study of the limits of performance of a system capable of storing oscillatory energy reversibly, but the remainder of the theoretical description makes use of ordinary communication theory.

The discrimination ability of the normal ear is shown to be proportional to the one-fourth power of the level above threshold, and to relate closely to the sensation of loudness. Many features of the behavior of normal and impaired ears can be predicted by application of familiar network theory to the parameters derived from the model. The properties of the model may be used as criteria in the choice of experiments to develop explicit data on the way the ear performs its function.

10222. Durst, R. A., Taylor, J. K., **Modification of the fluoride activity electrode for microchemical analysis,** *Anal. Chem.* **39,** No. 12, 1483-1485 (Oct. 1967).

Key words: Electrochemical analysis; fluoride, analysis for; fluoride electrode; microchemical analysis; potentiometry; specific ion electrode.

A fluoride activity electrode has been modified for operation in the inverted position by converting the inner reference solution to a gel. Operation in this position makes possible the use of the single-crystal fluoride-sensitive membrane as the sample "container" and permits the measurement of sample volumes as small as one drop (50 μl). A calibration curve is obtained for solutions containing 10^{-1} *M* to 10^{-6} *M* NaF in 0.1 *M* KNO_3. The precision to which the fluoride concentration can be read from this calibration curve is calculated from the slope of the curve at the various concentrations and the standard deviation of the e.m.f. measurements. In the concentration range from 10^{-1} *M* to 10^{-3} *M* NaF, the calculated error is about 2 percent. At the 10^{-5} *M* NaF level, 10 nanograms of fluoride can be determined with an error of approximately 0.7 nanogram. For sample volumes of 50 μl, the modified fluoride electrode was found to exhibit a usable response in the range from 10^{-1} *M* to 5×10^{-6} *M* fluoride.

10223. Durst, R. A., Taylor, J. K., **Modified linear null-point potentiometry,** *Anal. Chem.* **39,** No. 12, 1374-1379 (Oct. 1967).

Key words: Electroanalysis; linear potentiometry; microtitration; null-point potentiometry; potentiometry; silver.

A modification of the technique of precision null-point potentiometry has been developed in which a linear titration curve is obtained when the logarithm of the amount of coulometrically generated titrant is plotted against the concentration cell potential. The equivalence point is evaluated graphically and by computer techniques. The analyses of standard 0.1 ml samples containing 0 to 13 μg of silver are discussed in detail. This technique was found to be applicable down to one nanoequivalent (0.1 μg) of silver with an error of less than 5 percent. Below this value, a positive deviation occurs due to the spontaneous dissolution of the silver indicator electrodes. The interference effects of several cations are also discussed.

10224. Ruffa, A. R., **Nature of ionic deformations in crystals; application to an analysis of the magnetic properties of the alkali-halide and alkaline-earth oxide crystals,** *Phys. Rev.* **159,** No. 3, 742-754 (July 15, 1967).

Key words: Alkali earth oxides; alkali halides; deformation; diamagnetism; ionic; ionic sizes; kinetic energy; paramagnetism; polarizabilities.

Absolute diamagnetic susceptibilities for the alkali-halide crystals are obtained theoretically and compared with the observed magnetic susceptibilities of these crystals in order to determine the crystalline paramagnetic susceptibilities. The paramagnetic susceptibilities obtained in this way are found to obey the linear relationship $\chi_{para} = 0.11\chi_{dia}$. Theoretical analysis confirms this relationship for the alkali halides and indicates, in addition, that (1) Virtually all of the increased kinetic energy which the ions acquire in the process of crystallization takes the form of rotational kinetic energy; (2) the angular deformations of the ions in all the alkali halides are the same in that the average eigenvalues of the square of the angular momentum operator per electronic orbital is constant for all these crystals; and (3) the general relationship between χ_{dia} and χ_{para} for an ionic crystal is of the form $\chi_{para} = C\chi_{dia}$, where C is very nearly proportional to the average cohesive energy per ion of the crystal. The last conclusion is confirmed in the alkaline-earth oxides where $C \approx 0.5$, in accord with the fact that the cohesive energies of these crystals are about five times those of the alkali halides. Furthermore, this analysis indicates that an ionic crystal with a large enough cohesive energy is paramagnetic, in agreement with observation.

10225. Mebs, R. W., Bennett, L. H., Leibowitz, J. R., **Nuclear magnetic acoustic resonance in $KTaO_3$,** *Physics Letters* **24A,** No. 12, 665-666 (June 5, 1967).

Key words: Dislocation damping of acoustic waves; nuclear magnetic acoustic resonance; nuclear magnetic resonance; nuclear quadrupole coupling; potassium tantalate.

Direct acoustic excitation of the ^{181}Ta nuclear spin is observed at room temperature in $KTaO_3$.

10226. Lide, D. R., Jr., Maki, A. G., **On the explanation of the so-called CN laser,** *Appl. Phys. Letters* **11,** No. 2, 62-64 (July 15, 1967).

Key words: CN; emission; far infrared; HCN; laser; spectra.

It is shown that the major features of the far infrared "CN laser" are due to the HCN molecule. The intense line at 337 microns and other near-by lines are explained as transitions involving the 11^10 and 04^00 vibrational states, which are mixed by a Coriolis perturbation. The mechanism of the laser is discussed.

10227. Mighell, A. D., Reimann, C. W., **On the structure of pyrazole,** *J. Phys. Chem.* **71,** No. 7, 2375-2376 (June 1967).

Key words: Betaine form; pyrazole; structure; x-ray.

The structure of pyrazole has been reexamined based upon an analysis of the complete crystal and molecular structure of dichlorotetra(pyrazole)nickel (II), $Ni(C_3H_4N_2)_4Cl_2$. This analysis shows that a relocation of a hydrogen atom in the previously reported structure of pyrazole is required to bring the two formuations of pyrazole into agreement. The relocation of the hydrogen atom, however, alters the previous conclusions regarding the relative contribution of the betaine form to the resonance hybrid.

10228. Kokoszka, G. F., Reimann, C. W., Allen, H. C., Jr., Gordon, G., **Optical and magnetic measurements on single crystals of copper(II)-doped tris(phenanthroline)zinc(II)nitrate dihydrate,** *Inorg. Chem.* **6,** No. 9, 1657-1661 (1967).

Key words: D-d transitions; EPR spectrum; Jahn-Teller effect; polarized optical spectrum; trisphenanthroline copper(II) nitrate dihydrate; trisphenanthroline zinc(II) nitrate dihydrate.

The electron paramagnetic resonance spectrum in single crystals of copper(II)-doped tris(phenanthroline)zinc(II) nitrate dihydrate has been observed between 4 and 350 °K. The results have been interpreted in terms of a Jahn-Teller effect for the copper(II) ion. At 350 °K the spectrum is nearly isotropic with $g = 2.13$ and no observed hyperfine splitting. At 77 °K anisotropy of the g tensor is observed with $g_{\parallel} = 2.273$, $g_{\perp} = 2.064$, $A = 160 \times 10^{-4}$ cm^{-1}, $B < 7 \times 10^{-4}$ cm^{-1}, $A' = 12.5 \times 10^{-4}$ cm^{-1}, and $B' = 10.5 \times 10^{-4}$ cm^{-1}. No significant change in the spectrum was observed at temperatures below 77 °K. The optical d-d transitions and their polarization properties are reported. Two bands are observed at 7000 and 14,900 cm^{-1}. The 14,900-cm^{-1} band is split at 77 °K into components at 14,700 and 15,200 cm^{-1}. The optical axes do not coincide with the principal magnetic axes.

10229. Crow, E. L., Siddiqui, M. M., **Robust estimation of location,** *J. Am. Stat. Assoc.* **62,** No. 318, 353-389 (June 1967).

Key words: Asymptotic theory; efficiency; median; order statistics; probability distributions; robust estimators; statistical estimation; weighted means; wild observations.

The problem of estimating a location parameter from a random sample when the form of distribution is unknown or there is contamination of the target distribution is attacked by deriving estimators which are efficient over a class of two or more forms ("pencils") of continuous symmetric unimodal distributions. The pencils considered are the normal, double exponential, Cauchy, parabolic, triangular, and rectangular (a limiting case). The estimators considered are special symmetrical linear combinations of order statistics: trimmed means, Winsorized means, "linearly weighted" means, and a combination of the median and two other order statistics. These are also compared asymptotically with a Hodges-Lehmann estimator. Efficiencies are tabulated for sample sizes of 4 or 5, 8 or 9, 16 or 17, and ∞. The theory required for deriving asymptotic variances is presented. Efficiencies of at least 0.82 relative to the best estimator for any single pencil are achieved by using the best trimmed mean or linearly weighted mean over a range of pencils of distributions from the normal to the Cauchy. However, the combination of the median and two other order statistics is almost as efficient (0.80) over the same range and is more efficient than the other estimators if the range is extended through the rectangular pencil.

10230. Schafft, H. A., **Second breakdown—A comprehensive review,** *Proc. IEEE* **55,** No. 8, 1272-1288 (Aug. 1967).

Key words: Circuit reliability; diodes; failure mechanisms; failure modes; review; second breakdown; semiconductor devices; thermal breakdown; transistor reliability; transistors.

This paper is a comprehensive review of the published literature dealing with the phenomenon of second breakdown in semiconductor devices and the problems it creates in the design, fabrication, testing, and application of transistors.

10231. Robinson, E. J., Geltman, S., **Single- and double-quantum photodetachment of negative ions,** *Phys. Rev.* **153,** No. 1, 4-8 (Jan. 1967).

Key words: Double-quantum; elastic scattering; negative ions; photodetachment; single-quantum.

The recent measurement of the transition probability for the double-quantum detachment of an electron from I^- has prompted a new theoretical study of this problem. A central field model for bound and free states is used, in which a parameter is adjusted in the potential to yield the observed binding energies of the negative ions. An implicit sum method, requiring the solution of inhomogeneous radial equations, is used to evaluate the sums over intermediate states. The results for I^- lie within the experimental uncertainty. The single-quantum photodetachment and electron elastic scattering (from the neutral atom) cross sections are also given for the ions studied: C^-, O^-, F^-, Si^-, S^-, Cl^-, Br^-, I^-.

10232. Bean, B. R., Warner, B. D., **Some radio-physical considerations in studies of the fine scale structure of the at-**

mosphere, *Proc. Intern. Conf. Fine Scale Structure of the Atmosphere, Moscow, USSR, June 1965*, pp. 215-224 (1965).

Key words: Angular scatter; atmospheric fine structure; dot angels; radar returns; radio path-length variations; refractive index; water vapor density.

Radar returns from the clear air have been extensively utilized as a method of studying the fine structure of the atmosphere. These studies have heretofore utilized a single radar. Presented here are the first tentative results of a two-radar study of the angular "scattering" pattern of clear air returns. These preliminary results for warm, turbulent, summer days indicate that the "dot angels" returns are more in agreement with a scatter mechanism rather than with specular reflection. It is also demonstrated that the electrical path length may be used to determine the average water vapor content of the radio path.

10233. Milligan, D. E., Jacox, M. E., **Spectroscopic study of the vacuum-ultraviolet photolysis of matrix-isolated HCN and halogen cyanides. Infrared spectra of the species CN and XNC,** *J. Chem. Phys.* **47,** No. 1, 278-285 (July 1, 1967).

Key words: CN free radical; cyanogen; cyanogen bromide; cyanogen chloride; cyanogen fluoride; halogen isocyanides; hydrogen cyanide; hydrogen isocyanide; infrared spectrum; matrix isolation technique; ultraviolet spectrum; vacuum ultraviolet photolysis.

Vacuum-ultraviolet photolysis of HCN isolated in Ar and N_2 matrices at 14 °K is found to lead to the production of HNC in concentration sufficient for direct infrared observation of all three vibrational fundamentals. The spectrum of this species is found to be appreciably perturbed by the presence of N_2. The force constants and thermodynamic properties of HNC have been revised to the values appropriate to this species in an environment free of perturbation by an adjacent N_2 molecule. The free radical CN is also produced in these systems in concentration sufficient for direct observation not only of the $B(^2\Sigma^+) - X(^2\Sigma^+)$ transition but also of the ground-state vibrational fundamental. Isotopic data supporting this identification are presented. Upon vacuum-ultraviolet photolysis of matrix-isolated FCN, two infrared absorptions appear which can be identified with the stretching fundamentals of the species FNC. In analogous experiments on the species ClCN and BrCN, infrared absorptions tentatively assigned to ClNC and BrNC have been observed.

10234. Smith, E. K., **Sporadic-E ionization,** *Annual Supplement Encyclopedic Dictionary of Physics,* J. Therolis, ed., **Suppl. I,** 329-331 (Pergamon Press Inc., New York, N.Y., 1966).

Key words: Auroral types of sporadic E; equatorial; ionization; sporadic-E.

A brief review is presented on the structure of the sporadic-E layer, its temporal characteristics, and finally of the current thinking of the cause of equatorial, temporate and auroral types of sporadic E.

10235. Schooley, J. F., Frederikse, H. P. R., Hosler, W. R., Pfeiffer, E. R., **Superconductive properties of ceramic mixed titanates,** *Phys. Rev.* **159,** No. 2, 301-305 (July 10, 1967).

Key words: $BaSrTiO_3$; $CaSrTiO_3$; ceramics; magnetization; mixed titanates; semiconductors; $SrTiO_3$; superconductivity.

The superconducting transition temperature of a series of mixed barium-strontium and calcium-strontium titanate ceramic specimens have been determined. For several of these samples the low-field magnetization has also been investigated. The results are compared with those obtained from single-crystal $SrTiO_3$.

10236. Peterson, R. L., **Suppressed and accelerated spin-lattice relaxation,** *Phys. Rev.* **159,** No. 2, 227-233 (July 10, 1967).

Key words: Inelastic phonon-boundary scattering; phonon avalanche; phonon bottleneck; spin-lattice relaxation; spin-phonon interactions.

The transient magnetic behavior of a paramagnetic substance, after an initial disturbance, is considered theoretically for a variety of situations in which the lattice temperature rises as a result of energy flow from the magnetic (electron spin) system. The direct and T^9 Raman spin-phonon processes are considered. Coupling between phonon modes, and leakage of energy into a bath are taken into account. Graphs of the resultant behavior are presented. Effects such as suppressed and accelerated spin relaxation, and rapid decay (phonon avalanche) after spin inversion, are discussed. It is pointed out that experiments performed without the usual helium bath may provide reliable measurements of inelastic phonon-boundary scattering.

10237. Ochs, G. R., **Synchrotron radiation measurements near the magnetic equator,** Chapter in *Radiation Trapped in the Earth's Magnetic Field,* B. McCormac, ed., pp. 703-713 (D. Riedel Publ. Co., Dordrecht, The Netherlands, 1966).

Key words: Decay; intensity; magnetic equator; observations; radio frequencies; starfish; synchrotron radiation.

The radiation produced in the radio spectrum by relativistic electrons injected into trapped orbits in the earth's magnetic field at the time of the Starfish nuclear explosion of July 9, 1962, has been monitored near Lima, Peru, for one year at 30 Mc/s and almost three years at 50 Mc/s. After an initial brief transient increase of 4.5×10^4 °K, the excess antenna temperature at 50 Mc/s rapidly decreased to 1×10^4 °K. Later, the temperature T_{50} at a time t days after the explosion approximately followed the law,

$$T_{50} = 6600e^{-(t/270)},$$

for $t > 90$ days. At 30 Mc/s, the initial transient increase was not observed, but the subsequent behavior was similar. The decay was more rapid and the early signal was of greater intensity, however. After the first three months, the temperature T_{30} approximately followed the law,

$$T_{30} = 16000e^{-(t/180)}.$$

10238. Utton, D. B., **Temperature dependence of the nuclear quadrupole resonance frequency of ^{35}Cl in $KClO_3$ between 12° and 90 °K,** *J. Chem. Phys.* **47,** No. 2, 371-373 (July 15, 1967).

Key words: Bayer-Kushida theory; chlorine; nuclear quadrupole resonance; potassium chlorate; temperature variation; 12 °K – 90 °K.

A precise measurement of the temperature dependence of the N.Q.R. frequency of Cl^{35} in $KClO_3$ has been made at constant pressure in the range 12 °K – 90 °K. Analysis using the Bayer-Kushida theory predicts lattice modes at 60 cm^{-1} and 126 cm^{-1}. A comparison is made with the Raman spectrum.

10239. Shimazaki, T., **The application of the partial correlation analyses to the study of the occurrence probability of spread-F,** (Proc. AGARD Conf. Spread F and Its Effects Upon Radiowave Propagation and Communication, Copenhagen, Denmark, Aug. 1964), *AGARDograph* **95,** pp. 167-188 (W. and J. Mackay, London, England, 1966).

Key words: Charged particles; extra-terrestrial origins; higher solar activity; hydromagnetic waves; solar activity; spread-F.

It is well known that the spread-F occurrence probability is inversely correlated to solar activity during the solar cycle at most stations except at very high latitudes. This is strange because extra-terrestrial origins of spread-F, such as impinging charged particles or hydromagnetic waves, may develop more strongly and more extensively during higher solar activity. The cause of this apparent inverse correlation may be sought in the ionospheric and upper atmospheric conditions.

In past studies, several ionospheric parameters have been considered as the possible factors which control the occurrence of spread-F, and the correlation coefficients between each parameter and the occurrence probability of spread-F have been examined. However, each of these correlations has ignored the effect of other parameters. Before examining the correlation between each parameter and the spread-F occurrence probability, the effect of other factors should be eliminated systematically. The technique of partial correlation is useful for this purpose.

In this study, the partial correlation coefficients between various ionospheric, solar and geomagnetic parameters and the spread-F occurrence probability are studied for Washington and Wakkanai. The result shows that the partial correlation analyses give better and more reasonable results than the simple one in many respects.

10240. Reimann, C. W., Mighell, A. D., Mauer, F. A., **The crystal and molecular structure of tetrakis-pyrazole-nickel chloride, $Ni(C_3H_4N_2)_4Cl_2$,** *Acta Cryst.* **23,** Part 1, 135-141 (July 1967).

Key words: Octahedral complex; single crystal; structure; tetrakis-pyrazole-nickel chloride; x-ray.

The crystal and molecular structure of tetrakis-pyrazole-nickel chloride $Ni(C_3H_4N_2)_4Cl_2$ was determined by single crystal x-ray diffraction techniques. $Ni(C_3H_4N_2)_4Cl_2$ crystallizes in the monoclinic system with $a = 13.876 \pm 0.001$, $b = 9.263 \pm 0.006$, $c = 14.451 \pm 0.003$ Å, $\beta = 116.83 \pm 0.01°$, space group C2/c, $\rho_o = 1.61$ gm cm^{-3} and $Z = 4$. Three-dimensional data (2401 reflections) were used and the structure solved by an analysis of the Patterson. The $Ni(C_3H_4N_2)_4Cl_2$ molecule is centric with the nickel atom at the center of an octahedron formed by two chlorine atoms and a nitrogen atom from each of the four pyrazole molecules. One pair of coordinated nitrogen atoms lies 2.097 Å and the other pair 2.087 Å from the nickel atom. The nickel-chlorine vector makes an angle of 0.4° with the normal to the plane of the coordinating nitrogen atoms and the chlorine atom lies 2.507 Å from the nickel atom. The pyrazole rings were found to be planar within experimental error. Final refinement by a three-dimensional anisotropic least-squares analysis resulted in an R value of 5.4 percent.

10241. Davies, K., Barghausen, A. F., **The effect of spread F on the propagation of radiowaves near the equator,** (Proc. AGARD Conf. Spread F and Its Effects Upon Radiowave Propagation and Communication, Copenhagen, Denmark, Aug. 1964), *AGARDograph* **95,** pp. 437-466 (W. and J. Mackay, London, England, 1966).

Key words: Frequency measuring technique; high frequency; ionosonde technique; propagation studies; radio waves; spread F.

A phenomonological description is given of certain aspects of high-frequency radio propagation studies, via the ionosphere, in Africa. Using the ionosonde technique with oblique propagation and a frequency measuring technique the following phenomena were studied, primarily from an engineering viewpoint: (1) F scatter, (2) flutter fading, (3) accuracy of MUF calculations. The measurements were carried out at two epochs of the sunspot cycle. The main features of the data are: (1) F scatter is more prevalent on magnetically quiet days at high solar activity but is nearly absent at low solar activity. (2) The duration of flutter fading is roughly proportional to the change of layer height (or phase path) near sunset. (3) The rate of amplitude fading appears to decrease with increase of frequency during the evening disturbance. (4) On the whole, there is relatively good agreement between maximum observed frequencies (MOFs) and those calculated from midpoint data. Predicted values, however, show discrepancies being too small for paths to the north of the dip equator and too large near the dip equator.

10242. Kieffer, L. J., Van Brunt, R. J., **The energies of N^+ from the dissociative ionization of N_2,** (Proc. 18th Annual Gaseous Electronics Conf., Minneapolis, Minn., Oct 21, 1965), *Bull. Am. Phys. Soc.* **11,** No. 4, 499 (1966).

Key words: Angular distribution; dissociative ionization; electron impact.

Using an apparatus previously described in the literature, the energy distribution and angular distribution of energetic N^+ ions from the dissociative ionization of N_2 by electron impact have been observed. The data are not consistent with the measurements of Tate and Lozier. Ions were observed with energies from 1.0 eV to 17.0 eV. One interesting feature of these data is that there are two well defined groups of ions. The angular distribution data does not indicate any significant anistropy as observed previously for H_2.

10243. Richardson, J. M., **The functions of Commission I of the International Scientific Radio Union,** *Proc. IEEE* **55,** No. 6, 743-745 (June 1967).

Key words: International Scientific Radio Union (URSI); measurements; radio; standards.

The distinctive task of Commission I of the International Scientific Radio Union (URSI) is to extend the ability of all radio scientists to make valid measurements as a necessary means for the international exchange of scientific and engineering results. The Commission concentrates on: improved measurement methods applicable either to new phenomena or to closer tolerances for familiar phenomena, the highest national and international levels of accuracy, and progress for the long term. The Commission functions by surveying both progress and deficiencies in radio measurements and standards, by evaluating new results for their lasting contribution to the measurement structure of radio, by recommending the general adoption of proven advances and the pursuit of further research to remove deficiencies, and by giving its recommendations force and effect through the efforts of its members. A sketch of the international and national URSI organizations and operations is given. The functions are performed mainly by organizing technical meetings devoted to measurement and instrumentation, by encouraging pertinent publications, and by committee interactions with other international organizations having related interests. The organization has exerted significant impact on time and frequency standards, on international uniformity of radio standards, and on precision coaxial connectors as an aid to more accurate radio techniques.

10244. Winogradoff, N. N., Owen, K., Curnutt, R. M., **The radiative band pinch effect and temperature dependence of radiative recombination in GaAs,** *Int. J. Electronics* **22,** No. 3, 229-233 (Mar. 29, 1967).

Key words: GaAs; quantum efficiency; radiative recombination; ruby laser; temperature dependence.

Localized heating of GaAs by intense ruby laser flashes cause a reduction or "pinching" of the band gap in the illuminated region. The increase in wavelength of the recombination radiation from this region permits the study of the temperature dependence of the internal quantum efficiency without absorption in the colder, wide band gap regions.

The results show that the internal quantum efficiency decrease with an increase in temperature.

10245. Chivers, H. J. A., Hargreaves, J. K., **The use of multiple antennas in studies of absorption at conjugate points,** *Proc. Symp. High Latitude Particles and the Ionosphere, Alpbach, Austria, 1964,* pp. 257-264 (Academic Press Inc., New York, N.Y., 1965).

Key words: Absorption measurement; antennas-multiple; magnetically conjugate regions; multiple antenna.

As part of a program of absorption measurements in magnetically conjugate regions, a multiple antenna based on the corner reflector has been constructed. The use of this antenna is described and some preliminary results are mentioned.

10246. Milligan, D. E., Jacox, M. E., Abouaf-Marguin, L., **Vacuum-ultraviolet photolysis of acetylene in inert matrices. Spectroscopic study of the species C_2,** *J. Chem. Phys.* **46,** No. 12, 4562-4570 (June 15, 1967).

Key words: Acetylene; C_2; HC_2; infrared spectrum; Mulliken bands of C_2; Swan bands of C_2; ultraviolet spectrum; vacuum ultraviolet photolysis.

The vacuum ultraviolet photolysis of acetylene isolated in Ar, Ne, and N_2 matrices at 4° and at 14 °K is shown to lead to the appearance of a number of visible-ultraviolet absorption bands which may be assigned to the species C_2, as well as to an 1848 cm^{-1} infrared absorption assigned, with the aid of isotopic substitution studies, to the free radical HC_2. The (O,O) band of the Mulliken system of C_2 is observed with great intensity at 2382 Å (Ar matrix) or at 2323 Å (Ne matrix), indicating that the $x^1\sigma^+_g$ state of C_2 is the ground state of this species not only in the gas phase but also in the matrix. Features assigned by previous workers to the Swan transition of triplet C_2 appear at 5206 and 4725 Å. A third member of the progression, not previously observed, appears at 4334 Å. Experiments utilizing C_2D_2 and C_2H_2 (58% ^{13}C) support the assignment of these features to C_2. The 5206 Å band system decreases in intensity and finally disappears when the sample is subjected to radiation of wavelength near 2500 Å. Problems associated with the assignment of these features are discussed, and a possible mechanism for their photolytic destruction is suggested.

10247. Geltman, S., Holøein, E., **Variational calculations for quartet states of three-electron atomic systems,** *Phys. Rev.* **153,** No. 1, 81 (1967).

Key words: Basis functions; He^-; Li^+; Rayleigh-Ritz variational method.

The conventional Rayleigh-Ritz variational method in which one uses pure Slater-type orbitals and correlated factors $r^2_{\mu\nu}$ in the basis functions has been applied to obtain the eigenvalues of the five lowest lying states with symmetries $^4P^o$, $^4P^e$ and $^4S^e$ for three-electron atomic systems. To find the absolute minimum which is attainable for each eigenvalue, the nonlinear parameters (exponential parameters) have been varied freely in submatrices up to order 30 with 20 noncorrelated and 10 correlated basis functions. This variation has been carried through separately to find the five lowest eigenvalues of each symmetry in Li and for only the lowest one in He^-. For the other members of the isoelectronic sequence up to $Z = 10$, the absolute minima of the three lowest lying eigenvalues are found approximately by using the correlated subset of order 30 with common fixed exponential parameters for each symmetry and by freely varying the scale parameter.

The lowest $^4P^o$ state is found to be bound in He^- with a binding energy $\geq .033$ eV. No sign of binding is indicated for the lowest $^4S^e$ state, but the lowest $^4P^e$ state is also found to be bound by $\geq .20$ eV.

The results for Li indicate as certain that the transitions $^4S^e(1) - {}^4P^o(1)$ and $^4P^e(1) - {}^4P^o(1)$ are responsible for the two observed multiplets present at 2934 Å and 3714 Å, respectively, in the optical spectrum. These lines cannot be classified in the normal singly-excited spectrum of the atom or ion.

The results for Li are compared in detail with those obtained by recent electron impact experiments and by other theoretical calculations.

10248. Florin, R. E., **Comment on "Paramagnetic resonance of alkyl nitroxides,"** *J. Chem. Phys.* **47,** No. 1, 345-346 (July 1, 1967).

Key words: Diethylamine; diethyl nitroxide; dimethylamine; dimethyl nitroxide; electron spin resonance; free radicals; oxidation.

Intense ESR spectra of dimethyl nitroxide and diethyl nitroxide were obtained by mixing an amine carbonate solution of pH about 8, containing hydrogen peroxide, with ceric ammonium sulfate in a rapid flow mixer. In water at 25 °C, the spectral parameters are: $(CH_3)_2NO$, $a^N = 17.1$ G, $a_\beta{}^H = 14.6$ G, $g = 2.0055$; $(C_2H_5)_2NO$, $a^N = 16.8$ G, $a_\beta{}^H = 11.6$ G, $g = 2.0054$. The splittings are 10-20 percent larger than those reported in chloroform.

10249. Wait, J. R., **Characteristics of a slotted-sphere antenna immersed in a compressible plasma,** (Proc. Conf. Microwave Behaviour of Ferrimagnetics and Plasmas), *Conf. Publ.* No. 13, pp. 1-4 (Inst. Electrical Engineers, London, England, 1965).

Key words: Antenna; compressible plasma; plasma; slotted-sphere antenna.

Radiation from a spherical antenna in a compressible plasma is considered. The model is a perfectly conducting rigid sphere which is excited by an annular slot. The configuration is such that Maxwell's equations, when combined with a (single fluid) continuum theory of fluid dynamics, are separable.

In general, it is found that the electromagnetic component G_e of the radiation conductance is only slightly modified from that expected in a cold plasma. On the other hand, the electroacoustic component G_p of the radiation conductance has an appreciable magnitude for the warm plasma.

Numerical results indicate that G_p may become very large for certain values of the parameters. These are interpreted as resonances of the azimuthal surface waves which propagate along the rigid metal-plasma boundary.

10250. Vinti, J. P., **The spheroidal method in satellite astronomy,** Chapter in *Space Mathematics* **5,** Part 1, 119-129 (American Mathematical Society, Providence, Rhode Island, 1966).

Key words: Astronomy; dynamical astronomy; oblate planet; satellite astronomy; spheroidal method.

To calculate the drag-free orbit of an artificial satellite of an oblate planet, the author has devised a very accurate approximation for its gravitational potential, leading to separability of the problem in oblate spheroidal coordinates. The present paper sketches the procedures for finding this potential and for calculating the corresponding orbit. It then discusses the remaining perturbing potential and a method for accounting for its effect on the orbit.

10251. Niesen, E., **Protection circuit insulated for high voltage,** *Rev. Sci. Instr.* **38,** No. 5, 689 (May 1967).

Key words: Circuit; high voltage; microamperes; millivolts; optical meter relay.

A circuit using standard components for floating an optical meter relay at high voltage is presented. By plugging in available optical meter relays, sensitivities in microamperes to amperes, millivolts to kilovolts can be controlled for a high or low limit.

10252. Brualdi, R. A., Newman, M., **Proof of a permanental inequality,** *Quart. J. Math.* **17,** No. 67, 234-238 (Sept. 1966).

Key words: Non-negative row-stochastic matrix; permanental inequality; row-stochastic matrix.

The principal result of this note is that if A is a non-negative row-stochastic matrix then per(I-A) $\geqslant 0$ where per(A) denotes the permanent of A. The case of equality is discussed.

10253. Kerns, D. M., Grandy, W. T., Jr., **Perturbation theorems for waveguide junctions, with applications,** *IEEE Trans. Microwave Theory Tech.* **MTT-14,** No. 2, 85-92 (Feb. 1966).

Key words: Matrix elements; perturbation approach; waveguide junctions.

Perturbation theorems are derived in the context of a theory of waveguide junctions. These theorems express changes in impedance or admittance matrix elements, due to changes in a waveguide junction, in terms of integrals over products of perturbed and unperturbed basis fields associated with the junction and with its adjoint. Media involved are required only to be linear.

Concepts of first-order perturbation theory are discussed briefly, and the term "correct to the lowest order" is precisely defined. The need of explicit theorems telling when one may expect results actually correct to the lowest order is noted.

Two problems are solved approximately by the perturbation approach: (1) reflection at the junction of rectangular waveguide with filleted waveguide of the same main dimensions; and (2) the effect of finite conductivity of both obstacle and waveguide wall for half-round inductive obstacles in rectangular waveguide.

10254. Larson, W., **Analysis of rotationally misaligned stators in the rotary-vane attenuator,** *IEEE Trans. Instr. Meas.* **IM-16,** No. 3, 225-231 (Sept. 1967).

Key words: Attenuator; attenuation difference; attenuation error; misaligned stator; rotary-vane attenuator.

Two types of errors are caused by misaligned stators in the rotary-vane attenuator. For each type of error the actual attenuation will differ from the indicated attenuation values throughout most of the usable range of the attenuator.

This analysis illustrates that these two types of errors are related to the technique of alignment used in establishing the zero reference of the rotating vane to the stator vanes. Equations pertaining to these errors are discussed and are solved with the aid of tables of attenuation error as a function of vane angle error for rotary-vane attenuators. Graphs of both types of errors are presented determining the parameters needed to establish limits of machining tolerances for each waveguide size.

10255. Moore, G. A., **Application of computers to quantitative analysis of microstructures,** Chapter in *Proc. Second Intern. Congress for Stereology, Chicago, Ill., Apr. 8-13, 1967,* H. Elias, ed., pp. 281-284 (Springer-Verlag, New York, N.Y., 1967).

Key words: Automatic scanning (of micrographs); computer processing (of micrographs); logical modification of pictures; precision scanning (of micrographs); quantitative microscopy; stereological analysis.

Stereological projections from any micrograph require evaluation of particle size and shape, thus observation on a dense raster limited only by the resolution of the microscope and observing system. The required large number of observations dictate automatic scanning and computer processing of the image. Results are limited by statistical inefficiency and precision of observation. Using high precision scanning equipment, the inaccuracies of measurement remain comparable to the limits imposed by statistics. Presently attainable precision is, however, an order of magnitude better than can normally be obtained by manual methods.

The presence or absence of a specific phase can be represented by a two-dimensional binary array which can be rapidly processed to yield the required measurements. Logical modification by the computer is frequently necessary to substitute for some of the logical discriminations normally made by the human analyst and to facilitate the desired measurements. Logical processes can reveal stereological relationships, construct morphological models, and dissect and describe the individual particles.

10256. Franklin, A. D., **Born-model calculation of point-defect formation energies in alkaline-earth fluorides,** (Proc. 2nd Meeting Point Defects in Non-metallic Solids, University of Sussex, Brighton, England, Sept. 26-28, 1966) *Proc. British Ceram. Soc.* **9,** 15-24 (July 1967).

Key words: Alkaline earth fluorides; Born model; energies of formation; ionic crystals; point defects.

A Born-model calculation of the lattice energy required to form anion and cation vacancies and interstitials has been performed for SrF_2 and BaF_2, following techniques used earlier for CaF_2. Anion Frenkel pairs are the favored intrinsic defects for SrF_2 and BaF_2 as well as for CaF_2, the formation energy decreasing somewhat from CaF_2 to BaF_2. In the presence of substitutional trivalent cation impurities, the tendency to form anion interstitials as the charge-compensating defect should be strongest in BaF_2, least in CaF_2, with SrF_2 again intermediate.

10257. McCrackin, F. L., **Configuration of isolated polymer molecules adsorbed on solid surfaces studied by Monte-Carlo computer simulation,** *J. Chem. Phys.* **47,** No. 6, 1980-1986 (Sept. 15, 1967).

Key words: Adsorption; configurations; four-choice cubic lattice; Monte Carlo; polymers.

The configurations of adsorbed polymer molecules with excluded volume were simulated on a four-choice simple cubic lattice using a computer. The average values of the fraction of segments on the surface, loops off the surface, normal distance of the end of the molecule from the surface, root mean square of the normal distance, maximum normal distance from the surface, and root-mean-square end-to-end distance were calculated for various lengths of the molecules and various attractive energies between segments and the surface. When these averages over the configurations are compared with previous results which do not account for the excluded-volume effect, important differences are found.

10258. Silver, A. H., Zimmerman, J. E., Kamper, R. A., **Contribution of thermal noise to the line-width of Josephson radiation from superconducting point contacts,** *Appl. Phys. Letters* **11,** No. 6, 209-211 (Sept. 15, 1967).

Key words: Josephson radiation; line-width; point contacts; superconductivity; thermal noise.

The line-width of the Josephson oscillations of a voltage-biased superconducting point contact has been measured between 1.4 °K and 8 °K, with bias resistors R between $1.7 \times 10^{-10}\ \Omega$ and $2.6 \times 10^{-5}\ \Omega$. Within the experimental accuracy the line-width is proportional to RT, and is consistent with the estimated theoretical value $8kTR/\Phi_0^2$, where k is Boltzmann's constant and Φ_0 is the flux quantum. Line-widths below 0.1 Hz have been observed at 4.2 °K for $R = 1.7 \times 10^{-10}\ \Omega$, providing an experimental upper limit to other noise sources and indicating that this is useful as a voltmeter and thermometer below 10^{-16} V and 10^{-4} °K.

10259. Hust, J. G., McCarty, R. D., **Curve-fitting techniques and applications to thermodynamics,** *Cryogenics* **7,** No. 4, 200-206 (Aug. 1967).

Key words: Constraints; curve fitting; least squares; non-linear; thermodynamics; weighting.

The general problem of least squares fitting is considered. For completeness, derivations of well-known relations are included along with the developments of new techniques for imposing constraints on the unknown parameters, and of fitting data for several different properties simultaneously for both linear and non-linear equations. Several thermodynamic applications are included to illustrate the techniques developed.

10260. Phillips, C. W., Penny, R. W., **Development of a method for testing and rating refrigerated truck bodies,** *USDA Tech. Bull.* No. 1376 (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Sept. 1967, 15 cents).

Key words: Air leakage; cooling loads; rating and testing; refrigerated truck bodies; simulated solar heating; weight gain.

A recommended standard method is presented for testing and rating the cooling load due to heat transmission and air and moisture leakage into refrigerated truck bodies used for stop and go delivery of perishable chilled or frozen food. Results of laboratory tests of five typical vehicles, with and without simulated solar heating, were used as a basis for determining criteria for the testing and rating procedure. A steady-state test procedure, with appropriate multipliers to account for solar heating is recommended. Rating conditions of 0 °F and 35 °F interior temperature and 100 °F and 50 percent ambient temperature and relative humidity are suggested. Means for calculating air leakage rate from observed weight gain rate under standard test conditions are incorporated. Measurement of service cooling loads caused by warm cargo or by air exchange through opening and closing of doors is not included in the recommended procedure. However, such service loads must be considered in determining the capacity of an adequate refrigeration system.

10261. Bowen, R. L., Argentar, H., **Diminishing discoloration in methacrylate accelerator systems,** *J. Am. Dental Assoc.* **75,** No. 4, 918-923 (Oct. 1967).

Key words: Accelerators; color formation; discoloration; methacrylate; N,N - dimethyl - 3,5 - dimethylaniline; polymerization.

A method was devised for accentuating the formation of discoloration products that may form during the free radical polymerization of methacrylates at room temperature. Various accelerators and stabilizers were compared on an equimolar basis. The selection of the materials was based on literature information regarding current theories of free radical polymerization and the absorption of visible light by organic compounds. The use of the sterically hindered phenol, butylated hydroxytoluene, did not produce discoloration whereas, the use of hydroquinone or the monomethylether of hydroquinone had a darkening effect. A compound (N,N-dimethyl-3,5-dimethylaniline) was synthesized which was an effective accelerator and which produced less discoloration than N,N-dimethyl-p-toluidene.

10262. Schweitzer, W. G., Jr., Birky, M. M., White, J. A., **Ears on the line profile of decay transitions in a gas laser,** *J. Opt. Soc. Am.* **57,** No. 10, 1226-1230 (Oct. 1967).

Key words: Laser; lifetime; line profile; neon.

In a gas laser a spectrum line, whose upper state is the lower state of the laser transition, may contain a structure due to the laser action. We have observed this structure, which we refer to as ears, on the 6096-Å neon line emitted spontaneously in a 1.15 μ He-Ne laser. The width of the ear was measured interferometrically and compared with the width predicted from the phenomenological width γ_{ab}/π in the laser transition.

10263. Foley, C. L., Kruger, J., Bechtoldt, C. J., **Electron diffraction studies of active, passive, and transpassive oxide films formed on iron,** *J. Electrochem. Soc.* **114,** No. 10, 994-1001 (Oct. 1967).

Key words: Electron diffraction; gamma-Fe_2O_3; iron; passivation.

Iron foil specimens were anodically polarized by means of a potentiostat in 1N H_2SO_4, 0.1N NaOH and a sodium borate boric acid solution (pH, 8.5). Both passive, active and transpassive regions of the polarization curve were studied for each solution. The oxide films were examined while still in contact with the iron foil by selected area transmission electron diffraction. Five iron planes were studied: $\{100\}$, $\{110\}$, $\{111\}$, $\{210\}$ and $\{211\}$, and the epitaxial relationship of the oxide to the iron substrate determined. Evidence was found indicating that in all of the electrolytes used the passive film contained γ-Fe_2O_3, while the non-passive films did not.

10264. Peverley, J. R., Meijer, P. H. E., **Entropy and susceptibility of a pure dipole-dipole substance,** *Phys. Stat. Sol.* **23,** No. 1, 353-360 (1967).

Key words: Cerous magnesium nitrate; Curie-Weiss constant; dipole-dipole interaction (pure); entropy; lattice sums; magnetic susceptibility; transition temperature.

Recalculation of the lattice sums for a pure dipole-dipole interaction show that the Curie-Weiss constant, for fields perpendicular to the *c*-axis is equal to 0.273 mdeg for cerous magnesium nitrate. A *g*-value of 1.82 was used. The temperature dependence of the entropy was determined and is compared with the experimental values of Hudson and Kaeser. All lattice sums have been determined as a function of slight changes in the lattice constants. The *z*-component of the dipolar lattice sum is determined by means of a new procedure to improve the slow convergence of this series.

10265. Mullen, L. O., Hiza, M. J., **Experimental apparatus and procedures for evaluating parameters affecting the pumping efficiency of a cryogenically cooled plane,** *J. Vacuum Sci. Technol.* **4,** No. 5, 219-229 (Sept.-Oct. 1967).

Key words: Capture coefficient; cryocondensation; cryogenically cooled surfaces; cryopump; partial pressure measurements; pressure calibration with vapor pressures; pressure anisotropy; pumping efficiency; pumping speed; speed factor measurements; sticking coefficient; vacuum techniques.

The collection efficiency of a plane acting as a pump in a vacuum system can be determined by measuring the rate at which molecules of a given species strike and the rate at which they return from that plane. This paper discusses an experimental vacuum system incorporating a moveable partial pressure analyzer capable of making such measurements. The experimental procedure discussed here provides a means for evaluating parameters affecting the pumping efficiency. Efficiency values obtained by the present approach are compared with values obtained from kinetic theory and from speed factor measurements. The experimental data show that much of the deviation of reported pumping efficiencies can be explained by fragmentation of the test gas molecules and by a pressure anisotropy in the test dome. A means of calibrating the analyzer with vapor pressure data is also discussed.

10266. Brombacher, W. G., **40 years of precise measurement,** *Instr. Control Systems* **40,** No. 9, 87-92 (Sept. 1967).

Key words: Pressure gages; pressure measurement; vacuum measurement.

Progress in pressure measurement during the past 40 years is described. Most types of pressure-sensitive elements now available were already in use then. The advances made have consisted mainly of (a) increasing measurement range (b) increasing sensitivity, accuracy, and dependability, and (c) increasing use of gages to automate industrial processes.

10267. Rebbert, R. E., Ausloos, P., **Gas-phase photolysis of ethyl iodide at 2537 and 2288 Å. Reactions of hot ethyl radicals with added hydrocarbons,** *J. Chem. Phys.* **47,** No. 8, 2849-2855 (Oct. 15, 1967).

Key words: Alkyl radicals; deactivation; ethyl iodide; "hot" radicals; hydrogen abstraction; photolysis.

The photolysis of C_2H_5I and C_2D_5I have been investigated at 2537 Å and 2288 Å in the presence of thermal alkyl radical scavengers such as O_2 and I_2. The ethane (quantum yields at 2537 Å: $\Phi_{C_2H_6} = 0.82 \times 10^{-3}$, $\Phi_{C_2O_6} = 0.29 \times 10^{-3}$) formed in such mixtures can be entirely ascribed to abstraction of a H (or D) atom by a "hot" ethyl radical formed in the primary dissociation of ethyl iodide. When C_2D_5I or C_2H_5I is photolyzed in the presence of a cyclo-C_6H_{12} − cyclo-C_6D_{12} − O_2 mixture (1:1:0.1), or of a cyclohexane-1,1,2,2,3,3-d_6 − O_2 mixture, the relative probability for abstraction of an H atom versus that for abstraction of a D atom (π_H/π_D) is equal to 1.5 ± 0.1. Added gases do reduce the probability of the abstraction process. The relative quenching probability of the "hot" $C_2D_5^*$ radical by different additives is as follows: He − 0.50; Ne − 0.62; N_2 − 1.00; and CO_2 − 1.51.

When C_2H_5I is photolyzed at 2537 Å in the presence of $CD_3CH_2CD_3$, $CH_3CD_2CH_3$ or $CD_3CH_2CH_2CD_3$ the relative probability per atom for the abstraction of a primary compared to a secondary H-atom in a hydrocarbon molecule by a hot ethyl radical is 1:4.5. Moreover, the quantum yield for ethane formation at 2537 Å per secondary hydrogen atom for a series of cycloalkanes and normal alkanes is $0.32 \pm 0.07 \times 10^{-3}$.

10268. Marinenko, G., Taylor, J. K., **High-precision coulometric iodimetry,** *Anal. Chem.* **39,** No. 13, 1568-1571 (Nov. 1967).

Key words: Arsenious oxide; constant-current coulometry; current efficiency; high-precision analysis; iodimetry.

On the basis of measurement of the potential of the working platinum anode as a function of current density and concentration of KI in solution, conditions were established for 100.0000 percent efficient generation of iodine. NBS Standard Reference Material arsenious oxide was analyzed utilizing optimum conditions for generation of iodine and for the stoichiometric reaction of arsenious acid with iodine. The precision of the method for titration of 0.5g samples of As_2O_3 is about 0.003 percent. Analysis of data for the assay of samples ranging in size from 100mg to 1g indicates no bias in the method. Coulometric assay of SRM 83c is 99.986 ± 0.003 percent, which is in close agreement with the titrimetric comparison of 83c to iodine, purified by sublimation. This fact serves as additional evidence of the accuracy of the developed method.

10269. Lloyd, E. C., **Improving pressure and vacuum measurement standards,** *Instr. Control Systems* **40,** No. 9, 105-109 (Sept. 1967).

Key words: Accuracy; calibration; measurement; pressure; standards; vacuum.

Results of NBS developments are outlined in a number of projects relating to standards for improved measurement of pressures throughout the range from vacuum to very-high pressures. In the vacuum range this includes techniques for generation of stable reference pressures, and improved absolute instruments for force per unit area measurement down to 10^{-9} torr. In the range from a few millibars to hundreds of kilobars the use of fixed points, and the performance of improved piston gages and interpolation instruments, are described. Problems presently limiting accuracy of calibration and NBS investigations of possible solutions are mentioned. Two new "accuracy charts" are presented showing present and possible future NBS capabilities.

10270. Powell, C. J., **Inelastic scattering of kilovolt electrons by solids and liquids: determination of energy losses, cross sections, and correlations with optical data,** *Health Phys.* **13,** No. 12, 1265-1275 (1967).

Key words: Characteristic energy losses; comparison with optical data; cross sections; inelastic scattering; kilovolt electrons; liquids; solids.

Some recent measurements of the inelastic scattering of kilovolt electrons by solids and liquids are described. The determination of energy losses and cross sections is discussed as well as factors influencing the accuracy of measurement. The degree of correlation between optical and electron energy loss experiments also is described.

10271. McIntyre, D., Wims, A. M., **Light scattering phenomena near the critical point,** (Proc. 2nd Interdisciplinary Conf. Electromagnetic Scattering ICES-11, University of Massachusetts, Amherst, Mass., June 28-30, 1965), Chapter in *Electromagnetic Scattering,* R. L. Rowell and R. Stein, eds., pp. 457-484 (Gordon and Breach, Inc., New York, N.Y., 1967).

Key words: Binary mixtures; coexistence curves; critical mixtures; critical opalescence; light scattering; phase separations.

The scattering from liquids and liquid mixtures near their critical points has been extensively studied in recent years. The existing experimental data are discussed with respect to their usefulness and limitations in sorting out the various statistical mechanical descriptions of critical phenomena. Scattering measurements on polystyrene-cyclohexane, cyclohexane-aniline, perfluoroheptane-isooctane, nitroethane-3-methylpentane are reported and discussed.

10272. Matsushita, S., **Lunar tides in the ionosphere,** *Encyclopedia of Physics* **XLIX/2,** 547-602 (Springer-Verlag, Berlin, Germany, 1967).

Key words: Ionosphere; lunar tides; lunar variations; surface atmosphere.

All previous work on lunar tidal variations in the ionospheric F2, F1, E, Es, and D layers by various researchers are thoroughly reviewed and are compared with recent results of lunar tides obtained from ionospheric electron density profile data and also with radio observations of lunar tidal winds in the ionosphere. A world-wide behavior of the lunar tides in different ionospheric layers is then obtained.

After reviewing lunar tidal variations in the surface atmosphere, geomagnetic lunar variations at several places are examined, and a new lunar current system at about 100 Km altitude is suggested. Based on this current system the lunar tides in the ionosphere are discussed theoretically, taking into consideration both hydro and electro dynamical motions.

10273. Wegstein, J. H., Rafferty, J. F., **Machine oriented fingerprint classification system,** Proc. First Natl. Symp. Law Enforcement Science and Technology, Chicago, Illinois, Mar. 7-9, 1967, Chapter V in *Information Storage and Retrieval,* S.A. Yefsky, ed., **1,** 495-465 (Academic Press Inc., New York, N.Y., 1967).

Key words: Automated; bifurcations; classification; descriptor; endings; fingerprint; Henry system; identification; minutia; ridge; system.

The current state-of-the-art leads one to believe that computers and their associated high-speed mass stores can be utilized in handling large fingerprint files. Toward this end, a single-print classification system is explored. Requirements and objectives are listed. Needed measurements and statistical analyses of variations in details of fingerprints are identified.

10274. Dibeler, V. H., Walker, J. A., **Mass-spectrometric study of photoionization. VI. O_2, CO_2, COS, and CS_2,** *J. Opt. Soc. Am.* **57**, No. 8, 1007-1012 (Aug. 1967).

Key words: Autoionization; CO_2; COS; CS_2; electronic; excited states; heats of formation; ionization thresholds; ions; mass spectrometry; O_2; photoionization; radicals; Rydberg series; vaccum ultraviolet.

Photoionization efficiency curves are obtained for the molecule and fragment ions of the subject molecules in the wavelength region extending from onset of ionization to 600 Å. The initial onset of O_2^+ is observed at 12.072 eV. Autoionization in the continuum is correlated with various progressions of Rydberg series. Curves for both O^+ and O^- ions formed by the ion-pair process from O_2 are obtained and 1.48 eV is derived for the electron affinity of oxygen atoms. The shape of the CO_2^+ curve including structure ascribed to autoionization is discussed. The unresolved $^2\Pi_g$ doublet threshold is observed at 13.77 eV with the first vibrational level at 13.93 eV. The onset of the O^+ fragment ion indicates about 0.04 eV excess energy in the dissociation process. It is suggested that dissociative ionization occurs from the autoionizing Rydberg level just above the calculated threshold value. Partially resolved doublet components of COS^+ are observed at 11.18 and 11.22 eV, respectively. Intense autoionization is observed. Various thermochemical values are calculated from the fragment ion thresholds. The doublet components of the ion ground state of CS_2^+ are observed at 10.059 and 10.12 eV, respectively. Intense autoionization is observed at wavelengths which are in excellent agreement with known Rydberg levels for the molecule. Although the S^+ ion is formed with excess energy, the CS^+ ion gives a value of 11.71 eV for the ionization energy of the CS radical. This is in agreement with, but more precise than, a directly measured electron impact value.

10275. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the reaction of carbon atoms with HCl. The infrared spectrum of the free radical HCCl,** *J. Chem. Phys.* **47**, No. 5, 1626-1633 (Sept. 1, 1967).

Key words: C atom reactions; cyanogen azide; electronic spectrum; force constants; HCCl free radical; HCl reaction; infrared spectrum; matrix isolation; monochlorocarbodiimide; monochlorocyanamide; NCN reactions; photolysis; thermodynamic properties.

The infrared spectrum of samples of cyanogen azide plus hydrogen chloride isolated in an argon or a nitrogen matrix at 14 °K and subjected to photolyzing radiation under conditions previously shown to lead to the production of carbon atoms includes features at 815 and 1201 cm^{-1} which may be assigned to the free radical HCCl. ^{13}C- and D-substitution experiments are consistent with this identification. A band system extending between about 7500 and 5600 Å corresponds to the band system previously reported for HCCl in the gas phase. These observations confirm the production of HCCl in the present experiments and indicate that the lower state of the transition observed for HCCl in the gas phase studies is the ground state. The force constants and thermodynamic properties of HCCl have been estimated. Evidence is presented for the reaction of NCN, a photolytic intermediate in the production of carbon atoms from cyanogen azide, with HCl to produce an incompletely characterized species, probably either monochlorocyanamide or monochlorocarbodiimide. HCCl reacts with HCl with little or no activation energy, leading to the stabilization of CH_2Cl_2.

10276. Horowitz, E., **Metallo-organic polymers,** *Mod. Plastics* **45**, No. 3, 146-148 (Nov. 1967).

Key words: Metallo-organic polymers; role of metal and ligand; synthesis; thermal stability.

Certain organic molecules containing electron-donating groups such as derivatives of bis(8-hydroxyquinoline) can be reacted with metal ions to yield metallo-organic polymers in which the metal atoms are linked in the backbone. Both linear and cross-linked polymers have been prepared and their thermal stabilities have been investigated. It has been shown that the thermal stability of these polymers is related to the properties of the metal and the composition of the organic component.

10277. Mountain, R. D., Litovitz, T. A., **Negative dispersion and Brillouin scattering,** *J. Acoust. Soc. Am.* **42**, No. 2, 516-517 (Aug. 1967).

Key words: Brillouin scattering; elastic modulus; liquid; negative dispersion relaxation of viscosity; temporal absorption.

The fluctuations in density observed in Brillouin scattering may be represented as temporally absorbed waves. Negative dispersion occurs for these waves although it may be masked by positive dispersion due to relaxation processes. Numerical estimates of velocity and of negative dispersion are made for CCl_4 at 20 °C. The importance of measuring both the position and the width of the Brillouin peaks in order to obtain the elastic modulus of the liquid is stressed.

10278. Johannesen, R. B., **NMR studies of inorganic fluorides. III. Si_3F_8,** *J. Chem. Phys.* **47**, No. 3, 955-960 (Aug. 1, 1967).

Key words: Chemical shift; double resonance; fluorine; fluorosilanes; nuclear magnetic resonance; octafluorotrisilane; silicon; spin coupling constants.

A high-resolution NMR study of octafluorotrisilane, Si_3F_8, is reported. The chemical shifts of ^{19}F and ^{29}Si, relative to SiF_4 as a reference, are given. Coupling constants, including in every case the relative sign, are given for isotopic species containing not more than one ^{29}Si atom. The results are compared with the corresponding values for SiF_4 and Si_2F_6.

10279. Dibeler, V. H., **N_2O bond dissociation energy by photon impact,** *J. Chem. Phys.* **47**, No. 6, 2191-2192 (Sept. 15, 1967).

Key words: Bond-dissociation energy; N_2O, N_2^+ photoionization.

A brief report is made of the dissociative ionization of N_2O to give the N_2^+ ion from ordinary and from ^{15}N-labeled material. The latter is employed to avoid the effects of nitrogen impurity. The resulting experimental value of $D(N_2\text{-}O) = 39.0$ kcal mol^{-1} is in good agreement with the value calculated from heats of formation.

10280. Bennett, L. H., **Nuclear magnetic resonance in sodium thallide,** *Acta Met.* **14**, No. 8, 997-999 (1966).

Key words: Alloys; compounds; intermetallic; Knight shift; nuclear magnetic resonance; sodium; thallium; x-ray diffraction.

The nuclear magnetic resonance signal for $Tl^{203,205}$ is observed in sodium thallide alloys. It is determined that the previously reported negative Knight shift value of one percent for NaTl was essentially correct, and the more recently reported negative value of one-half percent was in fact for $NaTl_2$. A crystal structure is proposed for $NaTl_2$.

10281. Bennett, L. H., **Nuclear magnetic resonance in zintl intermediate phases LiCd and LiZn,** *Phys. Rev.* **150,** No. 2, 418-420 (Oct. 1966).

Key words: B-32 structure; Knight shifts; LiCd; linewidths; LiZn; nuclear magnetic resonance; zintl phase.

The nuclear magnetic resonances have been observed for Li^7 and Cd^{113} in LiCd and for Li^7 and Zn^{67} in LiZn. The Knight shift for $LiCd^{113}$ is 0.39 percent for $LiZn^{67}$ 0.20 percent, for LiCd or LiZn less than 0.01 percent. An energy band scheme is proposed.

10282. Utton, D. B., **Nuclear quadrupole resonance thermometry,** *Metrologia* **3,** No. 4, 98-105 (Oct. 1967).

Key words: Instrumentation; nuclear quadrupole resonance thermometry 12 °K – 297 °K; potassium chlorate.

The nuclear quadrupole resonance frequency of ^{35}Cl in $KClO_3$ has been studied in the temperature range 12 °K – 297 °K. The combined uncertainties in the frequency and temperature measurements correspond to ±.001 °K in the range 50 °K – 297 °K, deteriorating to ±.004 °K at 30 °K and ±.010 °K at 20 °K. Both the nuclear resonance spectrometer and the temperature control apparatus are described. The experimental data are fitted to a theoretical expression in the temperature range 12 °K – 90 °K; at higher temperatures the data are fitted to empirical polynomials.

10283. Smith, A. L., **Observing the effect of a change in mass on deBroglie wavelength: the 600-Å bands of $^3He_2$,** *J. Chem. Phys.* **47,** No. 4, 1561-1562 (Aug. 15, 1967).

Key words: Band strengths; continuum emission; deBroglie wavelength; diatomic molecule; He_2; helium isotopes; radiative deexcitation; ultraviolet spectra; quantum mechanics.

The band-like continuum emitted in the radiative deexcitation of singlet metastable ^3He by ^3He has been observed. This spectrum and the corresponding continuum in ^4He are interpreted as reflecting the structure of a standing deBroglie wave over an attractive potential well. The ^3He continuum contains one less maximum than does the ^4He continuum in the range $602\ Å < \lambda < 666\ Å$; i.e., for two particles of different mass moving with the same energy over the same attractive well, the lighter particle has the longer deBroglie wavelength. The shifts in peak positions are accounted for quantitatively by calculating the continuum-continuum band strengths of the $A^1\Sigma_u^+ \rightarrow X^1\Sigma_g^+$ transition of He_2 for both isotopes.

10284. Mork, K. J., **Pair production by photons on electrons,** *Phys. Rev.* **160,** No. 5, 1065-1071 (Aug. 1967).

Key words: Cross sections; electron pairs; exchange; numerical integration; photons.

The cross section for production of electron pairs by unpolarized photons in the field of an electron is calculated. The total cross section is obtained by numerical integration. The contributions to the total cross section from different diagrams (exchange and γ-e terms) are calculated separately, and it is shown that Borsellino's result for the cross section is valid for photon energies above about 8 MeV, the deviation from the correct cross section being of order 1 percent at this energy. Votruba's results for the total cross section are confirmed for energies very close to threshold (within about 10 keV of threshold). The results of Kopylov *et al.* appear to be in error by a factor of 2. Dividing their results by this factor, we find agreement with ours within limits of error. The recoil momentum distribution is computed numerically for some energies and it is found to agree with the results of Borsellino. At high energies it is also in agreement with the results of Suh and Bethe. The momentum distribution for pair production in the field of a very heavy particle is also calculated for some energies from the formulas of Borsellino and Jost *et al.* From a comparison of the recoil distributions for pair production on electrons with that on very heavy particles, an estimate of the error in the Wheeler-Lamb results can be made. Comparison with some experiments is given.

10285. Fatiadi, A. J., **Periodic acid, a novel oxidant of polycyclic aromatic hydrocarbons,** *Chem. Commun.* **21,** 1087-1088 (1967).

Key words: Aprotic solvent; paraperiodic acid; polycyclic aromatic hydrocarbons; reaction mechanism; sodium periodate.

Certain polycyclic, aromatic hydrocarbons can be oxidized in good yield to quinones with paraperiodic acid in aprotic solvents containing a small proportion of water. No reaction was observed when oxidation was attempted with sodium periodate, instead of periodic acid. A possible reaction path for the oxidation has been suggested.

10286. Fatiadi, A. J., Isbell, H. S., **Phenylhydrazono-phenylazo tautomerism. Part II. Structures of 2-oxo-1,3-bis(phenylhydrazono) compounds and related compounds,** *Carbohydr. Res.* **5,** 302-319 (1967).

Key words: Diphenylformazans; enolic phenylhydrazono-phenylazo structure; infrared spectra; molecular structure; nuclear magnetic resonance; oxo-bis (phenylhydrazono) compounds; phenylhydrazono-phenylazo tautomerism; phenylosazones; tautomerism; ultraviolet spectra.

The structures of xylo-4,5,6-trihydroxy-2-oxo-1,3-bis(phenylhydrazono) cyclohexane (*1*), 2-oxo-1,3-bis(phenylhydrazono) cyclohexane (*2*), 2-oxo-1,3-bis(phenylhydrazono)cyclopentane (*3*), 3-oxo-2,4-bis(phenylhydrazono)cyclohexanecarboxylic acid (*4*), 2-oxo-1,3-bis(phenylhydrazono)indane (*5*), and 2-oxo-1,3-bis(phenylhydrazono)propane (*6*), were studied by comparison of their n.m.r., u.v., visible and i.r. spectra with the spectra of reference compounds of known structures. The results show the compounds exist in two forms. The red forms have an enolic (chelated) phenylhydrazono – phenylazo structure.

A similarity of the compounds to the diphenylformazans is noted and substantiated by a comparison of absorption spectra. Compound 2 crystallizes from aqueous ethyl alcohol in the form of a yellow hydrate shown to have a phenylhydrazono structure. On dehydration, the yellow hydrate yields the red enolic form. The structures of the 1,2,3-tris(phenylhydrazono) derivatives of cyclohexane, cyclopentane and cyclohexanecarboxylic acid were also studied.

10287. Coriell, S. R., Jackson, J. L., **Probability distribution of the radius of gyration of a flexible polymer,** *J. Math. Phys.* **8,** No. 6, 1276-1284 (June 1967).

Key words: Brownian chain; distribution; Gaussian; polymer; radius of gyration; Tchebichef Polynomial.

Various aspects of the mathematics of the probability distribution $P_N(S_x)$ of one component of the square of the radius of gyration of an ideal Brownian chain with N units are presented. A rigorous expression for $P_N(S_x)$ in the form of a contour integral is obtained. The resulting integral is written in terms of Tchebichef Polynomials. Various rigorous and approximate results are obtained for both the limiting distribution (N infinite) and for finite N.

10288. Hord, J., **Response of pneumatic pressure-measurement systems to a step input in the free molecule, transition, and continuum flow regimes,** *ISA Trans.* **6,** No. 3, 252-260 (July 1967).

Key words: Response of pneumatic pressure-measurement systems in the free molecule, transition, and continuum flow regimes; response of pneumatic pressure-sensing tubulation; response of pneumatic transmission lines; time constants of pneumatic pressure lines; time lag and delay in pneumatic pressure-sensing lines; time response of pneumatic pressure-sensing systems to step inputs.

A simplified analysis of the response of pressure-sensing devices and their interconnecting tubing is presented. The results are conveniently presented in the form of time equations, with a fraction of the applied step (usually 63.2%) attained at the sensor as the variable. A single algebraic equation adequately predicts the response of pressure-measuring systems in the free molecule, transition, and continuum flow regimes. Two very simple algebraic equations may be used to predict time response in the free molecule and continuum flow regimes. The formulas are limited where viscous flow occurs, and they are not restricted for free molecule flow. All of the formulas are suitable for field engineering applications. The literature is synthesized by comparing the results from selected references with those of the analysis. Factors influencing transient pressure measurements are reviewed.

10289. Lane, N. F., Geltman, S., **Rotational excitation of diatomic molecules by slow electrons: application to H_2,** *Phys. Rev.* **160,** No. 1, 53-67 (Aug. 5, 1967).

Key words: Diatomic molecules; electron scattering; H_2; rigid rotator; rotational excitation.

The theory of electron scattering from a rigid rotator is applied to the case of low-energy scattering of electrons from hydrogen molecules in ground electronic and vibrational states. The coupled equations are solved numerically and the resulting S matrix is used to calculate elastic, rotational excitation, and rotational de-excitation cross sections. The electron-molecule interaction potential is based on the approximate charge distribution of H_2 and includes the effects of polarization, which are shown to be important. Cross sections are given for several rotational states, and it is pointed out that while the elastic and inelastic cross sections are found to depend on the initial rotational angular momentum j of the molecule, their variation in j is such that the total cross section remains independent of j. The effects of "back coupling" and coupling with higher rotational states are illustrated by comparing the results of the close-coupling calculation with those of the Born and distorted-wave methods; the distorted-wave and close-coupling results for rotational excitation are found to agree within 20 percent for all energies.

10290. Schoen, L. J., **Sapphire window mountings for low temperature spectroscopy,** *Rev. Sci. Instr.* **38,** No. 10, 1531-1532 (Oct. 1967).

Key words: Cryostat; deposit; thermal conductivity; thermal contact; window holder.

Two newly designed sapphire window mountings suitable for use at cryogenic temperatures are described. These should prove valuable in maintaining efficient, reproducible and trouble free thermal contact with conventional refrigerants.

10291. Oppenheim, I., Shuler, K. E., Weiss, G. H., **Stochastic theory of multistate relaxation processes,** *Adv. Mol. Relaxation Processes* **1,** No. 1, 13-68 (Nov. 1967).

Key words: First passage times; Fokker-Planck equation; Markov processes; master equation; relaxation processes; stochastic processes.

The stochastic theory of multistate relaxation processes is discussed with special reference to Markov Processes, the derivation and properties of the Master Equation, the derivation and properties of the Fokker-Planck Equation and First Passage Time problems. The theory developed is then applied to a number of examples.

10292. Danos, M., Gillet, V., **Stretch scheme, a shell-model description of deformed nuclei,** *Phys. Rev.* **161,** No. 4, 1034-1044 (Sept. 20, 1967).

Key words: Deformed nuclei; nuclear moments of inertia; nuclear rotation; nuclear shell model; nuclear spectra; nuclear structure.

A good angular momentum wave function containing the maximum possible intrinsic angular momenta leads to a microscopic description of the nuclear rotational spectra in terms of spherical shell model states. The rotational excitation energies arise from the residual two-body force. In the actual model calculations the only approximation was a partial violation of the exclusion principle. The computed departures from the $I(I + 1)$ law are consistent with the experiment. Reasons are given for the preference of positive over negative intrinsic deformations.

10293. Coyle, T. D., Ritter, J. J., **Structure, isomerization, and cleavage of 1,2-bis(dichloroboryl)ethylene,** *J. Am. Chem. Soc.* **89,** 5739-5740 (1967).

Key words: Acetylene; organoboron compounds; proton magnetic resonance; protonolysis; stereochemistry; tetrachlorodiborane(4); 1,2-bis(dichloroboryl)ethylene.

The product of the reaction of tetrachloroborane(4) with excess acetylene has been shown to be the *cis* isomer of 1,2-bis(dichloroboryl)-ethylene. This compound can be converted to the corresponding *trans* isomer by ultraviolet irradiation. Cleavage of the isomerically pure, deuterated organoboron compounds with ammoniacal silver oxide produces isomerically pure dideuteroethylenes. Acetic acid cleavage is not stereospecific.

10294. Weiss, A. W., **Superposition of configurations and atomic oscillator strengths – carbon I and II,** *Phys. Rev.* **162,** No. 1, 71-80 (Oct. 5, 1967).

Key words: Atomic energy levels; oscillator strengths; superposition of configurations; wavefunctions.

Variational wavefunctions are computed for the ground state and a number of excited states of carbon I and II by the method of superposition of configurations. To accelerate convergence, the virtual orbitals are obtained from a pseudo-natural orbital transformation on a single electron-pair, out of all those possible within a given quantum shell. Expansions of up to 50 configurations are generated and used to study the effects of correlation on the oscillator strengths. The method appears to be fairly successful in correcting for most of the correlation error in both the energy and "correlation sensitive" oscillator strengths. Term values are substantially improved over the Hartree-Fock, and generally, although not always, f-values appear to be obtainable with an accuracy of about 25 percent.

10295. Barbrow, L. E., **The metric system in Illuminating Engineering,** *Illum. Engr.* **LXII,** No. 11, 638-640 (Nov. 1967).

Key words: Exitance; illumination; luminance; lux; metric units; nit; SI units in illuminating engineering.

The most commonly used unit of illumination in the USA is the footcandle. There are two commonly used units of luminance, the footlambert and the candela per square inch. The growing international adoption of SI units makes it advisable for illuminating engineers to introduce the use of these units in their publications in the immediate future and to understand the implications of the use of the SI units. The SI unit of illumination is the lux (one lumen per square meter). The SI unit of luminance is one candela per square meter (sometimes named the nit). One of the basic principles and advantages of SI is that there can be only one unit for each quantity; thus there cannot be an SI unit similar to footlambert which is expressed in terms of lumens per unit area. Council of the Illuminating Engineering Society has been officially requested to (1) approve the policy of having SI units given primary use in its publications, and (2) promote the deprecation of "lumens per unit area" as a unit of luminance and sponsor its use solely as a unit of luminous exitance (formerly emittance).

10296. Meshkov, S., Yodh, G. B., **SU(3), meson-baryon scattering, and asymptotic limits,** *Phys. Rev. Letters* **19,** No. 10, 603-608 (Sept. 4, 1967).

Key words: Asymptotic; baryons; mesons; reaction; scattering; SU(3).

The meson-baryon total cross sections and elastic-scattering data in the forward direction are fitted using SU(3)-invariant t-channel amplitudes. The analysis implies that (1) $0 \leqslant \sigma_{tot}(s \to \infty) \leqslant 15.5$ mb, and (2) $-0.11 \leqslant \mathrm{Re}T(s,t=0)/\mathrm{Im}T(s,t=0) \leqslant 0$ as $s \to \infty$.

10297. Tomezsko, E. S. J., Furukawa, G. T., **Thermal titration of platinum black and the initial heat of adsorption for hydrogen,** *J. Catalysis* **8,** No. 4, 386-388 (Aug. 1967).

Key words: Adsorption of hydrogen on platinum black; heat of adsorption of hydrogen; platinum black; thermal titration.

The heat of adsorption of hydrogen on platinum black was investigated by means of an automatically controlled adiabatic calorimeter. When the platinum black was carefully freed of adsorbed oxygen, no rapid decrease was observed in the heats of adsorption with increasing coverage of hydrogen. The heat of adsorption of hydrogen on clean platinum surface was found to be 17.5 (73.2 kJ/mole) kcal/mole of hydrogen, with an estimated uncertainty of ±0.2 kcal/mole (±0.8 kJ/mole).

10298. Dragoo, A. L., Diamond, J. J., **Transitions in vapor-deposited alumina from 300° to 1200°C,** *J. Am. Ceramic Soc.* **50,** No. 11, 568-574 (Nov. 1967).

Key words: Alpha alumina; alumina; amorphous alumina; delta alumina; gamma alumina; intermediate aluminas; metastable aluminas; phase transitions; theta alumina.

The transition of amorphous alumina to α-alumina was studied by x-ray diffraction, electron diffraction, DTA, TGA, and microscopic observation. The amorphous alumina was prepared by condensing vapor from evaporating molten alumina in vacuo onto the glass envelope of the vacuum chamber. The amorphous alumina was transformed to a poorly crystalline material by heating for 16 hr between 570° and 670 °C. Between 670° and 1200 °C, the poorly crystalline alumina was converted to α-alumina via two parallel series of transition aluminas. The principal series was γ-alumina to δ-alumina to α-alumina. A minor amount of θ-alumina developed from the initial crystallization and persisted throughout the duration of the principal series as a parallel path. Some conversion of δ- to θ-alumina was detected above 900 °C. DTA produced an unexplained exothermic peak at 320 °C and a second exothermic peak at 860 °C which corresponded to formation of metastable aluminas.

10299. Urbach, P. F., **User reaction as a system design tool at CFSTI,** *Proc. Fourth Annual National Colloquium on Information Retrieval, May 3-4, 1967,* A. B. Tonik, ed., pp. 7-18 (International Information, Inc., Philadelphia, Pa., 1967).

Key words: Announcement journals; demand; document dissemination; important dissemination; system design; unit price; users chargers and costs; users study; users survey.

User reaction to the operation of document announcement and dissemination systems at CFSTI was measured by a number of user studies ranging from questionnaires covering the gamut of CFSTI services to experiments in which user interaction with the system was monitored. In one experiment, user reaction was monitored to compare the relative impact of a free and paid announcement service upon document sales. On the basis of the results, the free announcement service was discontinued. In another experiment, the sales prices of documents were modified and resulting sales monitored to establish the relationship between sales price and document demand. The knowledge of this relationship was used together with cost estimates to set a near optimum document price. Document sales are used as a criterion for measuring the effectiveness of announcement media and experiments to determine cost benefit relationships for various announcement media have been developed.

10300. Christensen, R. G., Cassel, J. M., **Volume changes accompanying collagen denaturation,** *Biopolymers* **5,** 685-689 (1967).

Key words: Collagen; denaturation; dilatometry; hydration; partial specific volume; solvation.

A dilatometric technique is employed to measure the volume changes occurring on denaturation of collagen solutions and tendons. Partial specific volumes of tropocollagen are calculated to be 0.686 ml/g in water and 0.689 ml/g in 0.1M citrate buffer. From data on non-aqueous solutions, it is estimated that most of the volume change arises from changes in polymer configuration rather than from changes in solvation.

10301. Allan, D. W., Fey, L., Machlan, H. E., Barnes, J. A., **An ultra-precise time synchronization system designed by computer simulation,** *Frequency* **6,** No. 1, 11-14 (Jan. 1968).

Key words: Computer simulation; flicker noise; frequency drift; optimum prediction; third order feedback system; time scales; time synchronization.

Any two independent time scales will exhibit time departure due to two main causes, i.e., systematic differences in the frequency standards and inherent random noise processes. For time synchronization, some theoretical considerations indicate the plausibility of a third-order feedback system which will automatically remove the systematic difficulties of typical frequency standards used in time scale work. Because of the random nature of the second difficulty, the whole system is simulated with a computer to determine the systems feasibility and operating parameters. Two basic assumptions are that time comparisons for synchronization would be intermittent and that the model for the frequency standard is represented by a systematic linear frequency drift with a random flicker noise spectrum $(1/|\omega|)$ of the frequency fluctuations.

On the basis of the computer results an electromechanical system was designed and built. When the input to the system is the frequency from a high quality quartz crystal oscillator, the output frequency has no frequency drift. If synchronization is performed every 12 hours, the rms time error predicted by the system at the time of the next synchronization is 70 nanoseconds, which is near optimum.

10302. Arenhovel, H., Hayward, E., **Scattering of plane-polarized photons by the giant resonances of nuclei,** *Phys. Rev.* **165,** No. 4, 1170-1174 (Jan. 20, 1968).

Key words: Giant resonance; photon scattering; polarized photons; sum rule.

The cross sections for the electric dipole scattering of plane polarized photons are expressed in terms of the angular momentum transferred to the nucleus in the two-step scattering process. These scattering cross sections have been evaluated in the dynamic collective model for a number of vibrational nuclei at 15.1 MeV and for a number of deformed nuclei at 11.4 and 15.1 MeV. A sum rule is derived that relates the total scattering cross section for an odd-A nucleus to that of its even-even neighbor.

10303. Astin, A. V., **A time for action in international standardization,** *Mater. Res. Std.* **8,** No. 5, 18-24 (May 1968).

Key words: Consumers; evaluation; purchasing; standards.

Technology and economics find a common challenge in the field of international standardization. How well or poorly America faces this challenge will have a great influence on the stature of the United States in the world markets. Since the resources for standards used in U.S. trade are in the private sector, it behooves private industry and groups such as ASTM in the private sector to fulfill the urgent need for sound standards.

10304. Ausloos, P., **Chemical changes induced by high energy radiation. The present state of our knowledge,** *Scientia* **CII,** 1-14 (Sept.-Oct. 1967).

Key words: Chemical changes; free radical reactions; high-energy radiation; ion-molecule reactions.

The chemical changes in matter brought about by absorption of low energy radiation such as visible and ultraviolet light have been intensively investigated for several decades. On the other hand, the chemical transformations induced by high energy radiation (X, gamma, β, α-rays) were long considered to be of such complexity that the task of unravelling them was considered insurmountably difficult. However, during the last decade, impressive advances have been made towards achieving an understanding of the fundamental chemical processes induced by high energy radiation. Many experimental techniques, some of which are new and some of which have been used in other areas of physics or physical chemistry, have now been brought to bear on the problem. Through these various approaches definitive information has been obtained concerning the existence and reactions of the various highly reactive intermediate species (radicals, ions, excited molecules produced by high energy radiation. The understanding of such systems has now reached a degree of sophistication such that high energy radiation can be used to obtain accurate information about various well defined chemical and physical processes which are of general scientific interest.

10305. Ausloos, P., Lias, S. G., **Gas-phase photolysis of hydrocarbons in the photoionization region,** *Radiation Res. Rev.* **1,** No. 1, 75-107 (Mar. 1967).

Key words: Absorption; excitation; hydrocarbons; ionization; gas phase photolysis.

When a molecule is irradiated with photons whose energy is higher than the threshold for ionization, not only ions but also neutral excited molecules, similar in lifetime and behaviour to those formed at lower energies, will be produced. Until very recently, most studies of molecules irradiated in the photoionization region have been concerned only with ionization phenomena. Such studies ranged from simple measurements of ion currents during photolysis to actual identification and quantitative measurement of the ions formed, by means of a light source linked with a mass spectrometer. In these studies, which have been reviewed recently, the fate of the excited molecules was generally not considered since the light sources used were of such low intensity that the steady state concentration of neutral intermediates was necessarily well below the limits of detection for uncharged species.

The study of the behaviour of neutral excited molecules is of concern to the photochemist and radiation chemist who usually deduce information about primary and secondary processes from a chemical analysis of the final products formed when a compound is irradiated in a closed vessel. The recent development of high intensity monochromatic light sources in the vacuum ultraviolet wavelength range made possible the use of traditional photochemical methods in the investigation of events following absorption of radiation in the photoionization region. This review is primarily concerned with presenting information derived from such studies; the emphasis will be on information obtained from analysis of end products formed upon photolysis in a closed system. Information from studies concerned with physical measurement of ionization phenomena will be presented here whenever pertinent, but a complete survey of these studies is not within the scope of this review.

It is evident that, in addition to permitting the study of the excitation events which accompany photoionization phenomena, the use of a closed system also allows the investigator a certain flexibility in the design of his experiments denied him by the nature of the instrumentation in alternate approaches such as mass spectrometry. For example, pressure and temperature can easily be varied over wide ranges permitting him to determine the effect of these parameters on ionic and neutral fragmentation mechanisms.

10306. Ausloos, P., Lias, S. G., **Gas-phase radiolysis of hydrocarbons,** Chapter in *Actions Chimique et Biologiques des Radiations,* M. Haissinsky, ed., **10,** 1 (Masson and Company, Paris, France, 1967).

Key words: Free radicals; hydrocarbon; ion molecule reactions; neutral excited molecules; radiolysis.

This manuscript is a critical review of the gas phase radiolysis of hydrocarbons covering the literature up to September 1, 1966.

10307. Ausloos, P., Lias, S. G., **Photoionization of cycloalkanes in the gas phase. A study of charge transfer-processes,** Chapter in *The Chemistry of Ionization and Excitation,* G. Johnson and G. Schales, eds., pp. 77-89 (Taylor and Francis, Ltd., London, England, 1967).

Key words: Charge transfer; cycloalkanes; photochemistry.

The photoionization of cyclopentane (I.P. 10·5 eV), cyclohexane (I.P. 9·9 eV) and cycloheptane (I.P. 10 eV) has been investigated at 11·6 – 11·8 eV using an argon resonance lamp as light source. It is shown that because of the limited degree of fragmentation of the parent cycloalkane ion at these energies, the importance of charge transfer between the different cycloalkanes can be evaluated. The yield of the parent cycloalkane ion is estimated by measuring the products CD_3CDHCD_2H and C_3D_8 formed by the H_2 and D_2-transfer reactions:

$$C_nH_{2n}^+ + C_3D_6 \rightarrow C_nH_{2n-2}^+ + CD_3CDHCD_2H,$$

$$C_nD_{2n}^+ + C_3D_6 \rightarrow C_nD_{2n-2}^+ + C_3D_8.$$

On the basis of these reactions, charge transfer can readily be established in mixtures such as $C_6H_{12} + C_6D_{12}$, $C_6D_{12} + C_5H_{10}$, $C_5D_{10} + C_7H_{14}$, and $C_6D_{12} + C_7H_{14}$ to which small amounts of propylene-d_6 has been added. It is, for instance, noted that charge transfer occurs from $C_6D_{12}^+$ to C_6H_{12} as well as from $C_6H_{12}^+$ to C_6D_{12}. In addition, the cyclohexane parent ions can transfer their charge to propylene. Taking this process into account, a value of 0·38 is obtained for the equilibrium ratio $C_6D_{12}^+/C_6H_{12}^+$ independent of the composition of the mixture. In the mixtures of cycloalkanes of different chemical identity, charge transfer from the parent ion with the higher ionization potential to that with the lower ionization potential occurs efficiently. It is shown that charge transfer occurs in all cases with a rate which is comparable to that of the H_2 and D_2-transfer reactions, whose rate is probably close to the collision rate.

10308. Ausloos, P., Scala, A. A., Lias, S. G., **Ion-molecule reactions in the condensed-phase radiolysis of hydrocarbon mixtures. II. Cyclopentane and cyclohexane,** *J. Am. Chem. Soc.* **89,** 3677-3683 (1967).

Key words: Cyclohexane; cyclopentane; free radical; H_2-transfer reactions; ion-molecule reactions.

The radiolysis of c-C_5H_{10} and c-C_5H_{12}, as well as of equimolar c-$C_5H_{10}-c$-C_5D_{10} and c-$C_5H_{12}-c$-C_6D_{12} mixtures, has been investigated in the presence of 0.5 to 5 mole percent $(CD_2)_3$, C_2D_2, C_2D_4, or CD_3CDCD_2. Isotopic analysis of the products formed in the radiolysis of cycloalkane$-(CD_2)_3$ mixtures points to the occurrence of the following ion-molecule reactions: (a) $C_nH_{2n}^+ + (CD_2)_3 \rightarrow C_nH_{2n-2}^+ + CD_2HCD_2CD_2H$ and (b) $C_nH_{2n}^+ + (CD_2)_3 \rightarrow C_nH_{2n-1}^+ + CD_2HCD_2CD_2$. The formation of n-propyl radicals in reaction b is confirmed by the production of $CD_3CD_2CD_2H$ as a major species in the radiolysis of $C_nD_{2n}-(CD_2)_3-H_2S$ mixtures. The ion-molecule character of the reactions is further confirmed by the facts that addition of a known parent ion interceptor such as H_2S reduces G(propane), while addition of an electron scavenger such as CCl_4 raises G(propane). When cyclopentane is the solvent, the H_2-transfer reaction (a) is of major importance. The most efficient H_2-acceptor molecule for the cyclopentane parent ion is C_2D_4, and the least efficient is C_2D_2. When c-$C_5H_{10}-c$-C_5D_{10} (1:1) mixtures are irradiated in the presence of deuterated H_2-acceptor molecules such as C_2D_4 or C_2D_2, the ratio of products of reaction a, $C_2D_4H_2/C_2D_6$ or $C_2D_2H_2/C_2D_4$, is greater than unity, indicating the occurrence of charge-transfer processes favoring the formation of c-$C_5H_{10}^+$: (c) c-$C_5D_{10}^+ + c$-$C_5H_{10} \rightarrow c$-$C_5H_{10}^+ + c$-C_5D_{10}. A decrease in the mole percent of the C_2D_4 or C_2D_2 from 6 to 2 percent raises $C_2D_4H_2/C_2D_6$ or $C_2D_2H_2/C_2D_4$ from 1.7 to 2.6, demonstrating that relatively high concentrations of H_2-acceptor molecules can interfere with the charge-transfer mechanism. When cyclohexane is the solvent, reaction b predominates over reaction a. A plot of the square root of the $(CD_2)_3$ concentration *vs.* G(propane) yields a straight line which goes through the origin, demonstrating the difficulty of obtaining chemical evidence for the presence of free ions.

10309. Balling, L. C., **g_I/g_J ratios of Rb^{85} and Rb^{87},** *Phys. Rev.* **163,** No. 1, 114-118 (Nov. 5, 1967).

Key words: G-factor; nuclear moment; optical pumping; rubidium.

An optical-pumping experiment has been performed to measure $g_I/g_J(Rb^{85})$ and $g_I/g_J(Rb^{87})$. The measurements were made in a magnetic field of 40 G. The field was produced by a precision-wound solenoid surrounded by three coaxial magnetic shields. The magnetic field varied by three parts in 10^6 over the volume of the optical pumping cells. The optical-pumping cells were filled with various pressures of helium and neon buffer gases. The measured ratios did not depend upon the nature or pressure of the buffer gas. The results of the measurements were $g_I/g_J(Rb^{85}) = -1.46648(8) \times 10^{-4}$; $g_I/gJ,(Rb^{87}) = -4.96997(9) \times 10^{-4}$.

10310. Barnes, J. A., Allan, D. W., **An approach to the prediction of coordinated universal time,** *Frequency* **5,** No. 6, 15-20 (Nov.-Dec. 1967)..

Key words: Coordinated Universal Time; offset frequency; prediction; rotation of the earth.

By computing the root mean square of the third differences of the fluctuations of Universal Time for various sample times, a spectral classification of the fluctuations is made. For periods from 0.02 years to 20 years, the data indicates a power spectral density for the fluctuations given by $|\omega|^{-}\alpha$ where α lies in the range $3 \leqslant \alpha \leqslant 5$.

Based on the spectral classification, some simple and practical methods of predicting frequency offsets for coordinated Universal Time are compared to theoretically optimum (linear) prediction. Three methods are considered and are applied to past UT 2 data for comparison. A conclusion from the paper is that the frequency offset for the coordinated time scales may be predicted such that no resets of epoch are required for roughly 60 percent of the years for which the prediction is made.

10311. Bates, R. G., Covington, A. K., **Behavior of the glass electrode and other pH-responsive electrodes in biological media,** *Ann. N.Y. Acad. Sci.* **148,** 67-80 (Feb. 1, 1968).

Key words: Antimony electrode; bioelectrodes; biological systems; electrodes; glass electrode; membrane electrodes; pH measurement; quinhydrone electrode.

The theory and experimental techniques underlying the use of hydrogen-ion-responsive electrodes in biological systems are reviewed. Particular attention is given to the development of special forms of electrodes for bio-medical purposes and to applications reported during the past 15 years.

10312. Bender, P. L., **Radio reflection by free radicals in earth's atmosphere,** *Science* **158,** No. 3807, 1487-1488 (Dec. 15, 1967).

Key words: Alouette II satellite; earth's atmosphere; free radicals; magnetic dipole radiation.

The suggestion by Barry, Coleman, Libby, and Libby that some of the signals observed by the Alouette II satellite were due to stimulated emission of magnetic dipole radiation from free radicals is shown to be incorrect.

10313. Bennett, L. H.,, Swartzendruber, L. J., Watson, R. E., **Hyperfine fields and electronic structure of CsCl-type ternary alloys of the first transition series,** *Phys. Rev.* **165,** No. 2, 500-505 (Jan. 10, 1968).

Key words: Alloys; electronic specific heat; electronic structure; Fe Co; hyperfine fields; isomer shift; Knight shift; s-admixture; Ti.

The ^{59}Co Knight shift K and the ^{57}Fe isomer shift have been measured in $TiFe_{1-x}Co_x$ alloys over most of the composition range $0 \leqslant x \leqslant 1$. The experimental results are discussed in terms of correlations with electron concentration and s admixture in the d bands. At room temperature, K varies from a maximum of (3.2 ± 0.2) percent at $x \approx 0.8$, and roughly follows the electronic specific heat as the composition is vation, from -0.15 ± 0.01 (mm/sec relative to pure Fe) at TiFe to -0.19 ± 0.02 at TiCo, is similar to that of Fe in Cr-Mn. The $^{47,49}Ti$ Knight shift in TiFe (0.26 ± 0.04) percent at room and at liquid-nitrogen temperatures.

10314. Berger, M. J., **Energy deposition in water by photons from point isotropic sources,** *J. Nucl. Med. Suppl.* **1,** 15-25 (Feb. 1968).

Key words: Absorbed fraction; buildup factor; energy absorption; gamma rays; photons; point-isotropic source.

This pamphlet contains tabulations of energy absorption buildup factors for point isotropic gamma ray sources for use in nineteen source energies between 3 MeV and 15 keV. An analytical representation of the buildup factors in the form of a polynomial in the source-detector distance is also given.

10315. Berman, H. A., West, E. D., Rozner, A. G., **Anomalous heat capacity of TiNi,** *J. Appl. Phys.* **38,** No. 11, 4473-4476 (Oct. 1967).

Key words: Titanium-nickel heat capacity; titanium-nickel phase transition.

Calorimetric measurements on a sample of TiNi (50 atomic percent Ti) show that the heat-capacity maximum at approximately 87 °C represents a higher-order transition. The transition was shifted to lower temperatures each time the material was heated through the transition from slightly above room temperature to about 150-200 °C. The transition enthalpy decreased in three such cycles from 4150 to 3375 J/mole TiNi.

10316. Blandford, J. M., **A progress report on the NBS-ARF apparel materials evaluation project,** *First Annual Conf. Apparel Research Foundation, Washington, D.C., Nov. 29-Dec. 1, 1967,* (Apparel Research Foundation, Washington, D.C. 20036, 1967).

Key words: Apparel materials; quality control; test methods.

A project on the evaluation of apparel materials, to be conducted in collaboration with the Apparel Research Foundation (ARF), was initiated in the Materials Evaluation Division of the Institute for Applied Technology (IAT) in July 1967. Its objective is to aid the small manufacturers of apparel in evaluating the essential properties of materials purchased and products fabricated. This report summarizes a survey made by visits with experts in representative apparel companies and supplier firms of the operations and problems which relate to quality control and testing; current evaluation and testing procedures; value to the industry of the project; and development of the project.

10317. Bowman, R. R., **Remarks on the paper "Field strength above 1 GHz: Measurement procedures for standard antennas,"** *Proc. IEEE* **56,** No. 2, 216 (Feb. 1968).

Key words: Electromagnetic horns; error analysis; gain corrections; gain measurements.

Some comments concerning error analysis and the measurement of standard gain horns are made in reply to a correspondence item by E. V. Jull.

10318. Brady, E. L., Wallenstein, M. B., **The national standard reference data system,** *Science* **156,** No. 3776, 754-762 (May 12, 1967).

Key words: Critical evaluation; information centers; information services; NSRDS; physical properties; standard reference data.

The National Standard Reference Data System is a government-wide effort to give to the technical community of the United States optimum access to the quantitative data of physical science, critically evaluated and compiled for convenience. This program was established in 1963 through action of the President's Office of Science and Technology and the Federal Council for Science and Technology, acting upon the recommendation of FCST's Committee on Scientific and Technical Information. The National Bureau of Standards has been assigned responsibility for administering the effort. The general objective of the System is to coordinate and integrate existing data evaluation and compilation activities into a systematic, comprehensive program, supplementing and expanding technical coverage when necessary, establishing and maintaining standards for the output of the participating groups, and providing mechanisms for the dissemination of the output as required.

10319. Brauer, G. M., **New developments in zinc oxide-eugenol cement,** *Ann. Dentistry* **26,** No. 2, 44-50 (1967).

Key words: Dental cements; dental materials; EBA cements; new developments in dental materials; zinc oxide-eugenol cements.

During the last few years considerable interest has been generated in improving zinc oxide-eugenol materials. A better understanding of the setting mechanism of these cements has become available which has lead to the development of modified ZOE cements usually containing *o*-ethoxy-benzoic acid (EBA). These materials show reactions to the tissues including the dental pulp similar to ZOE cements. Physical properties of the EBA containing cements approach those of the biologically less desirable zinc phosphate cements.

10320. Brehm, B., Gusinow, M. A., Hall, J. L., **Electron affinity of helium via laser photodetachment of its negative ion,** *Phys. Rev. Letters* **19,** No. 13, 737-741 (Sept. 25, 1967).

Key words: Electron affinity; electrons; energy analysis; helium; laser photodetachment; monochromatic (laser) light; negative ions.

We have measured the electron affinity of helium (2^3S) using the technique of energy analysis of electrons photodetached from a beam of negative ions by monochromatic (laser) light. Uncertainties in the contact potentials are eliminated by comparison with an ion of known affinity (H^-). The $4P_{5/2}$ state of He^- is found to be bound with respect to the 2^3S state of neutral helium by 80.0 millivolts, with a probable error of 2 millivolts.

10321. Brown, R. L., Dittmann, S., **Vibrational relaxation and quenching in the yellow nitrogen afterglow,** *Chem. Commun.* **21,** 1144-1146 (Nov. 8, 1967).

Key words: Active nitrogen; afterglow; atom recombination; nitrogen atoms; quenching; vibrational relaxation.

The vibrational distribution in the $B^3\Pi_g$ state of molecular nitrogen populated by recombination of nitrogen atoms has been found to depend on pressure and on the nitrogen atom concentration. These effects can be explained by a mechanism involving quenching of the $B^3\Pi_g$ state by nitrogen atoms and by carrier gas molecules and collision induced vibrational relaxation.

10322. Burley, G., **The "memory effect" in silver iodide,** *Acta Cryst.* **23,** Part 1, 1-5 (July 1967).

Key words: Alpha-phase; crystallography; silver iodide; site-occupation; structure; structure memory.

Radial distribution and least squares site occupation analyses were performed on powder diffraction patterns of the high temperature phase of silver iodide taken at 155 °C and 250 °C. A preferential occupation of certain sites by the silver atoms occurs near the transition temperature at 147 °C, involving those silver atom positions nearest to those in the low-temperature wurtzite- and sphalerite-type structures, respectively. The regeneration of a particular derivative low-temperature structure is thus facilitated, and a crystallographic explanation can be given for the observed "memory effect."

10323. Cassidy, E. C., Abramowitz, S., **Time-resolved spectroscopic studies of exploding wires in controlled atmospheres,** *Appl. Spectry.* **21,** No. 6, 360-364 (Nov.-Dec. 1967).

Key words: Electrical discharges; exploding wires; high-speed measurement techniques; high-speed photography; time-resolved spectroscopy.

Electrically exploded wires in various controlled atmospheres were employed for excitation of atomic and molecular species. The spectrographic time histories of the various constituents (stable and unstable) of the explosion mixture were studied with the use of a rotating drum camera, focussed on the exit slit plane of a spectrograph. A rotating high-speed shutter was then utilized to study the spectrum of selected intermediate species. Results obtained with aluminum wires in various atmospheres are presented, in order to illustrate the experimental techniques involved. Several considerations found to be important in the design of the explosion chamber are discussed.

10324. Chamberlain, G. E., Simpson, J. A., Mielczarek, S. R., Kuyatt, C. E., **Effect of double scattering on cross-section measurements at large momentum transfer,** *J. Chem. Phys.* **47,** No. 10, 4266-4267 (Nov. 15, 1967).

Key words: Cross section; differential; electron; experimental; helium; inelastic; pressure dependence.

Experimental evidence from measurements of inelastic electron scattering in helium is given to show that for large momentum transfer double scattering causes apparent cross section values to be too large. These errors occur at pressures usually thought to be sufficiently low to observe only single scattering.

10325. Chappell, S. E., Sparrow, J. H., **The average energy required to produce an ion pair in argon, nitrogen, and air for 1- to 5-MeV alpha particles,** *Radiation Res.* **32,** No. 3, 383-403 (Nov. 1967).

Key words: Air; alpha particles; argon; average energy; ion pair; measurement; nitrogen.

The absolute value of W, the average energy required to produce an ion pair, has been measured in argon, nitrogen and air for alpha particles with initial energies between 1 and 5 MeV. Six alpha-particle sources having different energies were fabricated by placing various thicknesses of mylar film over a collimated polonium-210 (5.3 MeV) alpha-particle source. For each source the total ionization produced in each gas by a determined number of alpha particles was measured in a parallel plate ionization chamber. Then the mean energy of each source was evaluated by using a time-of-flight apparatus. From these combined results, W was calculated. It was found to be constant within experimental error for argon but exhibited an increase in value of approximately 1 percent for nitrogen and air over the specified energy range. These results for nitrogen and air disagree with the energy dependence for W found by other investigators.

10326. Christ, B. W., Giles, P. M., **Metallurgical uses of the Fe^{57} Mössbauer effect in metallic iron and plain carbon steels,** Chapter in *Advances in Mössbauer Methodology* 3, 37-65 (Plenum Press, Inc., New York, N.Y., Jan. 1967).

Key words: Carbon steels; Fe^{57} iron; retained austenite hyperfine interactions; tempering.

Literature describing the Fe^{57} Mössbauer effect in metallic iron, steels and ferrous compounds occurring in steels is reviewed and compared with new, computer-analyzed data obtained in 298 °K measurements on metallic iron and carbon steels. Characteristics of Mössbauer patterns are sensitive to carbon content and thermomechanical history. Relative to standard sodium nitroprusside, the average effective magnetic field (EMF) for three grades of recrystallized iron is 339 ± 3 kilo-oersteds.

Patterns reveal several superimposed hyperfine interactions between 0.02 and 1 w/o C. The most intense magnetic hyperfine pattern (MHP) is attributable to iron atoms remote from interstitials. The EMF of this pattern increases with increasing C in solution, e.g., 355 ± 3 kilo-oersteds at 1 w/o C. In quenched 0.3, 0.7 and 1 w/o C alloys, irregularities in peak shape arise from sets of iron atoms with various C near-neighbor configurations. A weak, resolvable MHP exhibiting a small quadrupole effect and an EMF 20 percent smaller than that of the intense pattern originates at iron atoms with one carbon nearest neighbor.

Phases identifiable by their patterns include ferrite, martensite, austenite, cementite, and ϵ-carbide. Dislocations produce no detectable effect. Application of Mössbauer spectroscopy to the study of martensite tempering and quantitative analysis for retained austenite is discussed.

10327. Christ, B. W., Smith, G. V., **Strengthening of polycrystalline iron by nitrogen,** *Trans. ASM* **60,** 732-734 (1967).

Key words: Carbide strengthening; hydrogen-purified iron; nitride strengthening; nitrogen ferrite; polycrystalline; solid solution strengthening; tensile tests.

The strengthening of polycrystalline iron by an interstitial impurity has been measured in tensile tests on 0.050-inch diameter wire. Nitrogen was introduced into hydrogen-purified iron by equilibration with an ammonia-hydrogen mixture. The distribution of nitrogen was changed by varying the rate of cooling from the solution temperature. Nitrogen in solid solution is not as effective a strengthener as carbon in solid solution. Nitride precipitation occurring during air cooling results in strengthening comparable to that due to carbide precipitation during quench aging. The observed linear variation of flow strength with nitrogen concentration supports the Schoeck-Seeger or Mott-Nabarro models of solution strengthening.

10328. Christ, B. W., Smith, G. V., **Yield and flow stress increase in pure polycrystalline iron during 600 °C treatment after wet hydrogen purification,** *Scripta Met.* **1,** No. 3, 123-130 (1967).

Key words: Hydrogen-purified iron; Luder's strain; polycrystalline iron; tensile properties; ultimate tensile stress; yield stress.

The tensile properties of polycrystalline iron (0.060 mm grain size) have been measured at 298 and 163 °K. Wet hydrogen treatment of rolled and drawn zone-refined iron for 7 hours at 750 °C decreased the average yield stress and ultimate tensile stress at 298 °K from 16,500 and 30,600 psi to 7,600 and 27,600 psi, respectively. The wet-hydrogen purified iron displayed practically no Luder's extension at room temperature but exhibited 6-7 percent Luder's extension at 163 °K. Annealing at 600 °C for 20 and 40 hours in both dry hydrogen and sealed vycor capsules (10^{-5} torr) caused an upward shift in the stress-elongation curve at 163 °K. These results are discussed in terms of the influence of possible structural modifications during 600 °C annealing on the athermal and thermal components of stress.

10329. Chueh, P. L., Prausnitz, J. M., **Third virial coefficients of nonpolar gases and their mixtures,** *AIChE J.* **13,** No. 5, 896-902 (Sept. 1967).

Key words: Nonpolar gases; quantum gases; third virial coefficients; virial equation.

While much attention has been given to second virial coefficients of nonpolar gases, experimental and theoretical studies on third virial coefficients are scarce. This work presents a correlation of third virial coefficients within the framework of the corresponding-states principle. The correlation is useful for estimating third virial coefficients of pure and mixed nonpolar gases, including the quantum gases helium, hydrogen and neon. The importance of third virial cross-coefficients in phase equilibrium predictions is illustrated with calculations for the solid-gas, methane-hydrogen system at 76 °K.

Brief attention is given to the pressure-series form of the virial equation. Because of fortuitous cancellations, it is shown that, for reduced temperatures above 1.4, the pressure-series, truncated after the second term, is applicable to a wider range of density than the density series truncated after the second term. However, when both series are truncated after the third term, the density series appears to be superior regardless of reduced temperature.

10330. Colwell, J. H., **The heat capacity of a mixed titanate superconductor,** *Physics Letters* **25A,** No. 8, 623-624 (Oct. 1967).

Key words: Electronic band structure; heat capacity; mixed titanate; phase transition; semiconductor; $SrTiO_3$; superconductor.

The heat capacity of semiconducting $Sr_{0.925}Ba_{0.075}TiO_3$ has been measured in the temperature region 0.3 to 4 °K. This material becomes superconducting with a transition temperature, T_c, of about 0.53 °K. The heat capacity increases gradually with decreasing temperature below T_c and has a broad maximum at 0.45 °K. There is an unusual heat capacity anomaly just above T_c which is described as a gradual decrease in the electronic heat capacity coefficient, γ, between 0.8 and 2.0 °K. The change in γ is interpreted as a phase transition causing a change in the number of occupied valleys in the conduction band. In the phase existing at the superconducting transition the conduction band has the same number of valleys and a comparable density of states at the Fermi surface as that in semiconducting $SrTiO_3$.

10331. Corliss, C. H., **Revision of the NBS tables of spectral-line intensities below 2450 Å,** *Spectrochim. Acta* **23B,** 117-127 (1967).

> Key words: Atomic spectra; intensities; spectral-line intensities; ultraviolet intensities.

A calibration is applied to the intensity measurements of the 1400 lines below 2500 Å in the NBS Tables of Spectral-Line Intensities. Tables of the new values are presented with the lines arranged by element and by wavelength.

10332. Cullen, W. C., Boone, T. H., **A thermal-shock resistance factor for bituminous built-up roofing membranes,** Part 1, *Roofing Siding Insulation Mag.* **44,** No. 11, 30-35 (Nov. 1967); Part 2, *Roofing Siding Insulation Mag.* **44,** No. 12, 35-39 (Dec. 1967).

> Key words: Development; roofing membrane; strength properties; thermally induced forces; thermal-shock resistance factor.

The resistance of bituminous built-up roofing membranes to thermally induced forces is considered in terms of their strength properties such as breaking load in tension, modulus of elongation and apparent linear thermal expansion coefficient. The development of a Thermal-Shock Resistance Factor is described and values are given for three bituminous built-up membranes at temperatures of −30 °F (−34.4 °C), 0 °F (−17.8 °C), 30°F (−1.1 °C) and 73 °F (22.8 °C). The apparent relation between the values obtained in the laboratory and the observed performance of roofing membranes in service is considered. The utilization of the Thermal-Shock Resistance Factor in the reduction of potential failures of bituminous built-up roofing membranes in service from thermally induced forces is also discussed.

10333. Currie, L. A., **Limits for qualitative detection and quantitative determination, application to radiochemistry,** *Anal. Chem.* **40,** No. 3, 586-593 (Mar. 1968).

> Key words: Activation analysis; analytical chemistry; decision level; detection limit; determination limit; hypothesis testing; interference; Poisson distribution; radioactivity.

The occurrence in the literature of numerous, inconsistent and limited definitions of a detection limit has led to a re-examination of the questions of signal detection and signal extraction in analytical chemistry and nuclear chemistry. Three limiting levels have been defined: L_C—the net signal level (instrument response) above which an *observed* signal may be reliably recognized as "detected"; L_D—the "true" net signal level which may be *a priori* expected to lead to detection; and L_Q—the level at which the measurement precision will be satisfactory for quantitative determination. Exact defining equations as well as series of working formulae are presented both for the general analytical case and for radioactivity. The latter, assumed to be governed by the Poisson distribution, is treated in such a manner that accurate limits may be derived for both short- and long-lived radionuclides either in the presence or absence of interference. The principles are illustrated by simple examples of spectrophotometry and radioactivity, and by a more complicated example of activation analysis in which a choice must be made between alternative nuclear reactions.

10334. Cuthill, J. R., McAlister, A. J., Williams, M. L., Watson, R. E., **Density of states of Ni: Soft-x-ray spectrum and comparison with photoemission and ion neutralization studies,** *Phys. Rev.* **164,** No. 3, 1006-1007 (Dec. 15, 1967).

> Key words: Density of states; emission spectrum; linear detection; nickel; oxide free; paramagnetic; soft x-ray; transition probability.

Soft x-ray studies have been made on paramagnetic Ni and interpreted in terms of the single-particle density of states. In particular, the $M_{2,3}$ emission spectrum has been investigated, using improved experimental techniques. Measurements were made at 960 °C, at an average pressure of 5×10^{-8} Torr, using an oxide-free surface. Fine structure was observed in the spectrum. Although first-principles correction of self-absorption effects and satellite and subband overlap is not yet possible, careful consideration is given them, with the result that the M_3 band can be resolved from the accompanying structure in a plausible way. Most of its features can be taken with reasonable confidence to be characteristic of the true M_3 emission band. Comparison is made with earlier soft x-ray results, with band calculations for paramagnetic Ni, and with ion neutralization and photoemission measurements on ferromagnetic Ni. Systematic variations in transition matrix elements and lifetime broadening appear important when relating any experiment with theory, and an aspect of each of these problems has been considered quantitatively. The variation obtained is more severe for the photoemission than for the soft-x-ray analysis. The ion-neutralization and soft-x-ray results appear closer to the single-particle density of states.

10335. Damburg, R. J., Geltman, S., **Excitation of n = 2 states in hydrogen by electron impact,** *Phys. Rev. Letters* **20,** No. 10, 485-487 (Mar. 4, 1968).

> Key words: Close-coupling; electron impact; excitation; hydrogen; Lyman α; polarization.

A possible source of incompleteness in the most recent close coupling calculations for the excitation cross sections of the n = 2 levels in hydrogen, some of the results of which disagree with experiment, is pointed out. We present a method which removes this difficulty by the implicit inclusion of all important effective polarization potential terms of order α/r^4.

10336. Daney, D. E., Mann, D. B., **Quality determination of liquid-solid hydrogen mixtures,** *Cryogenics* 7, No. 5, 280-285 (Oct. 1967).

> Key words: Liquid-solid hydrogen mixtures; quality determination; rocket propellant; slush hydrogen.

A theoretical and experimental investigation of the feasibility of predicting the quality of liquid-solid hydrogen mixtures from the mass fraction of vapor pumped off in the freeze-thaw process is presented. Three independent methods of experimental quality determination were used to check the correctness of the qualities predicted from the measured mass fraction pumped off in forming liquid-solid mixtures. In all cases only freshly made mixtures were used.

It is suggested that an independent means of determining the edge of the triple-point region, such as measurement of the vapor pressure, be used. With this modification, measurement of the mass fraction pumped off during the freeze-thaw process provides a simple, non-destructive and accurate method of bulk quality determination. The method is not appropriate for cases in which a partial transfer from the dewar is made and it requires accurate knowledge of the heat leak if long storage times are to be used. Low accuracy in large volume gas flowmeters also places a restriction on the method.

10337. deWit, R., **Thermodynamic force on a dislocation,** *J. Appl. Phys.* **39,** No. 1, 137-141 (Jan. 1968).

Key words: Concentration; crystal; defect; dislocation; energy; equilibrium; force; hydrostatic; pressure; vacancy.

The thermodynamic force on a dislocation is defined as the negative gradient of the Gibbs free energy of the crystal with respect to dislocation motion. This is shown to lead to a consistent force expression which contains two terms: the Peach-Koehler force due to the stress and the Bardeen-Herring force due to the vacancy concentration. The precise definition of these two terms is arbitrary, though their sum is unique. Various forms of the force expression are derived in terms of different reference vacancy concentrations, including the original forms of Weertman and Lothè and Hirth.

10338. Dibeler, V. H., Liston, S. K., **Mass-spectrometric study of photoionization. VIII. Dicyanogen and the cyanogen halides,** *J. Chem. Phys.* **47,** No. 11, 4548-4555 (Dec. 1, 1967).

Key words: Autoionization; BrCN; C_2N_2; ClCN; FCN; heats of formation; ICN; mass spectrometer; photoionization; Rydberg levels; vacuum uv monochromator.

Photoionization-yield curves are obtained for the molecule and selected radical ions of C_2N_2, FCN, ClCN, BrCN, and ICN from threshold to 600 Å. Vibrationally excited states of ions and autoionization of Rydberg levels in the molecules are observed and discussed briefly. The X^+ ion thresholds in the heavier cyanogen halides are used to obtain: $\Delta Hf_0°(CN) = 101.5$ kcal mole^{-1}, $\Delta Hf_0°(CN^+) = 430.0$ kcal mole^{-1}, and $I(CN) = 14.2$ eV. These are applied to compute $\Delta Hf_0°(FCN) = 5.6$ kcal mole^{-1}, $D(F-CN) = 5.0$ eV, $I(C_2) = 12.15$ eV, and other thermodynamic properties. The formation of CN^+ from dicyanogen apparently includes about 0.6 eV excess energy near the threshold.

10339. Dickson, G., Oglesby, P. L., **Elastic constants of dental amalgam,** *J. Dental Res.* **46,** No. 6, Part 2, 1475 (Nov.-Dec. 1967).

Key words: Bulk modulus; dental amalgam; elastic constants; Poisson's ratio; pulse-echo technic; shear modulus; Young's modulus.

Elastic constants of dental amalgam were determined by an ultrasonic pulse-echo technic. Longitudinal and transverse wave velocities of a 5.5 MHz pulse were determined in cylindrical amalgam specimens 8mm in diameter by 6 to 15 mm in length. Values of 9.1×10^6 psi for Young's modulus, 3.4×10^6 psi for shear modulus, 9.1×10^6 psi for bulk modulus and 0.33 for Poisson's ratio were obtained for amalgams containing 49 percent mercury. Values for all of these constants increased as the mercury content of specimens was reduced to 35 percent.

10340. DiMarzio, E. A., **Some contributions to the kinetics of growth of multicomponent chains with application to the problems of ciliation and fractionation in polymer crystallization,** *J. Chem. Phys.* **47,** No. 9, 3451-3469 (Nov. 1, 1967).

Key words: Crystallization; kinetics; multicomponent chains; polymer crystallization.

The problem of the growth rate and purity of crystals formed by the sequential deposition of molecules in a mixed system is solved. The solution is given in terms of the fundamental rates $a_\nu^{ij}(\beta_{\nu+1}^{ij})$ for laying down (taking off) species j at the $(\nu + 1)$th position of the growing crystal given that species i occupies the (ν)th position. The fundamental rates are thus dependent on nearest-neighbor interaction but not on neighbors further removed. The method used complements a previously used method and additionally solves the problem for ν-dependent α_ν^{ij} and β_ν^{ij}. The ν dependence of the α's and β's allows for the stochastic-like distribution of the various species in the substrate upon which we are growing our linear chain of molecules. It is shown that there exists one unique flux-determined steady-state solution for a wide variety of initial conditions. Several diagrams descriptive of various physical processes are displayed. The one describing ciliation (the growth process which results in the ends of polymer chains dangling out of the crystal lamella) is treated in some detail. It is found that there are two classes of α's and β's. One class gives large growth rates and very little ciliation. The second class gives growth rates which are orders of magnitudes smaller and results in much ciliation. It is concluded that when chain-folded crystallization occurs the amount of material dangling out of the crystal is less than 50 percent of the total amount of material participating. The problem of fractionation in polymers is treated. Formulas are given for the purity of polymer crystals which are formed by high molecular weight material crystallizing concomitantly with polymeric material of lower molecular weight and/or of different kind. Fractionation can be substantial even when the molecular weights of the mixed system are all large. Simple formulas are derived. More complicated diagrams that allow for more than nearest-neighbor interaction can be reduced to the nearest-neighbor case but with a larger number of components.

10341. Eberhard, J. P., **Systems and design—an extrapolation to 2000 A.D.,** *Mater. Res. Std.* **8,** No. 5, 12-17 (May 1968).

Key words: City planning; human factors; standards; systems engineering.

Systems analysis is necessary for a thorough re-thinking of major hardware problems of the city. One of the problems concerns itself with performance standards in this context and their need to include an understanding of how they interact with man. A need for an ideal model of the highest concept of civilization must be defined in order to build a practical approach to urban systems design and construction. It is hoped that new mass production techniques may provide practical solutions to the problem of low cost urban living units that will be both attractive as well as providing inspiration. This paper was originally presented at the Third Annual Meeting of the National Academy of Engineering, 20-24 September, 1967, University of Michigan, Ann Arbor, Mich.

10342. Eberhard, J. P., Schofer, R. E., **The role of technology in developing future transportation systems,** *Proc. Analysis and Control of Traffic Flow Symp., Detroit, Michigan, Jan. 9-10, 1968,* pp. 1-4 (Society of Automotive Engineers, Inc., New York, N.Y., 1968).

Key words: Future transportation; regional transportation; technology; transportation; transportation technology; urban transportation.

As we approach the twenty-first century it is becoming increasingly apparent that, as megalopolitan areas increase in size and number throughout the country, we must search for new transportation technologies. In this paper, the authors set forth some of the areas where more and better coordinated research needs to be done.

There are three basic types of transportation technologies. The planning technology entails the obtaining of enough information in advance to develop sound transportation systems to meet future requirements. More research is needed to determine the impact on transportation requirements made by a changing city form. Secondly, research directed at improved operating strategies for existing systems will provide information needed for the development of future systems. Finally, more work is needed in the area of transportation hardware technology. No proposal should go without careful evaluation; latent technologies must be explored in the search for better systems.

Governments can encourage technological innovation by defining areas of needed research, sponsoring research, disseminating information on research activities, and by coordinating research efforts.

To preserve the vitality of transportation in the United States, the Federal Government must assume the overall responsibility for encouraging development of new transportation technologies.

10343. Eick, J. D., Caul, H. J., Smith, D. L., Rasberry, S. D., **Analysis of gold and platinum group alloys by x-ray emission with corrections for interelement effects,** *Appl. Spectry.* **21,** No. 5, 324-328 (Sept.-Oct. 1967).

Key words: Gold and platinum group alloys; noble metal alloys; x-ray emission.

The x-ray emission analysis of noble metal alloys was investigated critically to determine optimum conditions for accurate analysis. The analytical curves for the elements Cu, Pd, Pt, and Zn were found to be linear with a deviation of less than ±0.2 percent. However, a nonlinear relationship existed for gold and for silver. These discrepancies could not be eliminated by variation in sample preparation. An interelement effect due to x-ray absorption and enhancement was found and was corrected to an accuracy of 0.2 percent by means of a mathematical treatment suggested by Lucas-Tooth and Price. The analysis by x-ray emission can be accomplished in approximately one-tenth of the time necessary for conventional wet chemical methods.

10344. Fatiadi, A. J., **Acetic anhydride phosphoric acid as an acetylating agent,** *Carbohydrate Res.* **6,** 237-240 (1968).

Key words: Acetic anhydride; acetylation; anhydrous phosphoric acid; esterification.

Anhydrous phosphoric acid in acetic anhydride can be recommended as an efficient agent for the acetylation of carbohydrates, enediols, enols, inositols, and sterically hindered phenols. A mixture of anhydrous phosphoric acid with higher fatty acid anhydrides (isobutyric, butyric, or propionic) has been used successfully for the esterification of inositols.

10345. Fatiadi, A. J., **Stable radicals obtained by treatment of azulene with periodic acid and other oxidants,** *Chem. Commun.* **8,** 456-458 (Apr. 24, 1968).

Key words: Azulene; periodic acid; polymeric product; stable free radical.

Treatment of the non-benzenoid, aromatic hydrocarbon azulene with periodic acid gives a free radical which is extremely stable to air and heat; the product has been found to be polymeric. Treatment of azulene with iodic acid of antimony pentachloride also gives stable free radicals. for conventional wet chemical methods.

10346. Faust, J. W., Jr., Ogburn, F., Kahan, D., Ruff, A. W., Jr., **Twin configurations in FCC dendrites,** *J. Electrochem. Soc.: Solid State Science* **114,** No. 12, 1211-1212 (Dec. 1967).

Key words: Dendrites; electrodeposition; growth twins; silver.

The authors discuss possible configurations of intersections of twin planes which might be present in dendrites of diamond-type materials and fcc metals. They show that for dendrites growing in a [110] direction there will be a mismatch boundary wherever two or more twin planes intersect.

Experimental evidence is given for the existence of a configuration of two crossing twin lamellas with two mismatch boundaries in a silver dendrite.

10347. Fine, J., Scheer, M. D., **Positive and negative self-surface ionization of molybdenum,** *J. Chem. Phys.* **47,** No. 10, 4267-4268 (Nov. 15, 1967).

Key words: Electron affinity; ion sublimation energy; mass spectrometry; molybdenum; positive and negative ions; self-surface ionization.

The positive and negative self surface ionization of molybdenum has been observed in the 1800-2100 °K temperature range. The positive and negative ion sublimation energies were found to be 9.5 and 10 eV respectively. The electron affinity was determined as 1.0 ± 0.2 eV. (estimated uncertainty)

10348. Franklin, A. D., **Born model calculation of enthalpies of solution in CaF_2,** *J. Am. Ceram. Soc.* **50,** No. 12, 648-652 (Dec. 1967).

Key words: Born model of ionic solids; CaF_2; enthalpy of solution; ionic solids; lattice expansion.

The Born model of ionic solids was used to calculate the lattice energy, as an estimate of the enthalpy of solution, needed to dissolve NaF and YF_3 in CaF_2, in the limit of infinite dilution. For NaF sufficient experimental data are available to provide resonable estimates for the parameters describing the repulsive interactions between Na^+ and surrounding ions, and the calculated enthalpy of solution is in good agreement with the available experimental value, 1.4 ± 0.3 eV for NaF. For YF_3 the experimental data are not available and the estimated enthalpy of solution of about zero is subject to a large uncertainty. The results for NaF are consistent with the model normally assumed, in which each substitutional Na^+ ion is accompanied by an F^- vacancy; however, they do not rule out charge compensation by interstitial Na^+ ions. The calculations also yield an estimate for the lattice expansion.

10349. Frenkiel, F. N., Klebanoff, P. S., **Correlation measurement in a turbulent flow using high-speed computing methods,** *Phys. Fluids* **10,** No. 8, 1737-1747 (Aug. 1967).

Key words: Correlations; even-order; grid; hot-wire anemometer; isotropy; nonlinear response; odd-order; turbulence.

Third-order time-correlations downstream of a grid were measured with a hot-wire anemometer using high-speed computing methods. The nonlinear response of the hot-wire to the fluctuations of velocities is taken into account as well as the effect of transverse velocities. It is found that the third-order correlations are substantially different from previous results and demonstrate that the assumption of isotropy is not adequate for these correlations downstream of a grid. The nonlinear response does not significantly affect the difference $u_1^2u_2 - u_1u_2^2$. Since previous conclusions concerning the nature of third-order correlations were based on the measurements of such differences they masked the effects of nonlinearity on the individual correlations. Correlations of fifth-order are also presented and their relations to the third-order correlation are discussed. Although the nonlinear corrections are quite important for odd-order correlations they are negligible for correlations of even-order.

10350. Goldstein, J. I., Majeske, F. J., Yakowitz, H., **Preparation of electron probe microanalyzer standards using a rapid quench method,** *Advan. X-ray Anal.* **10,** 431-446 (1967).

Key words: Al-Mg; Au-Si; electron probe standards; quantitative microanalysis; splat cooling; standard preparation.

Standards for microprobe anlysis can be made to serve two purposes: (1) Proposed correction models can be tested with them, and (2) Analysis can be performed more accurately in the system which includes the standard. Few microprobe standards are presently available because they must be homogeneous on the micron scale and their composition must be known accurately. A modified Duwez splat cooling method is described which enables the investigator to prepare suitable standards in most cases. The apparatus which is relatively simple and inexpensive is described in detail. The systems Au-Si and Al-Mg were chosen as test cases. Suitable standards were prepared at different concentrations in each system. The analytical results for all compositions in Al-Mg are presented and discussed.

10351. Gorden, R., Jr., Ausloos, P., **Photolysis of ethylene at 1048-1067 Å. Reactions of $C_2H_4^+$ and fragmentation of the superexcited ethylene molecule,** *J. Chem. Phys.* **47,** No. 5, 1799-1806 (Sept. 1, 1967).

Key words: Cis-2-butene; ethylene; hydrocarbons; photoionization; trans-2-butene.

$C_2H_4 - NO$, $C_2H_4 - O_2$ and $C_2H_4 - (CH_3)_2NH - O_2$ mixtures have been irradiated with an argon resonance lamp emitting only the 1048 and 1067 Å lines. The ionization efficiency ratios: η_{C2D4}/η_{NO}, η_{C2H4}/η_{NO}, η_{C2D4}/η_{C2H4} were determined to be 0.30 ± 0.003, 0.27 ± 0.003 and 1.12 respectively. Trans-2-butene and cis-2-butene are major products when NO (I. P. = 9.25 eV) or $(CH_3)_3NH$ (I. P. = 8.24 eV) are added to C_2H_4. Radiation of pure C_2H_4 or of $C_2H_4 - O_2$ mixtures yielded only minor traces of $2-C_4H_8$. In accord with earlier radiolysis studies we ascribe the formation of $2-C_4H_8$ to the charge transfer process:

$$C_4H_8^+ + NO\ (\text{or } (CH_3)_2NH \rightarrow C_4H_8 + NO^+\ (\text{or } (CH_3)_2NH^+)$$

where $C_4H_8^+$ may possess some excess internal energy carried over from the exothermic condensation reaction $(C_2H_4^*)^+ + C_2H_4 \rightarrow (C_4H_8^*)^+$. For a constant $C_2H_4 - NO$ mixture $M(C_4H_8)/N$ increases drastically with an increase of the pressure of C_2H_4 from 0.1 to 6 torr. Also, in pure C_2H_4, $M(CH_3)/N$ which is close to unity at 0.5 torr is seen to diminish to 0.2 when the pressure is raised to 29.8 torr. These effects are largely ascribed to a competition between decomposition and stabilization of the $[C_4H_8^*]^+$ product ion.

A rate constant of 10^7 sec^{-1} is derived for the unimolecular decomposition of $(C_4H_8^*)^+$ assuming that stabilization occurs at every collision with C_2H_4. It is shown that Ne is about 100 times less efficient than C_2H_4 in stabilizing $(C_4H_8^*)^+$.

The superexcited $C_2H_4^*$ dissociates as follows, $C_2H_4^* \rightarrow C_2H_2 + H_2$ and $C_2H_4^* \rightarrow C_2H_2 + 2H$. Isotopic analysis of the hydrogen formed in the photoionization of CH_2CD_2 shows that the relative probabilities for the elimination of H_2, HD and D_2 from $CH_2CD_2^*$ are the same for the superexcited molecule as for the excited molecule formed by absorption of 8.4 to 10 eV photons.

10352. Grosch, H. R. J., **The National Bureau of Standards program in computer sciences and technology,** *Statist. Reptr.* **68-3,** 37-41 (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Sept. 1967, 20 cents).

Key words: Brooks Bill; computer standards; computer technology; data processing; government.

The NBS Center for Computer Sciences and Technology was established in 1965 to perform the Bureau's work in the field of computer technology—a broad program of standardization activities, applied research, and services to Federal agencies. Work on standards includes that on USASCII (for use in Federal procurement, under the terms of the Brooks Bill of October 1, 1965) and on optical character recognition. Services to other branches of government include providing data processing services, computational assistance, and consultation. The activities of the center's Technical Information Exchange and the continued experimentation with computers will have industry-wide benefits.

10353. Gross, D., Loftus, J. J., Robertson, A. F., **Method for measuring smoke from burning materials,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **422,** 166-204 (1967).

Key words: Aerosol; combustion; fire hazard; pyrolysis; smoke; smoke density; visual obscuration.

Based on a study of possible smoke-measuring methods, a laboratory test has been developed for the photometric measurement of smoke from burning materials. The method assumes the applicability of Bouguer's law to the attenuation of light by smoke, and smoke quantity is therefore reported in terms of optical density rather than light absorptance or transmittance. Optical density is the single measurement most characteristic of a "quantity of smoke" with regard to visual obscuration.

Experiments have been performed on a variety of building finish materials under both flaming and nonflaming (smoldering) conditions, and the results are reported in terms of (a) maximum smoke accumulation, (b) maximum rate of smoke accumulation, and (c) the time period to reach an arbitrary "critical" smoke level.

10354. Haber, S., **A theorem on arbitrary functions,** *Am. Math. Monthly* **74,** No. 8, 973-975 (Oct. 1967).

Key words: Arbitrary functions; continuity; maxima; real variable.

It is shown that if a_i and b_i, $i = 1, \ldots, n$ are arbitrary real functions of a real variable, then the function $f(x,y) = a_1(x)b_1(y) + \ldots + a_n(x)b_n(y)$ has a certain partial continuity property.

10355. Haber, S., **Midpoint quadrature formulas,** *Math. Compt.* **21,** No. 100, 719-721 (Oct. 1967).

Key words: Computing; integration; numerical analysis; quadrature.

A family of quadrature formulas for the interval (0,1) can be defined by partitioning the interval into subintervals and taking as nodes the midpoints of these intervals, with the lengths of the intervals serving as coefficients. The errors of these formulas are determined.

10356. Hafner, H., Simpson, J. A., Kuyatt, C. E., **Comparison of the spherical deflector and the cylindrical mirror analyzers,** *Rev. Sci. Instr.* **39,** No. 1, 33-35 (Jan. 1968).

Key words: Cylindrical mirror; electron energy analyzer; electron optics; spherical deflector.

The calculated performance of the cylindrical mirror deflection energy analyzer for charged particles is compared with that of the spherical analyzer. It is shown that through terms in $\sim^3$ the cylindrical device is significantly superior.

10357. Haller, W., **Correlation between chromatographic and diffusional behaviour of substances in beds of pore controlled glass. Contribution to the mechanism of steric chromatography,** *J. Chromatog.* **32,** 676-684 (1968).

Key words: Chromatography; diffusion; gel chromatography; gel filtration; gel-permeation chromatography; glass chromatography; GPC; pore-controlled glass; restricted diffusion; steric-exclusion chromatography.

Chromatography and diffusion experiments were performed with columns and suspensions of grains of pore-controlled glass of 620 Å pore diameter. The elution positions of tobacco mosaic virus and of benzyl alcohol coincide with the actual void volume and the total fluid volume of the column. A spherical virus (MS2) of 260 Å diameter eluted at a normalized elution volume of $k_e = 0.44$, and its peak position shifted only very slightly over a wide range of elution rates.

The diffusional uptake of virus (MS2) by the porous glass grains from a well stirred suspension indicated that the total pore volume of the glass was accessible to the virus. It took approximately 30 seconds for one half of the ultimate amount of virus to penetrate the glass. In the light of these results it is very unlikely that a volume exclusion mechanism determines the elution position of the virus. Since porous glass columns of uniform and controlled pore size display elution spectra similar to those of gel columns, it is also unlikely that volume exclusion governs the elution spectrum in steric chromatography on gels.

10358. Haller, W., **Virus isolation with glass of controlled pore size: MS2 bacteriophage and Kilham virus,** *Virology* **33,** No. 4, 740-743 (Dec. 1967).

Key words: Chromatography; glass; Kilham rat virus; MS2 virus; porous glass; virus.

MS2 bacteriophage and tritiated Kilham Rat virus have been isolated from natural lysates by restricted-diffusion chromatography on pore-controlled glass. Measurements of infectivity and hemagglutinating activity, as well as radioactivity and UV absorption, were used to determine recovery and purity of isolated viruses. The recoveries proved to be nearly 100 percent and the viruses were essentially host protein free.

10359. Hamer, W. J., **A Joule centennial,** *J. Chem. Educ.* **45,** No. 2, 123-125 (Feb. 1968).

Key words: B.A. resistance unit; equivalent; Joule; Joule centennial; mechanical equivalent of heat.

The centennial of Joule's determination of the mechanical equivalent of heat by electric means is noted. His results are compared with those he had obtained eighteen years earlier by mechanical means, namely, by the agitation of water. The cause for the difference Joule found in the results obtained by the two methods is discussed. The main cause of the difference rested with the assignment of a value for the B.A. (British Association for the Advancement of Science) unit of resistance in cgs units. It is pointed out that this factor played a part in the establishment of the international electric units by the Chicago International Electrical Congress of 1893.

10360. Hamer, W. J., **Evaluation procedures and annual performance data for Leclanché cells,** *Electrochem. Technol.* **5,** No. 11-12, 490-498 (Nov.-Dec. 1967).

Key words: Advances in dry cells; battery nomenclature; dry cell specifications; dry cell standards; dry cell tests; international dry cell standards.

This paper deals with the development over the past 48 years of so-called "standardized tests" for the evaluation of Leclanché cells and batteries. Data covering this time period or a part of this time period are given for (1) general-purpose flashlight cells, (2) industrial flashlight cells, (3) railroad lantern batteries, (4) photoflash cells, (5) No. 6 cells for various end uses, (6) radio "A" batteries, (7) radio "B" batteries, (8) hearing-aid "A" batteries, (9) hearing-aid "B" batteries, and (10) transistor hearing-aid batteries. The presently used standard tests, 27 in number, are described. A history of the development of dry cells of the Leclanché type is also included.

10361. Hanley, H. J. M., Childs, G. E., **Discrepancies between viscosity data for simple gases,** *Science* **159,** No. 3819, 1114-1117 (Mar. 8, 1968).

Key words: Argon; correlation; dilute gas; discrepancies; high temperature viscosity; potential function.

It has been known for some time that Kestin and his co-workers have reported dilute gas viscosity coefficients which differ from the usually accepted values. Recent work supplements Kestin's results. We show that there is no evidence for not accepting this different data. We feel that the whole subject of dilute gas viscosity measurements above room temperature should be reexamined both from the experimenter's and correlater's viewpoint. There is evidence that published tables may be incorrect by as much as 10 percent above about 600 °K.

10362. Hanley, H. J. M., **Thermodynamics of transport phenomena in membrane systems,** *J. Chem. Educ.* **44,** No. 12, 717-719 (Dec. 1967).

Key words: Continuous systems; diffusion flow; discontinuous systems; membranes; nonequilibrium thermodynamics; porous media; thermal transpiration; transport phenomena; viscous flow.

This article shows how the theory of nonequilibrium thermodynamics, developed for continuous systems, can be applied to systems with a membrane. The idea being to develop a straightforward pedagogical thermodynamic approach to transport processes in this type of system which will encourage a reader to dig deeper. Some points on the "continuous" versus "discontinuous" approach to nonequilibrium thermodynamics are also mentioned. The development is based on a discussion of nonisothermal diffusion flow in a porous medium.

10363. Hayward, H. W., Tauber, S. J., **The HAYSTAQ experiment,** Chapter 26 in *Proc. ICIREPAT Fifth Annual Meeting, London, England, Aug. 31-Sept. 10, 1965,* pp. 337-350 (Thompson Book Co., Washington. D.C., 1967).

Key words: Chemistry; compounds; computer; file organization; HAYSTAQ; Hayward; information retrieval; linear notation; Markush; mixtures; reactions; representations; screens; structures; topological codes.

The background of the Haystaq system is recapitulated. Shortcomings of an earlier chemical structure representation are reviewed; the scope and some advantages of the Hayward notation are stated. Suggestions are made for representing mixtures and classes of compounds. The scope is stated of notations for classes of reactions. The organization of files of chemical information and patterns of retrieval are discussed. Capabilities, limitations, and future implications of the techniques evolved are pointed out.

10364. Hetzer, H. B., Robinson, R. A., Bates, R. G., **Conventional pa_H values for buffer solutions of piperazine phosphate from 0° to 50 °C,** *Anal. Chem.* **40,** 634-636 (Mar. 1968).

Key words: Buffer solutions; pH; piperazine phosphate.

Piperazine phosphate, a salt of the composition PzH_3PO_4—where $Pz = C_4H_{10}N_2$—has a pH value of 6.26 at 25 °C in the 0.05*m* aqueous solution (*1*). Its solutions, therefore, contain both the PzH_2^{2+} and PzH^+ cations and both the primary and secondary phosphate anions $H_2PO_4^-$ and HPO_4^{2-}. The salt is available commercially and is readily crystallizable from water. Its buffer capacity and stability are high, and the salt is a useful buffer substance. We have now made emf measurements of the pa_H values of 0.02*m* and 0.05*m* solutions of piperazine phosphate from 0° to 50 °C.

10365. Hollstein, M. G., DeVoe, J. R., **Determination of medium-weight elements by gamma-excited x-ray fluorescence,** (Proc. Second Symp. on Low Energy X- and Gamma Sources and Applications, University of Texas, Austin, Texas, Mar. 27-29, 1967). *Oak Ridge National Laboratory-IIC*-**10**, pp. 483-502 (1967).

Key words: Gamma-excitation; medium-weight elements; molybdenum; quantitative analysis; tin; x-ray fluorescence.

The application of gamma-excited x-ray fluorescence in the determination of medium weight elements has been studied. The pertinent components of the spectrometer are an ^{241}Am source and a solid state detector, with a low-noise preamplifier and multi-channel analyzer. The resolution of the system is between 1.2 and 1.3 keV (FWHM) for 8 to 45 keV photons. Three different techniques of sample mounting were investigated. For single elements in the range from Cu to Dy the estimated detection limits are 10-100 μg and 0.01-1 mg/ml, depending upon the sample mounting procedure. The corresponding K_α-peak intensities are $2 \times 10^4 - 3 \times 10^3$ cpm per mg and $4 \times 10^4 - 6 \times 10^2$ cpm per mg/ml, respectively. For testing the application of the method two series of NBS Standard Reference Materials were analyzed for Sn and Mo as minor constituents within a concentration range from about 0.04 to 9 percent. The best results were obtained by direct counting of the solid samples. Using this technique, a non-destructive analysis for Mo and Sn can be performed in a relatively short time with a precision of a few percent, a detection limit of about 100 ppm and a sensitivity of 6×10^3 to 1.4×10^4 cpm per percent concentration.

10366. Holt, H. K, **Frequency-correlation effects in cascade transitions involving stimulated emission,** *Phys. Rev. Letters* **19,** No. 22, 1275-1277 (Nov. 27, 1967).

Key words: Laser; line profile; neon.

The effect of the frequency correlation of photons emitted in an atomic cascade transition on the frequency profile of the light emitted in the second transition when the first transition is participating in laser action is examined.

10367. Holt, H. K., **Observation of the effect of frequency correlations on a cascade transition,** *Phys. Rev. Letters* **20,** No. 9, 410-412 (Feb. 26, 1968).

Key words: Laser; line profile; neon.

The effect of frequency correlations on a cascade transition has been observed.

10368. Hudson, R. P., **Generation of matrix elements of angular-momentum operators,** *J. Opt. Soc. Am. Letters to Editor* **57,** No. 12, 1552-1553 (Dec. 1967).

Key words: Angular momentum operators; matrix elements.

A simple numerical array is shown to give the matrix elements of certain important angular momentum operators.

10369. Hummer, D. G., **Non-coherent scattering-III. The effect of continuous absorption on the formation of spectral lines,** *Monthly Notices Roy. Astron. Soc.* **138,** No. 1, 73-108 (Jan. 1968).

Key words: Continuous absorption; non-coherent scattering; Planck function; source function; spectral lines.

The formation of spectral lines by completely redistributed non-coherent scattering is systematically investigated for situations in which photo-ionization or extinction by dust grains occurs at the line frequencies. Particular attention is given to cases for which the source function associated with the continuous opacity differs from the Planck function at the local electron temperature. Very large effects are found to occur, even when the ratio of continuous opacity to line opacity is very small. Extensive numerical results are presented, and the relevant scaling laws and the generalized thermalization length are discussed.

10370. Ito, J., **A new yttrium magnesium silicate garnet, $Y_6Mg_5Si_5O_{24}$ and its rare earth and nickel analogues,** *Mater. Res. Bull* 2, 1093-1098 (1967).

Key words: Crystal chemistry; hydrothermal synthesis; rare-earth garnet; x-ray powder analysis.

A new magnesium yttrium silicate garnet and its rare-earth analogues with 4 and 6 coordinated magnesium and nickel ions have been synthesized hydrothermically. Its solid solubility with yttrium aluminum garnet was investigated.

10371. Jensen, M. W., **Milk meters, farm milk tank testing, and plastic containers for milk,** *Proc. 31st Annual Meeting International Association of Milk Control Agencies, Biloxi, Mississippi, Oct. 23-25, 1967,* pp. 26-31 (1968).

Key words: Farm milk tanks; milk handling; milk meters; plastic milk containers.

The role of the National Bureau of Standards in weights and measures administration was discussed, as were current technical developments in mechanical metering of milk, gauging and testing of farm milk tanks, and acceptance for measuring and packaging purposes of plastic containers for milk.

10372. Jespersen, J. L., Kamas, G., Morgan, A. H., **A proposed ranging system with application to VLF timing,** *IEEE Trans. Instr. Meas.* **IM-16,** No. 4, 282-285 (Dec. 1967).

Key words: Dispersion; range; time; VLF.

In general, without a clock it is not possible to determine the range between a radio transmitting and receiving site by making only passive observations at the receiving site. However, if the medium is dispersive, signals transmitted simultaneously from the same site, at different carrier frequencies, will not arrive simultaneously at some distant point. Thus, the difference in arrival time is related to the observer's distance from the transmitter. This effect is considered in conjunction with the VLF two-frequency timing system.

10373. Johannesen, R. B., **NMR studies of inorganic fluorides. IV. Relative signs of coupling constants in CH_3SiF_3, $HSiF_3$, and HPF_2,** *J. Chem. Phys.* **47,** No. 8, 3088-3089 (Oct. 15, 1967).

Key words: Double resonance; fluorine; fluorosilanes; hydrogen; nuclear magnetic resonance; phosphorus; relative signs; silicon; spin coupling constants.

The high-resolution n.m.r. spectra of CH_3SiF_3, $HSiF_3$, and HPF_2 have been recorded, and all of the coupling constants, including the relative signs, are reported (except for $J_{^{13}C-^{29}Si}$).

10374. Johannesen, R. B., Brinckman, F. E., Coyle, T. D., **Nuclear magnetic resonance studies of inorganic fluorides. V. Fluorosilanes,** *J. Phys. Chem.* **72,** 660-667 (1968).

Key words: Chemical shift; coupling constant; double resonance; fluorine; fluorosilanes; nuclear magnetic resonance; silicon; spin-coupling; solvent effects.

Nuclear magnetic resonance (nmr) chemical shifts of ^{19}F nuclei and $^{29}Si-^{19}F$ coupling constants have been measured for a number of compounds containing silicon—fluorine bonds. For most of these, ^{29}Si chemical shifts were also determined by (heteronuclear) ($^{19}F-\{^{29}Si\}$) double resonance. With few exceptions, ^{19}F and ^{29}Si resonances in substituted fluorosilanes are on the low-field side of the corresponding resonances in SiF_4. The ^{29}Si shift in the SiF_6^{2-} ion is about 75 ppm to high field of SiF_4 and is well outside the range of previously reported silicon shift values. Magnitudes of $^{29}Si-^{19}F$ coupling constants range from 167.6 Hz in Si_2OF_6 to 384.9 Hz in Si_2Cl_5F. The variation of these parameters with the nature and extent of substitution on silicon is discussed. A significant solvent dependence of the chemical shifts in SiF_4 and similar compounds has been observed.

10375. Judd, D. B., **A flattery index for artificial illuminants,** *Illum. Eng.* **62,** No. 10, 593-598 (Oct. 1967).

Key words: Color; flattery; illuminants; preference; rendition of color.

Artificial illuminants are used for (1) light-dark discrimination of objects, (2) critical appraisal of colored objects, and (3) appreciative viewing of colored objects. A light source that renders object colors in accord with their preferred colors may be said to flatter those objects. A flattery index has been derived for light sources used for appreciative viewing of colored objects to measure the degree to which such sources render object colors as we would like to see them. This index is based solely on spectral distribution and is modeled after the index of color rendition recently recommended by the CIE. It uses 10 of the 14 test samples established for appraisal of color rendition, and it uses the same definition of reference illuminants. It is scaled so that the reference illuminant receives a flattery index of 90, and a test illuminant rendering object colors precisely in accord with the preferred colors of the test samples receives a flattery index of 100. The test sample representative of the human complexion receives about one-third of the total weight; the two test samples representative of food colors, about one-third; the seven other test samples the remainder.

10376. Kamper, R. A., **Millidegree noise thermometry,** *Proc. Symp. Physics of Superconducting Devices, University of Virginia, Charlottesville, Va., Apr. 28-29, 1967,* pp. M-1—M-5 (Office of Naval Research, Washington, D.C., 1968).

Key words: Josephson effect; linewidth; millidegree; noise; superconductivity; thermometry.

Assuming that the linewidth of the A. C. Josephson radiation is caused entirely by thermal fluctuations in the bias voltage, we show that it can be used with quite simple instrumentation to measure absolute temperatures down to one millidegree or lower.

10377. Klein, R., Scheer, M. D., **Mechanism of $O(^3P)$ addition to condensed films. II. Propene, 1-butene, and their mixtures,** *J. Phys. Chem.* **72,** No. 2, 616-622 (Feb. 1968).

Key words: Low temperature chemistry; olefins; oxidation; oxygen atom; propylene; 1-butene.

The kinetics of $O(^3P)$ addition to condensed films of propene and 1-butene has been investigated at 90 °K. The reaction rate was found to be independent of olefin concentration for both propene and 1-butene using propane as an inert dilutent. Films containing mixtures of propene and 1-butene yielded mostly C_3 products at high olefin concentration and approached a limiting value of about 1.6 for the C_3/C_4 product ratio at infinite dilution in propane. When C_3D_6 films were used, the ratio of carbonyl to epoxide was measurably less than that obtained with C_3H_6. The results are interpreted in terms of a model which depicts the olefin film to be a nearly perfect sink for $O(^3P)$ atoms. The primary process is assumed to be the formation of a triplet adduct which undergoes either ring closure to form the epoxide or an intramolecular migration of a hydrogen atom to produce a carbonyl compound. The latter exhibits the expected isotope effect when D is substituted for H in the olefin reactant. The behavior of propene-1-butene mixtures can be accounted for qualitatively by assuming that propene not only reacts more rapidly but diffuses more easily than does the 1-butene.

10378. Knight, J. M., O'Connell, J. S., Prats, F., **Two- and three-body photodisintegration cross sections of ^{3}H and ^{3}He,** *Phys. Rev.* **164,** No. 4, 1354-1359 (Dec. 20, 1967).

Key words: Cross sections; dipole; final state interactions; helium 3; photodisintegration; tritium.

Electric dipole photodisintegration cross sections of ^{3}H, ^{3}He into deuteron plus nucleon and into three nucleons are calculated using simple zero range forms for the initial and final state wave functions. Final state interaction between nucleon pairs in s-states are taken into account. Shape fits to the experimental data are obtained, but the required normalization of the ground state wave function is found to differ between two- and three-body breakup.

10379. Kolbenstvedt, H., **Energy transfer in the collision of electron beams,** *Phys. Rev.* **163,** No. 1, 112-114 (Nov. 5, 1967).

Key words: Average; cross-section; distribution; electrons; energy; isotropic; motion; scattering.

The cross section for electron-electron scattering differential in energy transfer, is derived for the case that both electrons are in motion in the laboratory system. The result is valid for all electron energies much higher than the Rydberg energy.

For the case in which both electrons are nonrelativistic and one of the electrons has an isotropic velocity-distribution, the cross section is averaged over the directions of motion of this electron.

10380. Kolbenstvedt, H., **Simple theory for K-ionization by relativistic electrons,** *J. Appl. Phys.* **38,** No. 12, 4785-4787 (Nov. 1967).

Key words: Collision; cross section; electrons; energy; ionization; photons; silver; tin.

The total cross section for ionization of K-electrons by electrons has been derived using the method of virtual photons combined with the photoelectric cross section for distant collisions and the Møller cross section for close collisions. Good agreement with experiments is obtained for the elements silver ($Z = 47$) and tin ($Z = 50$) when the electron energy is much higher than the ionization energy.

10381. Koonce, C. S., Cohen, M. L., Schooley, J. F., Hosler, W. R., Pfeiffer, E. R., **Superconducting transition temperatures of semiconducting $SrTiO_3$,** *Phys. Rev.* **163,** No. 2, 380-390 (Nov. 10, 1967).

Key words: Semiconductors; $SrTiO_3$; superconductivity; transition temperatures.

The superconducting transition temperature T_c of $SrTiO_3$ has been measured for specimens having electron carrier concentrations n_c from 6.9×10^{18} cm^{-3} to 5.5×10^{20} cm^{-3}. The curve exhibits a maximum in T_c for n_c near 9×10^{19} cm^{-3}. The transition temperature has also been calculated using one adjustable parameter ξ, the intervalley deformation potential, in addition to the known normal-state properties of $SrTiO_3$. A good fit to the experimental curve is obtained.

10382. Krause, R. E., Jr., Douglas, T. B., **The vapor pressure, vapor dimerization, and heat of sublimation of aluminum fluoride, using the entrainment method,** *J. Phys. Chem.* **72,** No. 2, 475-481 (Feb. 1968).

Key words: Aluminum fluoride; entrainment method; heat of sublimation; temperature; vapor dimerization; vapor pressure.

The vapor pressure P of anhydrous aluminum fluoride was measured at eight temperatures between 1194 and 1258 °K by an entrainment method. The standard deviation of P from a least-square fit was 0.15 percent, and possible systematic errors of 0.5 percent in P and 1° in T were estimated. Smoothed values of P and dP/dT at 1225 °K were determined. Considering P as the sum of the ideal monomeric and twice the dimeric vapor pressure, the other two thermodynamic properties necessary to define (1) $AlF_3() \rightleftharpoons AlF_3(g)$ and (2) $2AlF_3(g) \rightleftharpoons Al_2F_6(g)$ were taken as (a) $\Delta S°(1)$, derived from published spectroscopic and crystalline heat capacity data, and (b) $2\Delta H°(1) + \Delta H°(2)$, reported in a recent mass spectrometric study. The derived results at 1225 °K along with their estimated uncertainties were $\Delta H°(1) = 67.0 \pm 0.4$ kcal, $\Delta S°(1) = 43.0 \pm 0.4$ eu, and $\Delta G°(2) = -7 \pm 1$ kcal.

10383. Kuriyama, M., **Distortion correction in anomalous absorption coefficients,** *Phys. Stat. Sol.* **24,** 743-748 (1967).

Key words: Anomalous transmission; atomic displacement; Debye-Waller factor; distorted crystal; Laue case; photon Green's function; theory; x-ray diffraction.

Based on the theory of x-ray diffraction by a distorted crystal which has recently been completed by the present author, the temperature-and distortion-correction in anomalous absorption coefficients has been studied in the case of a single symmetrical Bragg reflection (a symmetrical Laue case).

If the distribution of atomic displacements is given, then the anomalous absorption coefficient has the distortion correction of the same form, in terms of the second moment of the distribution, as the Debye-Waller factor. If the displacement of atoms in a distorted crystal is replaced by a proper time-average value of the thermal motion of atoms, then the temperature correction in the absorption coefficient is given by the Debye-Waller factor multiplied by the structure factor.

10384. Kuriyama, M., **Theory of X-ray diffraction by a distorted crystal,** *J. Phys. Soc. Japan* **23,** No. 6, 1369-1379 (Dec. 1967).

Key words: Atom; Bragg condition; displacement; distorted crystal; electron overlap; Green's function; lattice; photon; theory; x-ray diffraction.

Based on the quantum theory of X-ray diffraction by a perfect crystal (M. Ashkin and M. Kuriyama, *J. Phys. Soc. Japan* **21** (1966), 1549), a diffraction theory for a distorted crystal has been developed. The scattering amplitude for the case of a single Bragg reflection has been obtained in terms of a lattice sum including the displacement of each atom. A basic assumption for this formulation is that there is no overlap of the electron wave functions of the displaced atoms. The existing basic assumption in the dynamical theory for a distorted crystal, that the local distortion in the crystal must change very slowly so that the local wave field can be described by the dynamical theory for a perfect crystal, has been successfully ruled out in the present formulation. A criticism has also been made to the so-called "Fourier" expansion of polarizability or electron distribution in the distorted crystal, which has been important for the dynamical theory.

10385. Lafferty, W. J., **Direct *l*-type doubling transitions in some axially symmetric molecules,** *J. Mol. Spectry.* **25,** No. 8, 359-364 (Mar. 1968).

Key words: Cyanocetylene; direct *l*-type doubling transitions; fluorocyanogen; *l*-type doubling constants; *l*-type resonance; methyl cyanide; microwave spectroscopy.

Direct *l*-type doubling transitions have been observed in the states $\nu_2{}^1$ in FCN, $\nu_7{}^1$ and $3\nu_7{}^1$ in cyanoacetylene and $\nu_8(E)$ in methyl cyanide. Precise values for q and the higher order term μ have been obtained for each of these vibrations. The effect of the *l*-type resonance between the π and Φ levels of $3\nu_7$ of cyanoacetylene is discussed.

10386. Landgrebe, A. R., McSharry, W. O., Cefola, M., **The radiometric titration of trace amounts of zinc,** *Intern. J. Appl. Radiation Isotopes* **19,** 1, 23-26 (1968).

Key words: Batch; column; cationic exchanger; EDTA; radiometric; titrations; zinc.

A method of radiometric titration for the determination of trace amounts of metals has been developed. The EDTA complex of the metal to be determined is formed, and the excess, uncomplexed metal ions are removed by means of a cationic exchanger. A titration curve is then constructed by plotting the activity of the liquid phase, versus the amount of EDTA added. Both the batch and column method were tried in this laboratory, and it is our opinion that the batch method is easier from a manipulative point of view. A new method of determining the end point was developed. If both the resin and solution are counted, this is a simple way of determining the half equivalent point. Methods are underway to maximize the sensitivity for zinc by chelating radiometric titration.

10387. Landgrebe, A. R., Rodriguez-Pasques, R. H., Schima, F. J., **The rapid radiochemical separation of radioactive praseodymium from radioactive cerium,** *Intern. J. Appl. Radiation Isotopes* **19,** No. 2, 147-149 (1968).

Key words: Cerium; linac; praseodymium; precipitation; radioactive; rapid separation; solvent extraction.

A method of rapid radiochemical separation was developed to separate the cerium and praseodymium radioactivities produced after a praseodymium target was irradiated at the NBS Linac. The praseodymium metal is dissolved in nitric acid and the solution is divided into at least two portions. One fraction is used to precipitate cerium (IV) iodate, giving an aqueous phase free of cerium radioactivity. A second fraction is extracted with hydrogen di-(2 ethylhexyl) orthophosphoric acid (HDEHP). The organic phase is free from any praseodymium radioactivities.

10388. LeLevier, R. E., Branscomb, L. M., **Ion chemistry governing mesospheric electron concentrations,** *J. Geophys. Res., Space Physics* **73,** No. 1, 27-41 (Jan. 1, 1968).

Key words: Ion chemistry; mesospheric electron concentrations; microscopic chemical reactions; negative ions.

A theory and methodology for investigating the ion chemistry governing mesospheric electron concentrations is presented. In this theory, macroscopic reaction coefficients are defined in terms of the microscopic chemical reactions that take place between positive ions, electrons, and negative ions. The role of minor constituents of the atmosphere, O, O_3, CO_2, NO, and NO_2, is discussed using reaction rates measured in the laboratory. One reaction, the associative detachment of O_2^- by atomic oxygen, is so fast that mechanisms for inhibiting or suppressing this reaction are required. The need for such mechanisms is dictated by field data on riometer absorption induced by the nuclear explosions of the 1962 Christmas Island air drops. The importance of terminating negative ions, i.e., negative ions that withstand the attack of atomic oxygen, is emphasized. Also emphasized is the influence of the ion-ion mutual neutralization coefficient of terminating negative ions. Four illustrative models of the ion chemistry are presented ranging from the simplest O_2^- model which is certainly unrealistic, to a more complex model involving six species of negative ions. This model, which is suggested by recent measurements of reaction rates in the laboratory, does not include the effect of water vapor in the reaction scheme since little laboratory data exist on the reaction of negative ions with water.

10389. Little, W. E., Ellerbruch, D. A., Engen, G. F., **An analysis of the "quarter-wave" technique of reducing the errors in UHF and microwave impedance measurement,** *IEEE Trans. Microwave Theory Tech.* **MTT-15,** No. 9, 504-507 (Sept. 1967).

Key words: Impedance measurement; microwave; quarter wave; reflection coefficient measurement; standing wave machine; UHF.

An analysis is given of the "quarter-wave" impedance measurement technique. This technique, which finds its widest potential application in conjunction with standing wave machines, permits the approximate elimination of the error due to residual reflection or VSWR. If the other sources of error are small, the potential reduction in error is in the ratio $|t_{11}| / 2|S_{11}|$, where S_{11} and t_{11} are the residual reflection coefficients of the standing wave machine and quarter wavelength section respectively.

10390. Logan, H. L., **Some techniques used in the study of stress corrosion cracking,** *Am Soc. Testing Mater. Spec. Tech. Publ. Stress Corrosion Testing* **425,** 127-144 (1967).

Key words: Experimental techniques for stress corrosion testing; high strength steels; hydrogen embrittlement; low carbon steels; stainless steels; stress-corrosion; titanium alloys.

Techniques used at the National Bureau of Standards in the study of stress-corrosion cracking of metals are described together with precautions taken in these investigations. Especially designed specimen of low carbon and stainless steels and a titanium alloy and supplementary techniques for obtaining data as to the mechanism of the stress-corrosion process are also described. A specimen and technique recently used to determine whether hydrogen plays a part in the delayed failures of high strength steels in chloride solutions is described.

10391. Lovell, W. S., Anderson, M. M., Seiller, F. E., **Laser harmonics useful for frequency translation,** *Appl. Opt.* **6,** No. 8, 1430-1432 (Aug. 1967).

Key words: Accidental coincidences; frequency locking; frequency translation; laser harmonics.

Accidental coincidences betweeen laser fundamental and harmonic frequencies usable (in principle) for frequency translation are tabulated.

10392. Madey, T. E., Yates, J. T., Jr., **Work function studies: Chemisorption of diatomic molecules on single-crystal tungsten,** *Nuovo Cimento, Suppl. Series I,* **5,** No. 1, 483-505 (1967).

Key words: Adsorption; carbon monoxide; chemisorption; desorption; electron reflection; nitrogen; oxygen; single crystal; sticking coefficient; thermionic emission; work function.

The work function changes accompanying the chemisorption of diatomic molecules on single crystal (100) and (110) tungsten have been studied using a modification of Shelton's retarding potential method. Each crystal wafer was cut and polished to the desired orientation on both sides, suspended by fine W wires, and heated by electron bombardment. This mode of suspension and heating allowed measurements of surface coverage to be made with a minimum of error due to edge effects and desorption from support loads. The work function difference $\phi(110)-\phi(100)=0.65$ eV was found to be independent of which crystal was used as emitter. The changes in work function and electron reflection upon chemisorption, as well as measurements of surface coverage and sticking coefficients have been made, where possible, for N_2, O_2, and CO on these two crystals.

10393. Maki, A. G., Jr., Lide, D. R., Jr., **Microwave and infrared measurements on HCN and DCN: observations on *l*-type resonance doublets,** *J. Chem. Phys.* **47,** No. 9, 3206-3210 (Nov. 1, 1967).

Key words: Deuterium cyanide; hydrogen cyanide; infrared spectra; microwave spectra; molecular constants; molecular structure; spectra.

Microwave measurements have been made on the direct doublet splittings ($\Delta J=0$ transitions) of the 01^10, 02^20, 03^10, and 03^30 levels of DCN and the 01^10 and 02^20 levels of HCN. The sensitivity of the Δ and Φ level splittings to certain vibrational and rotational constants enables us to obtain new values for those constants. New infrared measurements are given for ν_1, $3\nu_2{}^1$, $4\nu_2{}^0-\nu_2{}^1$ and $4\nu_2{}^2-\nu_2{}^1$ of HCN.

10394. Mann, R. H., Maryott, A. A., **Dipole moment of $CO(CO)_3NO$ from the nonresonant microwave absorption of the vapor,** *J. Chem. Phys.* **47,** No. 10, 4275-4276 (Nov. 15, 1967).

Key words: Cobalt tricarbonyl nitrosyl; dipole moment; gas phase; nonresonant; microwave absorption.

The electric dipole moment of cobalt tricarbonyl nitrosyl ($CO(CO_3)NO$) in the vapor phase was determined by the method of nonresonant microwave absorption in dilute mixtures with CO_2 and SF_6. The dipole moment is found to be 0.363 D with an estimated uncertainty of about 3 percent.

10395. Manson, S. T., Cooper, J. W., **Photoionization in the soft x-ray range: Z dependence in a central-potential model,** *Phys. Rev.* **165,** No. 1, 126-138 (Jan. 5, 1968).

Key words: Central potential model; photoabsorption cross section; photoionization cross section; soft x-rays.

Using one electron model with a realistic central potential, photoionization calculations have been performed which emphasize the soft x-ray spectral range (~ 100 eV to ~ 2 keV). The $M_{II,III}$(3p) subshell was studied in Ar, Cu and Ge, as well as the $M_{IV,V}$(3d) and $M_{II,III}$ in Kr, Rh, Xe, Eu, Au and Fm in an effort to explain the combined Z and energy dependence of the photoionization cross sections for these subshells. In addition, calculations have been performed for 3s, 4s, 5s, 4p, 5p, 4d, 5d and 4f subshells in certain elements. The results, which are considerably different from the predictions of the hydrogen-like model, show certain regularities which are explained in terms of the potentials. Comparisons with experiment show that the model correctly predicts the gross spectral shape of photoionization cross sections but the results are somewhat numerically inaccurate in the vicinity of large absorption peaks. This calculation is considered to be a first approximation which can be improved by taking exchange into account more exactly and by including electron-electron correlation.

10396. Marantz, S., Armstrong, G. T., **Heats of combustion of *trans*-stilbene and *trans*-2,2.,4,4′,6,6′-hexanitrostilbene (HNS),** *J. Chem. Eng. Data* **13,** No. 1, 118-121 (Jan. 1968).

Key words: Bond energy, (C=C) bond; hexanitrostilbene, heat of combustion; stilbene, heat of combustion.

The standard heats of combustion, ΔH°_{c298}, of *trans*-stilbene(c) and *trans*-2,2′,4,4′,6,6′-hexanitrostilbene(c) were measured in an oxygen bomb calorimeter and were -1759.28 and -1535.54 kcal. mole^{-1}, respectively. Estimated uncertainties of these results, respectively, were 0.93 and 1.08 kcal. moles^{-1} including contribution of errors from both random and systematic sources. With these results, the standard heats of formation, ΔH°_{f298}, of *trans*-stilbene(c) and *trans*-2,2′,4,4′,6,6′-hexanitrostilbene(c) were -32.68 and -13.89 kcal. mole^{-1}, respectively. The standard heats of formation of the gas phases were -12.0 and $+29.2$ kcal. mole^{-1}, respectively. In the light of these results, and analogous data for toluene(g) and trinitrotoluene(g), the addition of six nitro groups to *trans*-stilbene may be interpreted as weakening the central C=C bond by 34.1 kcal. mole^{-1}.

10397. Margoshes, M., **What's in that microgram? You can be sure . . . to 10 ppm,** *Sci. Res.* **3,** No. 5, 40-42 (Mar. 4, 1968).

Key words: Electron microprobe; emission spectrometry; laser; mass spectrometry; microanalysis; spark; x-ray spectrometry.

Spectrometric methods of microanalysis are briefly reviewed and compared. The techniques considered include emission spectrometry with the laser probe and microspark, mass spectrometry with laser, spark, and sputtering vaporization; and x-ray spectrometry with the milliprobe and electron microprobe.

10398. Marshak, H., Langsford, A., Wong, C. Y., Tamura, T., **Total neutron cross section of oriented ^{165}Ho from 2 to 135 MeV,** *Phys. Rev. Letters* **20,** No. 11, 554-558 (Mar. 11, 1968).

Key words: Black nucleus; coupled-channel calculations; nuclear deformation effect; nuclear orientation; nuclear Ramsauer effect; ^{165}Ho nucleus; optical model; total neutron cross section.

The effect of nuclear orientation on the total neutron cross section of the highly deformed ^{165}Ho nucleus has been measured from 2 to 135 MeV. The data are successfully fitted by adiabatic coupled-channel calculations. The origin of this effect can also be understood by a semi-empirical model which makes use of both the black-nucleus model and the nuclear Ramsauer effect.

10399. Marzetta, L. A., **Incorrect usage of exact closed-loop voltage gain formula in operational amplifiers,** *Analog Dialogue Letter* **2,** No. 1, 6 (Mar. 1968).

Key words: Closed-loop gain; operational amplifiers; voltage gain.

Much of the literature currently available on operational amplifiers has been found to contain an incorrectly applied gain formula. The publications in question offer an expression for calculating exact closed-loop voltage gain in amplifiers. In their neglect of the phasor nature of one of the factors, the formula can lead to serious errors when applied to operational type amplifiers.

10400. Maximon, L. C., Tzara, C., **Influence of the radiative background on muon and electron scattering from nuclei,** *Physics Letters* **26B,** No. 4, 201-203 (Jan. 22, 1968).

Key words: Electron scattering; inelastic scattering; muon scattering; radiative corrections; radiative tail.

The influence of radiative tails and radiative corrections to inelastic scattering on nuclei at low excitation is compared for muons and electrons. It is found that only for low momentum transfers $Q \leq 50$ MeV/c is the radiative background substantially less for muons than for electrons.

10401. May, L., Snediker, D. K., **Criteria for selection of absorber mounting materials in Mössbauer spectroscopy,** *Nucl. Instr. Methods* **55,** 183-188 (1967).

Key words: Absorber mounting devices; absorption coefficients; gamma-rays and x-rays; half-thickness; Mössbauer spectroscopy; 14.4 keV.

The criteria for the selection of materials for mounting absorbers include their mechanical and chemical properties and their attenuation of the γ-rays and x-rays emitted from the Mössbauer source. Attenuation of the 14.4-keV γ-ray and 6.3-keV x-ray associated with ^{57}Fe was measured for nine commercial materials including plastics and metals. The linear absorption coefficients and half-thicknesses for each material were measured. The usefulness and limitations of each material are discussed, along with three different absorber mounting techniques.

10402. May, L., Spijkerman, J. J., **Mössbauer spectroscopy,** *Chemistry* **40,** 14-17 (Dec. 1967).

Key words: Chemistry; Mössbauer spectroscopy.

A review of Mössbauer spectroscopy is presented for the high school senior and college freshman chemistry students. The fundamental concepts of nuclear resonance fluorescence are described in particular for its application to chemistry. Specific examples are given of how Mössbauer spectroscopy solved analytical and structural problems. A list of selected references are included for further study by the readers.

10403. Mielenz, K. D., Nefflen, K. F., Rowley, W. R. C., Wilson, D. C., Engelhard, E., **Reproducibility of helium-neon laser wavelengths at 633 nm,** *Appl. Opt.* **7,** No. 2, 289-293 (Feb. 1968).

Key words: Frequency-stabilized; helium-neon; krypton 86 lamp; Lamb dip; laser; wavelength.

Measurements on helium-neon lasers stabilized on the Lamb dip, performed at NBS, NPL, and PTB, have shown that the wavelengths of such lasers are reproducible within approximately 1 part in 10^7.

Beyond this limit, different lasers were found to emit different wavelengths. In addition, the wavelength of a given laser may vary during the life of its discharge tube. Pressure shifts appear to be a major cause of such variations.

10404. Milligan, D. E., Jacox, M. E., **Infrared and ultraviolet spectroscopic study of the products of the vacuum-ultraviolet photolysis of methane in Ar and N_2 matrices. The infrared spectrum of the free radical CH_3,** *J. Chem. Phys.* **47,** No. 12, 5146-5156 (Dec. 15, 1967).

Key words: Free radical; infrared; matrix isolation; methyl; methylene; photolysis; rotation; spectrum; ultraviolet; vacuum ultraviolet.

The vacuum ultraviolet photolysis of methane in an argon or a nitrogen matrix at 14 °K leads to the formation of a sufficient concentration of the methyl radical for observation both of its 1500 Å electronic transitions and of its out-of-plane deformation fundamental, which appears at 611 cm^{-1} for CH_3 trapped in a nitrogen matrix. The value observed for this fundamental of CD_3 is in reasonable agreement with the value previously derived from analysis of the 2160 Å band system. Isotopic substitution studies support the assignment of the 611 cm^{-1} feature to ν_2 of CH_3. Data are consistent with the previous report of a planar structure. Evidence is presented suggesting that CH_3 may rotate in an argon matrix. Although CH_2 has not been directly observed, an appreciable concentration of CH_2N_2 appears in the N_2 matrix experiments. Three electronic transitions of CH are observed in the argon matrix experiments, and there is evidence for the production of a small concentration of C atoms.

10405. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the infrared and ultraviolet spectra of the free radical NCO,** *J. Chem. Phys.* **47,** No. 12, 5157-5168 (Dec. 15, 1967).

Key words: C atom reaction; CN reaction; HN_3 photolysis; infrared spectrum; matrix isolation; NCO free radical; NO reaction; O^3 atom reaction; ultraviolet spectrum; vacuum ultraviolet photolysis.

The free radical NCO is stabilized in sufficient concentration for direct infrared and ultraviolet spectroscopic identification upon vacuum ultraviolet photolysis of HNCO suspended in various matrix materials at 4° and 14 °K. Observations on the $B(^2\Pi)-X(^2\Pi)$ electronic transition of NCO have been extended to shorter wavelengths than those previously reported. Isotopically substituted NCO has been prepared in supplementary experiments involving the vacuum ultraviolet photolysis of $CO:HN_3$ and $Ar:HCN:N_2O$ samples, as well as by the mercury arc photolysis of matrix-isolated samples of $NO + N_3CN$. The three vibrational fundamentals of ground-state NCO appear at 487, 1275, 1922 cm^{-1} in an Ar matrix. The values obtained for the stretching force constants suggest that the carbon-oxygen bond may be somewhat stronger than the carbon-nitrogen bond. There is an appreciable positive stretching-interaction force constant. NCO is found to photolyze when subjected to radiation of wavelength near 2537 Å, leading to the production of N + CO. Reactions occurring in the various systems investigated are discussed.

10406. Moore-Sitterly, C. E., **Annual report on spectroscopy,** *Astron. J.* **72,** No. 9, 1117-1118 (Nov. 1967).

Key words: Atomic spectra; lanthanon spectra; molecular spectra; rare earth spectra; transition probabilities; ultraviolet spectra.

Astrophysicists are keenly interested in the spectroscopic programs at this Bureau. The present type of report is furnished annually to the Astronomical Journal to be published with the Observatory Reports. It provides a brief summary of our progress in fields of astrophysical interest.

10407. Moore-Sitterly, C. E., **Necrology: Carl C. Kiess,** *J. Opt. Soc. Am.* **58,** No. 2, 292-293 (Feb. 1968).

Key words: Kiess, Carl C.; obituary.

10408. Myers, V. W., **Inelastic scattering of cold neutrons in polycrystalline gray tin,** *J. Phys. Chem. Solids* **28,** 2207-2210 (Feb. 1967).

Key words: Cold neutron scattering; force constants; gray tin; phonon energies.

The inelastic scattering of cold neutrons by polycrystalline gray tin (diamond structure) at 0 °C has been investigated using the Brookhaven cold neutron facility. It is possible to obtain information on the phonon critical points. There is a narrow peak centered at about 7 meV phonon energy which is attributed to the transverse acoustic modes. A broad band centered around 23 meV is probably due to a combination of the longitudinal optic and acoustic modes. The results are consistent with single crystal dispersion measurements in Si and Ge when the frequencies are scaled inversely as the square root of the mass. This indicates that the force constants in Si, Ge, and Sn are of the same strength.

10409. O'Connell, J. S., Prats, F., **Photodisintegration of the trinucleon system in a separable potential model,** *Physics Letters* **26B,** No. 4, 197-200 (Jan. 22, 1968).

Key words: Cross sections; electric dipole; helium-3; photodisintegration; separable potential; tritium.

Two- and three-body photodisintegration cross sections of ^3H and ^3He are calculated. The ground state wave function used is an exact solution of the three-body Schrödinger equation with separable potentials of the Yamaguchi type. The final states contain the interactions between nucleon pairs. Results are shown both for the Yamaguchi-Sitenko-Kharchenko set and for the Tabakin set of interaction parameters.

10410. Ohashi, M., Stanford, J. W., Paffenbarger, G. C., **Pertinent data on some physical properties of different investments used in the casting of gold alloys,** *J. Nihon Univ. Sch. Dent.* **9,** No. 3, 121-126 (Sept. 1967).

Key words: Alloy castings; gold alloys; hygroscopic inlay; thermal inlay; thermal partial denture.

Fineness, time of setting, compressive strength, linear thermal expansion, normal setting expansion, and surface defects of alloy castings were determined using casting investments of three types thermal inlay, hygroscopic inlay, and thermal partial denture. The use of the normal setting expansion combined with either the hygroscopic or thermal expansion to compensate for the shrinkage of casting gold alloys is discussed.

10411. Okabe, H., Lenzi, M., **Photodissociation of NH_3 in the vacuum ultraviolet,** *J. Chem. Phys.* **47,** No. 12, 5241-5246 (Dec. 15, 1967).

Key words: Adsorption; excited NH; excited NH_2; fluorescence; NH_3; photodissociation; vacuum ultraviolet.

Two photodissociation processes of NH_3 producing electronically excited radicals have been studied in the vacuum ultraviolet. $NH_3 \rightarrow NH_2 A^2A_1 + H$ (1) – $NH_3 \rightarrow NH\ c^1\Pi + H_2$ (2). The intensity of the fluorescence from these radicals, lying in the spectral regions 4000 Å to 6000 Å and at 3240 Å respectively, has been measured as a function of wavelength of incident light with a resolution of 7 Å. The fluorescence curves thus obtained were compared with the absorption spectrum of NH_3. It is shown that the process (1) may be correlated with the $^1E''$ (1665 Å bands), $^1A_2''$ (1434 Å bands), $^1A_2''$ (1330 Å bands), 1286 Å bands and the continuum (1250 to 1600 Å). On the other hand, the process (2) may be associated with the continua (1250 Å to 1600 Å and below 1250 Å). The threshold wavelength of process (2) is 1325±7 Å. The electronic energy 'a' of the first singlet state NH $a^1\Delta$ with respect to the ground triplet state $X^3 =^-$ is $a \leqslant 1.6 + 0.1$ eV which is obtained from the threshold wavelength together with the heat of reaction (3.9±0.1 eV) $NH_2 \rightarrow NH\ X^3\Sigma^- + H_2$ and the electronic energy of the NH $c^1\ \Pi$ (3.813 eV) with respect to the $a^1\Delta$. Various other primary processes are discussed in conjunction with the absorption spectrum. For incident light of wavelength below 1200 Å the ionization process $NH_3 \rightarrow NH_3^+ + e$ (3) and the process (2) both of which may arise from the continuum become predominant. Dissociation processes appear to be dictated by the spin conservation rule.

10412. Pella, P. A., Landgrebe, A. R., DeVoe, J. R., Purdy, W. C., **Differential controlled-potential coulometry utilizing substoichiometric radioisotope dilution,** *Anal. Chem.* **39,** 1781-1785 (Dec. 1967).

Key words: Cadmium; coulometry; electrolysis; radioactive tracers; radioisotope dilution; substoichiometric; trace analysis; zinc spelter.

A controlled-potential coulometric procedure is described which permits the utilization of the principle of substoichiometric radioisotope dilution. This technique employs two identical cells connected in series. Under prescribed conditions, the same amount of the element to be analyzed is deposited in each cell. The procedure involves the addition of a known amount of the element to the control cell, which is held at a constant potential, and an unknown amount to the sample cell. An equal, known amount of a radioisotope of that element is then added to each cell. The difference in the amount is determined by measuring the radioactivity remaining in each of the cells after a finite electrolysis time. This method was applied to the determination of cadmium in an NBS Standard Reference Material, zinc spelter, with a result of 0.0928 percent with a standard deviation of the mean of 0.0005 percent.

10413. Pfeiffer, E. R., Schooley, J. F., **Effect of stress on the superconductive transition temperature of strontium titanate,** *Phys. Rev. Letters* **19,** No. 14, 783-785 (Oct. 2, 1967).

Key words: Anisotropic uniaxial stress effect; hydrostatic pressure; reduced strontium titanate; single crystal; stresses; superconductive transition temperatures; uniaxial stresses.

The superconductive transition temperatures T_c of single crystal specimens of reduced strontium titanate have been measured as functions of hydrostatic and uniaxial compressional stresses up to 1.5 kbar. The prominent features of the experimental results are a large non-linear hydrostatic pressure effect and an anisotropic uniaxial stress effect. The relative decrease of transition temperature with pressure $d \ln T_c / d\,p$ is about an order of magnitude larger than that seen in metallic superconductors.

10414. Pierce, E. T., Price, O. W., Edelman, S. E., Jones, E., **Accelerometer resonances affect vibration measurement,** *J. Environ. Sci.* **10,** No. 6, 17-21 (Dec. 1967).

Key words: Accelerometer; calibration; pickup; resonance; vibration.

Errors in vibration measurement can be caused by unintended relative motion in the pickup. Near the resonant frequency of such relative motion, the pickup can affect the motion of surface to which it is attached. The paper gives details of two cases of resonances of this kind; resonances which are unexpected on the basis of the usual mass-spring theory.

10415. Post, M. A., **Qualitative and quantitative determination of emulsion-polymerised binders in latex paints,** *J. Appl. Chem.* **17,** 315-320 (Nov. 1967).

Key words: Acrylic; identification; infrared spectroscopy; latex paints; polyvinyl acetate; separation; styrene-butadiene; vinyl-acrylic.

Methods for the separation and identification by infrared absorption spectroscopy of styrene-butadiene, acrylic, vinyl-acrylic and polyvinyl acetate homopolymer and dibutyl maleate copolymer in emulsion paints based on these materials are presented. Detailed procedures for their quantitative determination are discussed.

10416. Preston, G. T., Chapman, T. W., Prausnitz, J. M., **Transport properties of cryogenic liquids and their mixtures,** *Cryogenics* **7,** No. 5, 274-279 (Oct. 1967).

Key words: Corresponding-states principle correlation; cryogenic liquids and liquid mixtures; mutual-diffusivity; self-diffusivity; thermal conductivity.

Based on the corresponding-states principle, a correlation is presented for the viscosities, thermal conductivities and self-diffusivities of nine cryogenic liquids from the triple-point temperatures to temperatures close to the critical. Experimental data are reduced with two molecular parameters for each liquid: a characteristic energy and a characteristic size. The correlations are useful for predicting transport properties of pure liquids at temperatures where experimental data are not available; in addition, using reasonable mixing rules, the correlations may be used to estimate transport properties of liquid mixtures.

10417. Prince, E., Rush, J. J., **Many disciplines unite to study solid structure and dynamics,** *Phys. Today* **21,** No. 2, 95-99 (Feb. 1968).

Key words: Crystal dynamics; crystallography; crystal structure; inorganic; molecular solid; organic; polymers; rotation; spectroscopy.

A review is presented of the Second Materials Research Symposium, "Molecular Dynamics and Structure of Solids," sponsored by the NBS Institute for Materials Research and held at NBS on October 16-19, 1967.

10418. Pytte, E., Bennett, H. S., **Ultrasonic attenuation in the Heisenberg paramagnet. II. Antiferromagnets,** *Phys. Rev.* **164,** No. 2, 712-715 (Dec. 10, 1967).

Key words: Antiferromagnetic insulators; correlation function; ferromagnetic insulators; Heisenberg; Néel point; ultrasonic attenuation.

The propagation of sound waves in antiferromagnetic insulators is studied within the framework of two models which describe the interaction between the spin system and the lattice. In particular, expressions for the ultrasonic attenuation coefficient near the Néel point are obtained in terms of time dependent correlation functions. The attenuation coefficient is found to be proportional to the square of the phonon frequency, to increase rapidly in the vicinity of the Néel point, and to be less singular than the attenuation coefficient for ferromagnetic insulators.

10419. Rasberry, S. D., Caul, H. J., Yezer, A., **X-ray fluorescence analysis of silver dental alloys with correction for a line interference,** *Spectrochim. Acta* **23B,** 345-351 (Mar. 1968).

Key words: Analysis; line interference correction; silver dental alloys; specimen preparation; spectrometry; x-ray fluorescence.

An x-ray fluorescence spectrometric method has been developed for the rapid analysis of granular silver dental amalgam alloys having the nominal composition, in percent, of silver 69, tin 26, copper 4, and zinc 1. Several methods of specimen preparation were investigated; a method employing briquettes pressed at 1400 kg/cm^2 without binder was the most satisfactory. Analytical curves relating intensitites of K_α lines to concentration of silver, copper, and zinc were linear but no calibration curve could be obtained for the tin K_α line due to line interference from the silver K_β emission. To correct for this interference, the ratio of intensities (Sn K_α + Ag K_β)/Ag K_α was plotted versus the ratio of concentrations Sn/Ag, producing a linear analytical curve. Observed typical coefficients of variation for the method were Ag 0.4 percent, Sn 0.8 percent, Cu 3 percent, and Zn 0.6 percent.

10420. Risley, A. S., **Parallel pump susceptibility of YIG under cw drive conditions,** *Physics Letters* **25A,** No. 6, 471-472 (Sept. 25, 1967).

Key words: Parallel pump susceptibility; sample heating; saturation.

The parallel pump susceptibility χ'', has been measured versus the level and time duration of applied rf power. Unlike previously reported data taken by the pulse technique, χ'' increases at the higher drive levels.

10421. Rodriguez-Pasques, R. H., Mullen, P. A., George, G. A., Harding, J. E., **Transmission through aluminum of beta-particles emitted by infinitely-thick sources,** *Intern. J. Appl. Radiation Isotopes* **18,** No. 12, 835-847 (1967).

Key words: Beta absorption; beta-particle energy; beta-particle transmission; half-thickness; infinitely-thick sources; low-level; synthetic beta sources; transmission curves.

The problem of determining the energy of beta particles emitted from sources containing low concentrations of radioactive substances is examined. Transmission curves of beta particles emitted by "infinitely-thick" disc-shaped sources were obtained with two different detectors and compared to the curves similarly obtained for beta particles coming from very thin "weightless" deposits on similar solid discs. Different matrix materials and beta-particle energies were used. The curves were studied for shape, secondary radiations and half-thickness. A series of curves were also obtained from four different potassium-salt thick sources, in order to investigate possible influences from variations of effective atomic number.

No substantial difference was found between the curves corresponding to the three types of sources, in connection with half-thickness-maximum-energy relationship.

Guiding rules are proposed for the determination of maximum beta-ray energies by means of absorption studies and half-thickness determination.

10422. Ronn, A. M., Lide, D. R., Jr., **Infrared-microwave double resonance using a CO_2 laser,** *J. Chem. Phys.* **47,** No. 9, 3669-3670 (Nov. 1, 1967).

Key words: Double resonance; infrared; laser; methyl bromide; microwave; pumping; saturation.

A double resonance experiment is described in which a vibrational transition is pumped with a carbon dioxide laser and the effect of the pumping is detected through a rotational transition in the microwave region. Positive results have been found with methyl bromide. The interpretation of the results are discussed.

10423. Ruegg, F. C., **Multiplex for dual-spectrum Mössbauer spectrometry,** (Proc. Second Symp. on Low Energy X- and Gamma Sources and Applications, University of Texas, Austin Texas, Mar. 27-29, 1967), *Oak Ridge National Laboratory-IIC*-**10,** pp. 157-175 (1967).

Key words: Dual spectra; Mössbauer; multiplex; spectroscopy.

It is often desirable to have the capability of accumulating two Mössbauer spectra simultaneously with both spectra having exactly the same Doppler velocity dependence. This is possible with a multiplexing system which allows accumulation of two spectra simultaneously and storing of each spectrum in a 200 channel subgroup of a multichannel analyzer. The memory of the analyzer which is operated in the time mode is used on a demand basis by the two detector systems, and the counts are routed to the proper subgroup in complimentary channel locations, i.e., the channel location in the second subgroup is the channel number in the first subgroup plus 200. The logic, circuitry and performance are described.

10424. Rush, J. J., **Neutron-scattering study of hindered rotations in methylbenzenes,** *J. Chem. Phys.* **47,** No. 10, 3936-3941 (Nov. 15, 1967).

Key words: Barrier to rotation; cosine potential; frequency spectra; hindered rotation; internal rotation; methylbenzenes; methyl groups; neutron scattering; torsional modes.

The low-frequency modes of a number of methylbenzenes in their solid and liquid phases have been investigated by the energy-gain scattering of cold neutrons. The compounds studied include benzene, o-xylene (1,2), hemimellitene (1,2,3), mesitylene (1,3,5), durene (1,2,4;5), prehnitene (1,2,3,4), and hexamethylbenzene. The neutron spectra for molecules with adjacent methyl groups (e.g. o-xylene) exhibit bands peaked near 170 cm^{-1}, which are assigned primarily to the $1 \rightarrow 0$ transitions of the torsional oscillations of the methyl groups. The hemimellitene and prehnitene spectra appear to show a second broad maximum in the region of 100 cm^{-1}, which is attributed to torsional modes due to methyl groups centered between two adjacent groups. Previous results on hexamethylbenzene show torsional bands peaked at 120 and 137 cm^{-1}, respectively, above and below the λ-transition near 115 °K. The mesitylene spectra indicate less hindrance to rotation of the methyl groups in this compound, with torsional frequencies less than 100 cm^{-1}. In addition, the results for all the compounds in their solid phases show broad bands below 90 cm^{-1}, which are assigned to whole-molecule librations and translations.

If simple threefold cosine potentials are assumed for all the methyl groups, "average" barriers to rotation 2 and ~ 0.7 kcal/mol are calculated from the average torsional peak frequencies of 170 and ~ 95 cm^{-1}, respectively. A comparison of these results indicates that methyl groups surrounded by two adjacent groups on the benzene ring experience a considerably different potential (and possibly a significantly lower barrier) than that experienced by methyl groups with one neighboring group. The neutron results are compared in detail with nmr and thermodynamic data.

10425. Rush, J. J., **Neutron-scattering study of low-frequency modes in urea and ferroelectric thiourea,** *J. Chem. Phys.* **47,** No. 10, 4278-4279 (Nov. 15, 1967).

Key words: Ferroelectric; libration; molecular vibrations; neutron spectra; phase transitions; potential barrier; rotation; thiourea; urea.

The low frequency modes in crystalline urea and three phases of thiourea have been investigated by the inelastic scattering of cold neutrons. The neutron spectra for thiourea in phases I, III and V exhibit bands peaked around 490, 110 and 46 cm^{-1} which are attributed, respectively, to NH_2 librations and whole-molecule librational and translational modes. The fact that there is little change in these spectra in passing from phases I to V suggests little correlation between molecular motions and the ferroelectric transitions in this compound. The spectrum for urea at 295 °K shows bands peaked around 550, 168, 138 and 74 cm^{-1}, whose assignments are similar to those for thiourea. A comparison of the results for the two compounds suggests that hydrogen bonds in thiourea, if they exist, are much weaker than in urea and have little effect on the transition mechanisms.

Assuming twofold cosine potentials for the NH_2 groups, rotational barriers of 22 and 17.5 kcal/mol are calculated from the librational peaks in urea and thiourea.

10426. Scala, A. A., Ausloos, P., **Condensed-phase photolysis and radiolysis of 2-methylbutane,** *J. Chem. Phys.* **47,** No. 12, 5129-5139 (Dec. 15, 1967).

Key words: Condensed phase radiolysis; ionization; photolysis; 2-methylbutane.

The condensed phase photolysis of $i\text{-}C_5H_{12}-i\text{-}C_5D_{12}$ mixtures, and of $CH_3CD(CH_3)CH_2CH_3$ has been investigated at photon energies above and below the ionization energy of 2-methylbutane (10.32 eV), that is, at 1470 Å (8.4 eV), 1236 Å (10.0 eV) and 1048-67 Å (11.6-11.8 eV). The electronically excited 2-methylbutane molecule undergoes essentially the same decomposition processes in the condensed phase as in the gas phase. The internally excited fragments formed in primary processes are entirely deactivated. In the krypton and argon sensitized radiolysis at 77° and 20 °K, respectively, energy transfer from the rare gas matrix to 2-methylbutane occurs with high efficiency. In these experiments, all products can be accounted for by decomposition of neutral excited 2-methylbutane, formed by excitation transfer and/or neutralization of ions formed in charge transfer reactions with rare gas ions.

In the radiolysis of pure 2-methylbutane in the presence of oxygen at 77 °K or at 195 °K, ethane and propane are almost entirely formed through molecular elimination and geminate radical disproportionation processes. Addition of an electron scavenger such as CCl_4 lowers the yields of these products, as well as those of the corresponding olefins (e.g. C_8H_6 and C_2H_4 indicating that in the pure alkane, these products are mainly formed as a result of neutralization of the parent ion. Apparently fragmentation of the parent ion is unimportant. The product butane (G ~ 0.1) can, however, with some degree of certainty be related to the reaction of the fragment $C_4H_8^+$ ion. The modes of formation of other products, such as the pentenes and the hydrogen remain unexplained.

10427. Schima, F. J., Hutchinson, J. M. R., **Energy of the isomeric transition in ^{109}Ag,** *Nucl. Phys.* **A102,** 667-672 (1967).

Key words: Measured E_γ; radioactivity; ^{109}Cd.

The energy of the isomeric transition in ^{109}Ag, from the decay of ^{109}Cd, has been measured by intercomparison with x rays of well-known energies. Using a Ge(Li) detector with 1.45 keV resolution, the gamma-ray energy was found to be 88.041 keV, with an uncertainty believed to be less than .087 keV.

10428. Schneider, W. E., Stair, R., Jackson, J. K., **Spectral irradiances as determined through the use of prism and filter spectroradiometric techniques,** *Appl. Opt.* **6,** No. 9, 1479-1486 (Sept. 1967).

Key words: Filter-spectroradiometer; measurement techniques; prism-spectroradiometer; radiometry; sources; spectral irradiance.

Two spectroradiometers, one based on a conventional prism monochromator and the other on a system employing narrow band-pass interference filters, have been set up and independently used in the determination of the spectral irradiances of a number of sources over the wavelength range 0.25 μm to 2.5 μm. Basically, the method of calibration for each system consists of comparing the spectral irradiance of the source under investigation to that of an NBS standard of spectral irradiance. The results obtained with each system on a number of "continuous" sources agree to about one percent whereas the differences in the spectral irradiances obtained with the two set-ups on a number of line sources range up to several percent.

10429. Schofer, R. E., Levin, B. M., **The urban transportation planning process,** *Socio-Econ. Plan. Sci.* **1,** 185-197 (Pergamon Press Ltd., London, England, 1967).

Key words: Modal choice; systems analysis; transportation planning; travel forecasting; urban transportation.

The goal of urban transportation planning is to develop a plan for efficient, balanced transportation system for an urban area—one which will promote a desirable pattern of human activities. While the process has been standardized to some extent, each study must nevertheless acquire and manage a massive amount of information about the specific region with which it is concerned. This information, together with computer representations of transportation networks and travel patterns, is used to produce estimates of future travel demand and utilization of facilities. Thus computers play an important role in providing transportation planners with the capability for evaluating a variety of proposed transportation systems in order to recommend allocation of government resources and to guide transportation policy. This paper describes specific computer applications to the process of urban transportation planning.

10430. Shirley, J. H., **Effect of a sinusoidal excitation amplitude on the performance of an atomic-beam spectrometer,** *Phys. Rev.* **160,,** No. 1, 95-99 (Aug. 5, 1967).

Key words: Atomic beam; frequency shift; Rabi spectrometer; Schrödinger equation; transition probability; velocity average.

A theoretical analysis has been made of the transition probabilities for a Rabi-type atomic beam spectrometer in which the exciting field amplitude seen by the atoms has a sinusoidal rather than a rectangular envelope. The time-dependent Schrödinger equation was integrated numerically and a velocity average of the transition probabilities performed. The results indicate that the line width increases as the fourth root of the excitation power and that frequency shifts due to coupling of the exciting field with other atomic states can be reduced by an order of magnitude.

10431. Simpson, J. A., **Electron guns,** Chapter in *Methods of Experimental Physics,* Sources of Atomic Particles, **Volume 4,** Atomic and Electron Physics, pp. 84-95 (Academic Press Inc., New York, N.Y., 1967).

Key words: Atomic source; electron gun; electron physics.

The physical limitations on electron beams are discussed. Design procedures for electron guns of optimum performance are given and illustrated by examples from the literature.

10432. Simpson, J. A., **Special sources of monoenergetic electrons,** Chapter in *Methods of Experimental Physics,* Sources of Atomic Particles, **Volume 4,** Atomic and Electron Physics, pp. 124-135 (Academic Press Inc., New York, N.Y., 1967).

Key words: Atomic source; electron source; monoenergetic electron.

10433. Smith, J. C., Fenstermaker, C. A., **Strain-wave propagation in strips of natural rubber subjected to high-velocity transverse impact,** *J. Appl. Phys.* **38,** No. 11, 4218-4224 (Oct. 1967).

Key words: High-speed photography; impact testing; natural rubber; strain waves; viscoelasticity.

If a flexible filament, marked at intervals along its length is struck transversely by a flying projectile, high speed photography reveals a shifting of the marks caused by passage of a strain wave, and analysis of these shifts provides data on the strain and average strain velocity in the wave. Tests were performed on strips of lightly vulcanized natural rubber at transverse impact velocities up to 65 m/s, and the resulting strain-velocity distributions analyzed for viscoelastic effects. The analysis showed that although creep effects were small in the observation time interval of 1 msec to 8 msec after impact, significant creep must have occurred at the point of impact within the first millisecond, and additional significant creep occurs at times greater than 8 msec. The strain wave front velocity calculated from the quasi-static stress-strain curve was 35.2 m/s, but a value of approximately 60 m/s was observed in the tests. The strain at the wave front, however, tended to attenuate as the wave propagated causing a progressive decrease in the observed value of the strain wave front velocity.

10434. Sparks, L. L., Powell, R. L., **Metals characterization by low-temperature thermoelectric methods,** *Meas. Data* **1,** No. 5, 89-96 (Sept.-Oct. 1967).

Key words: Cryogenic tests; impurity characterization; metals; thermoelectric.

The thermoelectric properties of wire specimens provide a means of determining the effective electronic purity or homogeneity of metals and alloys. This characterization method is described in detail and examples are given of tests on commercial copper and high-purity platinum. The method involves use of a cryogenic liquid, usually liquid nitrogen or helium.

10435. Spijkerman, J. J., **Application of Mössbauer spectroscopy to structure analysis,** (Proc. Second Symp. on Low Energy X- and Gamma Sources and Applications, University of Texas, Austin, Texas, Mar. 27-29, 1967), *Oak Ridge National Laboratory-IIC*-**10,** pp. 85-100 (1967).

Key words: Chemical shift; magnetic hyperfine splitting; Mössbauer spectroscopy; Mössbauer spectrum parameters; quadrupole splitting; structural analysis.

A unique characteristic of the Mössbauer effect is its wide applicability to many scientific disciplines such as physics, chemistry, molecular biology and metallurgy. As a result of this versatility, Mössbauer spectroscopy becomes a very useful tool for structural analysis.

Furthermore it complements many of the physico-chemical methods available by obtaining microscopic information, where macroscopic measurements have been made before.

The Mössbauer spectrum parameters of chemical shift, quadrupole splitting, magnetic hyperfine splitting, and their temperature dependence uniquely characterize the material. The interpretation of these parameters in terms of structural analyses and their relation to other spectroscopic techniques is discussed. A specific example is the determination of austenite and martensite in steel, with particular emphasis on the dynamic equilibrium exhibited by these carbon impurity states.

10436. Spijkerman, J. J., **The Mössbauer chemical shift in tin chemistry,** *Advan. Chem. Ser.* **68,** 105-112 (1968).

Key words: Chemical shift; Mössbauer spectroscopy; tin chemistry.

The Mössbauer spectra of a large number of organic and inorganic tin compounds have been published. From these spectra, the oxidation state of tin in most compounds can be determined.

To interpret the Mössbauer spectra properly, the relationship between the chemical shift and the electron density at the Sn nucleus must be established. This requires that the magnitude and sign of $\Delta R/R$ (a factor that relates the change in the effective charge radius of the tin nucleus on passing from the excited to the ground state) must be known; in most instances, this factor can be determined from nuclear shell model calculation, but. for tin, it must be evaluated experimentally. The discussion includes the results of the various experiments that were designed to obtain this factor so that the chemical shift observed for tin compounds could be interpreted correctly.

10437. Stern, K. H., **Glass-membrane potentials in mixed anion melts,** *J. Electrochem. Soc. Tech. Note* **114,** No. 12, 1257-1258 (Dec. 1967).

Key words: Galvanic cells; membrane potentials; molten salts.

The emf of the four-ion concentration cell with membrane

$$Ag|Ag^+, Na^+, Cl^-, Br^-|glass|Ag^+. Na^+. Cl^-, Br^-|Ag$$

is derived for the case $X_{Na+} \ll X_{Ag+}$ by assuming that the cationic chemical potentials are additive functions in the mole fractions of the thermodynamic components, e.g., $\mu_{Ag+} = X_{AgCl}\ \mu_{AgCl} + X_{AgBr}\ \mu_{AgBr}$. For solutions very dilute in sodium, corrections for non-ideality are negligible. Experimental results agree satisfactorily with calculated ones.

10438. Stromberg, R. R., Peyser, P., Tutas, D. J., **Conformation of polyesters adsorbed on solid surfaces,** Chapter in *Fundamental Aspects of Fiber Reinforced Plastic Composites,* R. T. Schwartz and H. S. Schwartz, eds., pp. 163-176 (Interscience Publ., New York, N.Y., 1968).

Key words: Adsorption; configuration of adsorbed polymer; conformation of adsorbed polymer; ellipsometry; infrared; polyester; polymer adsorption.

The conformation of a polyester, poly(ethylene *o*-phthalate), of relatively low molecular weight was studied after adsorption. The extension of the adsorbed molecule in a poor solvent on several planar metal surfaces was studied by ellipsometry and the fraction, p, of attached groups on colloidal silica particles in a good solvent was determined by the shift in the infrared absorption frequency between free and adsorbed carbonyl groups. In contrast to previously reported results for polystyrene, the extension normal to the surface remained constant (~70 Å) while the concentration of polymer in the adsorbed film increased during the adsorption period. The value of p (0.34 for MW = 5400) is relatively high and was independent of surface population for the range of solution concentrations measured. Differences between these results and those for polystyrene are interpreted as resulting from differences in interaction energy and chain stiffness.

10439. Swanson, N., **Characteristic energy-loss spectra and $-\mathrm{Im}(1/\epsilon)$ for amorphous and polycrystalline Al_2O_3,** *Phys. Rev.* **165,** No. 3, 1067-1070 (Jan. 15, 1968).

Key words: Aluminum oxide; characteristic energy loss; cross section; dielectric constant; oscillator strength; plasmon.

Characteristic energy loss spectra of 20 keV electrons in amorphous and polycrystalline Al_2O_3 have been measured in transmission at zero scattering angle. The dominant loss peak, due to plasmon excitation, occurred at 22.6 ± 0.2 eV and 24.3 ± 0.2 eV for the amorphous and polycrystalline films, respectively. Lower lying weaker losses were observed at about 8.7 eV and 13.5 eV in both films, with an additional loss at 17.7 eV in the polycrystalline film. Using a previously developed technique, values of $-\mathrm{Im}\ \epsilon^{-1}$ and electron energy loss oscillator strength were derived from the loss spectra. The results for anodized Al_2O_3 are in excellent agreement with existing optical measurements.

10440. Swartzendruber, L. J., Bennett, L. H., **The effect of Fe on the corrosion rate of copper rich Cu-Ni alloys,** *Scripta Met.* **2,** 93-98 (1968).

Key words Copper; corrosion; d-electron; iron; magnetic moment; Mössbauer effect; nickel.

The occurrence of a minimum in the reduction of the corrosion rate in hot sea water upon the addition of small quantities of Fe to copper rich Cu-Ni alloys is studied in relation to the Mössbauer spectra of ^{57}Fe in these alloys. It is proposed that as long as Fe remains in solid solution it reduces the corrosion rate due to the formation of local magnetic moments, but when Fe rich precipitates are formed the corrosion rate increases.

10441. Taylor, L. S., **Responsibilities of the physician in his use of radiation,** *Rev. Mex. Radiol.* **XVIII,** No. 69, 22-31 (Jan.-Feb. 1964).

Key words: Radiation exposure; radiation hazards.

After comparing various sources of radiation exposure to which the public is subjected, suggestions are given with regard to the responsibility of the medical profession in the protection of patients during medical procedures.

Attention is directed to the substantial difference in practice between the radiologist and the general practitioner. Practically all of the conditions under which the general practitioner has to operate militate against maximizing the protection of the patient as well as the staff.

Public concern over radiation hazards in medical procedures has reached such proportions that better doctor-patient relationships in the administration of radiation are clearly called for.

10442. Tauber, S. J., Bolotsky, G. R., Fraction, G. F., Kirby, C. L., Reed, G. R., **Algorithms for utilizing Hayward chemical structure notations,** Chapter 27 in *Proc. ICIREPAT Fifth Annual Meeting, London, England, Aug. 31-Sept. 10, 1965,* pp. 351-377 (Thompson Book Co., Washington, D.C., 1967).

Key words: Chemical structures; computer; connection tables; Hayward notation: matrices; molecular formulae.

Computer techniques are described for obtaining connection tables representing chemical structures from Hayward linear notations and binary structure matrices from connection tables. The general approach and some of the detail are described for obtaining Hayward notations from connection tables. Several types of data derivable from Hayward notations are mentioned, and a computer technique is described for calculating molecular formulae. Data formats and restrictions are described, and logical flow charts are presented.

10443. Van Blerkom, D., Hummer, D. G., **The ionization structure of planetary nebulae-VI. The Lyman continuum problem,** *Monthly Notices Roy. Astron. Soc.* **137,** No. 3, 353-374 (Nov. 1967).

Key words: Ionization structure; Lyman continuum problem; planetary nebulae; radiation.

Because of the recent evidence that a planetary nebula does not completely absorb Lyman continuum radiation for a substantial part of its life, we have used a generalized discrete-ordinate method to obtain accurate numerical solutions to the ionization balance problem in pure hydrogen, plane-parallel model nebulae of various optical thicknesses. The effects of incomplete absorption, interior boundary conditions and non-Planckian stellar fluxes are examined.

We find that the density of neutral hydrogen in the nebula increases by less than a factor of two as the optical thickness varies from 0.5 to ∞, and is insensitive to large deviations in the stellar flux from the Planckian distribution, if the total number of Lyman photons is constant. The radius of the Strömgren sphere differs by about 5 percent for the two boundary conditions considered.

The accuracy of two simple approximations are assessed, and conditions for their validity are obtained.

10444. Van Zyl, B., Dunn, G. H., **Dissociation of N_2^+ and O_2^+ by electron impact,** *Phys. Rev.* **163,** No. 1, 43-45 (Nov. 5, 1967).

Key words: Dissociation; electron impact; interaction energies; N_2^+; O_2^+.

Cross sections for dissociation of N_2^+ and O_2^+ by electron impact were measured for interaction energies between 10 eV and 500 eV and between 15 eV and 500 eV respectively. The cross section versus interaction-energy curves exhibit maxima in the vicinity of 75 eV and decrease monotonically at higher energies with an A/E log BE dependence. Maximum cross section values are 4.3 πa_o^2 for N_2^+ and 4.1 πa_o^2 for O_2^+. The curves are remarkably similar at the higher interaction energies. The ion targets are typical of those formed by bombardment of gas by electrons of 150 eV and greater, and some may be in excited electronic states.

10445. Vriens, L., Simpson, J. A., Mielczarek, S. R., **Tests of Born approximations: differential and total 2^3S, 2^1P, and 2^1S cross sections for excitation of He by 100- to 400-eV electrons,** *Phys. Rev.* **165,** No. 1, 7-15 (Jan. 5, 1968).

Key words: Born approximation; cross sections; electrons; excitation cross sections; helium; Ochkur approximation.

The angular dependence of 2^3S, 2^1P and 2^1S excitation of He for incident electron energies from 100 to 225 eV (2^3S) and 400 eV (2^1P and 2^1S) has been measured. Apparent generalized oscillator strengths f(K) and differential cross sections for the transition $1^1S \rightarrow 2^1P$ are obtained by normalizing on the optical oscillator strength of Schiff and Pekeris. From the experimental intensity ratios $2^3S/2^1P$ and $2^1S/2^1P$ we then calculate differential $1^1S \rightarrow 2^3S$ and $1^1S \rightarrow 2^1S$ cross sections. The differential cross sections are integrated to get total cross sections. The f(K) found here for 2^1P and 2^1S excitation decrease faster with increasing K than in earlier studies. Departures from the Born approximation appear only below 200 eV for 2^1P excitation, but occur at higher energy for 2^1S excitation and are larger for large momentum transfers. The angular dependence found for 2^3S excitation disagrees strongly with the Ochkur approximation. Our total 2^3S cross sections are much lower than all other existing theoretical and experimental data.

10446. Weiss, A. W., **Theoretical electron affinities for some of the alkali and alkaline-earth elements,** *Phys. Rev.* **166,** No. 1, 70-74 (Feb. 5, 1968).

Key words: Atomic wavefunction; correlation energy; electron affinity; superposition of configurations.

The $(ns)^2$ correlation energies for the negative ions, Li^-, Na^- and K^-, have been calculated by the method of superposition of configurations. Comparisons with Hartree-Fock calculations of the neutral species yield electron affinities of .62, .54, and .47 eV respectively. A study of the computed ionization potentials of the neighboring isoelectronic atoms and ions suggests a maximum uncertainty of .1 eV. Similar calculations on the $ns(np)^2\,{}^4P$ states of Be^- and Mg^- indicate they are metastable with electron affinities, relative to the nsnp ^3P of the neutral, of .24 and .32 eV respectively.

10447. Weiss, A. W., **Theoretical multiplet strengths for Mg I, Al II, and Si III,** *J. Chem. Phys.* **47,** No. 9, 3573-3578 (Nov. 1, 1967).

Key words: Multiplet strengths; superposition of configurations; wavefunctions.

Superposition of configurations wavefunctions have been computed for the ground state and some lower excited states of the first three members of the magnesium isoelectronic sequence. The excited states are all those with configurations involving the low-lying orbitals, 3s, 3p, 3d and 4s. Multiplet strengths were also computed for all the allowed electric dipole transitions among these states. Only excitations of the outer two valence electrons were included in the multi-configuration expansion, with the virtual orbitals being derived from a pseudo-natural orbital transformation. Comparisons are made with predictions of the Z-expansion method.

10448. Wells, J. S., Matarrese, L. M., and Sukle, D. J., **Electron spin resonance in single crystals of anhydrous copper sulfate,** *J. Chem. Phys.* **47,** No. 7, 2259-2262 (Oct. 1, 1967).

Key words: Anhydrous copper sulfate; antiferromagnetic resonance; electron spin resonance.

The magnetic resonance of synthetic anhydrous copper sulfate has been investigated at 23.3 GHz at temperatures between 77 °K and 4.1 °K. In the paramagnetic region, the observed resonance consists of two lines. One of these is relatively narrow and remains essentially fixed even down to 4.1 °K. The second line is unusually broad and its behavior indicates that it is due to the copper ions in the anhydrous crystal. The g values and corresponding line-widths have been measured for the broad line at 77 °K. As the temperature drops to the Neel point, this broad line increases in width, shifts, and disappears rather rapidly, indicating that it is associated with the antiferromagnetic phase.

10449. Whittaker, J. K., **Instability and decoupling in nuclear electronics,** *Nucl. Instr. Methods* **57,** No. 1, 156 (Dec. 1967).

Key words: Decoupling; f_T; high frequency; instability; low frequency; NIM System.

The instabilities which can occur in semiconductor electronics and the necessary decoupling to remove these instabilities and their effects are discussed, with particular reference to the present concept of modular electronic systems.

10450. Wilcox, R. M., **Some thoughts on Fitzgerald's particle waves,** *J. Acoust. Soc. Am.* **42,** No. 3, 678-679 (Sept. 1967).

Key words: Deformation phenomena; Fitzgerald, E. R.; particle-waves; phonon.

The particle-wave theory recently put forth by E. R. Fitzgerald to explain various deformation phenomena in crystalline solids is criticized. The theory is shown to be based upon a misconception regarding the nature of phonons.

10451. Williams, G., Lauritzen, J. I., Jr., Hoffman, J. D., **Effect of chain twisting on the effective barrier to reorientation for a hindered rotator,** *J. Appl. Phys.* **38,** No. 11, 4203-4208 (Oct. 1967).

Key words: Activation energy; chain twisting; hindered rotator; parabolic potential model; sinusoidal potential model; two-site model.

The effective barrier to reorientation is calculated for a chain which may occupy two equivalent energy states, 180° apart for the case where the chain is allowed to twist during the reorientation process. Results are obtained for (1) a "parabola-antiparabola" and (II) a cosine form for the intermolecular energy. The results for (I) and (II) are similar, but differ both in form and magnitude from that obtained earlier using a cusplike barrier. Both (I) and (II) lead to the conclusion that a chain will behave as a rigid rod up to a critical chain length, and then exhibit twisting for all lengths exceeding this critical value.

10452. Yakowitz, H., Heinrich, K. F. J., **Quantitative electron probe microanalysis: Absorption correction uncertainty,** *Mikrochim. Acta* **1,** 182-200 (1968).

Key words: Absorption of x-rays; Al-Mg analysis; electron microprobe; errors in microanalysis; microprobe absorption correction comparisons; microprobe experimental conditions; quantitative microanalysis.

The accuracy of the x-ray absorption correction for quantitative microprobe analysis is affected by errors in the input parameters (mass attenuation coefficients, x-ray emergence angle, and operating voltage), as well as by inaccuracies in the proposed absorption correction models. If the mass attenuation coefficient is known within 5 percent, then to keep the error of this correction below 1 percent, the absorption function, $f(\chi)$, must be equal to or higher than 0.8. Experimental conditions leading to small absorption corrections are discussed, and the advantages of high x-ray emergence angles are demonstrated. As an illustration, the analysis (theoretical and experimental) of aluminum-magnesium alloys is discussed.

10453. Yates, J. T., Jr., Madey, T. E., Payn, J. K., **Desorption by electron impact: Carbon monoxide, nitric oxide and oxygen on tungsten,** *Nuovo Cimento Suppl. Series I,* **5,** No. 2, 558-581 (1967).

Key words: Binding states; carbon monoxide; chemisorption; cross section; electronic desorption; electron impact; ion energy distribution; nitric oxide; oxygen; threshold voltage; tungsten.

The interaction of low energy electrons with chemisorbed species has been employed as a tool for the characterization of various binding states for CO, NO, and Oxygen on a polycrystalline tungsten ribbon. The apparatus employed is similar to that of Redhead.

Cross sections as a function of coverage for positive ion desorption, and average cross sections for neutral desorption have been measured. Threshold energies for ion production and ion energy distributions are compared for these three oxygen-bearing adsorbates. The electronic desorption phenomenon is shown to be useful for observing details of thermal interconversion and desorption from various binding states in the chemisorbed layer.

10454. Armstrong, R. W., **NBS dynamic seat belt tester,** *Proc. 10th Stapp Car Crash Conf., 6571st Aeromedical Research Laboratory, Alamogordo, New Mex., Nov. 8-9, 1966,* pp. 38-45 (Society of Automotive Engineers, New York, N.Y., 1966).

Key words: Acceleration; anthropomorphic dummy; automobile crash simulator; dynamic tests; flywheel; seat belts.

The NBS Dynamic Seat Belt Tester provides relatively inexpensive laboratory equipment capable of simulating an automobile crash. The machine is economical to operate with reproducible output. The sled of the test machine carries a seat and belted dummy or other equipment and is given an acceleration simulating the deceleration experienced by the passenger compartment of an automobile in a 30 mile per hour crash. The acceleration is produced by a rotating flywheel through a tow tape attached to the sled. The ratio of the combined momentum of the flywheel and the sled to that of the dummy is about that of an automobile to a passenger. The test machine has an overall length of 35 feet and is adequately powered by a 10 horsepower motor.

10455. Astin, A. V., **Welcoming remarks,** (Proc. Fifth Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3-4, 1967), *Telemetry Working Group Document* **112-68,** pp. 3-4 (Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1968).

Key words: NBS; transducer workshop.

Welcoming remarks addressed to attendees of the Fifth Transducer Workshop (Oct. 3-4, 1967, National Bureau of Standards, Gaithersburg, Md.) describe NBS' responsibilities as a scientific and technical service agency. NBS activities are generally in two major program areas—physical measurement system and transfer of technology. Mentioned as being instrumental in carrying out these responsibilities are such Bureau efforts as the data program, materials research program, assistance to standards-writing groups, and a number of specialized information services.

Further remarks call attention to the new NBS facilities, particularly those available for conference activities.

10456. Beckett, C. W., **Status of properties research in the kilodegree range,** Chapter 1 in *The Characterization of High-Temperature Vapors,* J. L. Margrave, ed., pp. 3-15 (John Wiley and Sons, Inc., New York, N.Y., 1967).

Key words: High temperature chemistry; high temperatures; kilodegree range; thermodynamic properties; vapors.

This paper is an informal discussion of the status of thermodynamic and other properties at high temperatures in relation to current technical needs. It contains comment on a few noteworthy achievements, some unexplored areas, and on the lag between basic research on properties and well-known technical needs. It is to be included in the transactions of an ACS symposium on high temperature chemistry at the request of the publisher.

10457. Berendt, R. D., Winzer, G. E., Burroughs, C. B., **A guide to airborne, impact, and structure-borne noise control in multifamily dwellings,** U.S. Dept. Housing and Urban Development, *FT/TS*-**24** (Superintendent of Documents, Government Printing Office, Washington, D.C., Jan. 1968, $2.50).

Key words: Airborne; multifamily; noise control; structure-borne noise control.

The guide analyzes the basic causes of the airborne, impact and structure-borne noise problems in multifamily dwellings and recommends corrective measures, building structures and construction techniques to alleviate and control such problems.

Airborne and impact sound insulation criteria for three grades of multifamily dwellings are presented and recommended for use by the FHA in its Minimum Property Standards. Sound insulation data, fire ratings, descriptions and architectural illustrations are presented for 137 wall constructions and 111 ceiling-floor structures. The guide is illustrated with 345 detailed architectural drawings which show the proper construction and installation of wall and floor assemblies, building equipment, appliances, heating, air-conditioning, plumbing and electrical systems, services or utilities required for adequate sound insulation, noise control and privacy in multifamily dwellings.

In addition, the guide summarizes the sound insulation criteria of various foreign countries and contains three appendices which discuss fire ratings, the relationship between laboratory and field measurements of sound insulation and common noise sources.

Highly technical and mathematical discussions were purposely avoided in the writing of this guide, so that it could be widely used and readily understood by architects, builders, craftsmen, laymen and others engaged in the design and construction of multifamily residences.

10458. Bloss, R. L., **The measurement of strain,** (Proc. 22nd Annual ISA Conf., Chicago, Ill., Sept. 11-14, 1967), *ISA Preprint* No. PI-1-PHYMMID-67 (1967).

Key words: Extensometer; historical; measurement; state of the art; strain; strain gage.

This paper presents a brief overview of the field of strain measurement, including some discussion of philosophy, history and current "state of the art" of the field. There is some discussion of benefits that have resulted from the technical advances in the field of strain measurement, and a few predictions of future developments.

10459. Bowman, H. A., Gallagher, W., Schoonover, R. M., **The development of a working density standard,** (Proc. 20th Annual ISA Conf., Oct. 4-7, 1965, Los Angeles, Calif.), *ISA Preprint* No. 14.8-4-65 (1965).

Key words: Density; density standard; hydrostatic weighing; volume; volumetric measurement.

Inasmuch as density is the ratio between two well standardized quantities, any working standard of density must be consistent with them. The establishment of fixed reference points on the density scale presents several unique problems which demand techniques and apparatus of interest to instrumentation scientists. NBS has gone far down the road toward a working standard. Progress to date and goals believed achievable at the present state of the art will be discussed.

10460. Bozman, W. R., **The application of computers in printing scientific manuscripts,** Chapter 13 in *New Techniques in Office Operations,* pp. 120-124 (The Business Press, Elmhurst, Ill., Mar. 1968).

Key words: Computer typesetting; data processing; photocomposing; phototypesetting.

A description is given of the use of computers to help prepare a file of information on 30,000 organic and inorganic crystals. Some of the problems of input keyboarding, and data corrections are discussed, as well as cross-checking the data for internal consistency and preparation of the final output magnetic tape for operation of a phototypesetting machine.

10461. Brady, G., McIntyre, D., Myers, M. E., Jr., Wims, A. M., **Critical scattering of perfluoroheptane-isooctane system,** (Proc. Conf. Small-Angle X-Ray Scattering, Syracuse University, Syracuse, N.Y., June 1965), Chapter in *Small-Angle X-Ray Scattering,* H. Brumberger, ed., pp. 425-448 (Gordon and Breach, Science Publ. Inc., New York, N.Y., 1967).

Key words: Correlation function; critical opalescence; critical phenomena; isooctane; low angle x-ray scattering; perfluoroheptane.

The critical opalescence of mixtures of perfluoroheptane-isooctane near and at the critical concentration has been examined by x-ray scattering measurements over a large angular range.

The measurementss are discussed and shown to agree well with the assumed correlation function proportional to $e^{-kr/r^{1.1}}$ near the critical temperature. The evidence for the persistence of large molecular clusters away from the critical point is reviewed.

10462. Braun, W., Lenzi, M., **Resonance fluorescence method for kinetics of atomic reactions. Reactions of atomic hydrogen with olefins,** *Discussions Faraday Soc.* **44,** 252-262 (1967).

Key words: Absolute rate constants; apparatus; flash photolysis-emission spectroscopy; hydrogen atom reactions; Lyman-α fluorescence; olefins.

Using the technique of flash photolysis, absorption of Lyman-α radiation by H atoms and measurement of the subsequent Lyman alpha emission, the absolute rate constants for the reaction of hydrogen atoms with several olefins have been measured at room temperature. The method distinguishes hydrogen from deuterium atoms and can be used to measure either.

The absolute limiting high pressure rate constants at room temperature for the reactions H + C_2H_4, C_2D_4, and trans-2-butene, have been found to be approximately the same, $k = 1.0 \pm (15\%) \times 10^{-12}$ cc molecule^{-1} sec^{-1}. The absolute rate constant for the reaction H + isobutene was found to be $k = 3.8 \pm (15\%) \times 10^{-12}$ cc molecule^{-1} sec^{-1}. For the reaction H + C_2H_4 a pressure effect on the bimolecular rate constant has been observed and this effect on the bimolecular rate constant has been observed and this effect is discussed. The experimental method is described in detail since it appears to be the first of its kind and in principle generally applicable to the study of reactions of atoms other than hydrogen or deuterium.

10463. Bridges, J. M., Wiese, W. L., **Comparison of the Stark widths of the Balmer lines H_β and H_α,** *Proc. Seventh Intern. Conf. Phenomena in Ionized Gases,* B. Perovic and D. Tosic, eds., **III,** pp. 165-167 (Gradevinska Knjiga Publ. Co., Beograd, Yugoslavia, 1966).

Key words: Balmer lines H_α and H_β; half-widths; line profiles; Stark broadening; wall-stabilized arc.

The Stark broadened profiles of the Balmer lines H_α and H_β were studied photoelectrically in a wall-stabilized arc. The arc was operated in argon to which small amounts of hydrogen were added. These relatively low hydrogen concentrations were required to avoid self-absorption of H_α. Repeated measurements of the half-widths were undertaken for currents from 15 to 50 amps and compared with recent Stark broadening calculations. Normalizing theory and experiment for the case of H_β, for which refined calculations are available, one consistently observes that the theoretical half-widths for H_α are about 20 percent too small for the range of electron densities from $2\text{-}6 \times 10^{-16}$cm^{-3}.

10464. Brown, W. E., **A mechanism for growth of apotitic crystals,** (Proc. Intern. Symp. Composition, Properties and Fundamental Structure of Tooth Enamel, London, England, Apr. 1964), Chapter in *Tooth Enamel,* pp. 11-14 (John Wright and Sons, Ltd., Bristol, England, 1965).

Key words: Apotitic crystals; crystals; enamel; tooth enamel.

10465. Bullis, W. M., Coleman, J. A., **Characterization of germanium and silicon for nuclear radiation detectors,** Chapter in *Nucleonics In Aerospace,* P. Polishuk, ed., pp. 166-175 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Carrier drift mobility; carrier trapping; charge collection efficiency; energy resolution; gamma ray detectors; Hall mobility; infrared absorption; lithium drift mobility; lithium precipitation; oxygen; photoconductive decay lifetime; reverse recovery time.

Semiconductor detectors have been extensively used for about eight years. Uncontrolled variations in the quality of germanium and silicon intended for this application have occurred during this period for reasons which, even now, are not well understood. Crystals are presently selected on the basis of room temperature resistivity, photoconductive decay lifetime and etch pit density. Use of these parameters does not always enable one to discriminate between material suitable for detector fabrication and material which is not. This paper describes a research program now in progress at the National Bureau of Standards which has the objective of identifying those parameters which will be the most useful in specifying detector-grade material. Because of the immediacy of the problem, study of results of this program should also be applicable in the characterization of detector-grade silicon.

10466. Bur, A. J., Roberts, D. E., **High polymeric materials,** *1964 Digest of Literature on Dielectrics* **28**, 231-260 (National Academy of Sciences – National Research Council, Washington, D.C., 1964).

Key words: Biopolymers; dipole moments; effects of radiation; relaxation phenomena; semiconducting polymers; technology.

The literature on polymer dielectrics published in 1964 is reviewed. The following subjects are covered: theory; relaxation phenomena; dipole moments; semiconducting polymers; biopolymers; effects of radiation; and technology. (229 references).

10467. Butterfield, M. A., **Care and preservation of the new media-equipment needs,** *Proc. A Pioneer Presentation of a National Symposium on the Impact of Automation on Documentation, Denver, Colo., Apr. 27-29, 1967,* pp. 60-64 (1968).

Key words: Analog library storage; archival storage and retrieval; automated archival equipment; automated archives; automated library equipment; automated library storage; digital library storage; library storage and retrieval.

Automated storage systems are postulated for librarians and archivists of the future. Equipment requirements are discussed for accessing, storing, and retrieving information on magnetic tape media. Problem areas are presented for both analog and digital recording methods.

10468. Campbell, P. G., Wright, J. R., **Asphalt hardening by gaseous oxidants: the relationship between softening point and chemical change as measured by infrared spectroscopy,** *J. Mater.* **2**, No. 3, 581-596 (Sept. 1967).

Key words: Asphalt flux; carbonyl absorbance; coating-grade asphalt; infrared analysis; nitrogen oxides; oxidation; softening point; sulfur dioxide.

The use of oxidized asphalts has been increasing steadily and much work had been reported on the process of blowing asphalt fluxes to produce a coating grade asphalt. Previous work was reviewed in which asphalt fluxes were treated with various oxidants (oxygen, ozone, air, nitrogen oxides) at relatively mild temperatures and the complex changes taking place during the hardening process were studied by infrared spectroscopy. This work was extended to include other gaseous mixtures (sulfur dioxide, sulfur dioxide-air, nitrogen dioxide-air).

The study of the effects of the gaseous oxidants on the softening points of the asphalt fluxes with time of blowing indicated that, in every case, the rate of softening point increase was greater than that obtained when air alone was used to harden the flux. Infrared spectral analysis, in which changes in functionality are detected, was found to be a convenient method to follow the asphalt hardening process.

10469. Canfield, L. R., Johnson, R. G., Codling, K., Madden, R. P., **Comparison of an ionization chamber and a thermopile as absolute detectors in the extreme ultraviolet,** *Appl. Opt.* **6**, No. 11, 1886-1888 (Nov. 1967).

Key words: Absolute radiometry; detectors; extreme ultraviolet; ionization chamber; monochromator; thermopile.

A comparison has been made between a calibrated thermopile and an argon ionization chamber as absolute detectors of radiant flux of wavelengths 584 and 735 Å. Corrections were applied to the data to account for the absorption due to gases in the monochromator, the energy carried away from the thermopile by photoejected electrons, non-uniformity of response across the surface of the thermopile and uneven illumination of the thermopile by the flux from the monochromator. The two detectors were found to agree within the 3 percent estimated probable error in the measurements.

10470. Cassidy, E. C., **Time-resolved studies of spectra produced by electrically exploded wires,** *Naturwissenschaften* **55**, No. 3, 125-128 (1968).

Key words: AlO; atomic spectra; electrical discharge; exploding wire; molecular spectra; time-resolved spectroscopy.

Time-resolved spectroscopic studies of electrically exploded wires are described. The spectral distribution of the radiation emitted by aluminum and titanium wires exploded in various controlled atmospheres are given. Atomic and molecular species produced by the explosion are identified. The effects of environment, pressure, and electrical energy input on the explosion spectrum are discussed, and conditions which were found to be conducive to the production of several selected spectral features by the exploding wire method are indicated. This paper summarizes the results of spectroscopic exploding wire studies at the U.S. National Bureau of Standards over the past few years.

10471. Catanzaro, E. J., **Absolute isotopic abundance ratios of three common lead reference samples,** *Earth and Planetary Sci. Letters* **3**, No. 4, 343-346 (1968).

Key words: Absolute ratios; isotopic abundances; lead; reference samples.

The absolute isotopic abundance ratios have been determined for three common lead reference samples, using solid-sample mass spectrometry. Samples of known isotopic composition, prepared from nearly pure separated ^{206}Pb and ^{208}Pb isotopes, were used to calibrate the mass spectrometers. The resulting absolute values are as follows. GS 4: $^{204}\mathrm{Pb}/^{206}\mathrm{Pb} = 0.061888 \pm 0.000065$, $^{207}\mathrm{Pb}/^{206}\mathrm{Pb} = 0.95342 \pm 0.00036$, $^{208}\mathrm{Pb}/^{206}\mathrm{Pb} = 2.2181 \pm 0.0010$; NBS 200: $^{204}\mathrm{Pb}/^{206}\mathrm{Pb} = 0.068353$ ±s 0.000072, $^{207}\mathrm{Pb}/^{206}\mathrm{Pb} = 1.00538 \pm 0.00038$, $^{208}\mathrm{Pb}/^{206}\mathrm{Pb} = 2.3675 \pm 0.0011$; C.I.T. Pb Std.: $^{204}\mathrm{Pb}/^{206}\mathrm{Pb} = 0.060151 \pm 0.000063$, $^{207}\mathrm{Pb}/^{206}\mathrm{Pb} = 0.93081 \pm 0.00035$, $^{208}\mathrm{Pb}/^{206}\mathrm{Pb} = 2.1835 \pm 0.0010$. The indicated uncertainties are overall limits of error based on 95 percent confidence limits for the mean and allowances for effects of known sources of possible systematic error.

10472. Clark, J. E., Harrison, C. W., **Accelerated weathering of polymers: radiation,** *Appl. Polymer Symp.* **4**, 97-110 (Sept. 1967).

Key words: Carbon arc; degradation; irradiance; photodegradation; plastics; polymers; radiation; radiometry; sun; weathering; xenon arc.

The objective of this work was to study the radiation characteristics in three artificial weathering devices and to do a preliminary survey of the effects of high-intensity irradiation on plastics.

An absolute radiometer was used to measure radiation characteristics in the xenon arc and sunshine carbon and enclosed carbon arc Weather-Ometers. The irradiance from the xenon arc was stable over one hour, but the irradiance from the carbon arcs fluctuated. Irradiance received in one hour at the sample drum for sunshine and enclosed carbon arcs ranged from 315 to 1020 W/m^2 and 297 to 679 W/m^2, respectively, while the xenon arc showed a relatively constant irradiance of 910 W/m^2. All three devices had a maximum irradiance near the center of the sample drum with intensities at top and bottom being 15-40 percent less.

Seven plastic films were exposed to a xenon arc over a 200-fold intensity range by decreasing the arc-to-sample distance.

At up to 6.1 times earth-level sunlight, no significant changes resulted within 100 hours. At 81 times earth-level sunlight, white-pigmented film decomposed within 30 hours and clear films showed changes in ultraviolet and infrared spectra within 69 hours. At 379 times earth-level sunlight, five clear plastics decomposed within 12 hours or less.

10473. Coleman, J. A., **Germanium for gamma-ray detectors. A review of current problems,** (Proc. IAEA, Vienna, Austria, June 6-7, 1966), Chapter in *Lithium-Drifted Germanium Detectors, STI/Publ./*132, pp. 37-41 (International Atomic Energy Agency, Vienna, Austria, 1966).

Key words: Gamma ray detectors; germanium; semiconductor detectors.

The performance of germanium gamma radiation detectors depends, to a large extent, on the quality of the germanium used to produce the devices. Presently, the demand for better resolution, faster response times, and larger volume detectors imposes severe requirements on the germanium for detectors in terms of crystal purity and perfection. The specifications commonly used to describe germanium for detectors, such as resistivity, carrier lifetime, and etch pit density, were originally derived from those used by the semiconductor device industry. The relevance of these specifications for material to produce a detector with good performance, including long-term stability, is not well-understood. A semiconductor detector requires extreme perfection throughout a large volume single crystal. Common transistors and diodes have much smaller volumes and often operate at much higher currents and noise levels than a radiation detector; therefore, material requirements are usually not as stringent as those for detectors.

The Electron Devices Section of the NBS is engaged in studies of the correlations between the properties of semiconductor materials and the performance of semiconductor devices fabricated from such material. Presently, the effects of carrier lifetimes and mobility and impurities such as oxygen, copper and gold in germanium, on the performance and stability of gamma ray detectors are being investigated. The use of germanium gamma ray detectors at NBS for such applications as activation analysis, photonuclear reaction studies, decay scheme investigations and Mössbauer spectroscopy is limited at the present time, but it is expected to be greatly expanded in the very near future.

10474. Coleman, J. A., Love, D. P., Trainor, J. H., Williams, D. J., **Low-energy proton damage effects in silicon surface-barrier detectors,** *IEEE Trans. Nucl. Sci.* **NS-15,** No. 1, 482-490 (Feb. 1968).

Key words: Detector; proton; radiation effect; semiconductor; silicon.

In order to predict the useful lifetime of semiconductor detectors which operate in the Earth's trapped radiation belts, the effects of damage by 50 keV, 200 keV, 600 keV and 1 MeV protons on silicon, surface-barrier, transmission detectors have been studied for fluences from 10^{10} to 10^{14} protons/cm^2. Detector current, noise and capacitance increased with fluence, with significant increases occurring after 10^{13} protons/cm^2. Bias-voltage-dependent multiple peaking was observed with Am-241 alpha particles. The effect of damage by protons with these low energies is significantly reduced in transmission detectors if the protons enter the rear, aluminum contact rather than the front, gold contact.

10475. Cook, R. L., Kirchhoff, W. H., **Further investigations on the microwave spectrum of NSF: evaluation of the molecular force field, centrifugal distortion constants, and the dipole moment,** *J. Chem. Phys.* **47,** No. 11, 4521-4527 (Dec. 1, 1967).

Key words: Dipole moment; microwave spectrum; pyrazole; Stark effect; structure; tautomerism.

The measurements of the microwave spectrum of NSF has been extended to include transitions involving J as high as 40 and the centrifugal distortion effects have been accounted for. By combining the analysis of the vibrational and rotational spectra, the molecular force field for NSF has been calculated and the following quadratic potential constants, in mdynes/Å, were obtained: $f_1 = 10.703$, $f_2 = 2.872$, $F_\alpha/d^2 = 0.411$ and $f_{2\alpha}/d = 0.014$. Here 1 refers to the SN bond, 2 to the SF bond, α to the NSF bond angle and d is the geometric mean of the SN and SF bond distances. It was found that the data were too insensitive to calculate $f_{1\alpha}$ and f_{12} and these constants were assumed to be zero.

The dipole moment was calculated from the Stark effect of the $5_{1,4} - 4_{2,3}$ transition and was found to be 1.902 ± 0.012 D, where the uncertainty represents the spread in the value of the dipole moment obtained from different methods of treating the data.

10476. Covington, A. K., Paabo, M., Robinson, R. A., Bates, R. G., **Use of the glass electrode in deuterium oxide and the relation between the standardized pD (pa_D) scale and the operational pH in heavy water,** *Anal. Chem.* **40,** No. 4, 700-706 (Apr. 1968).

Key words: Acidity; deuterium electrode; deuterium oxide; glass electrode; heavy water; pD measurement.

Commercial glass electrodes have been compared both directly and indirectly with the deuterium gas electrode at 25 °C in buffered solutions of pD from 1 to 13. It is confirmed that the glass electrode functions as well in heavy water as in ordinary water. The relation between the operational pH of a buffer solution in heavy water (obtained with a glass electrode standardized in an ordinary light buffer solution) and its pD or pa_D value obtained from measurements on cells without liquid junction has been examined and correction factors determined for both glass and gas electrodes. The operational pH of buffer solutions in heavy water at 25 °C, measured with the glass electrode, can be converted into a pD value by adding 0.41 (molar scale) or 0.45 (molal scale) for $2 < pD < 9$.

10477. Deslattes, R. D., **Photoionization of the M shell of xenon,** *Phys. Rev. Letters* **20,** No. 10, 483-484 (Mar. 4, 1968).

Key words: M-shell; photoionization; xenon.

New measurements of the continuum photoionization cross sections of xenon in the region 670-800 eV are reported. These reveal, in the region of the M_N and M_V edges, extreme non-hydrogenic behavior previously observed only at longer wavelengths.

10478. Deslattes, R. D., **X-ray monochromators and resonators from single crystals,** *Appl. Phys. Letters* **12,** No. 4, 133-135 (Feb. 15, 1968).

Key words: Monochromators; single crystals; x-ray resonators.

Single crystal specimens shaped so as to permit successive x-ray diffraction by two non-parallel atomic planes are fixed wavelength monochromators. It is shown that certain plane pairs in Si and Ge pass wavelengths sufficiently close to strong characteristic lines to allow production of intense highly monochromatic beams. For interplanar angles of $2\pi/n$, resonators and retroreflectors may be obtained.

10479. Domsitz, M. G., **Transducer activities at NBS,** (Proc. Fifth Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3-4, 1967), *Telemetry Working Group Document* **112-68,** pp. 11-12 (Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1968).

Key words: Transducer activities; transducer instrumentation; transducers.

10480. Foster, B. E., **Attenuation of x-rays and gamma rays in concrete,** *Mater. Res. Std.* **8,** No. 3, 19-24 (Mar. 1968).

Key words: Concrete shields; gamma-ray attenuation; x-ray attenuation.

Concrete is widely used as a shielding material against x-ray and gamma-ray sources. The purpose of the paper is to furnish a brief elementary background for the concrete technologist on the physics of x-ray shielding. A brief description is given of the characteristics of x-ray and gamma rays. This is followed by a short discussion of attenuation by the photoelectric, pair-production, and Compton effect mechanisms, as a function of x-ray or gamma-ray energy, and barrier material. Performances of various shielding materials in various energy ranges are compared, and the problems in shield design brought about by the scattering processes are discussed.

10481. Goldman, D. T., **Suggested procedures for utilizing MUFT resonance parameters to include Doppler broadening,** *Nucl. Sci. Engr.* **31,** No. 2, 346-349 (Feb. 1968).

Key words: Doppler broadening; neutron; resonances; slowing down.

Keeping within the MUFT framework a method is proposed for including the effect of Doppler (temperature) broadening of resonances on the calculation of resonance integrals. This method is seen to be simple in its application. Some attempt has been made to determine its range of validity especially in comparison with the technique presently in use in MUFT. Finally, an additional proposal is made to replace the Narrow Resonance Infinite Mass approximation presently in use in MUFT with the Narrow Resonance approximation for all nuclei.

10482. Hall, J. L., Siegel, M. W., **Angular dependence of the laser photodetachment of the negative ions of carbon, oxygen, and hydrogen,** *J. Chem. Phys.* **48,** No. 2, 943-945 (Jan. 15, 1968).

Key words: Angular distribution; C^-; H^-; negative ion; O^-; photodetachment; photoelectron spectroscopy.

The angular distribution of electrons photodetached by polarized (laser) light from (a beam of) negative ions is dependent on the type of initial and final angular momentum states available. In O^- and C^-, a p-type electron is photodetached into either s-wave or d-wave continuum states. The experimental angular distributions are consistent with the predicted strong destructive interference between the s-wave and d-wave channels.

For H^-, only s-p transitions are expected, which is consistent with the experimental observation of pure $\cos^2\theta$ behavior in this case.

10483. Hilten, J. S., **The National Bureau of Standards inter-agency transducer project—a progress report,** (Proc. Fifth Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3-4, 1967). *Telemetry Working Group Document* **112-68,** pp. 17-36 (Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1968).

Key words: Acceleration; calibrator; dual centrifuge; dynamic; Inter-agency Transducer Project; life-cycling; pressure; shock tube; thermal transient; transducer.

This paper describes some of the techniques and apparatus used for the evaluation of pressure and acceleration transducers. Both static and dynamic tests are covered. Included are earth's field static calibrator, dual centrifuge, earth's field dynamic calibrator, shock tube, quick opening valve pressure calibrators, thermal transient test, temperature storage and cycling test, and life-cycling test.

10484. Hughes, E. E., **A simple technique for the absolute determination of atmospheric oxygen,** *Environ. Sci. Technol.* **2,** No. 3, 201-203 (Mar. 1968).

Key words: Atmospheric composition; gas analysis; oxygen analysis.

A method is presented for the absolute determination of oxygen at concentrations near atmospheric. The oxygen in a sample is determined gravimetrically after reaction with either white phosphorus or a sodium-potassium alloy. The method requires little time and simple laboratory equipment. and is capable of yielding values for oxygen concentrations having an overall uncertainty of ± 0.1 mole percent.

10485. Hughes, E. E., Dorko, W. D., **Accurate mass spectrometric determination of low concentrations of carbon dioxide in nitrogen,** *Anal. Chem.* **40,** No. 4, 750-755 (Apr. 1968).

Key words: Air analysis; carbon dioxide; gas analysis; mass spectrometric analysis.

A method for the rapid and accurate determination of low concentrations of carbon dioxide in nitrogen has been developed. The method is based on high-pressure mass spectrometry in which the mass 44 to mass 28 ratio is compared to the same ratio in a carefully calibrated standard. Concentrations from 180 to 380 parts per million were determined with an accuracy of better than 1 percent.

10486. Kasuya, T., Lafferty, W. J., Lide, D. R., Jr., **Microwave spectrum, structure, boron quadrupole coupling constants, and dipole moment of difluoroborane,** *J. Chem. Phys.* **48,** No. 1, 1-4 (Jan. 1, 1968).

Key words: Difluoroborane; dipole moment; microwave spectra; molecular structure; quadrupole coupling constants; rotational constants.

The microwave spectra of $HB^{10}F_2$, $HB^{11}F_2$, $DB^{10}F_2$, and $DB^{11}F_2$ have been assigned. Rotational constants are 74494.82, 10496.74, and 9181.67 MHz for $HB^{11}F_2$; 77244.25, 10495.35, and 9221.49 MHz for $HB^{10}F_2$; 52896.09, 10498.29, and 8740.56 MHz for $DB^{11}F_2$; and 54081.82, 10496.89, and 8771.57 MHz for $DB^{10}F_2$. The structural parameters obtained from these constants and their estimated uncertainties are $r_{BF} = 1.311 \pm 0.005$ Å, $r_{BH} = 1.189 \pm .010$ Å and $\angle FBF = 118.3° \pm 1°$. The quadrupole coupling constants have been obtained. The dipole moment is 0.971 ± 0.010 D.

10487. Kushner, L. M., **The role of the Institute for Applied Technology,** (Proc. Fifth Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3-4, 1967). *Telemetry Working Group Document* **112-68,** pp. 5-10 (Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1968).

Key words: Technological measurements; transfer of technology.

Welcoming address describing the major programs of the Institute for Applied Technology at the National Bureau of Standards.

10488. Lias, S. G., Ausloos, P., **Gas-phase photolysis and radiolysis of isobutane,** *J. Chem. Phys.* **48,** No. 1, 392-400 (Jan. 1, 1968).

Key words: Free radical reactions; ion-molecule reactions; isobutane; photoionization; photolysis; primary processes.

The photolysis of $(CH_3)_3CH$, $(CH_3)_3CD$, and of $(CH_3)_3CH-(CD_3CD$ and $(CD_3)_3CD-H_2S$ mixtures has been investigated at 1470 Å (8.4 eV), 1236 Å (10.0 eV), and 1048-67 Å (11.6-11.8 eV). Since the irradiating photons in these experiments have energies both higher and lower than the ionization energy of isobutane (10.6 eV), the modes of decomposition of the "superexcited" molecule can be compared with those of the molecule excited to states below the ionization potential. On the basis of isotopic analyses of the major products, it was determined that the following primary modes of decomposition of the excited isobutane molecule occur in the photolysis at all three energies: i-$C_4H_{10}^* \rightarrow CH_4 + C_3H_6$; i-$C_4H_{10}^* \rightarrow C_3H_8 + CH_2$; i-$C_4H_{10}^* \rightarrow CH_3$ + sec-C_3H_7; $C_4H_{10}^* \rightarrow H_2$ + i-C_4H_8. Most of the propyl radicals decompose further: C_3H_7 - $H + C_3H_6$; C_3H_7 - $CH_3 + C_2H_4$. An increase in photon energy increases the relative importance of C–C cleavage processes. The parent ions formed in the photolysis with 11.6-11.8 eV photons decompose to form $C_3H_6^+$ and sec-$C_3H_7^+$. The $C_3H_6^+$ ions react with isobutane to form sec-C_3H_7 radicals or propane: $C_3H_6^+$ + i-$C_4H_{10} \rightarrow$ $CH_3CHCH_3 + C_4H_9^+$; $C_3H_6^+$ + i-$C_4H_{10} \rightarrow C_3H_8$ +c $C_4H_8^+$. The probability of the former reaction is 1.5 times that of the latter, in agreement with a value for this ratio derived from the radiolysis of $C_4D_{10} - H_2S$ and $C_4H_{10} - C_4D_{10}$ mixtures. The role of superexcited molecules in the radiolysis is discussed and it is estimated that the number of dissociating neutral excited molecules per ion pair is no greater than 0.46.

10489. McKinley, J. D., **Effects of the reaction with bromine on nickel surface morphology,** *Surface Sci.* **10,** No. 2, 287-290 (May 1968).

Key words: Bromine; electron micrograph; nickel; single crystal; surface morphology; surface reaction.

Electron micrographs of single crystal nickel specimens show that exposure of nickel to bromine at 800 °K produces etch pits bounded by {100} crystallographic planes. The surface reaction product is volatile $NiBr_2$; reaction proceeds by recession of the {100} planes into the metal.

10490. Maienthal, E. J., Taylor, J. K., **Polarographic methods in determination of trace inorganics in water,** Chapter 10 in *Trace Inorganics in Water, Advances in Chemistry Series* **73,** 172-182 (American Chemical Society, Washington, D.C., Apr. 1968).

Key words: Polarographic analysis; trace analysis; water analysis.

Polarography is a particularly suitable method for the determination of trace inorganic material in water. Owing to the selectivity of electrode processes, interferences and hence prior chemical separations are minimized. Often several elements may be determined concurrently in the same supporting electrolyte. Anodic stripping and linear sweep voltammetry give an increased sensitivity which permits determinations in the ppb range to be made. Polarographic methodology is reviewed. A survey of the literature concerned with determination of trace inorganic material in water is given. Procedures used in this laboratory for the determination of such elements as aluminum, arsenic, cadmium, copper, indium, iodine, iron, lead, tellurium, and zinc are discussed. The matrices include laboratory distilled water, river water, and reactor cooling water. In addition a comparative technique is described whereby precisions of better than 1 percent can be obtained at the 0.1 ppm level.

10491. Maki, A. G., **Assignment of some DCN and HCN laser lines,** *Appl. Phys. Letters* **12,** No. 4, 122-124 (Feb. 15, 1968).

Key words: DCN; emission; far infrared; HCN; lasers: spectra.

The far infrared laser lines in DCN are explained as being due to transitions involving the 22^00 and $09^{1c}0$ levels which are mixed by a Coriolis resonance at J = 21. The HCN laser lines near 130 microns are explained by a Coriolis resonance which affects the 12^00, 12^20, and 05^10 levels. New laser transitions are predicted for these systems.

10492. Mies, F. H., **Quantum oscillations in the shape of pressure-broadened atomic lines,** *J. Chem. Phys.* **48,** No. 1, 482-494 (Jan. 1, 1968).

Key words: Atomic lines; band strengths; broadening; continuum-continuum transitions; diatomic molecules; emission absorption; interaction potential; pressure broadening; quantum mechanics; wavefunctions; W.K.B.

Oscillatory or bandlike structure is predicted to occur in the wings of pressure broadened atomic lines when the interaction potential between the emitting atom M* and the perturbing atom A is deeply attractive compared to kT and the interaction in the final state is repulsive. The oscillations in intensity arise from quantum effects and are associated with the nodal structure of the continuum wavefunction which describes the dissociated state of the diatomic molecule (A + M*). The number of maxima in the line shape is a measure of the number of bound states which can be supported in the potential while the amplitude and resolution of the oscillations depends on the long range behavior of the potential. The bandlike structure, which may extend over thousands of cm^{-1} on the long wavelength side of the atomic emission line, is resolvable as long as $kT <$ approximately 1/10 the vibrational quantum $\hbar\omega_e$ of the AM* molecule. This is a generalization of similar bandlike structure which has been calculated *and observed* to occur in the collision induced radiation of helium metastable atoms and which is merely a special case of pressure broadening involving forbidden lines. Specific calculations are presented for the broadening of the hydrogen Lyman α line by H(1s), and the visible absorption spectra of H(1s) in the presence of free protons.

The quantum theory of line shape which is employed here was first developed by Jablonski but then neglected due to difficulties involved in evaluating essentially the bandstrength for continuum-continuum transitions of diatomic molecules. Jablonski introduced the W.K.B. and other approximations into his theory which reduced it to the classical statistical theory. These approximations are compared to exact quantum mechanical calculations. The W.K.B. approximation is shown to be quite valid in the special case of attractive-repulsive transitions, but Jablonski then improperly averaged over these very quantum oscillations of interest here. This structure offers a unique and extremely sensitive method of studying interaction potentials involving excited states of atoms.

10493. Miller, K. J., Krauss, M., **Born inelastic differential cross sections in H_2,** *J. Chem. Phys.* **47,** No. 10, 3754-3762 (Nov. 15, 1967).

Key words: Born cross-sections; differential cross-sections; Hartree-Fock; hydrogen; Rydberg states.

First Born differential cross-sections are calculated for inelastic electron scattering of 300 eV electrons from the ground electronic-vibrational state of H_2 into the vibrational levels of the B, B′, C, D, and D′ Rydberg states. The initial and final state electronic wavefunctions were approximated by Hartree-Fock functions. In order to facilitate the calculation, the molecular orbitals were expanded in a linear combination of Gaussian-type atomic orbitals.

The variation of the electronic scattering amplitude was examined as a function of the molecular orientation, internuclear separation, and scattering angle (or electron momentum transfer). Use of the Franck-Condon factors to determine relative intensities for scattering into different vibrational levels yields errors less than 20 percent, and hence these factors are a good approximation to the relative intensities.

The theoretical differential cross-section for zero-angle scattering is in good agreement with the most recent experimental data. However, it is shown that transition moments extracted from electron scattering data are overestimated and in poor agreement with the theoretical values.

10494. Motz, J. W., Sparrow, J. H., **A simple device for the energy and current measurement of an accelerator electron beam,** *Record of the IEEE 9th Ann. Symp. Electron, Ion, and Laser Beam Technology, Berkeley, Calif., May 9-11, 1967,* pp. 34-41 (San Francisco Press, Inc., San Francisco, Calif., May 1967).

Key words: Electron beam; energy current; Møller scattering; Mott scattering; secondary electron; thin foils.

A simple apparatus has been developed which permits the simultaneous measurement of the electron energy and current of an accelerator electron beam. This measurement is accomplished with negligible interference of the beam during the continuous operation of the accelerator and applies to electron energies greater than approximately 50 keV. The apparatus consists of a thin aluminum foil which intercepts the beam with a negligible energy loss (less than one kilovolt), and two cylindrical aluminum electrodes which are positioned respectively on the incident and exit sides of the foil with axes normal to the foil surface and coincident with the beam direction. With a suitable distribution of electric potentials in this system, the incident electrode current, I_i, is inversely proportional to the square of the electron velocity and the exit electrode current, I_e, is inversely proportional to the square of the product of the electron velocity and momentum. Therefore, when an electron beam passes through this system, the electron energy can be determined from the current ratio, I_i/I_e, and the incident electron current can be determined from the current, I_i, as shown in previous measurements with secondary emission monitors. The energy dependences described above for each electrode has been confirmed over a wide range of electron velocities by measurements carried out with a constant potential electron accelerator in the energy region from 50 to 500 keV.

10495. Rebbert, R. E., Ausloos, P., **Photolysis of methyl iodide in matrices of organic compounds at 20° and 77 °K. Reactions of hot methyl radicals,** *J. Chem. Phys.* **48,** No. 1, 306-311 (Jan. 1, 1968).

Key words: D-atom; H-atom; hot methyl radicals; methyl iodide; photolysis.

Methyl iodide—hydrocarbon and methyl iodide—alcohol matrices have been photolyzed with 2537 Å radiation both at 20 and 77 °K. The probability of abstraction of an H atom by the hot CH_3 radical formed upon photodissociation CH_3I is at least a factor of 10 larger in the solid phase than in the gas phase. However, the relative probabilities of abstracting an H-atom from various organic compounds are about the same in both phases. Also hot CH_3 radicals are more reactive than CD_3 radicals in both phases.

Photolysis of CH_3I or CD_3I in the presence of (a) equimolar mixtures of perprotonated and perdeuterated hydrocarbons and (b) partially deuterium labelled hydrocarbons, shows that the hot methyl radicals abstracts an H-atom and D-atom with equal probability. The hot methyl radical does, however, exhibit a certain selectivity as to the position in the molecule from where it abstracts an H-atom. For instance, an H-atom is abstracted more readily when attached to a secondary carbon atom than to a primary carbon atom. This non-statistical behaviour is, however, less accentuated in the solid phase than in the gas phase. When the matrix consist of an unsaturated hydrocarbon, the hot methyl radical can add to the double bond as well as abstract an H-atom. It is shown that hot methyl radicals add to ethylene to form $\overline{nC_3H_7}$ radicals which subsequently react with the I-atom with which they are in juxtaposition. At 20 °K about one fourth of the hot methyl radicals add to C_2H_4.

10496. Stern, J., **Activities of the Basic Instrumentation Section,** (Proc. Fifth Transducer Workshop, National Bureau of Standards, Gaithersburg, Md., Oct. 3-4, 1967), *Telemetry Working Group Document* **112-68,** pp. 13-15 (Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico, 1968).

Key words: High temperatures; information services; instrumentation; transducer.

The activities of the Basic Instrumentation Section at the National Bureau of Standards are described. Major emphasis in the work of the Section is placed on the fundamentals of instrumentation, among them transducer problems in many areas including measurement of high temperatures. In addition, considerable effort is devoted to the development of information services for the field of instrumentation and the necessary methodology for this.

10497. Tauke, J., Litovitz, T. A., Macedo, P. B., **Viscous relaxation and non-Arrhenius behavior in B_2O_3,** *J. Am. Ceramic Soc.* **51,** No. 3, 158-163 (Mar. 1968).

Key words: B_2O_3; shear spectra of relaxation times; ultrasonic relaxation; viscous relaxation.

Ultrasonic shear and longitudinal relaxation measurements were made in B_2O_3 over a large temperature range (650°—1000 °C). From these data both the shear and volume relaxation time spectra were determined. Both spectra had the same temperature dependence, although the volume spectrum was always broader than the shear spectrum. The shear relaxation process can be represented by a single relaxation time above 800 °C in the region where the shear viscosity is Arrhenius. Both processes exhibit an increasingly broad distribution of relaxation times in the non-Arrhenius region. The temperature dependence of the shear spectrum was analyzed in terms of a distribution of activation energies. A surprising conclusion of this study is that activation energies smaller than the activation energy present in the Arrhenius region appear at low temperatures.

10498. van Reuth, E. C., Waterstrat, R. M., **Atomic ordering in binary A15-type phases,** *Acta Cryst.* **B24,** Part 2, 186-196 (Feb. 1968).

Key words: A15-type phase; atomic packing; beta-tungsten phase; electronic structure; order-disorder transformation; ordering of atoms; phase stability; sigma phases; transition metals.

The degree of long-range order has been determined for 18 binary A15-type phases containing only transition elements. A tendency toward a lower degree of order was noted as the component elements were chosen successively from columns in the periodic table approaching the Mn column. A comparison of the ordering in the A15-type phases with the ordering previously reported for various binary sigma phases suggests that the remarkable stability of these phases may result from an interdependence between the electronic structure and the ability of the atoms to undergo deformations in conforming to geometrical packing requirements.

10499. Woelfel, J. B., Paffenbarger, G. C., **Evaluation of complete dentures lined with resilient silicone rubber,** *J. Am. Dent. Assoc.* **76,** 582-590 (Mar. 1968).

Key words: Candida albicans; dentures; dimensional changes in dentures; oral tissues; resilient reliners; retention; silicone rubber; stability.

Twenty four complete dentures, which had been in use for at least seven years, were lined with a soft resilient silicone rubber. The dentures did not warp or change dimensions significantly during or after the lining. The liner was tasteless, odorless, was well tolerated by the tissues, did not bond well to the periphery of the hard denture base, could not be easily removed for the relief of inflamed mucosa, nor were the stability and retention of the dentures improved over that expected from rebasing or relining a denture with a hard resin. On half of the lined dentures colonies of Candida albicans developed on the silicone rubber. Many of the colonies could not be brushed or scraped off and attacked the lining. The liner is not a cure all for denture problems as has been reported in the literature and its routine use is not recommended, but it has some limited applications in special cases.

10500. Acquista, N., Schoen, L. J., Lide, D. R., Jr., **Infrared spectrum of the matrix-isolated OH radical,** *J. Chem. Phys.* **48,** No. 4, 1534-1536 (Feb. 15, 1968).

Key words: Doublet; infrared; isotope; matrix; photolysis; radical.

Infrared absorption in the region of 3450 cm^{-1} has been observed in water-rare gas matrices subjected to vacuum ultraviolet photolysis at 20.4 and 4.2 °K. The splittings and isotope frequency ratios obtained from H_2O^{16}-D_2O^{16}, H_2O^{16}-H_2O^{18} and D_2O^{16}-D_2O^{18} mixtures lead to the assignment of these spectra to trapped OH radicals. No evidence for rotational motion of OH is found in these experiments.

10501. Adams, J. W., Desch, R. F., **Experimental confirmation of barretter substitution error,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 3, 201-202 (Mar., 1968).

Key words: Bolometer substitution error; microwave power measurement.

Agreement of measured values of substitution error in barretters with calculated values based on a theoretical analysis by Carlin and Sucher substantiates both the measured and calculated values. The confirmed theory has interesting possible applications such as confirmation of accuracy of existing measurement techniques and extension to millimeter wave power measurement.

10502. Alley, C. O., Bender, P. L., **Information obtainable from laser range measurements to a lunar corner reflector,** Chapter in *IAU-IUGG Symposium No. 32 on Continental Drift, Secular Motion of the Pole and the Rotation of the Earth* **32,** 86-90 (Reidel Publ. Co., Dordrecht, The Netherlands, 1968).

Key words: Laser; lunar distance; surveyor.

It has been proposed to the U.S. National Aeronautics and Space Administration that optical retro-reflector packages be placed on the lunar surface under either the Surveyor or Apollo Programs. Methods for measuring the range to the reflectors with an expected accuracy of 15 cm have been presented. The new technique is briefly discussed, and an analysis of the determination of geocentric longitude is given, indicating a potential uncertainty of 0.25×10^{-3} seconds of time.

10503. Ambrose, J. R., Kruger, J., **The stress-corrosion of Ti and Ti-8Al-1Mo-1V in methanol vapor,** *Corrosion Sci.* **8,** 119-124 (1968).

Key words: Methanol; stress corrosion; titanium; titanium 8-1-1; vapor phase failure.

An investigation into the stress corrosion cracking of titanium and titanium 8Al-1V-1Mo in methanol has shown that failure will occur in the methanol vapor phase with times to failure being at least an order of magnitude shorter than previously reported. Those effects which significantly altered time to failure were system volume, metal surface condition, and environment composition.

10504. Astin, A. V., **Standards of measurement,** *Sci. Am.* **218,** No. 6, 50-62 (June 1968).

Key words: Measurement accuracy; physical measurement; physical standards; standards for science.

Virtually all measurements made in science and technology depend upon the four independent standards for length, mass, time, and temperature. This article traces the development of standards for these four quantities, with emphasis on recent advances that make possible greater measurement accuracy in science and industry. The possibilities for achieving even greater accuracy in measuring the four basic quantities are discussed.

10505. Astin, A. V., **Voluntary standardization and the government (fifty years of cooperation),** *Mag. Stds.* **39,** No. 6, 167-172 (June 1968).

Key words: Government/non-government cooperation; performance standards; safety codes; simplified practice recommendations; standards of quality; voluntary standardization.

A half-century of progress in cooperative development of voluntary national standards for science and technology is reviewed. Beginning with the 1919 reorganization of the American Engineering Standards Committee and Secretary of Commerce Herbert Hoover's "crusade for standardization," the article traces the growth of government and non-government agency teamwork to the present era in which some 500 national organizations collaborate in standardization on the basis of consensus and continuing review and modernization.

10506. Bates, R. G., **Standardization of acidity measurements. Extension of the pH concept to mixed solvents and heavy water,** *Anal. Chem.* **40,** 28A-38A (May 1968).

Key words: Acidity scales; deuterium oxide; nonaqueous media; pD; pH; pH*; pH concept; standards for acidity.

The modern concept of the operational pH value is examined in detail. Procedures by which the NBS pH scale (based on conventional hydrogen ion activity) was established are reviewed, and it is shown how these same methods and concepts can be extended to set up useful scales for acidity in nonaqueous and mixed solvent systems (using the unit pH*) and in heavy water (using the unit pD). The availability, in the form of standard reference materials, of two new pH standards and three new pD standards is announced.

10507. Bennett, J. A., **To avoid fatigue failures, pay attention to details,** *Current Engr. Pract.* **9,** 12-16 (Sept. 1966).

Key words: Crack initiation; fatigue; residual stress; service failures; stress concentration; surface hardening.

Several examples are cited to illustrate how apparently minor factors can cause fatigue fractures in engineering components. Failures such as these emphasize the fact that the development of fatigue cracks depends on the stress and strength conditions in small critical areas, not on the average stress in the cross section. Consequently the reliability of structures and machines subjected to fluctuating loads can be improved by eliminating sources of stress concentration, by improving the residual stress distribution, and by increasing the strength of the material at the surface.

10508. Billick, I. H., Dishon, M., Weiss, G. H., Yphantis, D. A., **Numerical solutions of the Lamm equation. IV. Rotor slowing experiments,** *Biopolymers* **5,** 1021-1028 (1967).

Key words: Lamm equation; molecular weight; numerical solutions; rotor slowing; sedimentation equilibrium; ultracentrifugation.

This paper presents the results of a numerical solution of the Lamm equation for rotor slowing specified by $\omega^2 = \omega_0^2 \exp(-\lambda\tau)$, for parameters relevant for equilibrium experiments. It is shown that in the two component system it is theoretically possible to deduce s/D from measurements of the difference of concentration across the cell with rotor slowing, provided that the time at which the difference reaches a maximum is known.

10509. Billick, I. H., Schulz, M., Weiss, G. H., **Quasi-equilibrium sedimentation experiments with rotor deceleration,** *J. Phys. Chem.* **71,** No. 8, 2496-2502 (July 1967).

Key words: Equilibrium sedimentation; Lamm equation; rotor deceleration; ultracentrifugation.

This paper presents an analysis of the rectangular approximation to the Lamm equation suitable for analyzing experiments with variable rotor speeds. The theory is applied to the case specified by deceleration described by $\omega^2 = \omega_0^2 \exp(-\lambda\tau)$. It is shown that s/D for a two component system can be determined experimentally by a measurement of concentration difference across the cell at a specified time after the beginning of the experiment. The resulting experiment offers the possibility of considerable savings in time over conventional sedimentation equilibrium experiments. Another experiment, involving a quasi-equilibrium state is analyzed. It is found that the rate of approach to the quasi-equilibrium state is slower than the rate of approach to equilibrium for conventional sedimentation equilibrium experiments under comparable conditions.

10510. Bleicher, M. N., Knopp, M. I., **Lattice points in a sphere,** *Acta Arith.* **X,** 369-376 (1965).

Key words: Geometry of numbers; lattice points; sphere.

Let $R_3(x)$ be the remainder in the classical lattice point problem for a 3-sphere of radius $\sqrt{x}$ and center (0,0,0). We prove that as $x \rightarrow +\infty$,

$$R_3(x) = 0(x^{3/4} \log x)$$

and

$$R_{3(x)} = \Omega(x^{1/2} \log \log x).$$

10511. Bollacasa, D., Goldman, D. T., **Importance of upscattering in the calculation of neutron spectra,** *Proc. Intern. Atomic Energy Agency Symp. Neutron Thermalization and Reactor Spectra, Ann Arbor, Michigan, July 17-21, 1967,* **1,** 537-554 (International Atomic Energy Agency, Vienna, Austria, Jan. 1968).

Key words: Cross sections; epithermal energy; group averaging; neutron; reactor spectrum; scattering; slowing down density.

A study has been made of the effect of raising the thermal energy cutoff higher than .625 eV. In most neutron thermalization calculations, the assumption is made that there is no upscattering above .625 eV. This may be a poor assumption especially for moderator models with chemically bound hydrogen even at room temperature. In the study, a thermal cutoff energy of 3.06 eV was chosen. This was done because the upscattering above this energy is small and this energy corresponds to that of a group in a slowing down program used in the calculations. Neutron spectra and group averaged cross sections were computed and the inadequacy of a thermal cutoff of .625 eV was manifested by comparisons between calculations at these energy cutoffs. A discontinuity can be observed in joining the thermal and epithermal fluxes at .625 eV, while the joining is smooth at 3.06 eV. This provides the possibility of directly normalizing the thermal neutron source to the slowing down density from the epithermal energy region. Thus, neutron spectra in the thermal and epithermal energy regions can be calculated in one process. Comparisons were made in group constants with no upscattering included between .625 eV and 3.06 and with upscattering included up to 3.06 eV. Differences up to 9 percent were observed. These effects could become significant in the calculation of criticality factors if large resonances were present or if systems with large metal-to-water ratios were considered. A spectrum calculation for a SHA (a homogenous assembly) fuel element was compared to a measurement made of its asymptotic spectrum. Even though the agreement between calculation and experiment was not exact, the calculated spectrum closely matched the measured spectrum above .625 eV.

10512. Branscomb, L. M., **The role of atomic collision processes in astrophysics,** Chapter in *The Physics of Electronic and Atomic Collisions: Invited papers from the Fifth International Conference, Leningrad, U.S.S.R., July 17-23, 1967,* L. M. Branscomb, ed., pp. 12-31 (Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colorado, 1968).

Key words: Atomic collision processes in astrophysics, review; review, atomic collision processes in astrophysics.

This paper is the manuscript of a lecture in which the importance of atomic collision processes in the field of astronomy is summarized. The paper deals primarily with the formation of stellar spectra, particularly from the sun, as well as problems of low density astrophysics such as the interstellar medium and planetary nebulae.

10513. Branscomb, L. M., **Twenty years of physics: atoms, molecules and electrons,** *Phys. Today* **21,** No. 5, 36-39 (May 1968).

Key words: Atomic and molecular physics; *historical* review of electron.

This is a review of the field of electron atomic and molecular physics.

10514. Breen, D. R., Keller, R. A., **Intramolecular energy transfer between triplet states of weakly interacting chromophores. I. Compounds in which the chromophores are separated by a series of methylene groups,** *J. Am. Chem. Soc.* **90,** No. 8, 1935-1940 (Apr. 10, 1968).

Key words: Energy transfer; fluorescence; phosphorescence; triplet states.

The intramolecular transfer of triplet excitation energy from the donor chromophor (phthalimide and carbazole) to the acceptor chromophor (naphthalene) was studied when the chromophors were separated by methylene groups. In all cases, complete transfer of triplet excitation energy occurred. New absorption and emission bands not characteristic of either chromophor were observed and were attributed to charge transfer absorption and emission.

10515. Brenner, A., Metzger, W. H., Jr., **Determination of the composition of complexes and their instability constants by calorimetry III. The complex in fused sodium molybdate and molybdenum trioxide,** *J. Electrochem. Soc.* **115,** No. 3, 258-261 (Mar. 1968).

Key words: Calorimetry; complex salts; composition of complex salts, determination of; fused salts; partial molal heat effect; sodium molybdate-molybdenum trioxide system.

A method of determining the composition of complexes in solution and their instability constants, which is based on the measurement of the partial molal heat effect developed when a small increment of each salt is added in turn to a series of mixtures covering the range of composition from 0 to 100 percent, has been applied to the molten $Na_2MoO_4 - MoO_3$ system at 800 °C. The data show that one complex is formed consisting of one molecule of Na_2MoO_4 and two molecules of MoO_3. The instability constant was approximately unity and the complex was between 50 percent and 75 percent dissociated.

10516. Brown, R. L., Brennen, W., **Spin-relaxation effects on the EPR spectrum of gaseous nitrogen atoms,** *J. Chem. Phys.* **47,** No. 11, 4697-4705 (Dec. 1, 1967).

Key words: Electron paramagnetic resonance; flow system kinetics; nitrogen atoms; spin exchange cross sections; spin-relaxation time.

Experimental evidence is presented which indicates that N atoms produced in a flow system by a microwave discharge through purified N_2 have a "spin-lattice" relaxation time T_1 of the order of 25 msec. In a fast flow system, the residence time of the atoms in the EPR magnet can easily be shorter than this. As a result, atoms which are generated outside of the magnet may arrive at the microwave cavity before they have had time to reach their equilibrium magnetization. Addition to the discharged gas of as little as 10 p.p.m. O_2 (which did not affect the N atom concentration) decreased the spin relaxation time, and led to increases as great as 7-fold in the N atom EPR signal. Because of the long relaxation time it was necessary to work at the low microwave power level of 0.006 μW to avoid saturation effects. Power saturation was governed primarily by the rate at which unsaturated atoms entered the cavity and not by collision relaxation processes. Interpretation of the effects of O_2 addition in terms of a two level spin model allowed us to estimate a value of $\sim 1.5 \times 10^{-15}$ cm² for the spin exchange cross section for $N\text{-}O_2$ collisions. Several qualitative observations regarding the nitrogen pink afterglow, electron production, and the effects of NO addition are also reported.

10517. Butterfield, M. A., **Optical character recognition as an archival tool,** *Proc. A Pioneer Presentation of a National Symposium on the Impact of Automation and Documentation, Denver, Colo., Apr. 27-29, 1967,* pp. 101-118 (1968).

Key words: OCR applications; OCR as an archival tool; OCR bibliography; OCR history and growth; OCR as a library tool; optical character recognition.

The exponential growth of technology and records in our Third Industrial Revolution will require librarians and archivists to adopt mechanized and automated techniques to overcome problems of volume. A suggest input mechanization technique is Optical Character Recognition (OCR). The history and growth of OCR is presented along with current status and specific uses. Typical user experiences are described. Bibliography.

10518. Caldwell, B. P., **Kubelka-Munk coefficients from transmittance,** *J. Opt. Soc. Am.* **58,** No. 6, 755-758 (June 1968).

Key words: Absorption; Kubelka-Munk coefficients; optical constants; scattering.

A simplified method is described for the exact computation of Kubelka-Munk coefficients from internal transmittance measurements of two specimens of the same material where one specimen is twice as thick as the other. Equations are derived for determining the scattering coefficient S, the absorption coefficient K, the Kubelka parameters a and b, the internal transmittance τ_i, the reflectance of an infinitely thick specimen $\rho\infty$, and the reflectance of a specimen with an ideal black background ρ_0. Graphs are given to estimate the range of error in $\rho\infty$, S, and K as a function of estimated measurement errors in transmittance.

10519. Chang, S. S., Bestul, A. B., **Heat capacities for atactic polystyrene of narrow molecular weight distribution to 360 °K,** *J. Polymer Sci.* **6,** Part A-2, 849-860 (1968).

Key words: Annealed sample; atactic polystyrene; enthalpy increment; entropy increment; glass; glass transformation; heat capacity calorimetry; literature values; narrow molecular weight distribution; precise heat capacities.

Precise heat capacity values are reported over the temperature range from 10° to 360 °K for a narrow molecular weight distribution atactic polystyrene sample taken from the same stock from which National Bureau of Standards Standard Sample 705, Narrow Molecular Weight Distribution Polystyrene, was established. Data are reported for the sample as received and after an annealing procedure. At temperatures below about 60 °K a systematic difference comparable with the limits of experimental precision appears between the values obtained for the present sample as received, and after the annealing, although at higher temperatures the values for the two did not show any systematic difference beyond the limits of precision of the measurements. At temperatures above 100 °K, previously published values for atactic polystyrene samples of various molecular weight distributions and for isotactic polystyrene agree within about 0.5 percent of the values from this investigation. At temperatures below 100 °K significant heat capacity differences appear, especially between values for the atactic and the isotactic isomers, and even between atactic samples of different molecular weight distribution.

10520. Childs, G. E., Hanley, H. J. M., **Applicability of dilute gas transport property tables to real gases,** *Cryogenics* **8,** No. 2, 94-97 (Apr. 1968).

Key words: Dilute gas; dilute limit; low pressure; mean-free-path; transport properties; validity range; viscosity.

The pressure range for which published "dilute" or "low pressure" transport property tables may be used is experimentally defined. The method is based on the fact that, in a well defined temperature range, transport properties can be computed from kinetic theory expressions. The method is general but specific examples are given for neon, argon, krypton, xenon, oxygen and nitrogen.

10521. Cohen, M. I., Blunt, R. F., **Optical properties of $SrTiO_3$ in the region of the absorption edge,** *Phys. Rev.* **168,** No. 3, 929-933 (Apr. 15, 1968).

Key words: Absorption coefficient; band structure; electroreflectance; optical properties; perovskite; reflectivity; strontium titanate.

The absorption coefficient, reflectivity, and electroreflectance of $SrTiO_3$ in the neighborhood of the fundamental absorption edge are reported. The absorption coefficient shows an exponential rise with incident energy (Urbach rule) over five orders of magnitude its logarithm has a slope of 1/kT. The data indicate that the band gap of $SrTiO_3$ is about 3.4 eV. Additional results for reduced $SrTiO_3$ show that Redfield's model for an exponential edge is not applicable to this material. The reflectivity indicates structure in the region of 3.4 eV and the electroreflectance shows appreciable signal from 2.5 to 5.0 eV with some structure near 3.4 eV. The electroreflectance signal appears to be due to some process other than the Franz-Keldysh effect. It could be due to a shift or splitting in the major oscillator (4.4 eV), responsible for the refractive index, with induced lattice polarization.

10522. Cooper, M. J., **Comments on the scaling-law equation of state,** *Phys. Rev.* **168,** No. 1, 183-184 (Apr. 5, 1968).

Key words: Critical indices; equation of state; scaling-laws.

A generalization of Kadanoff's scaling arguments is shown to provide a functional equation whose solution is a two-parameter power-law form for the equation of state.

10523. Cooper, M. J., Mountain, R. D., **Interpretation of relaxation times in the "electric-field effect on critical opalescence,"** *J. Chem. Phys.* **48,** No. 3, 1064-1066 (Feb. 1, 1968).

Key words: Binary mixture; concentration fluctuations; critical opalescence; electric field effect and light scattering; relaxation time.

The relaxation time characterizing the response of concentration fluctuations in a binary mixture to the application of an electric field is related to the free relaxation of concentration fluctuations. Examination of light scattered by such systems in the vicinity of the critical mixing point indicates that the change in the turbidity of the fluid with time can*not* be related to the diffusion coefficient as simply as is the change in the intensity with time of the light scattered through a given angle which is related to the diffusion coefficient D and change in the wavevector k by a factor $\exp(-2Dk^2t)$.

10524. Corliss, E. L. R., Burnett, E. D., Kobal, M. T., Bassin, M. A., **The relative importance of frequency distortion and changes in time constants in the intelligibility of speech,** *IEEE Trans. Audio Electroacoustics* **AU-16,** No. 1, 36-39 (Mar. 1968).

Key words: Measures of speech quality; perception of speech; sound reproduction; speech communication; speech intelligibility; telephony.

A recording technique developed by E. D. Burnett permitted changes to be made in the relative proportions of intermodulation and harmonic distortion introduced by squaring the input signal. This process was achieved by sending equal parts of the signal through a squaring device, and through a 90-degree phase dividing network followed by a squaring device, and combining the squared outputs. Coupling this procedure with the time-changing features inherent in the sound recording process, we were able to set up a sequence of intelligibility tests whose scores provided solutions to sets of simultaneous equations involving the variables of frequency doubling, frequency halving, and doubling and halving transition times. It was possible to set up an over-specified series of tests, so that more than one solution could be derived from the experiments.

Lowering of the characteristic frequency proved to have the most serious effect upon intelligibility. The next most serious was stretching the transition times. Doubling the frequency by second-harmonic distortion was considerably less damaging, though still significant. Reducing the transition times to half their initial values proved relatively trivial.

This work has been part of a program sponsored by Veterans Administration.

10525. Corliss, E. L. R., Burnett, E. D., Stimson, H. F., **Polyacusis, a hearing anomaly,** *J. Acoust. Soc. Am.* **43,** No. 6, 1231-1236 (June 1968).

Key words: Diplacusis; hearing; hearing loss; masking; physiology of hearing; pitch perception; theories of hearing.

A previously unrecognized anomaly of pitch was discovered by Dr. H. F. Stimson while testing his hearing. Signals above 3500 Hz did not produce the same pitch in each ear; the right ear's sensation was that of a sound at a lower frequency, for which he also had normal pitch perception. Between 3700 Hz and 5200 Hz the pitch perceived in the right ear was independent of the frequency of the stimulus. As intensity was raised, additional pitches appeared, and for an intense sound a chord was heard whose constituents were not harmonically related. Stimson can match these anomalous pitches with sinusoidal stimuli of the appropriate lower frequency within about 2 percent; part of this variation is a change of pitch with intensity. Tones in his normal pitch range having a pronounced overtone structure are perceived as multiple. Overtones falling in the anomalous range give rise to the anomalous pitch. This would indicate a Fourier type of analysis before pitch recognition. Beats are not excited by interference between the pitches evoked by signals in the anomalous range and those heard normally. Loudness studies show signal powers to be additive. Tone masking and loudness summation experiments yield data suggesting that the pitch recognition mechanism lies in that part of the auditory system in which loudness is perceived, i.e., beyond the cochlea.

10526. Cornell, R. G., Speckman, J. A., **Estimation for a simple exponential model,** *Biometrics* **23,** No. 4, 717-737 (Dec. 1967).

Key words: Biometrics; exponential model; non-linear estimation; statistics; statistical estimation.

In many public health situations an estimate is required of the parameter ρ in the statistical model $Y = 1 - \exp(-\rho t)$, where Y represents the expected value of an observed proportion y at time (or dosage) t. Ten methods of estimating ρ are discussed and illustrated: graphical, maximum likelihood, least squares, weighted least squares, moments, partial totals, Fisher, Spearman and two finite differences methods. Comparisons are made on the basis of ease of computation and large and small sample properties.

The maximum likelihood estimate has desirable large sample properties and a limited Monte Carlo study indicates that it has favorable small sample properties. However, it is difficult to compute. If the t's are equally spaced and small samples are used, the partial totals estimate has similar statistical properties and is much easier to compute. If the t's are exponentially spaced, either Fisher's or Spearman's estimate, both of which are easy to compute, is recommended as an alternative to the maximum likelihood estimate.

10527. Cornog, J. R., Bryan, H. L., Jr., **Manual and machine-assisted search methods used in examining patent applications in the transistor art,** *Proc. Natl. Electronics Conf., Chicago Ill., Oct. 25-27, 1965,* **XXI,** 672-677 (1965).

Key words: Information retrieval; information storage; mechanized; methodology; optical-coincidence; patents; references; search; systems; thinking.

The thinking patterns of a U.S. patent examiner as he searched for prior art manually and by mechanized methods are contrasted in this paper. The specific analysis presented is for a search of the U.S. Patent Office references in the transistor art, but generalizations in the Summary are based both on this protocol and several from similar searches in the organometallics files. Some advantages and limitations of mechanized reference retrieval systems are given.

10528. Costrell, L., **Standard nuclear instrument modules,** (Adopted by AEC Committee on Nuclear Instrument Modules, January 1968), *AEC Report* **TID-20893** (Rev. 2), (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 1968, 25 cents.)

Key words: Instrument; interchangeability; modules; nuclear; standard.

The interchangeability problem posed by the advent of modular instrumentation has been alleviated by the development of a Standard Nuclear Instrument Module (NIM) system by the AEC Committee on Nuclear Instrument Modules. The Committee held its first meeting on March 17, 1964. The completed specifications were issued in July 1964 and laboratory utilization and industry exhibit of the NIM system began in November 1964. Acceptance by the laboratories and by the nuclear instrument industry has been so rapid and so overwhelming that it is estimated that NIM instruments constituted over two-thirds of the total modular nuclear instrument production in the U.S. in

1966 and between 85 percent and 95 percent in 1967. Since all necessary components are available, other fields and other industries can readily adopt the system.

10529. Coyle, T. D., Cooper, J., Ritter, J. J., **Preparation and some reactions of difluoroborane,** *Inorg. Chem.* **7,** No. 5, 1014-1020 (May 1968).

Key words: Boron; difluoroborane; fluoride; hydride; hydroboration; isotope exchange; organoboron compounds.

Difluoroborane is produced by the direct interaction of boron trifluoride with diborane in the gas phase at 100 °C or above. Pyrolysis of $BF_3-B_2H_6$ mixtures at 250 °C for periods of 30 min to 1 hr, followed by rapid quenching, yields HBF_2-BF_3 mixtures free of B_2H_6. An alternative, synthetically useful route is the reaction of $HB(OCH_3)_2$ with excess BF_3. Difluoroborane undergoes rapid H – F exchange with boron trifluoride and H – D exchange with deuterated diborane, but does not exchange boron with diborane. Addition of difluoroborane to propene and isobutene yields *n*-propyldifluoroborane and isobutyldifluoroborane, respectively. Reactions with fluoroethylenes give boron trifluoride, ethylfluoroboranes, and less highly fluorinated olefins.

10530. Coyle, T. D., Ritter, J. J., **Reactions of diboron tetrahalides with some unsaturated organometallic compounds,** *J. Organometallic Chem.* **12,** 269-280 (1968).

Key words: Addition reactions; boron; boron subhalides; organometallic compounds; tetrachlorodiborane(4); tetrafluorodiborane(4).

Tetrachloro- and tetrafluorodiborane(4) add to the double bond in a number of vinyl derivatives of boron, carbon, silicon, germanium, and tin to form 1,2-bis(dihaloboryl)ethyl derivatives. Most of the compounds are stable *in vacuo* at temperatures in excess of 150 °C. Tetrachlorodiborane(4) undergoes addition considerably more readily than does tetrafluorodiborane(4). Relative rates of addition have been determined and shown to be markedly dependent on the nature of the substituent on the vinyl group.

10531. Crumlish, J. D., Wirth, G. F., **A preliminary study of engineering seismology benefits,** *Environmental Science Services Administration, Coast and Geodetic Survey* (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, Aug. 1967, 35 cents).

Key words: Benefit-costs; cost-effectiveness; economic benefits studies; engineering seismology; program evaluation and analysis; programming, planning, budgeting studies.

To examine the economic benefits of engineering seismology, a number of avenues were followed in this study. The main approach was a comparison of school earthquake damage records by pre-1933 and post-1933 construction categories. (In 1933, California began requiring strict earthquake-resistant design for public school facilities.)

This comparison revealed average damage of less than one percent for post-1933 schools compared to average damage as high as 78 percent for pre-1933 schools. School damage data for the Seattle (1965) earthquake and for the Alaska (1964) earthquake were also investigated.

10532. Cushen, W. E., **Systems engineering — Where did it come from . . . where will it go?,** *Consulting Engr.* **30,** No. 3, 130-134 (Mar. 1968).

Key words: Decisions; gaming; government; management; operations research; systems engineering.

Systems engineering is entering a totally new applications area. This area broadly covers such service functions as transportation, pollution control, urban and rural development, crime control, and education. This introductory article describes some of the implicit modifications that will need to be made to the customary procedures of systems engineering if the tremendous potential of its use is to be realized. A "flashback" into the history of operations research, systems analysis, and the multidisciplinary problem-solving approach of the Defense and industrial establishments of the nation is provided for perspective.

10533. Cuthill, J. R., McAlister, A. J., Williams, M. L., **Soft x-ray spectroscopy of alloys: TiNi and the Ni-Al system,** *J. Appl. Phys.* **39,** No. 5, 2204-2208 (Apr. 1968).

Key words: Absorption correction; density of states; lifetime broadening; nickel; overlapping spectra; soft x-ray spectra of alloys; temperature broadening; Ti-Al system; TiNi.

Meaningful comparisons can now be made between the soft x-ray spectra of pure metals and theoretical densities of states distributions. The comparison of the Ni-M spectrum with theoretical results is shown as an example. Also, useful information can now be obtained from alloy spectra although the analysis of alloy spectra involves all of the problems inherent in the interpretation of pure metal spectra plus additional problems. Overlapping spectra and more complex absorption corrections are two additional problems discussed. In fact, the soft x-ray spectroscopy technique should provide a crucial test of theoretical results on alloy systems.

Spectra from a series of Al-Ni compositions and the Ni-M spectrum from TiNi are discussed.

10534. Dehl, R. E., **Broadline NMR study of H_2O and D_2O in oriented rayon fibers,** *J. Chem. Phys.* **48,** No. 2, 831-835 (Jan. 15, 1968).

Key words: Broadline NMR; D_2O; dipole-dipole interaction; H_2O; oriented water; quadrupole-field gradient interaction; rayon fibers.

The broadline NMR spectra of H_2O and D_2O absorbed in parallel fibers of highly crystalline rayon have been found to consist of two lines, whose separation depends upon the angle between the fiber axis and the magnetic field. The D_2O splitting, resulting from quadrupole perturbation of the nuclear Zeeman levels, was about ten times greater than the H_2O splitting, produced by direct nuclear dipole-dipole interaction. Two models for the partial orientation of water molecules are discussed, (I) in which the molecules rotate about a fixed axis, and (II) in which the molecules reorient rapidly about all possible axes, but maintain a small resultant projection, along the fiber axis. Model I is shown to be incorrect for the rayon fibers, on the basis of the combined H_2O and D_2O results; Model II, however, appears to be applicable not only to rayon but to other examples of partially oriented water as well.

10535. deMain, P. A. D., Marron, B. A., **The SOLID SYSTEM. I. A method for organizing and searching files,** (Proc. Third Annual Colloquium on Information Retrieval, Philadelphia, Pa., May 12-13, 1966), Chapter in *Information Retrieval, A Critical View,* G. Schecter, ed., pp. 243-282 (Thompson Book Co., Washington, D.C., 1967).

Key words: Chemical structures; compressions; computer; files; information; storage and retrieval.

Here are described the *principles* of the SOLID SYSTEM, a *Self-Organizing, Large, Information Dissemination System.* In the SOLID SYSTEM, fully automatic compressors reduce both fast and slow (external) memory requirements to a minimum and provide item by item decoding by the system as the information is required. The computer constructs an INFORMATION REPRESENTATION (LABEL) and its BIT-MAPS for each document or query and then uses this information to locate or store information. With BIT-MAPS, storage requirements for LABEL are kept to a minimum. Together LABEL and its BIT-MAPS can preserve the hierarchic characteristics of the query or document to any depth. Override features permit any degree of uncertainty in both storage and retrieval. Unique non-algebraic transformation rules, easily executed by a computer, permit recanonicalization of LABEL and its BIT-MAPS to emphasize any kernel, class or group characteristic of the information when the system demands it.

The SOLID SYSTEM can be implemented with successively higher degrees of automation as usage, funds and "computer power" increase, without compromising either its early implementation or the later development of new techniques for entering the system.

Here chemical structural information is used to demonstrate the SOLID SYSTEM.

10536. DeSimone, D. V., **Education for innovation,** *IEEE Spectrum* **5,** No. 1, 83-90 (Jan. 1968).

Key words: Creative engineering; engineering education; innovation; invention; technological change.

Engineering education should encourage students to strive for a mastery of fundamentals and the cultivation of excellence — but this is not enough. Engineering education must be kept alive and relevant; and, to encourage creativity, it must stimulate the imaginations of students. The typical educational yardstick of a student's performance, however, is the accuracy with which he can repeat, by rote, information obtained from a lecture or text. Original or unconventional approaches to problems are discouraged, and their proponents often penalized, thus discouraging and depressing the student. Must inventiveness be sacrificed to education?

10537. DeVoe, J. R., Spijkerman, J. J., **Mössbauer spectrometry,** *Anal. Chem.* **40,** No. 5, 472R-489R (Apr. 1968).

Key words: Chemical applications; literature; Mössbauer spectroscopy; review.

A review of the literature on chemical applications of Mössbauer spectroscopy for 1966 and 1967 is presented. This is done primarily with a table of pertinent information on compounds and techniques. New developments in the field are also presented.

10538. Dibeler, V. H., Walker, J. A., **Mass spectrometric study of the photoionization of small polyatomic molecules,** (Proc. Conf. on Mass Spectrometry, Berlin, Germany, Sept. 1967), Chapter in *Advances in Mass Spectrometry* **4,** 767-780 (The Institute of Petroleum, London, England, 1968).

Key words: Bond dissociation; heats of formation; ionization energies; vacuum ultraviolet.

Photo-ionization measurements, absorption spectra, photoelectron spectra, and electron impact studies of CO_2, COS, CS_2, NO_2, and N_2O have been reported by various authors. There remains considerable uncertainty and disagreement regarding thresholds of ionization, particularly for dissociative ionization. In some cases, the bond energies derived from the latter are of considerable interest. The present report describes results obtained as part of a continuing programme of study of the photo-ionization of polyatomic molecules. In this study, mass analysis is employed to identify and to select ionic species produced by radiation from photon sources over the wavelength region 1500 to 600 Å and with band-widths of 1 Å.

10539. Dick, C. E., Marella, A. B., Miller, W. C., **A simple beam positioning system for low energy electrons,** *Nucl. Instr. Methods* **60,** 346-348 (1968).

Key words: Beam positioning system; low energy electrons.

A servo system utilizing fabricated steering coils has been devised to hold the electron beam from a 4 MeV Van de Graaff accelerator on the entrance slit of a magnet system used for high momentum resolution. It performs extremely well.

10540. Dickson, P. F., Jones, M. C., **Infrared spectral reflectances of metals at low temperatures,** *Cryogenics* **8,** No. 1, 24-29 (Feb. 1968).

Key words: Compilation; cryogenic; infrared; metals; reflectance.

Experimental results of infrared spectral reflectances of ten pure metals and one alloy system at low temperatures are reviewed. Reflectances are in many cases calculated from published optical constants or obtained from absorptance measurements. Comparisons with room temperature measurements are made where possible and some observations regarding the effect of sample preparation technique and surface oxidation are made.

10541. Dickson, R. W., Anderson, R. C., **Temperature dependence of the elastic moduli of $91Y_2O_3 + 9ThO_2$ from 25° to 1100 °C,** *J. Am. Ceram. Soc.* **51,** No. 4, 233 (Apr. 1968).

Key words: Elastic moduli; Poisson's ratio; porosity; shear modulus; Young's modulus; yttria.

Young's modulus and the shear modulus of pore-free, transparent yttria sintered with thoria ($90\ Y_2O_3 + 10\ ThO_2$) were determined from 25 °C to 1100 °C. Poisson's ratio was calculated and shows a slight increase with increasing temperature.

10542. Durst, R. A., **Fluoride microanalysis by linear null-point potentiometry,** *Anal. Chem.* **40,** No. 6, 931-935 (May 1968).

Key words: Fluoride activity electrode; fluoride analysis; linear null-point potentiometry; microanalysis; microcell design; potentiometry.

The modified fluoride activity electrode is used as the sample electrode in the technique of linear null-point potentiometry for the determination of fluoride at subnanogram levels in sample volumes of 10 $\mu\ell$. The emf vs. titrant concentration data are plotted semilogarithmically, and the equivalence point is obtained by a linear interpolation to the null-point potential. Data analysis is also accomplished by computer techniques whereby the equivalence point is obtained from the intercept of a linear least squares fit of the data. Fluoride solutions 10^{-3} to $2 \times 10^{-6}M$ (containing 190 to 0.38 nanograms of fluoride in 10 $\mu\ell$) were determined with an accuracy of approximately 1 percent over the entire range and a relative standard deviation of the mean of about 0.5 percent for 5 determinations. At the lowest concentration level, $2 \times 10^{-6}M$ fluoride, the error in determining 380 picograms of fluoride was approximately 2 picograms.

10543. Durst, R. A., May, E. L., Taylor, J. K., **Improved technique for the microdetermination of silver by linear null-point potentiometry,** *Anal. Chem.* **40,** No. 6, 977-978 (May 1968).

Key words: Linear null-point potentiometry; microdetermination of silver; potentiometry; silver.

The determination of submicrogram amounts of silver by linear null-point potentiometry has been significantly improved through the use of several modifications of the technique. Greater linearity of the titration curves, shorter analysis time, and improved accuracy are achieved by pregeneration of the standard solutions and the establishment of an equilibrium null-point potential. In this study, 54 nanograms of silver in a volume of 0.1 ml were determined with an error of less than 2 ng, while at concentrations above 10 μM, errors of less than 1 percent are easily obtained using the improvements discussed.

10544. Eisenhart, C., **Expression of uncertainties of final results,** *Science* **160,** No. 3833, 1201-1204 (June 14, 1968).

Key words: Accuracy; calibrations; expression of uncertainty; measurements; precision; standard error; systematic error; uncertainty.

The terms used to describe the precision and accuracy of measurements are defined and discussed. Specific rules are recommended for expressing the uncertainty of a reported value for four cases distinguished according to the relative magnitudes of the imprecision and the likely systematic error of the measurement process employed. Examples of recommended forms of uncertainty statements are given.

10545. Eisenhart, C., **Biography on Carl Friedrich Gauss,** *International Encyclopedia of the Social Sciences* **6,** 74-81 (The Macmillan Co. and The Free Press, New York, N.Y., 1968).

Key words: Gauss, Carl Friedrich; Method of Least Squares.

A biography of Gauss with particular attention to his role in the development of the Method of Least Squares.

10546. Eisenhauer, C., **Gamma radiation fluxes near a ground-air interface using an image source technique,** *Nucl. Sci. Engr.* **32,** 166-177 (1968).

Key words: Air-scatter; buildup factor; gamma rays; image source; interface; shielding; single scatter.

Calculations are made of the radiation flux of gamma rays which have originated from a point isotropic source and have been singly-scattered in the air lying beyond a plane interface. Calculations are made in the limit that the source-detector separation distance is small compared to a mean free path in air. These results are interpreted in terms of an image source. The results, combined with earlier calculations of the radiation flux reflected from a condensed medium, such as ground, predict the effect of the ground-air interface on radiation fluxes in air near the interface. The results are extrapolated to source-detector separation of the order of a mean free path by using infinite medium buildup factors. Comparisons with experiment show that the model produces results which are in qualitative agreement with experiment.

10547. Fatiadi, A. J., **Formation of arylazocyclohexene derivatives on acylation of certain inosose phenylhydrazones,** *Carbohydrate Res.* **7,** 89-94 (1968).

Key words: Acylation; arylazoethylenes; inosose phenylhydrazones.

It has been found that acetylation of *myo*-inosose-2 phenylhydrazone with acetic anhydride in the presence of pyridine at room temperature produces 1-phenylazo-1-cyclohexene-DL-*ido*-3,4,5,6-tetrol tetraacetate (β-elimination product) instead of the phenylhydrazone derivative reported. In contrast, acylation with propionyl anhydride and pyridine gives the phenylhydrazone pentapropionate. However, acylations of DL-*epi*-inosose-2 phenylhydrazone at 0 to 5 °C with acetic or propionic anhydrides give the corresponding pentaacylated phenylhydrazones.

10548. Fell, H., Mather, J., **Barely faithful algebras,** *Math. Monthly* **72,** No. 9, 1001-1003 (Nov. 1965).

Key words: Algebras; nontrivial linear associative algebras; nonzero element.

It is shown that nontrivial linear associative algebras, which are "barely faithful" in the sense that each nonzero element is a two-sided zero-divisor but neither a right nor a left annihilator, exist in all dimensions $\geqslant 4$ but not in lower dimensions.

10549. Flynn, D. R., O'Hagan, M. E., **Measurements of the thermal conductivity and electrical resistivity of platinum from 100 °C to 900 °C,** *Engelhard Ind. Tech. Bull.* **VIII,** No. 4, 117-147 (Mar. 1968).

Key words: Conductivity; electrical conductivity; electrical resistivity; heat conductivity; Lorenz function; platinum; reference material; resistivity; standard; thermal conductivity.

Measurements have been made of the thermal conductivity and the electrical resistivity of commercial grade platinum (99.98 percent pure) in the temperature range 100 to 900 °C. The measurements have been made with a view to providing accurate data on the thermal conductivity of platinum to serve as a basis for establishing platinum as a thermal conductivity standard reference material. Two methods of measuring the thermal conductivity have been employed, one an electrical method and the other a non-electrical method. In the electrical method, a direct current passed through a necked-down portion of the specimen and the thermal conductivity was determined in terms of the temperature and electrical potential distribution in the necked-down region. The second method was of the absolute guarded longitudinal heat flow type. The experiment was designed to permit measurements by both methods in the same apparatus and on the same specimen thereby providing as direct a comparison as possible between the methods. The data given by the two methods agree within experimental error and show the thermal conductivity of platinum to be a smoothly increasing function of temperature in the measured range. Additional measurements on samples of differing purities are necessary before platinum could be adopted as a thermal conductivity reference material.

10550. Fraction, G. F., Tauber, S. J., Walker, J. C., **Connection tables from Wiswesser line notation: A partial algorithm,** Proc. Wiswesser Line Notation Meeting of the Army Chemical Information and Data Systems Program, Edgewood Arsenal, Watertown, N.J., Oct. 6-7, 1966, *Edgewood Arsenal Spec. Publ.* **EASP-400-8,** pp. 139-197 (Jan. 1968).

Key words: Acyclic; benzene; chemical structure notations; connection tables; contractions; ring system; syntax analysis; transformation algorithm; Wiswesser.

An algorithm has been developed for transforming certain types of Wiswesser organic structure notations into connection tables. Acyclic and benzene structures are treated, and provision has been made for all of the types of contractions used by the Wiswesser notation system. A separate algorithm is presented for treating linearly fused ring aggregates. A syntax has been developed to describe those portions of Wiswesser notations which refer to non-benzene ring systems.

10551. Franklin, A. D., **Born model calculation of defect energies in CaF_2,** *J. Phys. Chem. Solids* **29,** 823-841 (1968).

Key words: Born model calculation; calcium fluoride; energies of formation; Frenkel pairs; interstitials; ionic crystals; point defects; Schottky pairs; vacancies.

A general formulation of the Born model as applied to the calculation of the energies to form point defects in ionic crystals is given, and then specialized to vacancies and interstitials of both kinds in CaF_2. After examination of the effects produced by several factors in the calculation, "best values" are chosen for the formation energies. These are used to compute the energies to form anion Frenkel pairs (2.7 ± 0.4 eV/pair), cation Frenkel pairs (7.5 ± 0.8 eV/pair), and Schottky trios (5.1 ± 0.7 eV/trio). The results are in reasonable agreement with Ure's experimental results, which indicate that anion Frenkel pairs are the equilibrium defects in CaF_2, with a formation energy of 2.8 eV.

10552. Goldman, A. J., Nemhauser, G. L., **A transport improvement problem transformable to a best-path problem,** *Transportation Sci.* **1,** No. 4, 295-307 (Nov. 1967).

Key words: Algorithm; graph; network; optimization; shortest-path; transportation.

For each arc (i,j) of a transport network, suppose given an initial traversal disutility d(i,j) and a function f(i,j,r) describing the reduced disutility which would result from applying *r* units of resources to "improve" the arc. For each origin-destination pair, there arises the problem of how a limited resource budget should be allocated among the arcs so as to optimize a best path from origin to destination in the improved network. It is shown here that this problem is transformable to a best-path problem in an enlarged network. The allowable investment levels in individual arcs can be constrained as desired.

10553. Goldman, D. T., Muehlhause, C. O., **Neutron Physics,** Chapter 7 in *Handbook of Physics, Second Ed., Part 9, Nuclear Physics,* E. U. Condon and H. Odishaw, eds., pp. 9-195—9-211 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Diffraction; inelastic; interaction; materials; neutron; properties; reaction; scattering; structure; transport.

The enclosed paper is a review article written for the second edition of the "Handbook of Physics" edited by E. U. Condon and H. Odishaw. As such it is a revision of one of the authors' (C. O. Muehlhause) original articles. The paper deals with the general features of the physical properties of the neutrons, containing initially the fundamental properties of the neutrons, their mass, charge, moments and certain basic interactions. The history of a neutron is then traced from its generation in, e.g., a reactor spectrum, including a discussion of the interactions of the neutron with atomic nuclei. The theory of the transport of neutrons is then outlined. The next section deals with the utilization of thermal energy neutrons as a probe for the determination of the detailed characteristics of solids and liquids and suggests other techniques which have been used. Finally, effective range theory is introduced to interpret low energy neutron-proton scattering.

10554. Gray, V. E., Cadoff, B. C., **Survey of techniques for evaluating effects of weathering on plastics,** *Appl. Polymer Symp.* **4,** 85-95 (Sept. 1967).

Key words: Color and gloss measurements; colorimetric analysis; infrared analysis; oxidation; plastics; ultraviolet analysis; weathering.

This paper surveys those physical and chemical test methods that could be applied in the prediction of the performance of plastics under outdoor exposure.

Techniques to measure appearance, strength, and flexibility are reviewed. Color changes alone, although widely used, are shown to be an insufficient measure of weathering.

The more sensitive spectroscopic and chemical test methods that have been found to measure oxidation and hydrolysis products in polymeric materials are examined for usefulness in quantitatively measuring plastic degradation. The methods reviewed are used to determine carbonyl, carboxyl, peroxidic, and hydroxyl groups.

10555. Halford, D., **A general mechanical model for $|f|^\alpha$ spectral density random noise with special reference to flicker noise $1/|f|$,** *Proc. IEEE* **56,** No. 3, 251-258 (Mar. 1968).

Key words: Flicker noise; low frequency noise; mechanical model; modulation noise; noise; noise model; noise simulation; precision measurements; random noise; reasonable perturbations; spectral density; $1/f$ noise.

Any class of reasonable time-dependent perturbations occurring at random, under certain internal constraints, generates random noise having a spectral density varying as $|f|^\alpha$ over an arbitrarily large range of spectral frequency f only for $-2 \leqslant \alpha \leqslant 0$. A class is the set of all perturbations which are equivalent under some individual independent scaling of amplitude, scaling of time, and translation of time. A subclass is characterized by $P(\tau)$ and $A^2(\tau)$. $P(\tau)$ is the lifetime probability density. $A^2(\tau)$ is a mean square amplitude of perturbations having lifetime τ. For a given class, $|f|^{\alpha_\infty}$ and $|f|^{\alpha_0}$ are the frequency-smoothed laws in the limits of infinite and zero frequencies, respectively. Any reasonable perturbation has $\alpha_\infty \leqslant -2$ and $\alpha_0 \geqslant 0$. To generate random noise having an $|f|^\alpha$ law over an arbitrarily large range of f from a subclass chosen from any class characterized by α_∞ and α_0, it is necessary that $\alpha_\infty \leqslant \alpha \leqslant \alpha_0$. For $\alpha_\infty < \alpha < \alpha_0$, it is necessary and sufficient that such subclasses satisfy the condition, $P(\tau)A^2(\tau) \approx B\tau^{-\alpha-3}$ with B constant, over a suitable range of τ, and that $P(\tau)A^2(\tau)$ not be larger than $B\tau^{-\alpha-3}$ outside the range. This general mechanical model is of immediate value in the formulation and criticism of specific physical models of $|f|^\alpha$ noise, including flicker noise, and in computer simulation of $|f|^\alpha$ noise.

10556. Hall, L. H., Spijkerman, J. J., Lambert, J. L., **Preparation and coordination studies of the complex acid, dihydrogen diethylenetriaminepentaacetatoferrate(III) dihydrate, and several of its metal (I) salts,** *J. Am. Chem. Soc.* **90,** No. 8, 2044-2048 (Apr. 10, 1968).

Key words: Coordination; infrared spectroscopy; magnetic susceptibility; Mössbauer spectroscopy; M_2FeDTRDS; photodecomposition; preparation; thermogravimetric analysis.

The coordination numbers of the central metal ion which exists in iron (III) chelated with diethylenetriaminepentaacetic acid, H_5DTPA have been investigated by the following methods: (a) infrared spectroscopy, (b) magnetic susceptibility, (c) Mössbauer spectroscopy, (d) photodecomposition and (e) thermogravimetric analysis. The iron(III) DTPA complexes were found to exist in three different forms in the solid phase: the complex acid, the mono-salt and the di-salt. All three forms were found to be high spin complexes. The complex acid H_2FeDTPA·$2H_2O$ was shown to have a coordination number of six around the central metal atom. The monoammonium salt, NH_4HFeDTPA·$1H_2O$ was found to be seven coordinated. However, the di-alkali metal salts M_2FeDTPA · nH_2O were found to have a coordination number of eight around the central atom but one of the iron(III) carboxylate bonds is different than the remaining four.

The cation in the salt of the complex interacts with the metal d-orbitals, and appears to decrease the size of the metal d-orbitals, which results in a concentration of the d-electron density nearer the nucleus.

10557. Hamer, W. J., **Battery, electric,** *Encyclopedia Americana* **3,** 357-363 (1967).

Key words: Battery; electric battery.

A brief description of the electric battery.

10558. Hamer, W. J., **Using standard cells,** *Meas. Data* **1,** No. 6, 64-67 (Nov.-Dec. 1967).

Key words: Early types of standard cells; life of standard cells; standard cells; temperature coefficient of standard cells.

This paper contains information on effects of temperature, pressure, electric current, light, shock, and vibration on standard cells. The paper also includes some information on the temperature range for which standard cells can be used and some information on their life.

10559. Hamer, W. J., Wood, R. E., **Electrolytic conductivity and electrode processes,** Chapter 9 in *Handbook of Physics, Second Ed., Part 4, Electricity and Magnetism,* E. U. Condon and H. Odishaw, eds., pp. 4-146—4-171 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Batteries; Debye-Hückel-Onsager theory of conductance; electrochemical thermodynamics; electrode mechanisms; electrolytic conductivity; fuel cells; ionic charge; ionization; standard cells; transference numbers.

This article deals with the general principles of electrolytic conductance and the mechanism of the processes that occur at the interfaces between electrodes and electrolytes. *Topics covered include:* Comparisons of electrolytic and electronic conductors, classes of electrolytic conductors, the process of ionization in conducting solutions, the determination of the degree of ionization in strong and weak electrolytes, ionic charge, values of the Faraday, equations for electrolytic conductivity, meaning of equivalent and molar conductance, ionic conductances and transference numbers, ionic mobilities, effects of interionic attraction on electrolytic conductance including a discussion of the Debye-Hückel-Onsager relations, high-field effects in conductance, conductance at high frequencies, electrochemical thermodynamics, activity coefficients, standard electrode potentials in aqueous solutions and molten electrolytes, standard cells, pH determinations, irreversible phenomena at electrodes, electrode polarization, hydrogen overvoltage, and electric cells and batteries including discussions of primary batteries, secondary batteries, reserve or delayed-action batteries, and fuel cells.

10560. Hammond, H. K., III, **Phototube response evaluation,** *Appl. Opt.* **7,** No. 5, 985 (May 1968).

Key words: Color temperature standards; phototube response evaluation; total irradiance standards.

Phototube response has been reported for many years on a photometric instead of a radiometric base. Theoretically a radiometric base would be preferable, but practically it appears to offer little advantage. Color temperature would still be required to specify the spectral distribution of each standard lamp. A conversion factor can be computed to go from a photometric to a radiometric base for a given color temperature, 2870 °K being the most frequently used.

10561. Harvey, M. E., **Precision temperature-controlled water bath,** *Rev. Sci. Instr.* **39,** No. 1, 13-18 (Jan. 1968).

Key words: Bath; control; temperature; water.

The water bath described was designed primarily to furnish an improved environment for microwave microcalorimeters but would also be useful for thermometer calibration, standard cells (suitably insulated), and other physical and chemical measurement systems. The bath and its associated temperature controller operate at any bath temperature between 18 °C to 28 °C which is not more than 6 °C below the ambient temperature. The bath provides a temperature stability of $\pm 25\mu$ °C over a 24-hour period when measured with a 100-second time constant. The short-term stability measured with a 0.7-second time constant is between $\pm 70\mu$ °C and $\pm 7\mu$ °C, depending on the location within the bath and the magnitude of the energy exchange between the heating and cooling mechanisms. The bath temperature change caused by an ambient temperature change of 2 °C is less than 5μ °C.

10562. Hayward, R. W., **Nuclear electromagnetic radiation,** Chapter 6 in *Handbook of Physics, Second Ed., Part 9, Nuclear Physics,* E. U. Condon and H. Odishaw, eds., pp. 9-172—9-194 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Gamma rays; internal conversion; nuclear electromagnetic radiation.

An elementary treatment of interactions of nuclei with the electromagnetic field.

10563. Heydemann, P. L. M., **An ultrasonic pressure gage,** *J. Basic Eng.* **89,** No. 3, 551-553 (Sept. 1967).

Key words: Fluid range; measure pressures; pressure gages; pressure-sensitive components; regenerating circuits; transit time; ultrasonic pulses.

The transit time of short ultrasonic pulses in solid rods is used to measure pressures throughout the fluid range. Self-excited regenerating circuits are used. Measurements to 3500 bar with an uncertainty of 0.3 bar and to 20 kb with an uncertainty of 2 bar are reported. Further improvements, temperature compensation, and stability are discussed.

10564. Huget, E. F., Brauer, G. M., Loebenstein, W. V., **Apparent heats of wetting and heats of reaction of the components of tooth structure and synthetic fluorapatite,** *J. Dental Res.* **47,** No. 2, 291-301 (Mar.-Apr. 1968).

Key words: Anorganic whole tooth; components of tooth structure; dentin; enamel; fluorapatite; heats of reaction of components of tooth structure; heats of wetting of components of tooth structure.

The apparent heats of wetting ΔH_w and heats of reaction ΔH_R of ground dentin, enamel, anorganic tooth and synthetic fluorapatite of known specific surface were determined calorimetrically. The values of ΔH_w in water are affected by the presence of collagenous matter. Dentin saturated with water vapor gave ΔH_w of 0.31 cal/gm compared to 12 cal/gm for powder dried at 10^{-3} mm Hg. Dry dentin reacts with 0.006-0.6 M aqueous NH_4 citrate, malonic, ascorbic, citric and methacrylic acid as evidenced by heats of reaction ΔH_R ranging from 29-56 cal/gm. These reactions at the surface are caused mainly by organic groups since the ΔH_R for anorganic tooth, enamel and fluorapatite are much smaller on exposure to these reagents. On the other hand, disodium EDTA and the phosphoric acid in cola beverages react primarily with the mineral components of tooth structure. Harkins method for surface area determination applied to water vapor saturated samples gave approximately the same specific values for dentin as those obtained by the BET method, but gave smaller values for anorganic whole tooth tissue. These results of the heats of reaction of odontic powders are useful for studying the modification of tooth surface and in determining those groups that will bond to tooth structure in an aqueous environment.

10565. Hutchinson, J. M. R., Naas, C. R., Walker, D. H., Mann, W. B., **Backscattering of alpha particles from thick metal backings as a function of atomic weight,** *Intern. J. Appl. Radiation Isotopes* **19,** No. 6, 517-522 (June 1968).

Key words: Alpha particles; backscattering; 1η; α-counter.

Alpha-particle backscattering from thick metal backings has been studied using two separate counters with geometries of 2 percent and approximately 1 percent steradians.

10566. Ives, L. K., Ruff, A. W., Jr., **Studies of the effect of annealing on extended dislocation nodes in silver-tin alloys,** *Phys. Stat. Sol.* **27,** 117-123 (1968).

Key words: Dislocations; electron microscopy; oxygen impurities; silver-tin alloys; stacking fault energy.

Extended dislocation nodes have been observed by transmission electron microscopy and measured in several solid solution silver-tin alloys after annealing at elevated temperatures. The intrinsic stacking fault energies were determined and compared with previously reported values for freshly deformed specimens. Only small irreversible changes in the fault energy were found after annealing up to 600 °C, in contrast to results found in some other alloy systems. The effect of oxygen on the node extensions in pure silver was also studied.

10567. Jensen, M. W., **The Fair Packaging and Labeling Act of 1966—its history and its implementation,** *Monthly Rev. J. Inst. Weights Measures Admin.* **76,** No. 4, 3-6 (Apr. 1968).

Key words: Commerce; consumers; labeling; measures; packages; weights.

The Fair Packaging and Labeling Act of 1966 was enacted by the Congress and signed into law by the President after some six years of legislative history. The Act gives certain regulatory responsibilities to the Department of Health, Education, and Welfare and the Federal Trade Commission, and makes the Secretary of Commerce responsible for the reduction of the quantities in which particular consumer commodities are offered for sale when such quantities are deemed by him to be unduly proliferated through voluntary action by the packaging industry. The weights and measures agencies of the individual States will play significant roles in the implementation of both the regulatory activities and the activities that will result in voluntary action by industry.

10568. Johannesen, R. B., **Relative signs of NMR coupling constants and isotope shifts in ammonium ions,** *J. Chem. Phys.* **48,** No. 3, 1414-1415 (Feb. 1, 1968).

Key words: Double resonance; isotopes; nitrogen-15; nuclear magnetic resonance; relative signs.

The NMR spectra of $^{14}NH_3DCl$ and $^{15}NH_3DCl$ have been measured and the signs of all coupling constants have been measured. Isotope shifts in the proton and nitrogen spectra are reported.

10569. Judd, D. B., **Color vision and colorimetry,** Chapter 4 in *Handbook of Physics, Second Ed., Part 6, Optics,* E. U. Condon and H. Odishaw, eds., pp. 6-65–6-77 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Anomalous trichromatism; color; colorimeter; dichromatism; luminous efficiency; photoelectric colorimetry.

The response functions of wavelengths defining the various types of human vision are given in terms of luminous-efficiency and color-matching functions. The types are trichromatic (normal, protanomalous, deuteranomalous), dichromatic (protanopic, deuteranopic, tritanopic), and monochromatic (twilight or rod vision). Measurement of color consists of determining the amounts of three primary colors defined by the Commission Internationale de l'Eclairage (CIE) required to match an unknown color. Equations are given to transform these amounts, called tristimulus values, from the CIE primary colors to any others. Theories of color vision are defined by the coefficients in the equations required to transfer the tristimulus values of a color from the CIE primaries to the set of primaries implied by that theory. The main theories are three-component (Young, Ladd-Franklin, and early König for cone photopigments; Helmholtz, late König for cone responses), opponent-color (Hering for optic-nerve processes), and zone or stage theories (v. Kries-Schrödinger, Adams, and Müller). Coefficients are also given for ten often used transformations of the CIE coordinate system. The uses are experimental determination of color-matching functions, color television, improved uniformity of color spacing, and measurement of color by photoelectric colorimeters.

10570. Keller, R. A., **Intramolecular energy transfer between triplet states of weakly interacting chromophores. II. Compounds in which the chromophores are perpendicular to each other,** *J. Am. Chem. Soc.* **90,** No. 8, 1940-1944 (Apr. 10, 1968).

Key words: Energy transfer; fluorescence; phosphorescence; triplet states.

The intramolecular energy transfer properties of the following two molecules were investigated at 77 °K. The spiro linkage holds the two chromophors perpendicular to each other. Complete transfer of both singlet and triplet excitation energy to the chromophor with the lowest excited state of a particular multiplicity was observed for both of these molecules. No absorption or emission bands were observed which could not be attributed to one of the chromophors.

10571. Kneissl, G. J., Richmond, J. C., Wiebelt, J. A., **A laser source integrating sphere for the measurement of directional hemispherical reflectance at high temperatures,** (Proc. Thermophysics Specialist Conf. of AIAA, New Orleans, La., Apr. 17-20, 1967), Chapter 1 in *Thermophysics of Spacecraft and Planetary Bodies, Radiation Properties of Solids and Their Measurement* **20,** 177-202 (Academic Press Inc., New York, N.Y., Dec. 1967).

Key words: Graphite; high temperature reflectance; integrating sphere; laser; reflectance; sodium chloride coating; thoria; tungsten.

The purpose of this research was to evaluate the high-temperature spectral emittance of refractory metals and ceramics by measuring their reflectance very accurately at high temperatures. An integrating sphere was used to measure the directional, hemispherical reflectance at temperatures up to 2000 °K. The accuracy of the measurement was practically independent of the directional distribution of the reflected flux, which made it possible to measure accurately any material of any surface texture. The source used for this instrument was an He-Ne CW laser operated at 0.6328, 1.15 and 3.39 μm. A narrow bandpass filter, whose peak transmittance coincided with the lasing wavelength, was placed in front of the detector to increase the signal-to-noise ratio. Since conventional sphere coatings could not be used for this high-temperature integrating sphere, a new sphere coating had to be developed. This coating exhibits a high reflectance at all three wavelengths in question, is a very good diffuser, possesses good mechanical properties, and can be used in a low-pressure system. Preliminary data are shown for materials such as graphite, tungsten, and thorium oxide.

10572. Kokoszka, G. F., Brinckman, F. E., **Electron paramagnetic resonance studies of phosphorus-containing reactive intermediates,** *Chem. Commun.* **7,** 349-350 (Apr. 10, 1968).

Key words: E.p.r.; free radicals; low-energy irradiation; low temperature; PCl_3; PCl_2; PCl_4; sp^2 hybrids; trigonal bipyramid.

The electron paramagnetic resonance (e.p.r) spectrum of the irradiation products of PCl_3 has been recorded at 77 °K with an X-band spectrometer. In the neat material two species have been identified. The first is PCl_2 with magnetic parameters $g = 2.017$ and $A_p \approx 33$ gauss. The second species is PCl_4 with parameters $g = 2.0124$, $A_p = 2106$ gauss, $A_{Cl} = 62$ gauss (2 chlorine atoms) and $A'_{Cl} = 7$ gauss (2 chlorine atoms). The uncertainties are believed to be less than 1 gauss in the A values and within 0.0005 for the g values.

When PCl_3 is diluted in a Xe matrix (PCl_3:Xe = 1:9) a large PCl_2 signal again develops but there is no evidence for PCl_4. In a mixture of PCl_3 and PF_3 (~10:1) the anisotropic spectrum associated with PCl_2 displays a seven-line chloride hyperfine pattern in the parallel portion.

In neat $MePCl_2$ a pentatomic phosphorus-containing species is produced. The data are constant with a formulation as Me_2PCl_2 or $MePCl_3$ but the former is believed to be more likely.

10573. Kuriyama, M., **Dynamical calculation of the x-ray diffraction profile from a distorted crystal,** *J. Appl. Phys.* **39,** No. 4, 2162-2163 (Mar. 1968).

Key words: Absorption; distortion; lattice sum; line broadening; perfect crystal; scattering amplitude; theory; x-ray diffraction.

A dynamical line-shape calculation for a distorted, parallel-sided crystal is given for the Laue geometry. The scattering amplitude previously formulated by the author is demonstrated to be indeed valid for an arbitrarily large distortion.

10574. Larsen, N. T., **50 microdegree temperature controller,** *Rev. Sci. Instr.* **39,** No. 1, 1-12 (Jan. 1968).

Key words: Controller; temperature control.

A temperature controller has been developed using a platinum resistance thermometer in a bridge with inductively-coupled ratio arms. It is capable of maintaining water bath temperatures constant to within ±25 microdegrees Celsius for 24 hours in an environment varying as much as ±1.5 °C at any temperature from 18 °C to 28 °C. The sensitivity of the controller approaches the theoretical limitation imposed by Johnson noise. The design makes possible control dials which are direct-reading in °C.

10575. Little, J. L., Mooers, C. N., **Standards for user procedures and data formats in automated information systems and networks,** *AFIPS Conf. Proc. Spring Joint Computer Conf., Atlantic City, N.J., Apr. 30-May 2, 1968,* **32,** 89-94 (Thompson Book Co., Washington, D.C., 1968).

Key words: Automated networks; automated systems; data formats; distributed data base; information networks; information system standards; on-line system reactive typewriters; retrieval; time-sharing computers; user procedures.

In the brave new world of the publicly accessible "on-line" computers and automated information systems, users are finding a rapidly growing chaos of incompatible control languages and methods of operation. Almost every automated system has been provided with a different language and method. The resulting chaos promises effectively to destroy much of the potential value of nationwide networks of such information systems. The community of users—and potential users—of such systems are the ones most seriously affected. In order to remedy this intolerable situation, the users must initiate immediate action to introduce standards for user control methods and languages which will permit easy and compatible utilization of automated information systems. This paper is devoted to an examination of twelve elementary logical functions for user control, and suggested keyboard assignment for these functions is reported.

10576. Lundgren, F. A., Nargolwalla, S. S., **Use of a dual sample-biaxial rotating assembly with a pneumatic tube transfer system for high precision 14-MeV neutron activation analysis,** *Anal. Chem.* **40,** No. 4, 672-677 (Apr. 1968).

Key words: Accuracy; activation analysis; design; oxygen; precision; sample rotator; 14 MeV neutrons.

Imprecision in 14-MeV neutron activation analysis is primarily due to nonhomogeneity and anisotropy in the usable neutron flux. This fact is considerably magnified in analyses pertaining to short-lived radioactivity such as in the determination of oxygen by $^{16}O(n,p)^{16}N$ reaction.

A design for a variable-speed dual sample rotating assembly is described. This assembly allows reproducible placement of pneumatically injected samples and permits both sample and standard to be exposed to an identical neutron flux as a result of biaxial rotation. The analytical precision, which is now most often limited by the total number of counts accumulated, is about 10 times better than that which standard normalization techniques can provide. The system permits the analyst to determine both neutron and gamma attenuation in dense samples.

This irradiation assembly is currently being utilized for the accurate and precise determination of oxygen in NBS Standard Reference Materials.

10577. Mahler, R. J., James, L. W., **Nuclear electric hexadecapole-phonon interaction,** (Proc. XIV Colloque Ampere, Sept. 6-11, 1966, Ljubljana, Yugoslavia) Chapter in *Magnetic Resonance and Relaxation,* R. Blinc, ed., pp. 938-945 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1967).

Key words: Angular dependence; hexadecapole; hexadecapole transitions; phonon-nuclear interactions; saturation factor; ultrasonically induced transitions.

A nucleus with spin 5/2 or larger may possess an electric hexadecapole as well as an electric quadrupole moment. These electric moments can interact with the lattice to yield a static shift in the nuclear energy levels, or with the lattice vibrations (phonons) to produce transitions between the nuclear energy levels.

One can show theoretically that the hexadecapole interaction can give rise to $\Delta m = \pm 1,2,3$, and 4 nuclear transitions, but experimentally the $\Delta m = \pm 1$ and 2 transitions would be masked by the much larger quadrupole interactions. Since a $\Delta m = \pm 3$ or 4 nuclear transition gives rise to a net change in the nuclear magnetization, pulsed NMR techniques are ideally suited to observe these interactions.

A theoretical expression for the hexadecapole-phonon interactions is derived, and the experimental procedure used to observe the interactions is discussed. Results of these and related experiments are given.

10578. Maki, A. G., Thibault, R., **Analysis of some perturbations in the ν_4 band of methyl chloride,** *J. Chem. Phys.* **48,** No. 5, 2163-2167 (Mar. 1, 1968).

Key words: Absorption spectra; infrared; methyl chloride; perturbations; spectra; vibrational resonance.

The ν_4 band of CH_3Cl has been analyzed in detail. It is found that there is a weak but important, vibrational resonance between ν_4^1 and $3\nu_6^1$. The resonance is quantitatively taken into account in order to determine the unperturbed rotational constants for both ν_4^1 and $3\nu_6^1$. Both chlorine isotopes are resolved and treated separately. The interaction parameter is found to be given by $3.519\,(\pm 0.006) + 0.028\,ki\,(\pm 0.003)\ cm^{-1}$. The k dependent term is evidently due to a Coriolis-like interaction which is also possible between ν_4^1 (E) and $3\nu_6^1$ (E).

10579. Manning, J. R., **Correlation factors for diffusion of vacancies in binary alloys,** (Proc. Subconference on Lattice Defects, Honolulu, Hawaii, Sept. 1965) Chapter in *Lattice Defects and Their Interactions,* R. R. Hasiguti, ed., pp. 269-289 (Gordon and Breach, New York, N.Y., 1967).

Key words: Binary alloys; calculations; correlation factors; diffusion; Kirkendall shift; thermodynamic equations for diffusion; vacancies.

A vacancy in a pure cubic crystal follows a random walk. In a binary alloy however, a vacancy usually has a higher jump frequency when exchanging with one type of atom than with the other. As a result, a vacancy in a binary alloy does not follow a random walk. Partial correlation factors f_r^A and f_r^B can be defined for vacancy jumps with A and B atoms, respectively. Then, the correlation factor for diffusion of vacancies is given by the weighted average $f_r = (w_A N_A f_r^A + w_B N_B f_r^B / (w_A N_A + w_B N_B)$, where w_A, w_B are vacancy jump frequencies for exchange with A and B atoms, while N_A, N_B are the mole fractions of A and B atoms. The partial correlation factors also enter into the equations for the vacancy flux in a Kirkendall shift experiment, but in a different combination than that for f_r. Consideration of this flux and the theory of correlated walks in a driving force allows f_r^A, f_r^B, and f_r to be calculated. Experimental applications are considered.

10580. Manning, J. R., **Reply to comments on "Diffusion and the Kirkendall shift in binary alloys,"** *Scripta Met.* **2**, 177-178 (1968).

> Key words: Binary alloys; diffusion; diffusion coefficients; kinetic theory; Onsager reciprocal relation; thermodynamic theory.

It is noted that Yao in his calculation of the parameter ϵ has not taken into account the relation $\partial c_A/\partial x = -\partial c_B/\partial x$ between the concentration gradients in a binary A-B alloy. As a result, Yao's calculation of ϵ is not correct. A kinetic equation for ϵ is calculated.

10581. Margoshes, M., Scribner, B. F., **Emission spectrometry,** *Anal. Chem.* **40**, No. 5, 223R-246R (Apr. 1968).

> Key words: Atomic absorption spectrometry; atomic fluorescence spectrometry; emission spectrometry; flame photometry; isotopic analysis; microanalysis; review; spectrometry.

A review is given of emission spectrometry and flame emission, atomic absorption, and atomic fluorescence spectrometry for the years 1966-67. Emphasis is placed on analytical applications, but some theoretical papers are included. The major subjects included are books and reviews; spectral descriptions and classifications; instrumentation; standards, samples, calibration, and calculation; excitation sources; flame emission, absorption, and fluorescence; trace analysis; lasers and microanalysis; and other applications. Six hundred and seventy-six references are listed.

10582. Marron, B. A., deMaine, P. A. D., **Automatic Data Compression,** *Commun. ACM* **10**, No. 11, 711-715 (Nov. 1967).

> Key words: Alphanumeric; automatic; compressor; computer; data; information handling; numeric.

The "Information Explosion" noted in recent years makes it essential that storage requirements for all information be kept to a minimum. A fully automic and rapid compressor, COPAK, developed for the SOLID SYSTEM, can be used with *any* body of information to greatly reduce slow external storage requirements and to increase the rate of information transmission through a computer. COPAK will also automatically decode the compressed information on an item by item basis when it is required.

The three components of COPAK, which can be used separately to accomplish their specific tasks, are described in this paper: NUPAK for the automatic compression of numerical data, ANPAK for the automatic compression of *any* information, and IOPAK for further compression of information to be stored on tape or cards.

10583. Marvin, R. S., **Twenty years of rheology,** *Phys. Today (20th Anniversary Edition)* **21**, No. 5, 52-53 (May 1968).

> Key words: Rheology.

A summary of the principal activities in the field of rheology over the last twenty years.

10584. Mattis, R. L., Phillips, W. E., Bullis, W. M., **Measurement and interpretation of carrier lifetime in silicon and germanium,** *Tech. Rept.* **AFML-TR-68-81,** (Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1968).

> Key words: Carrier lifetime; diode recovery time; germanium; photoconductive decay; photomagnetoelectric effect; silicon; surface photovoltage.

Minority carrier lifetime is a basic parameter for the specification of semiconductor materials for transistors, diodes, and similar devices. Photoconductive decay measurements are routinely made on many crystals used in the fabrication of these devices. Although this measurement suffers both from lack of precision and from limitations in the range of applicability it is the only method for determination of carrier lifetime which has been accepted as standard. This report describes the results obtained during the first year of a continuing research project which was undertaken in order to determine the fundamental limitations on the precision and applicability of this method and to develop alternate methods which might be more suitable under various conditions. Detailed studies of the photoconductive decay method were accompanied by preliminary studies of the photomagnetoelectric method, the diode recovery time method, and the surface photovoltage method and a critical survey of the various methods which have been reported in the literature. The photoconductive decay method was studied in greatest detail.

10585. Melmed, A. J., **Field emission shadow microscopy,** *Appl. Phys. Letters* **12**, No. 3, 100-102 (Feb. 1, 1968).

> Key words: Field electron microscope; field emission; microscope.

A microscope has been constructed which produces an electron shadow "image" of small electrically conducting objects in ultra-high vacuum. The microscope uses an electron field emitter as an approximate point source of electrons and casts a shadow of the object by direct projection onto a phosphor screen. When the object is also a field emitter, a second screen may be used to view its surface in the manner of a conventional field electron microscope. Thus far, magnifications up to 6,500, with a resolution of about 300 Å, have been realized. Magnifications of 20,000 or greater should easily be feasible with resolution of 10-30 Å possible.

10586. Menke, J. L., Schrack, R. A., **Feeble field feeler,** *Nucl. Instr. Methods* **57**, 158-159 (Dec. 1967).

> Key words: Detector; magnetic field; magnetic null; null measurable; remanent field; saturable ferrite.

A simple magnetic field detector is described which allows measurement of magnetic fields to within .1 gauss. Together with its associated circuits it can be used to adjust an electromagnetic system for minimum remanent field.

10587. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the reaction of atomic and molecular fluorine with carbon atoms. The infrared spectra of normal and ^{13}C-substituted CF_2 and CF_3,** *J. Chem. Phys.* **48**, No. 5, 2265-2271 (Mar. 1, 1968).

> Key words: C atom reaction; F atom reaction; F_2 reaction; force constants; free radical; infrared spectrum; matrix isolation; NF_2; photolysis, thermodynamic properties; ultraviolet spectrum; $^{12}CF_2$; $^{13}CF_2$; $^{12}CF_3$; $^{13}CF_3$.

Carbon atoms, resulting from the photolysis of cyanogen azide, are found to react with molecular fluorine in an argon matrix at 14 °K to produce CF_2. The use of carbon-13 has led to confirmation of the previous assignment of features at 1073 and 1191 cm^{-1} to $^{13}CF_2$ present in natural abundance. Using recent structural data on CF_2 and the $^{12}CF_2$ and $^{13}CF_2$ frequencies, it has been possible to calculate the complete valence force potential of CF_2. Values of the potential constants are compared with those of the related species NF_2 and OF_2. When the sample is subjected to radiation of wavelengths effective in photolyzing F_2, CF_3 is also produced. Sufficient yields of both $^{12}CF_3$ and $^{13}CF_3$ have been obtained for observation of all four vibrational fundamentals. Data have been fitted to a four-constant valence force potential. Agreement is most satisfactory for a C_{3v} structure with a deviation of 13° from planarity. Using this structure, the thermodynamic properties of CF_3 have been estimated.

10588. Moore-Sitterly, C., **IAU Commission 14—Fundamental spectroscopic data report of meetings, Aug. 23-25, 1967,** *Proc. XIIIth General Assembly Intern. Astronomical Union, Prague, Czechoslovakia, Aug. 22-31, 1967,* **13B,** 87-91 (1968).

Key words: Laboratory spectra; molecular spectra; solar spectrum; standards, wavelength; transition probabilities; wavelength standards.

During the 13th General Assembly of the International Astronomical Union, held in Prague August 22-31, 1967, there were four meetings of IAU Commission 14—Fundamental Spectroscopic Data. The present paper is a report on the business meeting and four scientific sessions of the Commission.

The Index of Refraction of Air, wavelength standards, laser sources, transition probabilities, molecular spectra and future trends in spectroscopy were the chief topics discussed.

10589. Nargolwalla, S. S., Crambes, M. R., DeVoe, J. R., **A technique for the evaluation of systematic errors in the activation analysis for oxygen with 14-MeV neutrons,** *Anal. Chem.* **40,** No. 4, 666-671 (Apr. 1968).

Key words: Correction factors; neutron and gamma-ray attenuation; oxygen; removal cross section; systematic errors; 14-MeV activation analysis.

In comparative 14-MeV neutron activation analysis of oxygen, the neutron and gamma ray attenuation differences in the sample and standard introduce systematic errors. A quantitative evaluation of these attenuation processes in a wide range of matrices and for three sample diameters is given.

The experimentally determined correction factor, in each case, shows an exponential dependence on the calculated difference between the appropriate attenuation coefficients for sample and standard. Over the range of sample diameters tested, the slope of each calibration line is linearly dependent on the sample diameter. For comparable diameters, the magnitude of the slope for neutron attenuation is approximately ten times greater than for gamma attenuation. These calibration lines are used to predict attenuation correction factors for the determination of oxygen in other matrices. Some typical analyses of Standard Reference Materials, corrected for attenuation, illustrate the high degree of accuracy and precision obtained.

10590. Newman, M., **Pairs of matrices generating discrete free groups and free products,** *Mich. Math. J.* **15,** 155-160 (1968).

Key words: Discrete matrix groups; free groups; free products.

It is shown that if

$$A=\begin{pmatrix}-a & b\\ -c & d\end{pmatrix},\ B=\begin{pmatrix}-\alpha & -\beta\\ \gamma & \delta\end{pmatrix}$$

are elements of SL(2,R) such that a, b, c, d, α, β, γ, $\delta \geqslant$ and d-a $\geqslant 2$, $\delta - \alpha \geqslant 2$, then the group {A,B} is a free discrete subgroup of SL(2,R). Generalizations to free products are given.

10591. Oppenheim, I., Shuler, K. E., Weiss, G. H., **On the decay of initial correlations in stochastic processes,** *J. Chem. Phys.* **46,** No. 10, 4100-4111 (May 15, 1967).

Key words: Eigenvalue spectrum; initial correlation; r-particle Ursell functions; stochastic process.

We study the relaxation of a non-interacting, initially correlated many particle system in contact with an infinite reservoir. We use the master equation to study the time development of the r-particle distribution function $P_r(n;t)$ and assume that the relaxation process is Markovian. We study the decay of the correlations by investigating the time development of the r-particle Ursell functions, $U_r(n;t)$. We show that the correlation function $U_r(n;t)$ goes to zero much more rapidly with time than the r-particle distribution function approaches its equilibrium value $P_r(n;\infty)=\prod_{i=1}^{r} P(n_i;\infty)$. The exact forms of the relaxation of $P_r(n;t)$ and $U_r(n;t)$ depend upon the eigenvalue spectrum of the transition rate matrix of the master equation. The general theory is developed and then applied to a number of examples.

10592. Osgood, C. F., **A method in diophantine approximation (II),** *Acta Arith.* **XIII,** 383-393 (1968).

Key words: Convolution product; differential equations; diophantine approximation; integers; irrational numbers; linear operators.

This paper applies the general method of approachh developed in *A Method in Diophantine Approximation* to obtain further results about the diophantine approximation of values of certain functions. Examples of such functions are the inverse Laplace transforms of all functions of the form $z^{-\alpha} \exp\left(\sum_{i=1}^{l=1} r_i z^{-i}\right)$ where α and the r_i are each rational, $\alpha > l+1$, α is not an integer and $r_{i=1} \neq 0$. For these latter functions we conclude that at any nonzero rational point the zeroth thru l-1 st derivatives are linearly independent over the rationals.

10593. Page, C. H., **Electronic circuits,** Chapter 4 in *Handbook of Physics, Second Ed., Part 4., Electricity and Magnetism,* E. U. Condon and H. Odishaw, eds., pp. 4-45—4-52 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Active; demodulation; gyrator; harmonic generation; modulation; nonlinear; parametric amplifier.

A brief outline of the properties and analysis of *nonlinear* and *active* electrical circuit elements, with reference to modulation, demodulation, harmonic generation, parametric amplifiers, and gyrators.

10594. Pichanick, F. M. J., Simpson, J. A., **Resonances in the total cross sections for metastable excitation of noble gases by electron impact,** *Phys. Rev.* **168,** No. 1, 64-70 (Apr. 5, 1968).

Key words: Cross sections; electron impact; excitation; helium; metastable.

Total cross sections for excitation by electron impact of metastable states in the noble gases helium, neon, argon, krypton and xenon have been measured as a function of impact energies. A 180° spherical monochromator was used to obtain incident beams of electrons with energy resolutions between 0.035 eV and 0.050 eV. Metastable atoms were detected in the scattering chamber by electron ejection from a metal surface. The detector was biassed negatively to repel scattered electrons, and was electrostatically shielded from the incident electron beam. The cross sections were measured for impact energies up to 5 eV above the metastable thresholds. Several narrow resonances associated with negative ion states were observed, and where possible their shapes and positions on the energy scale were compared with similar results obtained by different techniques.

10595. Radford, H. E., Evenson, K. M., **Paramagnetic-resonance spectrum of metastable (^2D) atomic nitrogen,** *Phys. Rev.* **168,** No. 1, 70-74 (Apr. 5, 1968).

Key words: Electric discharge; electron paramagnetic resonance; fine structure separation; g factors; metastable atomic nitrogen; Zeeman spectroscopy.

The paramagnetic resonance spectrum of free metastable (^2D) nitrogen atoms has been observed in the flowing products of an electric discharge in nitrogen-helium gas mixture. An analysis of the Zeeman effect and hyperfine structure yields the following values for the atomic g-factors and radial integrals: $g_j(^2D_{5/2}) = 1.20036 \pm 0.00001$; $g_j(^2D_{3/2}) = 0.79949 \pm 0.00002$; $\langle r_l^{-3} \rangle = (20.21 \pm 0.02) \times 10^{24}$ cm^{-3}; $\langle r_s^{-3} \rangle = (22.22 \pm 0.02) \times 10^{24}$ cm^{-3}. The ^2D fine structure separation is found to be -8.69 ± 0.02 cm^{-1}. Evidence is found of a small electric quadrupole hyperfine structure interaction.

10596. Reimann, C. W., Zocchi, M., **The structure of the trinuclear cation bis-[μ-(tri-1,2,4-triazolo-N^1,N^2)-triquonickel]-nickel,** *Chem. Commun.* **5,** 272 (Mar. 6, 1968).

Key words: Bis[triaquo tri μ(1,2,4 triazolo($-N_1$ $-N_2$)) nickel] nickel; crystal structure; trinuclear complex.

The complex bis[triaquo tri μ(1,2,4 triazolo($-N_1$ $-N_2$)) nickel] nickel hexanitrate dihydrate has been prepared and the crystal structure was determined by single crystal x-ray diffraction techniques. This complex crystallizes in the monoclinic system with a = 14.261, b = 11.745, c = 14.948 Å, $\beta = 127.9°$, space group $P2_1/c$, $\rho_o = 1.85$ g cm^{-3}, $\rho_c = 1.84$ g cm^{-3} and $z = 2$.

The bis[triaquo tri μ(1,2,4 triazolo($-N_1$ $-N_2$)) nickel] nickel cation was found to contain three colinear nickel atoms with the central nickel atom bridged to the terminal nickel atoms by three 1,2,4 triazole rings. The Ni–Ni separation was found to be 3.73 Å. The coordination about each nickel atom is octahedral. The octahedral coordination of the terminal nickel atoms is completed by three molecules of water.

10597. Rosenstock, H. M., **Theory of mass spectra – A general review,** (Proc. Conf. on Mass Spectrometry, Berlin, Germany, Sept. 1967), Chapter in *Advances in Mass Spectrometry* **4,** 523-545 (The Institute of Petroleum, London, England, 1968).

Key words: Franck-Condon factors; theory of mass spectra; unimolecular dissociation.

In this paper we shall discuss developments in the theory of mass spectra since 1961. At that time an appraisal of the status of theory was presented, the main conclusions of which were as follows: (1) Quasi-equilibrium theory can reasonably account for the general features of mass spectra. (2) Quantitative disagreement between theory and experiment was in large measure due to poor mathematical approximations made in enumerating densities of states of reactants and activated complexes. (3) Non-equilibrium or non-equilibration effects were difficult to predict *a priori,* but some meaningful tests could be made by designing experiments to study the effects of different initial preparation on the subsequent kinetic behavior of ions.

Since the publication of these conclusions, considerable work has been done on enumeration of states, calculation of mass spectra and breakdown curves, detailed energization and fragmentation mechanisms, behaviour of metastable transitions, initial preparation effects, and quantum-mechanical theory of ion decomposition. These subjects will be discussed in detail.

10598. Rush, J. J., Flotow, H. E., **Vibration spectra of vanadium hydride in three crystal phases by inelastic neutron scattering,** *J. Chem. Phys.* **48,** No. 8, 3795-3804 (Apr. 15, 1968).

Key words: Crystal structure; frequency distribution; hydrogen positions; hydrogen vibration; metal hydride; neutron inelastic scattering; phase transformation; vanadium hydride; vibration spectra.

The vibration spectra of vanadium hydride in three crystal phases have been investigated by the energy-gain scattering of cold neutrons. The measured spectra are generally split into two broad bands above and below about 300 cm^{-1}, which are primarily associated with optical hydrogen vibrations and metal-atom vibrations, respectively. Pseudo-frequency distributions for the hydrogen vibrations were derived from the measured neutron spectra. These indicate broad optical vibration bands peaked at 970 ± 50 and ~ 1400 cm^{-1} in the α (bcc) phase, 440 ± 20, 970 and ~ 1400 cm^{-1} in the β (bct) phase and ~ 1300 cm^{-1} in the γ (fcc) phase. The width of the 440 cm^{-1} band increases with hydrogen concentration, possibly due to hydrogen-hydrogen interactions. The "metal-atom" vibration spectra also show changes in peak positions and widths as the distribution of phases is changed. The changes in the neutron spectra with temperature and as a function of composition between $VH_{0.20}$ and $VH_{1.71}$ correlate quite well with the previously measured phase diagram.

A comparison of the present results with neutron spectra for hydrides with known hydrogen positions suggests that in the α phase hydrogens only occupy tetrahedral-type sites, while in the β phase both octahedral and tetrahedral sites are occupied. The results for $VH_{1.49}$ and $VH_{1.71}$ indicate that in the γ phase the hydrogens occupy regular tetrahedral sites corresponding to the fluorine positions in a CaF_2-type structure.

10599. Saunders, J. B., **Precision measurements,** Chapter 1 in *Advanced Optical Techniques,* pp. 3-22 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1967).

Key words: Double stars, measurement; expansion measurements; lens and mirror testing; optical engineering; optical surfaces; precision measurements; refractive indices; surface plate testing; temperature measurement; wavelength measurement.

This chapter contains methods and instrumentation for making precision measurements in a limited field of optical engineering. The fundamentals of all the included material has been published previously. The subjects that have been covered here are: refractive indices, wavelength measurement, testing of optical surfaces, surface plate testing, temperature measurement by optical methods, expansion measurements, lens and mirror testing, and the measurement of double stars.

10600. Schneider, W. E., Garvey, J. A., **Procedures for determining the spectral responsivity of an infrared radiometer,** *Appl. Opt.* **7,** No. 6, 1141-1148 (June 1968).

Key words: Calibration techniques; infrared radiometers; radiometric standards; radiometry; spectral responsivity.

With the increasing number of commercial radiometers employing rather varied and sophisticated optical designs, the determination of the spectral responsivity of these radiometers has accordingly become more involved. A joint National Bureau of Standards – U.S. Army calibration of an infrared radiometer was conducted at the White Sands Missile Range facility. The radiometer chosen for the measurements employed an uncooled PbS detector with an 8 inch Cassegrainian optical system. The selection of this particular type of instrument permitted two methods of measurement (each employing different standards and techniques) to be investigated. The methods of calibration and the uncertainties associated with each method are described and the application of the responsivity values to field measurements is discussed. The agreement of the spectral responsivity values as determined by each method is within the estimated uncertainty computed for each procedure.

10601. Sengers, J. M. H. L., **On the determination of virial coefficients from PVT data,** *Proc. 4th Symp. Thermophysical Pro-*

perties, University of Maryland, College Park, Md., Apr. 1-4, 1968, pp. 37-44 (American Society of Mechanical Engineers, New York, N.Y., 1968).

Key words: Density expansion; gas thermometry; power series coefficients; PVT; statistical analysis; virial coefficients.

In calculating coefficients of a power series expansion from experimental data, several factors besides experimental precision affect the standard error of these coefficients. Using the principles of statistical analysis, the effects of the factors: interval size, extrapolation, number, relative weight and distribution of experimental points have been studied by high-speed computer experiments.

For gas PVT data a density expansion is possible and approximate theoretical knowledge of the first five virials is available. This enables formulation of experimental conditions – other than improved precision – leading to decreased standard error in one or more of the first four virials.

10602. Sengers, J. V., Sengers, J. M. H. L., **The critical region,** *Chem. Eng. News* **46,** No. 25, 104-118 (June 10, 1968).

Key words: Critical phenomena; binary alloys; binary liquid mixture; critical opalescence; gas liquid transition; laser light scattering; magnets; superfluids; transport processes.

A comparative discussion is given of critical phenomena in gases, binary liquids, binary alloys, magnets and superfluids. Experiments show a striking similarity in thermodynamic behavior in widely different systems and transitions. The experimental results are in disagreement with the prediction of the classical theories of Van der Waals, Weiss and Bragg and Williams, but very similar to the theoretical predictions for the Ising model. The possibility of a universal equation of state, describing the various critical anomalies, is discussed. The behavior of transport properties near the critical point is summarized for gases and binary liquids. The paper concludes with a discussion of the phenomenon of critical opalescence and introduces the reader to the new possibilities for studying critical fluctuations with the aid of laser light scattering.

10603. Sengers, J. M. H. L., Vicentini-Missoni, M., **Thermodynamic anomalies near the gas-liquid critical point,** *Proc. 4th Symp. Thermophysical Properties, University of Maryland, College Park, Md., Apr. 1-4, 1968*, pp. 79-86 (American Society of Mechanical Engineers, New York, N.Y., 1968).

Key words: Chemical potential; critical region; lattice gas; scaling law; specific heat; thermodynamic anomalies; vapor pressure.

Thermodynamic anomalies near the gas-liquid critical point are more correctly described by the Ising model theory of the ferromagnet and the lattice gas than by Van der Waals-type theories. The inherent symmetries and the critical anomalies of the lattice gas are discussed using the proper variables, namely chemical potential, density and temperature. Part of the lattice gas symmetries are shown to be retained in the real gas if the same variables are used. The range of validity and some of the properties of a non-analytic equation-of-state in these variables, recently proposed by Widom, Kadanoff and Griffiths and representing successfully PVT data and density vs height isotherms in the critical region, are discussed.

10604. Shuler, K. E., **Microscopic and macroscopic approach to chemical rate processes,** (Proc. 7th AGARD Colloquium, Oslo, Norway, May 16-20, 1966), Chapter in *Recent Advances in Aerothermochemistry,* I. Glassman, ed., **1,** No. 12, 1-21 (Technical Editing and Reproduction Ltd., London, England, 1967).

Key words: Chemical kinetics; cross sections; rate theory; scattering theory; trajectory calculations; transport processes.

Chemical rate processes, like all other transport processes, can be considered on two levels – the molecular one and the statistical one. On the molecular (microscopic) level one is concerned with binary (or higher order) collisions between single atoms and/or molecules. Such elementary processes can best be studied through the scattering of the reactant species in atomic and molecular beams. The quantity of interest is the reactive scattering cross section; the theoretical approach involves the quantum theory of scattering. On the statistical (macroscopic) level one is concerned with the interactions of an ensemble of atoms and molecules characterized by their velocity and internal energy distribution functions. The experimental quantity of interest is now the rate coefficient; the theoretical approach involves the derivation and solution of the appropriate macroscopic transport equation in terms of the (microscopic) scattering cross sections and the distribution functions of reactants and products. In this paper, we will discuss these two approaches to the study of rate processes and their connection.

10605. Smit, J., Ogburn, F., Bechtoldt, C. J., **Multiple twin structures in electrodeposited silver dendrites,** *J. Electrochem. Soc.* **115,** No. 4, 372-374 (Apr. 1968).

Key words: Dendrites; electrocrystallization; faceting; silver; twinning; x-ray diffraction.

Silver dendrites, formed by electrocrystallization from aqueous solution were examined for twinning using optical goniometric, x-ray diffraction and metallographic techniques. The dendrites, in every case, were found to be twinned with a maximum of eight orientations in twin relation in a single dendrite. The growth axis of the dendrites was observed to be in the 110 direction. Dominant facets were found to be {111} planes on the 110 zone of the growth axis.

10606. Spijkerman, J. J., Hall, L. H., Lambert, J. L., **Coordination studies by Mössbauer spectroscopy of some metal(I) salts of the complex acid, hydrogen aquoethylenediaminetetraacetatoferrate (III),** *J. Am. Chem. Soc.* **90,** No. 8, 2039-2043 (Apr. 10, 1968).

Key words: Coordination studies; hydrogen aquoethylenediaminetetraacetatoferrate(III) infrared spectroscopy; magnetic susceptibility; $MFe(OH_2)EDTA \cdot nH_2O$; Mössbauer spectroscopy; photodecomposition; thermogravimetric analysis.

The coordination numbers of the central metal ion that exist when iron(III) is chelated with ethylenediaminetetraacetic acid, H_4EDTA, have been investigated by the following methods: (a) infrared spectroscopy, (b) magnetic susceptibility, (c) Mössbauer spectroscopy, (d) photodecomposition, and (e) thermogravimetric analysis.

The iron(III) EDTA complexes were found to exist in two different forms in the solid phase, the complex acid and its M^{+1} salt. Both forms were found to be high spin complexes. The complex acid, $HFe(OH_2)EDTA$, was found to be six coordinate; however, the M^{+1} salts, $MFe(OH_2)EDTA \cdot nH_2O$, were found to have a coordination number of seven around the central metal ion.

An interesting effect, ascribed to the influence of the cation in the salts of these complexes, was also observed. It is believed that this effect arises either from an interaction of the cation with the metal d-orbitals or with one of the carboxylate groups or both. Each interaction appears to result in a decrease of the size of the metal d-orbitals of the central metal ion. The results in a concentration of the d-electron density nearer the nucleus.

10607. Stern, K. H., **Ion diffusion into fused silica from molten salts,** *J. Phys. Chem.* **72,** No. 6, 2256-2259 (June 1968).

Key words: Glass; ion exchange; molten salts.

Compositional changes of fused silica containing a few ppm impurities resulting from immersion of the glass in molten salts were studied. At 570 °C immersion in AgCl and AgBr results in 1:1 exchange of Ag^+ with Na^+(glass). At 890° immersion in NaCl, KCl, and AgCl, respectively, increases the ionic concentration in Na^+, K^+, and Ag^+ above the initial total ($Na^+ + K^+ + Li^+$). Cl^- diffusion is virtually absent. Possible interpretations of these results are presented.

10608. Stern, K. H., **Membrane potentials and ion selectivity of fused silica in molten salts,** *J. Phys. Chem.* **72,** No. 6, 1963-1975 (June 1968).

Key words: Fused silica; ion selectivity; membrane potentials; molten salts.

The effect of alkali metal cations on membrane potentials at the molten salt-fused silica interface has been studied using the concentration cell Ag|AgCl, M_1Cl, M_2Cl . . . |glass|M_1Cl, M_2Cl . . ., AgCl|Ag where M_1, M_2 . . . are alkali metal cations and several types of fused silica and Vycor. The ion exchange theory is more appropriate for the interpretation of the data than the liquid junction theory, but the application of the theory requires detailed data on ion exchange and ionic mobility in fused silica which are not yet available.

The effect of anions on the membrane potential was studied with the cell M|MCl, NaCl|fused silica|MBr, NaBr|M where M = Ag, Tl, and Pb. The results for the three metals are quite analogous. The emf of the cells could be calculated by straightforward thermodynamic methods, without the assumption of specific anion-glass interactions. The emf measurement of these cells at low sodium halide concentration can also serve as an analytical tool for sodium determinations down to 10^{-3} mole percent, but not lower.

10609. Swanson, N., Powell, C. J., **Excitation of L-shell electrons in Al and Al_2O_3 by 20-keV electrons,** *Phys. Rev.* **167,** No. 3, 592-600 (Mar. 15, 1968).

Key words: Aluminum; amorphous Al_2O_3; cross sections; electron energy loss spectra; L-shell electrons; oscillator strengths; x-ray mass absorption coefficients; γ-Al_2O_3.

The energy loss distributions of ≈ 20 keV electrons transmitted through 210 to 575 Å thick specimens of Al and Al_2O_3 have been measured at zero scattering angle. Two types of Al_2O_3 were used: films of the γ-phase and amorphous films prepared by anodization. Loss spectra were obtained for an energy loss range of zero to 160 eV, in which structure due to L-shell excitation in Al and Al_2O_3 was observed. The positions of the absorption edges and of the peaks on the high-energy loss side of each edge agreed well with recent x-ray absorption measurements. Slightly different structure for the two forms of Al_2O_3 was found near the edge, as recently found by x-ray absorption. From the observed intensities, values of oscillator strengths, mass absorption coefficients and electron scattering cross sections have been derived for each material up to ≈ 85 eV beyond the absorption edge. The Al results are in good agreement with recent x-ray measurements and are consistent with the Al_2O_3 data. The similarity in the electron energy loss and x-ray absorption measurements are consistent with the equality of the longitudinal and transverse dielectric constants [$\epsilon(\omega)$] and the expectation that in this energy loss region $IM(\epsilon)$ equals $-Im(1/\epsilon)$ to a good approximation.

10610. Swartzendruber, L. J., Bennett, L. H., **Hyperfine field distributions in $(ZrCo_2)_x(ZrFe_2)_{1-x}$ alloys,** *J. Appl. Phys.* **39,** No. 2, Part II, 1323-1324 (Feb. 1, 1968).

Key words: Alloys; cobalt; hyperfine fields; iron; Mössbauer effect; zirconium.

Mössbauer effect measurements in the cubic Laves phase pseudo-binary magnetic alloys $(ZrCo_2)_x(ZrFe_2)_{1-x}$ yield complex spectra. Magnetization curves on these alloys have been previously reported. $ZrFe_2$, with a saturation moment at 4 °K of about 1.6 μ_B per Fe atom and a Brillouin type magnetization curve, displays a Mössbauer spectrum consisting of two six line patterns, each with a hyperfine field of about 200 kOe. ZrFeCo has been reported to show only a quadrupole splitting at 78 °K, although this is well below the Curie temperature. We have observed resolved hyperfine splitting in this composition at 78 °K and at 4 °K. The magnetization curves in $(ZrCo_2)_x(ZrFe_2)_{1-x}$ for $x = 0.2$, 0.4, 0.5 and 0.6 imply magnetic moment distributions. The Mössbauer spectra for these alloys show hyperfine field distributions that are strong functions of temperature over a wide range below the Curie temperatures.

10611. Swartzendruber, L. J., Bennett, L. H., **Line profiles in the nuclear magnetic resonance and Mössbauer effect of $TiFe_{1-x}Co_x$ alloys,** *J. Appl. Phys.* **39,** No. 5, 2215-2220 (Apr. 1968).

Key words: Co; Fe; intermetallic compounds; internal oxidation; line structure; Mössbauer effect; nuclear magnetic resonance.

The ^{57}Fe Mössbauer effect (ME) and the ^{59}Co nuclear magnetic resonance (NMR) have been investigated as a function of alloy concentration, temperature, and stoichiometry in $TiFe_{1-x}Co_x$ alloys over most of the range $0 \leq X \leq 1$. At room temperature, in carefully prepared samples, a single narrow ^{57}Fe ME line was observed for all values of x. This line broadened only slightly at low temperatures although the magnetic properties of these alloys would have led one to expect a larger broadening at certain compositions. The ^{59}Co NMR line width was relatively narrow for x close to 0 or 1 and was a strong function of x as well as of magnetic field. The intermediate compositions displayed resolved satellite structures. Annealing reduced both the ME and NMR linewidths. Deviations from stoichiometry and internal oxidation were readily observable from their effect on the ME line profile. Both the ME and NMR results are consistent with a CsCl structure over the entire composition range. The NMR results indicate a lack of ordering on the Co, Fe sublattice.

10612. Swartzendruber, L. J., Bennett, L. H., **Mössbauer line structure in "non-magnetic" Cu-Fe and Cu-Ni-Fe alloys,** *Physics Letters* **27A,** 141-142 (1968).

Key words: Alloys; copper; iron; local moments; magnetism; Mössbauer effect; nickel.

The high temperature ^{57}Fe Mössbauer effect residual line structure in Cu-rich Cu-Fe and Cu-Ni-Fe alloys is reinterpreted as being of magnetic origin, rather than arising from quadrupole interactions or lack of solubility.

10613. Swindells, J. F., **Thermometry and pyrometry,** Chapter 3 in *Handbook of Physics, Second Ed., Part 5, Heat and Thermodynamics,* E. U. Condon and H. Odishaw, eds., pp. 5-34–5-44 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Acoustical thermometry; black-body radiation; gas thermometry; Kirchoff's law; magnetic thermometry; "noise" thermometry; nuclear resonance thermometry; radiation thermometry; temperature measurement; temperature scales; temperature uncertainties; thermodynamic temperature scales.

The chapter defines an absolute thermodynamic temperature scale and describes methods for the realization of such a scale. The internationally accepted Kelvin scale is defined. Practical scales are discussed, and the International Practical Temperature Scale of 1948 is defined. Temperature differences between practical scales and the Thermodynamic Kelvin Scale are discussed. Estimated limits of uncertainty in realizing both thermodynamic and practical scales are tabulated. Uncertainties associated with the calibration and use of commonly used temperature measuring instruments are also tabulated.

10614. Sze, W. C., **Comparator for calibration of inductive voltage dividers from 1 to 10 kHz,** *ISA Trans.* **6,** No. 4, 263-267 (Oct. 1967).

Key words: Calibration; comparator; high permeability core; inductive voltage divider; phase angle; R-C network; shielded transformer; toroidal core; voltage divider; voltage ratio.

A high accuracy comparator is described for measuring the relative deviations in voltage ratios and phase angles of inductive voltage dividers. The new technique overcomes several inherent limitations of the existing comparison methods. The balance is accomplished by utilizing special shielded transformers and a resistance-capacitance network for in-phase and quadrature voltage injections. The measurements are accurate to within 1×10^{-7} of input in the frequency range from 1 to 10 kHz. Resolution is better than 2×10^{-10}.

10615. Watson, R. E., Bennett, L. H., Freeman, A. J., **Origin of solvent Knight shifts in alloys,** *Phys. Rev. Letters* **20,** No. 13, 653-656 (Mar. 25, 1968).

Key words: Alloys; charge impurity screening; hyperfine fields; Knight shift; noble metals; orthogonalized plane waves.

Consideration of the effects of conduction electron orthogonalization to the ion cores on the hyperfine field leads to the conclusion that current screening theories of Knight shifts of impurities in alloys require modification.

10616. Wiederhorn, S. M., Shorb, A. M., Moses, R. L., **Critical analysis of the theory of the double cantilever method of measuring fracture-surface energies,** *J. Appl. Phys.* **39,** No. 3, 1569-1572 (Feb. 15, 1968).

Key words: Cleavage; crack propagation; elasticity; fracture; fracture energy; surface energy.

This paper presents a critical discussion of the double cantilever method of measuring fracture surface energies. It was found that the equation developed by Gillis and Gilman is valid for crack lengths greater than 1.5 times the crack arm height. The constants in this equation were evaluated and were found to be practically independent of the elastic constants of the material for which they were evaluated, suggesting the equation could be used on any material. The Gilman and Gillis approach to the double cantilever problem was found to be consistent with the approach used by Gross and Srawley.

10617. Yakowitz, H., **Evaluation of specimen preparation and the use of standards in electron probe microanalysis,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **430,** Fifty Years of Progress in Metallographic Techniques, 383-408 (1968).

Key words: Electron probes; metallography; microanalysis; petrography; specimen preparation; x-ray analysis.

The magnitude of systematic and statistical errors in electron probe microanalysis due to faulty specimen preparation is discussed theoretically and experimentally. It is shown that this error increases as the energy of the x-ray line being monitored decreases and also as the x-ray emergence angle decreases. Specific specimens are chosen to illustrate various preparation problems in metallurgy, petrography, and biology. Generalizing from these, certain useful instrumental adjuncts can be listed; these adjuncts tend to allow the effects of the specimen surface on the analysis to be controlled more rigorously. Several conductive coatings commonly used are evaluated in terms of electron and optical transparency, adherence, x-ray attenuation, and thermal and electrical conductivity. Finally, a brief survey of standards employed in electron probe microanalysis is made. Situations for which nonelemental standards are required are outlined. The choice of standards for various types of work is discussed.

10618. Youden, W. J., **Statistical design of experiments,** Chapter 13 in *Handbook of Physics, Second Ed., Part 1, Mathematics,* E. U. Condon and H. Odishaw, eds., pp. 1-198—1-201 (McGraw-Hill Book Co., New York, N.Y., 1967).

Key words: Block design; design of experiments; experimental design; factorial design; Latin square; statistical design; Youden square.

Statistical design of experiments involves the scheduling or grouping of measurements with respect to experimental or environmental factors such as instruments, procedure, temperature or time so as to minimize the effect of extraneous factors on the value of the sought-after quantity. The extension of the simple example of drift elimination in the ABBA arrangement for intercomparing two objects, A and B, to the intercomparison of many objects is illustrated by arrangements that account for one source of variability (Block designs) and two sources of variability (Latin squares, Youden squares). A second class of designs for studying the effect of many factors on a single quantity, called factorial designs are illustrated. For both classes of designs the use of fractional designs to reduce the total number of observations is discussed.

10619. Ambs, W. J., **Field-emission studies of the oxidation of clean nickel surfaces,** *Proc. Second Intern. Congress on Metallic Corrosion, New York, N.Y., Mar. 11-15, 1963,* pp. 815-821 (Natl. Assoc. Corrosion Engr., Houston, Texas, 1966).

Key words: Emission microscopy; field-emission; nickel surfaces; oxidation.

The adsorption of oxygen on clean and slightly contaminated nickel surfaces and the subsequent oxidation of nickel have been studied by field-emission microscopy. The adsorption at room temperature depends strongly on crystal face, showing a considerable relative enhancement of emission on planes close to the {110}. This is interpreted as an independent confirmation of some of Germer's low energy electron diffraction results. Adsorption at 77 °K shows no such phenomenon. Formation of oxide whiskers at 600 °C and of epitaxial oxide layers at higher temperatures have also been observed. Preliminary experiments on iron show that iron whiskers can be grown by heating iron field emitters to about 900 °C in the electric field. The phase transition at 910 °C has also been observed.

10620. Armstrong, G. T., **Calorimetry,** *Encyclopaedic Dictionary of Physics, 2nd Supplementary Volume* **2,** 1-8 (Pergamon Press Inc., New York, N.Y., Oct. 1967).

Key words: Calorimetric instruments and procedures; calorimetric measurements; calorimetry: calorimetry to thermodynamics; standard samples for chemistry.

This survey deals in separate sections with materials supplementary to articles on calorimetry appearing in the main work of the Encyclopaedic Dictionary of Physics. Separate sections treat the relationship of calorimetry to thermodynamics, applications of the results of calorimetric measurements, current (1965) areas of activity in the development of calorimetric instruments and procedures, and the scope of calorimetric work including national and international coordination.

A short article on Standard Samples for Calorimetry is appended.

10621. Bates. A. A.. **Responsibility in building research**, *Proc. Third Australian Building Research Cong., Melbourne, Australia, Aug. 1967*, pp. 27-34 (1968).

Key words: Building research: corporate: historical: humane: individual: international: national: urban.

The aspects of building research are traced through the four historical periods of man's quest for an understanding and mastery of nature or "scientific research." These periods are identified as (1) individual, (2) the corporate, (3) the national, and (4) the international. The philosophic search for truth by individuals such as Archimedes, Galen, Bacon, Galileo, Newton and Faraday led to the industrial revolution and corporate investment in science and research for profit by the more industrially advanced nations. Motivated by public concern for national security and for the well being of people, organized building research developed during this period. This national concern expended to the international period which is now under way thereby establishing formal channels for cooperation between nations in building as well as other technology. The major broad objective of international research is to advance the welfare of mankind by providing food and shelter. Humane housing for every individual of whatever economic and social status is the urban problem of highest priority.

10622. Beaty, E. C., Patterson, P. L., **Mobilities and reaction rates in neon ions in neon**, *Phys. Rev.* 170, No. 1. 116-121 (June 5. 1968).

Key words: Ion: mobilities; neon: rates; reaction.

The mobilities of Ne^+ and Ne_2^- ions in neon has been measured at 300 °K. The mobility of Ne^- and Ne_2^- at low E/p_o are given by the equations: $K(Ne^-) = 4.07\ [1 + 8.0 \times 10^3\ (E/p_o)^2 + 2.0 \times 10^{-6}\ (E/p_o)^4]^{-1/8}$ and $K(Ne_2^-) = 6.14\ [(1 + 8.3 \times 10^{-3}\ (E/p_o)^2/(1 + 2.0 \times 10^{-3}\ (E/p_o)^2 + 8.4 \times 10^{-6}\ (E/p_o)^4)]^{1/4}$. The Ne^+ was observed to convert to Ne_2^- by a three-body reaction with a rate coefficient ranging from about 7×10^{-32} cm^6/sec at $E/p_o = 2.0$ to about 5×10^{-32} cm^6/sec at $E/p_o = 6.0$.

10623. Bennett. H. S.. **F center in ionic crystals: semicontinuum polaron models**, *Phys. Rev.* 169, No. 3. 729-745 (May 15. 1968).

Key words: Alkali halide: alkaline earth fluoride: alkaline earth oxide: F center: ionic crystal: polaron: semi-continuum model.

The states of the F center are considered on the basis of a model which treats the movement of the nearest neighbors to the F center and the F electron in a self-consistent manner. The lattice is described in terms of classical ionic crystal theory and the F electron is treated according to the semi-continuum polaron theory. The absorption energy, the emission energy, the lifetime of the first excited state, the thermal activation energies, and the Huang Rhys factor are evaluated for two models (Hartree and quasi-adiabatic) which differ in the evaluation of the optical polarization. It is shown that the Hartree semi-continuum polaron model agrees best with the experimental results for NaCl, KCl, CaF_2, SrF_2, and BaF_2. In addition, these models show that among the above quantities the thermal activation energies and the lifetime of the first excited state are most sensitive to the physical content of a given model.

10624. Bevan. A. W.. Jr.. Daniel. A. C.. Mahler. R. J.. **Indication of the effect of a magnon gap in the ^{19}F relaxation rate in antiferromagnetic CoF_2**, *Physics Letters* **25A**. No. 7. 555-556 (Oct. 9. 1967).

Key words: Antiferromagnetism: CoF_2: magnon gap: relaxation times.

The ^{19}F nuclear spin-lattice relaxation time in a CoF_2 single crystal has been measured in zero external magnetic field over the temperature range of 4° to 16 °K. The relaxation rate falls off exponentially, but faster than the $T^2\ \exp(-T_{AE}/T)$ predicted using a simplified spin wave theory.

10625. Branscomb. L. M.. **The misinformation explosion: Is the literature worth reviewing?**, *Sci. Res.* 3, No. 11. 49-52 (May 1968).

Key words: Manuscripts: publications: scientific literature.

The exponentially increasing scientific literature contains data on properties of matter needed by science and technology. Bold inventions, such as the National Standard Reference Data System, help the user pick his way through this morass. Urgent need exists for quality control as follows: the development (and adoption by investigators) of criteria to delimit systematic errors; the rejection by journal editors of manuscripts which report data but do not contain sufficient information to permit their evaluation.

10626. Broberg. J.. Leiss. J.. Schrack. R. A.. Wyckoff. J. M.. **On-line handling system for the NBS linac**, *IEEE Trans. Nucl. Sci.* **NS-11**, No. 3. 331-337 (June 1964).

Key words: Building blocks: computer control: digital computer: Linac. NBS: multiplex register unit: nuclear physics experiments.

To meet the needs of the new Linac facility at the National Bureau of Standards an SDS 920 digital computer has been obtained for concurrent on-line processing of data from several independent experiments. The system surrounding the computer contains several novel devices for allowing convenient real time operator control of computer functions and to provide privacy of programs by means of priority interrupt lines controlling the sequence of operations. A family of building blocks is being developed for the input of information. Surprisingly, the requirements of all nuclear physics experiments projected for the facility can be met with only six different blocks: an Analog Voltage Analog to Digital Converter, a Digital Register Unit, a Spectrum Analog to Digital Converter, a Scalar and a Group Enable Unit. These devices all feed information into the computer via a Multiplex Register Unit. The man machine interface is made flexible by the use of two decoding units, one for outgoing signals and one for sense switch type information to be used in computer control. The conventional computer output devices are supplemented in this system by direct analog, digital, graphic and scope output of data.

10627. Bussey. H. E.. **Instrumentation and measurement**, *1966 Digest of Literature on Dielectrics* 30, Publ. 1496. 1-21 (National Academy of Sciences — National Research Council, Washington, D.C.. 1966).

Key words: Breakdown: dielectric constant measurements: discharges in dielectrics: instrumentation for dielectrics: permittivity measurements.

A bibliography of 200 literature references is given on the instrumentation for and measurements of complex dielectric constant and discharge or breakdown of dielectrics. Applicable theoretical topics are included.

10628. Chang, T., Yang, G. C., **Temperature dependence of paramagnetic relaxation of Mo^{5+} in TiO_2**, *J. Chem. Phys.* **48**, No. 6, 2546-2549 (Mar. 15, 1968).

Key words: Mo^{5+}; paramagnetic relaxation; temperature dependence; TiO_2.

The relaxation rate of Mo^{5+} in TiO_2 was measured, by the measurement of line width at temperatures between 77 °K and 240 °K, and by the saturation and recovery method at temperatures at and below 4.2 °K. The line width is about 300 gauss at 240 °K, and 0.5 gauss at 77 °K. The relaxation time is about 5 sec. at 4.2 °K and about 100 min. at 1.05 °K. The temperature dependence of the relaxation rate is T^9 between 3 °K and 200 °K, T^5 between 1.5 °K and 3 °K, and T below 1.5 °K. At the linear dependence region, i.e., ~ 1 °K, the magnetic field dependence is H^4 as verified by experiments.

10629. Chappell, S. E., Humphreys, J. C., Motz, J. W., Berger, M. J., Seltzer, S. M., **Response of silicon transmission detectors to monoenergetic electrons,** *IEEE Trans. Nuclear Sci.* **NS-15,** No. 3, 359-362 (June 1968).

Key words: Monoenergetic electrons; Monte Carlo calculations; response function; semiconductor detectors; silicon.

Silicon transmission semiconductor detectors with thicknesses of 191 and 530 μm were exposed to normally incident electrons with energies of 0.25, 0.50, 0.75, and 1.00 MeV. When the detector thickness is less than the incident electron range, the pulse-height distributions produced by the electrons in these detectors were characterized by an absorption peak and a relatively broad escape peak which was associated with transmission and reflection of electrons. Comparisons were made between the experimental pulse-height distributions and Monte Carlo results calculated for identical conditions. Good agreement was found between theory and experiment at 0.75 and 1.00 MeV; however, differences, that remain to be explained, appeared in the position of the escape peak at 0.25 and 0.50 MeV.

10630. Cooper, M. J., **Electric field effect on critical opalescence of dipolar binary mixture,** *J. Chem. Phys.* **48,** No. 9, 4272-4277 (May 1, 1968).

Key words: Binary mixture; critical opalescence; electric field effect; excess concentration; van der Waals.

A modified van der Waals model is used to describe the effect of a time varying external electric field on the critical mixing point properties of a dipolar binary mixture. Assuming that the behavior of the concentration fluctuations about equilibrium is governed by linearized hydrodynamic equations and that the diffusion coefficient is determined by the instantaneous equilibrium state, the decay of the fluctuations is described. The relaxation time characterizing the electric field effect upon the light scattering by critical opalescence is related to the free relaxation of the concentration fluctuations.

10631. Corliss, E. L. R., **A mechanistic model for the limits of auditory perception,** *Proc. Symp. on Models for the Perception of Speech and Visual Form, Boston, Mass., Nov. 11-14, 1964,* pp. 339-343 (Massachusetts Institute of Technology, Boston, Mass., 1967).

Key words: Auditory detection; auditory discrimination; hearing; mechanistic model for hearing.

From a number of apparently diverse experiments on human hearing it has proved possible to construct a simple model describing the limits of auditory perception for normal and impaired ears. The model has been applied to interpret the perception of distorted speech by persons with normal and impaired hearing.

Two mechanisms are required: One element emits unit responses whose number is proportional to the amplitude of a sound. It is followed by a selector mechanism, analogous to a resonant circuit, that integrates the responses. Correspondingly, just two parameters are involved: the threshold of hearing and the "Q" of the selector mechanism. The theory of the selector mechanism is based upon a recently published study of the limits of performance of a system capable of storing oscillatory energy reversibly, but the remainder of the theoretical description makes use of ordinary communication theory.

The discriminating power of the normal ear is shown to be proportional to the one-fourth power of the level above threshold, and to relate closely to the sensation of loudness. This dependency results from considering the responses of the receptor mechanism to be integrated in random coherence by the selector mechanism, with the threshold of normal hearing representing a basic "least count" in the selector mechanism.

The model permits prediction of the influence of noise upon perception by normal and impaired ears. Experimental evidence from noise-masked audiometry indicates that the selector mechanism is unimpaired in many cases of sensorineural loss. In fact, the model is consistent with the selector mechanism having the same "least count" for normal and impaired ears; the observations on the effects of hearing loss can be referred to defects in the receptor mechanism alone. Loss with recruitment corresponds to emission of spontaneous responses from the receptor mechanism in addition to responses to the incoming sound. The classical type of loss without significant recruitment corresponds to a depression in the number of unit responses to sound of a given amplitude.

The model indicates quantitatively what has been recognized qualitatively: that amplification does not restore full discrimination in the presence of sensorineural loss. The application of the model to an experiment on the perception of distorted speech will be discussed.

10632. Davis, J. C., Faison, T. K., Achenbach, P. R., **Errors in temperature measurement in moving air under isothermal conditions using thermocouples, thermistors and thermometers,** *ASHRAE Trans.* **73,** Pt. I, VII 1.1 (1967).

Key words: Air in ducts; measurement errors; temperature measurement; thermistors; thermocouples; thermometers.

A study was made of the errors in measurement of the temperature of air moving in a duct at velocities from approximately 300 to 2000 fpm under isothermal conditions using copper-constantan thermocouples, thermistors, and mercury-in-glass thermometers. Generally, the indications of the three types of sensors agreed within 0.10 °F and in many cases to within 0.05 °F when installed in a test duct. Experience during this study showed, however, that such agreement is not attainable during laboratory use unless special calibration, application, and observation techniques are used. The change in calibration of the three types of sensors during successive annual intervals was also investigated. The annual drift in indicated temperature of the sensors was usually less than 0.05 °F except that the drift of the copper-constantan thermocouples approached 0.10 °F during the first year of the study. This investigation indicated that the accuracy in the measurement of temperature specified in testing standards for heating and air-conditioning equipment should be greater than 0.10 °F.

10633. Drechsel, D., Maximon, L. C., **Potential model calculation for coplanar and non-coplanar proton-proton bremsstrahlung,** *Physics Letters* **26B,** No. 8, 477-479 (Mar. 1968).

Key words: Coplanar and non-coplanar events; differential cross section; double scattering term; off-the-energy-shell behaviour; potential model calculation; proton-proton bremsstrahlung; scattering amplitude.

The cross section for proton-proton bremsstrahlung for both coplanar and non-coplanar events has been calculated using both Hamada-Johnston and Reid potentials. Prior calculations which disagreed with experiments left out double scattering terms. These terms, which are negligible in the center of momentum system, are shown to be particularly important when the calculation is performed in the lab system for non-coplanar events, even at high energies. The importance of these terms is, however, not reflected in the cross section for coplanar events integrated over photon angle at high energies, which accounts for the agreement between high energy experiments and calculations performed with this neglect. The present calculations show good agreement with the available experiments between 30 and 200 MeV and thus demonstrate that the local potentials in use all have the correct behaviour off the energy shell.

10634. Drechsel, D., Seaborn, J. B., Greiner, W., **Collective correlations in spherical nuclei and the structure of giant resonances,** *Phys. Rev.* **162,** No. 4, 983-991 (Oct. 1967).

Key words: Collective correlations; collective intermediate structure; dipole vibrations; giant resonance; particle-hole structure; photoabsorption; surface vibrations.

The theory of collective correlations in nuclei is formulated for giant resonances interacting with surface vibrations. The giant dipole states are treated in the particle-hole framework while the surface phonons are treated within the collective model. Consequently this treatment of nuclear structure goes as well beyond the common particle-hole model (including its various improvements which take groundstate correlations into account) as the pure collective model. The interaction between giant resonances and surface degrees of freedom as known from the dynamic collective theory is formulated in the particle-hole language. The theory contains therefore the particle-hole structures of giant resonances. Detailed calculations are performed for C^{12}, Si^{28}, and Ni^{60}. A good detailed agreement between theory and experiment is obtained for all these nuclei although only Ni^{60} is in the region where one would expect the theory to work well ($50 < A < 110$).

10635. Durst, R. A., Ross, J. W., Jr., **Electrochemical generation of fluoride ion by solid-state transference,** *Anal. Chem.* **40,** No. 8, 1343-1344 (July 1968).

Key words: Constant-current coulometry; electrochemical generation; fluoride; lanthanum fluoride membrane; solid-state transference.

Fluoride ion is electrochemically generated by the solid-state transport of fluoride ions through a permselective membrane of europium-doped lanthanum fluoride. Under the conditions described, a constant-current generation efficiency of 99.2 percent is achieved. Potential uses for this technique include coulometric analysis and fluoridation of water supplies.

10636. Evenson, K. M., **The optical detection of stimulated emission in CN at 20-CM wavelength,** *Appl. Phys. Letters* **12,** No. 8, 253-254 (Apr. 15, 1968).

Key words: CN; microwave spectra; optical detection; stimulated emission.

Six of the seven allowed electric dipole transitions between the hyperfine levels of the $J = 7/2$ lambda doublet in the 10th vibrational level of the excited $A^2\pi_{3/2}$ state of CN were observed. The transitions at frequencies between 1580 and 1650 MHz were between the more populated negative parity levels and the positive parity levels. The stimulated emission was detected by measuring an increase in the intensity of the $B^2\Sigma^+ \rightarrow X^2\Sigma^+(0,0)$ violet band of CN near 3875°. A similar optical detection technique was attempted on the 337 μm "so-called" CN laser in order to discover which of the proposed laser mechanisms was correct; there was no indication that any of the proposed mechanisms were correct.

10637. Forbes, E. J., **A graphic method of economic feasibility analysis,** (Proc. Inst. Electronics and Automation in Publishing, Washington, D.C., 1965), Chapter 13 in *Automation and Electronics in Publishing,* L. H. Hattery and G. P. Bush, eds., **3,** Part IV, 129-140 (Spartan Books, Washington, D.C., 1965).

Key words: Computer-typesetting; cost studies or economic feasibility; estimating complex keyboarding; micropublishing; photocomposition; printing.

A recently developed graphic method for visually presenting the results of computer composition production experiments and economic feasibility studies is demonstrated. Following an explanation of the method and use of the new cost curves, performance characteristics of two new types of high speed photocomposers are summarized. Then, feasibility predictions are shown for by-product computer photocomposition of a large document center's announcement journal and alternate indices.

10638. Forman, R. A., Cardona, M., **Exciton electroreflectance in II-VI compounds,** *Proc. Intern. Conf. II-VI Semiconducting Compounds, Brown University, Providence, Rhode Island, Sept. 6-8, 1967,* pp. 100-111 (W. A. Benjamin, Inc., New York, N.Y., 1967).

Key words: CdS; differential techniques; electric field broadening; electroreflectance; excitons; Stark effect; ZnS; ZnSe; II-VI compounds.

We have applied the method of differential reflectivity to high resistivity samples of CdS, ZnS, and ZnSe. We modulate the reflectivity by means of a transverse electric field applied between two evaporated gold films on the reflecting surface with small spacing between them. As has been found in other differential reflectivity measurements, the sensitivity is quite high, thus enabling us to observe structure which is not easily seen in the dc reflectivity. The high sensitivity facilitates the study of the exciton line-shapes as a function of electric field and temperature; differences between various types of line-shapes (e.g., Gaussian and Lorentzian) are more apparent in differential spectra than in dc spectra. Our measurements have been performed with square-wave modulation; the spectra obtained are the direct difference between field-on and field-off. At low fields, the spectra resemble derivatives of dispersive signals but as the field is increased, the spectra become closer to the dispersive signals themselves. At low fields a Stark-like shift of the exciton binding energy and a broadening is obtained. At high fields, the exciton is destroyed (ionized).

10639. Freeman, D. H., Aiyar, A. S., **Studies of ion exchange materials: homogeneous fractional sulfonation of copolymers of styrene and divinylbenzene,** *Anal. Chem.* **39,** No. 10, 1141-1144 (Aug. 1967).

Key words: Copolymer; divinylbenzene; homogeneity; ion-exchange; kinetics; nitrobenzene; styrene; sulfonation; sulfuric acid.

The feasibility of slow sulfonation of bead-copolymers of styrene and divinylbenzene to give homogeneous and fractionally substituted ion-exchange materials is shown. The reaction of copolymer with dilute solutions of sulfuric acid in nitrobenzene at 23.5° approaches second order kinetics at less than 60 percent sulfonation; at higher values the rate constant falls toward a value of zero at 100 percent sulfonation. Volume swelling measurements of the fractionally substituted ion-exchangers agree by extrapolation to corresponding measurements by Wiley on the fully substituted materials.

10640. Freeman, D. H., Paulson, R. A., **Chemical microstandards from ion exchange resin,** *Nature* **218,** 563-564 (May 11, 1968).

Key words: Analytical detection limits; ion exchange resins; measurements; microstandards; standards.

Ion exchange resins are available in the form of small spherical particles. These can be used to provide mass standards that individually contain extremely small and precisely defined quantities of matter. Their capabilities include the determination of analytical detection limits and the performance of chemical calibration down to, and below the level of one picogram.

10641. Gammon, W. H., **Remotes and displays,** *Proc. A Pioneer Presentation of a National Symposium on the Impact of Automation and Documentation, Denver, Colo., Apr. 27-29, 1967,* p. 119 (1968).

Key words: Archives; displays; information retrieval; remote input devices.

Briefly describes equipment available for recording and displaying material in archives. The conclusion is reached that while remote stations, such as teletypes, may become regularly a part of archive service, display consoles (cathode ray tubes) may not because of the economics involved in putting the material in the data bank for later display.

10642. Gammon, W. H., **Security and privacy problems brought on by automation,** *Proc. A Pioneer Presentation of a National Symposium on the Impact of Automation and Documentation, Denver, Colo., Apr. 27-29, 1967,* pp. 74-75 (1968).

Key words: Computer data banks; privacy of data.

There has recently been considerable public notice of the problems of the protection of privacy of the individual in connection with computer data banks. Three different Committees of the Congress have held hearings on this subject. Data banks for whatever purpose will have to protect the privacy of the data they collect. The presentation discusses six areas where precautions will have to be taken to assure the privacy of information. One illustration (showing all of the areas discussed) is included.

10643. Gammon, W. H., **Software as it relates to documentation,** *Proc. A Pioneer Presentation of a National Symposium on the Impact of Automation and Documentation, Denver, Colo., Apr. 27-29, 1967,* pp. 14-22 (1968).

Key words: Archives; computer programs; documentation; software.

An archivist receiving a reel of tape may find that the recording was made on any one of 174 different makes and models of computers, each one with its own executive routine and operating system. Thus, in order to read the tape, he would have to know the characteristics of the tape transport on which it was produced. This contrasts with the situation when a reel of microfilm is accessioned, where he can visually determine the width of the film and the magnification required to make it readable.

As an indication of the content of the applicable software documentation with which archivists need to be concerned, the presentation describes (using slides in the oral presentation) the components of a COBOL program. The paper includes illustrations of a flow chart, the machine language program and the COBOL version of a program to "compute FICA" (Federal Insurance Contributions Act).

10644. Gates, D. M., Keegan, H. J., Weidner, V. R., **Spectral reflectance and planetary reconnaissance,** (Proc. Third Goddard Memorial Symp. Scientific Experiments—Manned Orbital Flights, Washington, D.C., Mar. 18-19, 1965), Chapter 4 in *Scientific Experiments for Manned Orbital Flights,* pp. 71-86 (Western Periodicals Co., North Hollywood, Calif., 1965).

Key words: Planetary reconnaissance; spectral reflectance; spectrum of reflected sunlights; ultraviolet and visible wavelengths.

The spectral reflectance of selected vegetation, animal integuments, and minerals from 0.26 to 22.2 microns was measured and reported. Strong absorption by the material of incident radiation is caused by pigmentation at ultraviolet and visible wavelengths due to electronic quantum transitions. Strong absorption in the infrared beyond about 2.0 microns is caused by vibration-rotation quantum transitions due to water and organic molecules. A distinct absorption gap exists in the spectrum between these two wavelength regions which is exhibited by a strong reflectance in the 1.0 to 2.0 micron region. Plants with chlorophyll pigmentation display a very abrupt change in reflectance at 0.7 micron. Animal integuments and the bark of some trees do not exhibit this sharp edge. The reflectance spectra of plants and animals have a characteristic absorption band at about 3.5 microns due to C-H stretching.

If there is life on Mars it may be detected by searching with spectral reconnaissance for the presence of a sharp edge in the spectrum of reflected sunlight. The spectral characteristics of sunlight reflected from vegetation on the Earth's surface is described and the expected reflectance from Mars is discussed.

10645. Gould, H. A., Guernsey, R. L., Williams, R. H., **Comment on "the kinetic equation of a dilute gas with repulsive and attractive interactions,"** *J. Chem. Phys. Letter* **47,** No. 2, 872-873 (July 15, 1967).

Key words: Boltzmann equation; correlation term; dilute gas; Fokker-Planck equation; hard-core potential; Rice-Allnatt equation.

The Rice-Allnatt assumption has not been confirmed for a low density gas.

10646. Greenberg, L., **Kleinian groups,** *Proc. Am. Math. Soc.* **17,** No. 5, 1195-1198 (Oct. 1966).

Key words: Domain of discontinuity; Euler characteristic; fundamental polyhedron; Hilbert nullstellensatz; hyperbolic space; Kleinian group; limit set; parabolic triangle group; prime ideal.

A gap in a theorem by L. Ahlfors is filled, and further theorems on Kleinian groups are proved.

10647. Gugler, A. L., **A study of the adherence of porcelain enamel to aluminum,** *Proc. Porcelain Enamel Institute Forum* **29,** 202-208 (Nov. 1967).

Key words: Adherence; aluminum; chromium; electron microprobe; electron microscope; interface; magnesium; porcelain enamel; spall.

A study of the mechanism of adherence of porcelain enamel to aluminum has yielded some interesting observations. Various alloys of aluminum react quite differently when they are porcelain enameled. Enameled specimens which spall, exhibit an intermediate layer between the enamel and the base metal. When the layer is not present, adherence and spall resistance are good. Magnesium bearing alloys tend to form a layer of MgO on the outer surface of the alloy which the enamel does not completely take into solution. Chromium applied to the surface of the aluminum before enameling is beneficial, particularly on magnesium bearing alloys.

10648. Hall, M. B., Little, W. E., **A directional coupler with a readily calculable coupling ratio,** *IEEE Trans. Microwave Theory Tech.* **MTT-15,** No. 11, 598-603 (Nov. 1967).

Key words: Coupling ratio calculation; directional coupler; microwave.

A microwave (X-band) directional coupler consisting of two adjacent parallel waveguides with a common tantalum wall about four skin depths in thickness has been fabricated and studied. The coupler is of interest, particularly in Standards work, because its coupling ratio can be calculated by a straight forward procedure to within experimental error (currently a few tenths of a dB in 70 + dB).

10649. Harris, W. P., **Low frequency dielectric behavior,** (Proc. Seventh Electrical Insulation Conf., Chicago, Ill., Oct. 16-19, 1967), *IEEE Publ.* **32C79-42,** 123-125 (1967).

Key words: Bridge; dielectrics; dielectric measurements; dielectric phenomena; electrical measurements; low frequency; measurements; operational amplifiers; ultra low frequency.

Electrical engineers, as well as polymer physicists and materials researchers, can gain useful information from a study of the behavior of dielectrics, and of high-megohm resistors at very low frequencies. This is illustrated by examples.

There are two main methods of obtaining ultra-low-frequency data. One is to apply a d.c. voltage producing a time-dependent current which corresponds to an inverse frequency plot. The other is to use an alternating voltage, usually sinusoidal, and apply this to a bridge circuit including the material under study. Recent developments in the latter methods are presented, along with some typical results.

10650. Heinrich, K. F. J., **Electron probe microanalysis by specimen current measurement,** (Proc. Fourth Intern. Symp. X-ray Optics and Microanalysis, Orsay, France, Sept. 7-10, 1965), Chapter in *X-ray Optics and Microanalysis,* R. Castaing, P. Deschamps, and J. Philibert, eds., pp. 159-167 (Hermann, Paris, France, 1966).

Key words: Electron backscatter; electron probe microanalysis; microanalysis; specimen current.

Under appropriate instrumental conditions, electron backscatter coefficients of elements and compounds can be determined quantitatively in the electron probe microanalyzer, without interference of low energy electrons. It is shown that there is a simple relation between the backscatter coefficient of a binary target and those of its constituents. This relation can be used for quantitative analysis of binary specimens. The advantages and limitations of this method are discussed, and a practical application of the technique for quantitative metallography is demonstrated. The backscatter coefficients of several elements have been experimentally determined at electron energies of 10, 20, 30, 40, and 49 keV.

10651. Heinrich, K. F. J., **Scanning electron probe microanalysis,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **430,** 315-342 (1968).

Key words: Cathodoluminescence; electron backscatter; electron probe; microanalysis; scanning electron microscopy; x-ray spectrometry.

The combination of electron microprobe x-ray emission spectrometry with the scanning techniques first developed for the scanning electron microscope permits using the scanning electron probe as a microscope sensitive to elemental composition. This technique is particularly useful in the many applications in which spatial distribution of one or more elements in a specimen is more important than local composition. Although oscilloscope representation of probe scanning is usually obtained by the simple technique of producing a dot of light for each arriving photon, more sophisticated scanning techniques such as expanded contrast registration and concentration mapping can provide more quantitative information. Signals other than x-rays, such as target current, electron backscatter, or cathodoluminescence may be used for image formation. Electron beam scanning can also be performed in a discontinuous fashion, so that the electronn beam irradiates in succession a number of spots arranged in a square or rectangular pattern, and the number of photons registered in each position is retained in the memory of a multichannel analyzer. The application of these diverse scanning techniques is illustrated.

10652. Heinrich, K. F. J., Vieth, D., Yakowitz, H., **Correction for non-linearity of proportional counter systems in electron probe x-ray microanalysis,** *Advan. X-ray Anal.* **9,** 208-220 (1966).

Key words: Electron probe x-ray microanalysis; spectrometers; x-ray microanalysis.

While the theoretical basis for the correction of non-linearity or detector systems is well known, methods for the determination of dead time effects must be adapted to electron probe microanalyzer systems. Two such methods, one employing both x-ray and current measurements, and the other, simultaneous x-ray measurements on two spectrometers, are described. The effect of pulse height shrinkage at high counting rates on the linearity of the detector system is discussed. When the proposed corrections for the dead-time of x-ray detector systems employing proportional counters are applied to the x-ray intensity measurements obtained with the electron probe microanalyzer, count rates as high as 50,000 cts/sec can be used.

10653. Herron, J. T., Huie, R. E., **Arrhenius parameters for the reactions of atomic nitrogen with some olefins and acetylenes,** *J. Phys. Chem.* **72,** No. 7, 2538-2540 (July 1968).

Key words: Acetylene; activation energy; atomic nitrogen; chemical kinetics; olefin; rate constant.

The rates of reaction of atomic nitrogen with a series of olefins and acetylenes have been measured from 320 to 550 K. Pre-exponential factors and activation energies have been derived. In addition, upper limits are given for the rates of reaction of atomic nitrogen with several miscellaneous organic compounds.

10654. Herron, J. T., Huie, R. E., **On the reaction of atomic nitrogen with carbon dioxide,** *J. Phys. Chem.* **72,** No. 6, 2235-2236 (June 1968).

Key words: Active nitrogen; atomic nitrogen; carbon dioxide; mass spectrometry; rate constant.

The rate constant for the reaction of atomic nitrogen with carbon dioxide has been found to be less than about 10^8 cm^3 mol^{-1} s^{-1} from 330 to 550 K. This result is in serious disagreement with the results of L. I. Avramenko and V. M. Krasnen'kov (Izv. Akad. Nauk. SSSR Ser. Khim. 516 (1967)).

10655. Hetzer, H. B., Robinson, R. A., Bates, R. G., **Dissociation constants of piperazinium ion and related thermodynamic quantities from 0 to 50°,** *J. Phys. Chem.* **72,** 2081-2086 (1968).

Key words: Acid-base equilibria; dissociation constant; electrolyte; ionization; piperazine; piperazinium ion; thermodynamics of ionization.

The two thermodynamic dissociation constants of piperazinium ion at 11 temperatures from 0 to 50° have been determined from emf measurements of hydrogen-silver chloride cells without liquid junction. The first (acidic) dissociation constant (K_1) for the process $PzH_2^{++} + H_2O = H_3O^+ + PzH^+$ is given as a function of T (°K) by the equation $-\log K_1 = 952.111/T + 4.3919 - 0.007555T$. At 25°, $-\log K_1$ is 5.333, $\Delta H°$ is 31,080 J mole^{-1}, $\Delta S°$ is + 2.2 J deg^{-1} mole^{-1}, and ΔC_p° is 86 J deg^{-1} mole^{-1}. The second (acidic) dissociation constant (K_2) for the process $PzH^+ + H_2O = H_3O^+ + Pz$ is given by the equation $-\log K_2 = 1656.59/T + 6.1316 - 0.006556T$. At 25°, $-\log K_2$ is 9.73_1, $\Delta H°$ is 42,870 J mole^{-1}, $\Delta S°$ is −42.6 J deg^{-1} mole^{-1}, and ΔC_p° is 75 J deg^{-1} mole^{-1}. The results are compared with those for other protonated bases of similar structure.

10656. Hobbs, A. M., **Remarks on network simplification,** *J. Operations Res.* **15,** No. 3, 548-551 (May-June 1967).

Key words: Capacitated vertices; delta-wye network reductions; flows in networks; graph theory; mathematics; network simplification; single commodity flows; wye-delta network reductions.

In "The Use of Wye-Delta Transformation in Network Simplification," *8 OR* 1960, Sheldon B. Akers, Jr. stated two conditions which together were supposedly sufficient for delta-wye transformations in networks with finite node capacities. This letter gives a counter-example to the sufficiency of the two conditions and emphasizes that the first condition must be satisfied in any network before delta-wye transformations can be carried out.

10657. Hughes, E. E., Dorko, W. D., **Direct mass spectrometric determination of atmospheric carbon dioxide,** *Anal. Chem.* **40,** No. 6, 866-869 (May 1968).

Key words: Atmospheric carbon dioxide; carbon dioxide; gas analysis; mass spectrometric atmosphere analysis.

The direct mass spectrometric determination of atmospheric carbon dioxide cannot be performed with any useful degree of accuracy because of the high concentration of oxygen in the atmosphere. By removing the oxygen with phosphorus it is possible to admit sufficiently high pressures of the remaining gas to determine the carbon dioxide with an inaccuracy of less than 1 percent. Since the argon content of the atmosphere is presumed constant, a direct comparison of the carbon dioxide to argon ratio should provide a fixed reference for future surveys. The method is rapid and requires little equipment other than a mass spectrometer. Results obtained on analysis of rural air in the vicinity of Washington, D.C., are presented.

10658. Hummer, D. G., Mihalas, D., **Line formation with noncoherent electron scattering in O and B stars,** *Astrophys. J.* **150,** No. 1, L57-L59 (Oct. 1967).

Key words: Doppler noncoherence in electron scattering; electron scattering; line formation; O and B stars.

The importance of Doppler noncoherence in electron scattering is stressed for lines formed in the outer regions of O and B stars. The redistribution function is derived and the implications of the scattering mechanism are discussed.

10659. Ito, J., **Strontium rare-earth hydro- and germanate garnets,** *Mater. Res. Bull.* **3,** 495-500 (1968).

Key words: Garnet; hydrogarnet; inorganic synthesis; rare earths; germanate; x-ray powder analysis.

New strontium and lutetium and ytterbium hydrogarnets, $Sr_3(Yb, Lu)_2(OH)_{12}$ and anhydrous ytterbium germanate garnet, $Sr_3Yb_2Ge_3O_{12}$ were synthesized by precipitation in 1M NaOH solution in air at 115 °C. Partial solid solubility was found in the $Sr_3Yb_2Ge_3O_{12}$ and $Sr_3Yb_2(OH)_{12}$ series.

10660. Kerns, D. M., Beatty, R. W., **Basic theory of waveguide junctions and introductory microwave network analysis,** Chapter in *International Series of Monographs on Electromagnetic Waves* **13,** 150 pgs. (Pergamon Press, Inc., New York, N. Y., 1967).

Key words: Matrix description of waveguide junctions; microwave network analysis; waveguide junction.

This monograph presents material developed for a graduate course and found useful for reference as well. It consists of two main parts. Part 1, which is a relatively rigorous introduction to the matrix description of waveguide junctions, is the foundation for Part 2, which is an introductory presentation of microwave network analysis with particular emphasis on concepts and techniques needed in precise measurements.

In Part 1, starting with Maxwell's equations, the theory of ideal waveguides of arbitrary cross section is developed briefly, and relevant general properties are summarized. "Voltage" and "current" are defined for waveguides, and the requisite normalizations are stated as power and impedance normalizations. Impedance, admittance, and scattering matrices are defined for waveguide junctions; realizability and reciprocity conditions for these matrices are stated in general terms. Renormalization, sources, and joining equations are considered.

In Part 2, specific applications of these fundamental relationships are made and additional analytical tools are developed. In particular, expressions are obtained for the conditions of realizability and losslessness for 2-ports, using scattering coefficients. The concepts of available power, efficiency, mismatch loss, attenuation, intrinsic attenuation, and phase shift are carefully examined and equations are given. Transformation of reflection coefficients by 2-ports is discussed and a brief treatment of 3 and 4-ports is presented. Finally, rules for using signal flow graphs are given and a few examples are worked.

10661. Koch, H. W., Caswell, R. S., Muehlhause, C. O., **Neutron measurement at the National Bureau of Standards,** *Nuclear News* **10,** No. 11, 48-53 (Nov. 1967).

Key words: Neutron cross sections; neutron measurement standards; neutron radiation fields; neutron sources; standard reference materials.

The national requirements for neutron measurement standards are being satisfied by the present research and service programs of the National Bureau of Standards. These programs are based primarily on an NBS role as a custodian and developer of the equipment for neutron measurement standards. Future requirements can be met by enlarging this role and by adding the role of a participant in information exchange and measurements of standard neutron cross sections.

10662. Kokoszka, G. F., Allen, H. C., Jr., Gordon, G., **Magnetic and optical spectra of copper monochloroacetate 2.5 hydrate,** *J. Chem. Phys.* **47,** No. 1, 10-13 (July 1, 1967).

Key words: Copper monochloroacetate 2.5 hydrate; copper pairs; copper-zinc pairs; e.p.r. spectra; exchange coupled; optical spectra.

The electron paramagnetic resonance spectra of copper monochloroacetate 2.5 hydrate, $Cu(O_2CCH_2Cl)_2 \cdot 2.5H_2O$, $[Cu(ClAc)_2]$ and zinc-doped $Cu(ClAc)_2$ have been observed at both K-band and X-band frequencies. The e.p.r. spectrum of the pure material was characteristic of a species with a spin of one, while the spectrum from zinc-doped $Cu(ClAc)_2$ revealed an additional spectrum due to a species with a spin of 1/2. The g-values for both the copper-copper pairs and the copper-zinc pairs were identical with values $g_z = 2.38$ and $g_x = g_y = 2.07$. The hyperfine coupling constant for the copper-copper pairs was about 84×10^{-4} cm^{-1}, while in the copper-zinc spectrum it was about 158×10^{-4} cm^{-1}. These results are consistent with the assumption of a weakly coupled interaction. The temperature variation of the doubly integrated intensity of the derivative spectrum indicated that the triplet state lies some 230 cm^{-1} above the singlet ground state.

In the optical absorption spectrum of $Cu(ClAc)_2$ three bands were observed. A very intense band was found at 14,000 cm^{-1}, while two other bands were centered at 11,000 cm^{-1} and 26,000 cm^{-1}.

10663. Krauss, M., **Use of approximate Hartree-Fock calculations to estimate ionization potentials,** Chapter in *Advances in Mass Spectrometry* **4,** 575-578 (Elsevier Publ. Co., Amsterdam, The Netherlands, Aug. 14, 1967).

Key words: CH_3F; CH_3Cl; correlation energy; H_2O; Hartree-Fock energy; ionization potential.

Accuracy of calculation of the inner ionization potentials of polyatomic molecules is examined for the Hartree-Fock orbital energies and for the Hartree-Fock ionization potential determined from neutral and ion calculations of the total energy. The routine ease of the orbital energy procedure is emphasized as well as the approximate accuracy of the orbital differences.

Correlation energy estimates are made to correct the calculated Hartree-Fock ionization potential for H_2O. Although reasonable estimates can be obtained in this case, generally it is very difficult to estimate or calculate the correlation energy defined relative to the restricted Hartree-Fock energy.

10664. Landgrebe, A. R., Pella, P. A., McClendon, L. T., DeVoe, J. R., Purdy, W. C., **The application of substoichiometric radioisotopic dilution principles to controlled potential coulometry and solvent extraction,** *Anal. Chim. Acta* **39,** 151-159 (1967).

Key words: Cadmium; coulometry; extraction; microanalysis; solvent; substoichiometric radioisotope dilution; trace; zinc.

A radioisotope dilution principle has been applied to controlled-potential electrolysis and solvent extraction with dithizone for the analysis of trace amounts of cadmium. A method has been developed to verify whether or not the substoichiometric principle is obeyed. If the substoichiometric principle is not obeyed, an analysis is still possible through the use of calibration curves. In order to obtain independent verification of the series controlled-potential method and to establish a means of comparison with the radioisotope dilution technique a current integration procedure was also employed. A microtechnique was used to extend the sensitivity of the solvent extraction system for cadmium. To demonstrate the application to real samples, a Standard Reference Material No. 108 (zinc spelter) and a high purity zinc was analyzed for cadmium after separation by a method of standard addition.

10665. Larsen, S. Y., **Quantum-mechanical pair-correlation function of hard spheres,** *J. Chem. Phys.* **48,** No. 4, 1701-1708 (Feb. 15, 1968).

Key words: Correlation functions; hard spheres; quantum mechanical.

The density independent part of the quantum mechanical direct and exchange pair correlation functions for hard spheres have been calculated for $\lambda_T/\sigma = 1.4.2, 2.93761, 4, 6, 8$ and 10. In addition, points were obtained very near the surface of the sphere for $\lambda_T/\sigma = .025$ and .05. The results delineate the approach of the direct (Boltzmann) correlation function to the classical limit, and emphasize the rapid disappearance of the effects of statistics with increasing temperature. These features are explained using Wiener (path) integrals. Analytical expressions valid near the surface of the sphere are derived and compare well with numerical results. Virial coefficients obtained from the correlation functions are in satisfactory agreement with very precise value calculated by Boyd, Larsen and Kilpatrick.

10666. Lederer, P. S., **Performance testing, pressure transducers,** *Instr. Control System* **40,** No. 9, 93-99 (Sept. 1967).

Key words: Calibration; dynamic calibration; electromechanical; performance; pressure; telemetering; test method; transducer.

This publication describes methods in one particular program at NBS for the performance-testing of electro-mechanical pressure transducers (such as telemetering transducers used in aerospace testing). It covers static and dynamic calibration procedures in detail, delineates environmental and other tests, and describes the test equipment used. Examples of dynamic calibration results are interpreted.

10667. Leiss, J. E., **Electron linear accelerators as sources of high intensity neutron bursts,** *Proc. Seminar on Intense Neutron Sources, Santa Fe, New Mexico, Sept. 19-23, 1966,* Report No. CONF-660925, pp. 605-616 (1966).

Key words: Electron linear accelerator; high intensity neutron bursts.

Electron linear accelerators are used as non-booster sources of neutrons in two distinct modes of accelerator operation, in the accelerator steady-state and in the transient or stored-energy mode.

The basic neutron production process in heavy elements is examined and example accelerators proposed for each mode of accelerator operation which illustrate the present state of the art.

10668. Leiss, J. E., **The NBS linac,** *Proc. Linear Accelerator Conf., Los Alamos, New Mexico, Oct. 3-7, 1966,* Report No. LA-3609, p. 20 (1966).

Key words: Linac, NBS; linear electron accelerator; nuclear and radiation physics.

The NBS linear electron accelerator is a facility designed for a varied program in nuclear and radiation physics. Considerable attention has been spent in the design of the facility to the needs of experiments, the ability to rapidly (10-20 minute) switch the electron beam from one experimental area to another, and to providing experiments with high intensity electron beams having good energy resolution and stability.

The NBS linac and beam handling system are now operational. The linac has been in use for an experimental program since March, 1966 with experimental set-ups at the end of the accelerator. While we still have problems typical of a new facility, the general operation has been quite good. Variation of beam energy from below 10 MeV to 150 MeV without loss of beam has proven extremely easy and fast by back-phasing the last sections of the accelerator. The highest beam currents at which we have operated have been 0.6 milliampere average with about 60 kilowatts of beam power.

10669. Lenzi, M., Okabe, H., **Photodissociation of NOCl and NO_2 in the vacuum ultraviolet,** (Proc. Intern. Conf. Photochemistry, Munich, Germany, Sept. 6-9, 1967), *Ber. deut. Bunsenges. Phys. Chem.* **72,** No. 2, 169-173 (1968).

Key words: Absorption spectra; fluorescence excited states; nitrogen dioxide; photodissociation; vacuum ultraviolet nitrosyl chloride.

The photodissociation of NOCl and NO_2 in the vacuum ultraviolet yields the electronically excited NO molecule which fluoresces in the near ultraviolet. The fluorescence spectrum, which lies mostly in the region 2200 to 4000 Å, extends below 2200 Å as the wavelength of incident light decreases. This is interpreted in terms of the production of the NO $C^2\Pi$, $D^2\Sigma^+$, $B'^2\Delta$, $E^2\Sigma^+$ along with the production of the NO $A^2\Sigma^+$, $B^2\Pi$ molecule. The fluorescence intensity and the yield are measured as a function of incident wavelength. The fluorescence curves thus obtained are correlated with the absorption spectrum. The absorption coefficient of NOCl in the region 1100 to 2000 Å has been measured. The absorption spectrum between 1100 and 1700 Å may be divided into three regions each corresponding to the transitions providing the NO $A^2\Sigma^+$, NO $C^2\Pi$, $D^2\Sigma^+$ and NO $B'^2\Delta$, $E^2\Sigma^+$ molecule along with the ground state NO or other products. On the other hand the absorption by NO_2 in the spectral region from 1100 to 1450 Å involves not only transitions yielding the NO $A^2\Sigma^+$, $B^2\Pi$, NO $C^2\Pi$, $D^2\Sigma^+$ and NO $B'^2\Delta$, $E^2\Sigma^+$ but also those yielding different states which give products other than the electronically excited NO. The threshold energy of the incident photon producing the NO $A^2\Sigma^+$, $B^2\Pi$ gives an upper limit for the bond dissociation energy. The bond energies obtained are $D(NO\text{-}Cl) \leq 1.77 \pm 0.05$ eV and $D(NO\text{-}O) \leq 3.22 \pm 0.05$ eV which are 0.17 eV and 0.10 eV higher than the respective values obtained from the heat of formation.

10670. Leslie, R. T., Kuehner, E. C., **Ebulliometry,** Chapter 89 in *Treatise on Analytical Chemistry* **8,** Part D-5, 5085-5109 (1968).

Key words: Boiling points; chemical analytical applications; ebulliometry.

The definition and physical significance of the temperature called the boiling point is discussed. It is pointed out that the temperature of the boiling point is sometimes confused with condensation temperature, the temperature of a boiling liquid, and similar phenomena.

Approximate and precise methods of observing boiling points are described, including the use of thermal analysis and gas-liquid chromatography.

Some chemical analytical applications of boiling point determinations are described.

10671. Lightbody, J. W., Jr., Penner, S., **A 12-channel semiconductor counter system for the NBS electron scattering spectrometer,** *IEEE Trans. Nucl. Sci.* **NS-15,** 419-425 (June 1968).

Key words: Backup detectors; counting rate corrections; electron scattering; relative efficiencies; semiconductor array; stepping motor.

A 12-channel array of lithium-drifted silicon detectors for detecting high energy electrons in the focal plane of a magnetic spectrometer is described. The detectors are movable along the focal plane and are backed up by two large stationary plastic scintillators. The scintillators are placed one behind the other, such that a count is recorded when a triple coincidence occurs between both scintillators and a single semiconductor detector. The system has a momentum resolution of 0.036 percent, determined by the detector size and the spectrometer momentum dispersion. Discriminator curves have been obtained which show sufficiently flat plateaus to afford stable counting conditions over the entire energy range of the spectrometer. Detector efficiency measurements have also been made which show that the relative efficiencies of the detectors are stable and known to better than two percent of their values. An electron scattering experiment is now in progress using these detectors.

10672. Linzer, M., Forman, R. A., **NMR studies of single crystal ND_4Cl,** *J. Chem. Phys.* **46,** No. 12, 4690-4693 (June 15, 1968).

Key words: ND_4Cl; n.m.r.; quadrupole; single crystal.

The ^2D and ^{14}N n.m.r. spectra in single crystals of ND_4Cl have been studied from room temperature to −175 °C. At high temperatures, motion of the ammonium ion narrows the n.m.r. resonances and averages out both dipole-dipole and quadrupole interactions. As the temperature is lowered, a linewidth transition occurs and quadrupole splittings of the ^2D spectrum appear. No splitting is found for the ^{14}N spectrum in both NH_4Cl and ND_4Cl. From crystal rotation studies, the ^2D quadrupole coupling is determined to be 180.1 ± 1.0 KHz and the asymmetry parameter to be 0.00 ± 0.01, where the stated uncertainties are the estimated maximum errors.

10673. Litovitz, I., Macedo, P. B., **Ultrasonic relaxation, viscosity, and free volume in molten glasses,** (Proc. Intern. Conf. Physics of Non-Crystalline Solids, Delft, The Netherlands, July 6-10, 1964), Chapter in *Physics of Non-Crystalline Solids,* J. A. Prins, ed., p. 220 (North Holland Publ. Co., Amsterdam, The Netherlands, 1965).

Key words: Glasses; liquid viscosities; molten glasses; ultrasonic relaxation; viscosity.

Previous investigation by the authors have shown the connection between a distribution of structural relaxation times and the non-Arrhenius temperature dependence of the viscosity. The rate theory for liquid viscosities has been reformulated using the Cohen and Turnbull expression for the probability of finding a vacant site and yields an equation of the form,

$$\eta = A_0 \exp (E_v/RT + V_0/VF.$$

Consistent fits to both temperature and pressure dependence of viscosity were obtained. Using this "hybrid" equation as a basis, the relative role of activation energy and free volume were studied at the glass transition temperature. Once the reasons for non-Arrhenius temperature dependence of the viscosity was obtained, from the "hybrid" equation, it was compared with the origin of the distribution of relaxation times. This comparison seemed reasonable.

10674. Loftus, T. P., **Services and facilities for the calibration of soft x-ray detection instruments at the National Bureau of Standards,** (Proc. Conf. Detection and Measurement of X-Radiation from Color Television Receivers, Washington, D.C., Mar. 28-29, 1968), Chapter in *Conference on Detection and Measurement of X-Radiation from Color Television Receivers,* pp. 129-134 (U.S. Dept. Health, Education, and Welfare, Washington, D.C., Mar. 1968).

Key words: Calibration techniques; cavity ionization chamber; free-air chamber; soft x-rays.

The responsibility for the maintenance of national standards of measurement and the provision for access to these standards, for those requiring such services, is a statutory function of the National Bureau of Standards. In the field of x-ray exposure measurements, this responsibility is fulfilled by providing calibration services which reflect the needs of the public.

The standard free-air chamber is the primary standard used for the realization of the unit of x-ray exposure, the roentgen. In the energy range pertinent to the problems associated with stray radiation from color TV sets, two calibration ranges are available which include specially designed free-air chambers and x-ray tubes.

The equipment and calibration techniques set up, for these low-energy x-ray measurements, are designed to provide a calibration service for instruments such as those used in skin therapy. Modification of these methods will be necessary to establish a calibration service for instruments used in protection measurements where vastly different exposure rates are encountered. Investigations are being carried out which will provide information regarding the limitations of the equipment and the modifications required.

The instrument submitted for calibration should be appropriate for low-energy x-ray measurements, have a range within the limitations of the calibration equipment, and be of sufficiently high quality that it would be expected to retain its calibration.

10675. Lutz, G. J., DeSoete, D. A., **Determination of carbon in sodium by photon activation analysis,** *Anal. Chem.* **40,** No. 4, 820-822 (Apr. 1968).

Key words: Carbon; carbon separation; detection limit; internal standard; photon activation analysis; sodium matrix.

A photon activation analysis method has been developed for the determination of carbon in sodium. The method utilizes the photonuclear reaction $^{12}C(\gamma,n)^{11}C$. The ^{22}Na or ^{24}Na activity produced in the matrix by $^{23}Na(\gamma,n)^{22}Na$ or $^{23}Na(n,\gamma)^{24}Na$ reaction is used as an internal standard. The carbon separation is effected by combustion of the sample in oxygen, treatment with dilute acid and collection of the radioactive carbon as CO_2. The time of separation is about 15 minutes. The detection limit is 0.5 micrograms of carbon. A series of five samples at the 48ppm level gave a standard deviation of 10 percent. A series of five samples at the 4ppm level gave a standard deviation of 33 percent.

10676. McCulloh, K. E., **Franck-Condon calculations for double ionization of molecular hydrogen,** *J. Chem. Phys.* **48,** No. 4, 2090-2093 (Mar. 1, 1968).

Key words: Double ionization; Franck-Condon principle; H_2; kinetic energy; proton; reflection approximation; theoretical.

The Franck-Condon radial overlap integral for transition from the ground vibronic state of H_2 to a state in the H_2^{++} continuum is expanded as an asymptotic series in powers of a small parameter. The initial semi-convergence of the series is sufficiently rapid to provide a convenient basis for computing the kinetic energy distribution for protons formed by double ionization of H_2. The results of these computations are presented. The analysis includes a derivation of the reflection approximation for the particular case of transition to the repulsive Coulomb potential curve. Preliminary results of a more general study indicate that this approximation can be applied to a much larger class of repulsive potentials. Previous forms of the reflection approximation, which have heretofore lacked theoretical foundation, are classified and discussed in relation to the derived approximation.

10677. McCulloh, K. E., Rosenstock, H. M., **Experimental test of the Franck-Condon principle: Double ionization of molecular hydrogen,** *J. Chem. Phys.* **48,** No. 4, 2084-2089 (Mar. 1, 1968).

Key words: Double ionization; experimental; Franck-Condon principle; H_2; kinetic energy; proton.

The double ionization of molecular hydrogen by electron impact has been observed by coincidence detection of the resulting proton pairs in a system especially designed for absolute kinetic energy measurements. Monte Carlo calculations provided an accurate knowledge of the resolution with which the kinetic energy measurements were made. Experimental results agree closely with predictions based on accurate Franck-Condon overlap integrals for a model involving Morse oscillator wave functions for the molecule and Coulomb wave functions for the ion. In contrast, the reflection approximation and the harmonic oscillator approximation for molecular vibration, two approximations frequently made in such Franck-Condon calculations, do not agree well either with experiment or accurate calculations. Observations at electron energies of 0.5, 0.75, and 1 keV show that the kinetic energy distribution is independent of electron energy and suggest that the double ionization cross section is inversely proportional to electron energy in this range. These results are to be expected for a direct two-electron ejection mechanism for double ionization of H_2.

10678. McMurdie, H. F., **Progress in x-ray diffraction data compilations,** Chapter in *Fifty Years of Progress in Metallographic Techniques, Am. Soc. Testing Mater. Spec. Tech. Publ.* **430,** 192-200 (1968).

Key words: Compilations; crystallographic data; diffraction; x-ray diffraction.

Crystallography is a very active field for compilation efforts, the largest one being concerned with phase identification. The *X-Ray Powder Data File* and *Crystal Data* are the principal ones for this use. *Structure Reports* and *Crystal Structures* are the major continuous series reporting crystal structures. Details of the methods and procedures of producing data at NBS for the X-Ray Powder Data File are given.

10679. Mahaffey, C. T., **Basic construction standards and a technical information center recommended at a Pan American seminar,** *ASA Mag. Std.* **36,** No. 12, 375-377 (Dec. 1965).

Key words: COPANT; housing problems; industrialized building; Latin America; technical information center.

Agreements reached at the COPANT construction seminar will help provide Latin American countries with the basic tools they need to industrialize building and stimulate their economies. A by product of this meeting was the enthusiastic endorsement of a resolution proposing the establishment of a Pan American technical information center. Gathering existing data pertaining to construction and making it readily available at the point of use, is considered of primary importance in meeting the growing housing problems in Latin America.

10680. Maienthal, E. J., Taylor, J. K., **Improvement of polarographic precision by a comparative technique,** *Mikrochim. Acta* **5,** 939-945 (1967).

Key words: Cadmium, determination of; chemical analysis; copper, determination of; polarography; zinc, determination of.

Comparative techniques are described which give an increase in precision of 100-fold over conventional polarography. By interchanging cells during measurement, certain electrode and cell inequalities are minimized. Major constituents of many matrices may be determined on microgram-amounts of sample with a precision as good as 2 parts in 10,000. The technique is illustrated by the determination of copper, cadmium, and zinc in several materials.

10681. Maki, A. G., **Interpretation of the CS_2 laser transitions,** *Appl. Phys. Letters* **11,** No. 6, 204-205 (Sept. 1967).

Key words: Carbon disulfide; CS_2; excitation mechanism; infrared; lasers; spectra.

The N_2-CS_2 laser lines are identified as P-branch transitions with $J = 28$ to 46 for the 001-100 vibrational transition. A population ratio of $N_{001}/N_{100} = 1.07$ is determined for the system assuming a temperature of 300 °K. The mechanism of selectively populating the 001 level of CS_2 is discussed.

10682. Mann, D. E., Acquista, N., Linevsky, M. J., **An electronic band spectrum of yttrium monofluoride,** (Proc. 4th Rare Earth Research Conf., Phoenix, Ariz., Apr. 22-25, 1964), Chapter in *Proceedings of the Fourth Conference on Rare Earth Research,* pp. 363-372 (Gordon and Breach, New York, N.Y., 1965).

Key words: Electronic band spectrum; rare earth research; yttrium monofluoride.

A system of 19 double-headed red-degraded bands has been observed in absorption in the range 3075-3300 A when YF_3 is heated to about 2000 °C in a King furnace. They have been attributed to YF and a vibrational analysis made. The constants determined from measurements on the R heads are (in cm^{-1}): $\nu_{00} = 31218.0$, $\omega_e'' = 633.5$, $\omega_e''x_e'' = 2.0$, $\omega_e' = 539.0$, $\omega_e'x_e' = 2.0$. A series of 10 diffuse bands in the range 2500-3000 A was also seen in absorption. They have been tentatively ascribed to YF_2.

10683. Mann, D. E., White, D., Seshadri, K. S., Dever, D. F., Linevsky, M. J., **The infrared spectra, structures and thermodynamics of gaseous LiO, Li_2O and Li_2O_2,** *J. Chem. Phys.* **39,** 2463-2473 (1963).

Key words: Infrared matrix; infrared spectra; isolation spectroscopy; lithium oxide species; matrix spectra; spectroscopy.

The vapor above heated lithium oxide (Li_2O) has been investigated mass spectrometrically and by infrared matrix-isolation spectroscopy. The vapor composition and Knudsen effusion rates were measured as functions of temperature, and the matrix spectra of the principal lithium oxide species—Li_2O, LiO, Li_2O_2—identified and analyzed for different isotopic abundances. The predominant vapor species Li^7_2O is probably linear with r (Li-O) = 1.59 Å, and has fundamentals ν_1, ν_2, ν_3 at [760], [140], and 987 cm^{-1}, respectively. Its heat of formation $\Delta H^0_0(f) = -43.7 \pm 2.5$ kcal/mole. The diatomic molecule Li^7O has $\nu = 745$ cm^{-1}, an estimated bond length r = 1.62A, and $\Delta H^0_0(f) = +16.0 \pm 5$ kcal/mole. The previously undetected molecule $Li^7_2O_2$ is shown to resemble the alkali halide dimers in having a planar rhombic (V_h) structure for which the O-Li-O angle and Li-O bond length are estimated to be 116° and 1.90 Å, respectively. Its B_{2u} and B_{3u} frequencies are found at 324 and 522 cm^{-1}, respectively, in a krypton matrix. The remaining unobserved modes are estimated in cm^{-1} as follows: $\nu_1(Ag) = 400$, $\nu_2(A_g') = 250$, $\nu_3(B_{1g}) = 300$, $\nu_4(B_{1u}) = 270$. Its $\Delta H^0_0(f) = +27.5 + 6$ kcal/mole.

10684. Margoshes, M., **Selection of wavelengths for atomic absorption spectrometry,** *Anal. Chem.* **39,** No. 10, 1093-1096 (Aug. 1967).

Key words: Analysis; atomic absorption; Beer-Lambert law; continuum source; curve of growth: oscillator strength; wavelengths.

A method is described for the selection of wavelengths for atomic absorption spectrometry. The assumptions are made that the Beer-Lambert law applies approximately to the conditions of atomic absorption spectrometry and that the absorptivity is proportional to the oscillator strength of the line. The method permits selection of the most sensitive line or, if the absorbance measured with this line is too large, the selection of another line having an appropriate sensitivity. A test of the assumptions is made using published atomic absorption data, and it is shown that the accuracies of the predictions are adequate for the purpose of line selection. Modification of the theory for the case of atomic absorption with a continuum source is considered.

10685. Marton, L., **Photoelectricity,** *Encyclopedia of Physics,* R. M. Besancon, ed., pp. 512-514 (1966).

Key words: Photoelectricity; physics.

A short introduction into the principles of photoelectricity.

10686. Maryott, A. A., Birnbaum, G., **Line shape and collision effects in the microwave wing of far-infrared rotational lines,** *J. Chem. Phys.* **47,** No. 9, 3200-3205 (Nov. 1967).

Key words: Interacting molecular pairs; low frequency; microwave absorption; rotational spectra.

The microwave absorption located very far in the low frequency wings of the rotational spectra of HCl and DCl has been measured in order to test the applicability of the Van Vleck-Weisskopf relation for pressure broadening in the region many line widths removed from the resonance frequencies. Data for mixtures of HCl with the foreign gases, He, H_2, Ar, N_2, CH_4, C_2H_6, CO, SF_6, and CO_2, are also reported. Results for the mixtures with He and H_2 are in accord with theory. Results for the remaining mixtures and the pure gases do not agree with predictions, the observed absorption being from two to eight times greater. These discrepancies suggest the presence of an additional absorption region which is centered at a lower frequency than the normal rotational spectrum and which may by attributed to interacting molecular pairs.

10687. Mather, J. N., **Invariance of the homology of a lattice,** *Proc. Am. Math. Soc.* **17,** No. 5, 1120-1124 (Oct. 1966).

Key words: Combinatorics; cross-cut; homology; homotopy; lattice; simplicial complex.

Rota, Kan, Peterson and Whitehead have developed a homology theory for finite lattices which *a priori* depends upon the choice of a cross-cut of the lattice. It is shown here that the different cross-cuts of a lattice lead to simplicial complexes which have the same homotopy type and are therefore homology equivalent.

10688. Melmed, A. J., **Field emission microscopy,** Chapter in *Advances in Materials Research,* **Vol. 1,** *Experimental Methods,* H. Herman, ed., pp. 103-143 (Interscience Publ. Inc., New York, N.Y., 1967).

Key words: Field electron microscopy; field emission microscopy; field ion microscopy.

Field emission microscopy is reviewed. The field-electron-emission microscope and the field-ion microscope are treated separately, with a discussion of the imaging process, the capabilities, limitations, and research applications of each type of instrument.

10689. Melmed, A. J., **Whiskers, thin films, and applications (real and imagined) to mass spectrometry and biological molecule imaging,** Chapter in *Field-Ion Microscopy,* J. J. Hren and S. Ranganathan, eds., pp. 183-212 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Field-ion microscopy; mass spectrometry ionization sources; organic molecule imaging; thin films; whiskers.

Four separate topics in field-ion microscopy are discussed. These are: Field-ion microscopy of whiskers, field-ion microscopy of thin films, field-ionization mass spectrometry, and biological molecule imaging with the field-ion microscope. Emphasis is placed on depicting the current state of the art and the techniques, capabilities and limitations.

10690. Melmed, A. J., Layer, H. P., Kruger, J., **Ellipsometry, low energy electron diffraction and field emission microscopy combined,** *Surface Sci.* **9,** 476-483 (1968).

Key words: Ellipsometry; field electron emission microscopy; low energy electron diffraction; surface physics.

An experimental approach has been developed which simultaneously applies three techniques to the study of surface phenomena. This approach was designed to exploit the complimentary features of the techniques as well as to compare the measurements of each where they provide similar information. The observational techniques that are included in the experimental apparatus are: ellipsometry, low energy electron diffraction, and field electron emission microscopy. Preliminary results obtained for the adsorption of oxygen on the (001) plane of tungsten are presented.

10691. Miller, K. J., Krauss, M., **Inapplicability of the Born exchange scattering amplitude for He ($1^1S \rightarrow 2^3S$) transition,** *J. Chem. Phys.* **48**, No. 6, 2611-2614 (Mar. 15, 1968).

Key words: Bonham-Ochkur approximation; Born exchange scattering amplitude; differential cross-section; helium ($1^1S \rightarrow 2^3S$).

Differential cross-sections are calculated for the He ($1^1S \rightarrow 2^3S$) transition within the Born-Oppenheimer approximation. The Bonham-Ochkur (OB) approximation is compared to the exact exchange scattering amplitude and it is found to yield semiquantitative agreement, especially at high incident energies. However, the theoretical results show qualitatively different behavior from recent experimental results. Experimental differential cross-sections peak in the forward direction while theory predicts a maximum at large angles.

10692. Moiseiwitsch, B., Smith, S. J., **Electron impact excitation of atoms,** *Rev. Mod. Phys.* **40**, No. 2, 238-358 (Apr. 1968).

Key words: Atom; electron; excitation; experimental; helium; hydrogen; impact; review; theoretical.

The experimental and theoretical literature about the electron impact excitation of atoms is reviewed. Theoretical methods ranging from the Bethe and Born approximations to the close coupling approximations are discussed and intercompared. Where possible, on theoretical grounds or through intercomparison, the reliability of the various methods is discussed.

A general critique of the optical method of measuring excitation functions is given, with the objective of promoting higher quality future experimental work. A critical study of existing experimental work leads to the conclusion that most workers have ignored important physical and instrumental effects, and it may be presumed that the data in the literature is subject to many unrecognized systematic errors. The literature on hydrogen and helium is discussed critically. The literature on alkalis, heavy rare gases, mercury, cadmium and zinc is surveyed but the quality of the literature does not support critical review beyond some general comments about the physics of these atoms.

10693. Moore, G. A., **Automatic scanning and computer processes for the quantitative analysis of micrographs and equivalent subjects,** (Proc. Symp. Automatic Photo Interpretation, Washington, D.C., May 31-June 2, 1967), Chapter in *Pictorial Pattern Recognition*, G. C. Cheng, R. S. Ledley, D. K. Pollock, and A. Rosenfeld, eds., pp. 275-326 (Thompson Book Co., Washington, D.C., 1968).

Key words: Analysis of microstructures; automatic scanning (of micrographs); computer processing (of micrographs); logical modification of pictures; precision scanning (of micrographs); quantitative microscopy.

Basically identical measurement problems are treated in the microscopic branches of all material sciences and in microbiology and medical diagnosis. Visual-manual methods, in use over a century, permit determination of the relative volume of a material phase, and of the average size and spacing of particles of this phase. Redefining a phase as the set of all areas having similar nature and a distinctive tone or color in a photograph, these established methods can be extended to several varieties of nonmicrographic pictures.

Statistical considerations require the order of one million observations per picture to attain reasonable precision, dictating automatic scanning and computer processing. Treatment of phase images in binary format permits feasible memory capacities and processing time. Production of a valid binary image requires both high precision scanning and a battery of logical processes which can substitute for darkroom operations and logical discriminating normally made by a human analyst. Other logical processes permit dissection and description of individual phase areas. Presently attainable measurement precision is an order of magnitude greater than is normally attained by manual methods.

10694. Mopsik, F. I., **Molecular and ionic interactions,** Chapter 3 in *1966 Digest of Literature on Dielectrics* **30**, 62-90 (National Academy of Sciences – National Research Council, Washington, D.C., 1966).

Key words: Dielectrics literature; dielectric theory; Digest of Literature; molecular and ionic interactions; review of literature; 1966 dielectrics literature.

This year's chapter includes the literature covered by Physics Abstracts and Chemical Abstracts for the year 1966. The papers included are those, both theoretical and experimental, that are concerned with underlying dielectric phenomena. Papers that report values for dielectric parameters have been omitted unless there was a significant contribution to the understanding of dielectric theory. In particular, papers that should be adequately covered by the tables were not included.

10695. Mountain, R. D., **Relaxation times for the volume viscosity of simple fluids,** *J. Chem. Phys.* **48**, No. 5, 2189-2190 (Mar. 1, 1968).

Key words: Corresponding states fluid; elastic moduli in liquids; relaxation time for volume viscosity; shear relaxation time; time correlation function; volume viscosity.

Effective relaxation times for the volume viscosity of a corresponding states fluid in the dense gas region are calculated using low frequency volume viscosity data and previously developed estimates of high frequency elastic moduli The times are found to be on the order of 10^{-13} seconds.

10696. Mountain, R. D., Zwanzig, R., **Anomalous transport properties of a van der Waals gas,** *J. Chem. Phys.* **48**, No. 4, 1451-1458 (Feb. 15, 1968).

Key words: Critical phenomena; fluctuation and time correlation function; heat capacity; shear viscosity; thermal conductivity; van der Waals gas; volume viscosity.

The contribution of the long range potential to the transport coefficients of a van der Waals gas in the critical region are calculated using the time correlation function methods. The microscopic currents are expanded in terms of wave vector dependent density fluctuations (found previously by van Kampen), whose time dependence is assumed to be described by the linearized hydrodynamic equations. Self consistent solutions for the thermal conductivity and volume viscosity are found to diverge near the critical point. The fluctuation correction to the specific heat at constant volume is found to diverge as $|T-T_c|^{-1/2}$. The fluctuation correction to the equation of state indicated that these calculations are at best meaningful only in the critical region because the critical point is an apparent rather than a true critical point.

10697. Olver, F. W. J., **An extension of Miller's algorithm,** *Aplikace Mat.* **13**, 174-176 (1968).

Key words: Chebyshev series; difference equations; error analysis; Miller algorithm; recurrence methods; special functions.

A new algorithm is described for computing the solution of any second-order linear difference equation which is applicable when simple recurrence procedures cannot be used because of instability.

10698. Parker, R. L., **Report on the 1966 Boston International Conference on Crystal Growth,** *Proc. 1966 Intern. Union Crystallography, Moscow, U.S.S.R., July 12-21, 1966,* **7,** 341-354 (Academy of Sciences, Moscow, U.S.S.R., 1968).

Key words: Crystal; crystal growth; crystal morphology; interface kinetics; International Conference; ICCG; 1966 ICCG.

A report on the 1966 Boston International Conference on Crystal Growth (ICCG) is presented. The purpose of the interdisciplinary conference was to further the science and art of crystal growth by providing a forum for reporting and discussing recent original research in this field. Some data on the ICCG itself are given—its purpose and organization, registrants, and countries represented. Then brief summaries are given of 22 papers selected from the 170 papers presented at the conference. These papers dealt with such subjects as: Stability, Kinetics, Nucleation, Solidification, Whisker Growth, Phase Diagrams, Growth and Perfection. At the conference, particular attention was paid to certain macroscopic problems involved in crystallization, especially morphological stability and thermal convection.

10699. Patty, O. L., Little, W. E., Zanboorie, M. H., **Waveguide connector measurements with a millimeter wave reflectometer,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 2, 121-123 (Feb. 1968).

Key words: Connector; millimeterwave; reflectometer; WR-12.

A system is described which extends reflection coefficient measurement techniques to (60-90 GHz) "E-band." Special apparatus and procedures are discussed. A new graphical presentation of reflectometer data is given which simplifies the measurement of connector impedance. Examples of the measured reflection coefficient of some common E-band connectors are given.

10700. Penner, S., **Handling high power electron beams,** *IEEE. Trans. Nucl. Sci.* **NS-14,** 908 (June 1967).

Key words: Accelerators; beam handling; electron beams; high power electron beams.

In recent years accelerators have been designed and built which produce beams of extremely high power, current, and charge-per-pulse. The handling of these beams presents a number of difficult problems. Among these problems are: removal of large heat flux, fatigue failure of components due to pulsed nature of the beam, radiation damage of materials, corrosion, residual radioactivity, and chemical effects such as radiolysis of water and production of noxious gases. Consideration of these problems strongly influences the overall design of beam handling systems, as well as the designs of specific components. Examples of the problems encountered and the solutions adopted in various electron accelerator laboratories will be discussed.

10701. Penney, R. W., Phillips, C. W., **Refrigeration requirements for truck bodies—effects of door usage,** *U.S. Department of Agriculture Tech. Bull.* No. 1375 (Superintendent of Documents, Government Printing Office, Washington, D.C., 20402, Nov. 1967, 10 cents).

Key words: Air exchange; calculation method; cooling load; door usage; helium trace measurement; refrigerated trucks; testing method.

The selection of a refrigerating system of adequate capacity for use in a refrigerated truck body requires knowledge of system capacity and the total cooling load. Rating and testing methods to establish system capacity and body cooling load due to heat transmission and air infiltration are now available. The cooling load casued by air exchange during door usage in a refrigerated truck used in local delivery service can be the largest part of the total cooling load. A means to determine this door-usage cooling load is needed and this technical bulletin presents such a method. Laboratory tests of four refrigerated truck bodies were made under controlled conditions of 0 °F temperature in the truck body and 100 °F temperature and 50 percent relative humidity in the test room to determine the air exchange and cooling load resulting from door openings of one to three minutes in duration. The effect of cargo loading on air exchange was determined. A brine refrigerating system was used to obtain the initial steady-state temperature conditions, and liquid nitrogen was then used to determine increases in cooling loads caused by opening the door. Helium gas was used as a tracer to measure the air exchange resulting from door usage. Tests showed that a 1-minute door opening can cause air temperature inside the truck body to rise as much as 60 degrees F with more than two complete air changes, and a cooling load of more than 2000 B.t.u. Formulas were developed to estimate the amount of air exchange and the cooling load caused by door opening.

10702. Persson, K-B., Johnson, E. G., Jr., Uhlenbrock, D. A., **Theory for cyclotron harmonic radiation from plasmas,** *Phys. Fluids* **11,** No. 3, 619-628 (Mar. 1968).

Key words: Electron cyclotron frequency; emission; harmonic; microwave; theory.

A highly simplified hydrodynamic model for the cause of cyclotron harmonics radiation in a magnetized abnormal glow helium plasma is proposed. The high velocity electrons are treated as sources for the charge density waves in the plasma. With the very crucial existence of statistical fluctuations in the ion density, these waves act as sources for electromagnetic radiation. This radiation contains the cyclotron harmonics. Some numerical curves of the radiation spectra are shown for a number of plasma parameters.

10703. Peterson, R. L., **Ising chain as the basic cluster in effective-field theories of magnetism,** *Physics Letters* **27A,** 177 (June 10, 1968).

Key words: Effective-field theory; Ising interaction; magnetism.

A linear chain is used as the basic cluster in effective-field theories of Ising systems. The chain gives limited improvement over the finite clusters in a molecular-field approach. Results are independent of cluster size in a "constant coupling" approach.

10704. Peterson, R. L., **Suppressed spin-lattice relaxation,** *Phys. Rev. Letters* **20,** No. 24, 1346-1348 (June 10, 1968).

Key words: Gadolinium hexa-antipyrene iodide; spin-lattice relaxation.

A possible explanation of some power-dependent spin-lattice relaxation effects observed in gadolinium hexa-antipyrene iodide is offered.

10705. Roder, H. M., **The thermal conductivity of helium gas at moderate pressures,** *Proc. Thermodynamik Symp., Heidelberg, Germany, Sept. 1967, Sponsored by the International Union on Pure and Applied Chemistry,* K. L. Schafer, ed., **Paper No. V1-3,** pp. 1-8 (1968).

Key words: Capacitance method; critical density; experimental measurement; helium gas; parallel plate method; thermal conductivity.

The apparatus used is a doubly-guarded flat plate calorimeter in which the cell constant is determined by a capacitance method. Experimental values of the thermal conductivity of helium gas are presented for 15 isotherms between 20 and 282 °K at pressures from 1 to 30 atmospheres, except for the 50 °K isotherm which extends to 50 atmospheres. The highest density is, thus, just under the critical density. The results are analyzed in terms of their density and temperature dependence.

10706. Ronn, A. M., **Laser induced infrared fluorescense,** *J. Chem. Phys.* **48,** No. 1, 511-513 (Jan. 1968).

Key words: Ammonia; carbon dioxide; emission; ethylene; infrared; laser.

Laser induced infrared emission has been observed in several gases which have absorption bands in the vicinity of the CO_2 laser's frequency. Ethylene showed an intense emission spectrum at an optimal pressure of 50 mm demonstrating that the efficiency of collisional transfer is sufficient to populate all, or most, members of a room temperature vibrational band when one or two vibration-rotation lines are strongly irradiated by the laser. Ammonia showed some irregularities in the emission spectrum which are currently under investigation.

10707. Rybicki, G. B., Hummer, D. G., **Spectral line formation in variable-property media: the Riccati method,** *Astrophys. J.* **150,** No. 2, 607-635 (Nov. 1967).

Key words: Doppler width; radiative transfer media; Riccati method; spectral line formation; variable-property media.

A numerical method, based on the generalized Ricatti transformation of Rybicki and Usher, is presented for the integration of the radiative transfer equation for spectral line formation by non-coherent scattering in inhomogeneous plane-parallel media. An asymptotic theory is developed which permits the application of this method to problems involving semi-infinite media. Numerical results obtained by the Riccati method are used to discuss the effects of spatial variations in the Doppler width on lines formed by pure Doppler broadening.

10708. Scribner, B. F., **Advances in excitation sources for spectrochemical analysis,** *Pure Appl. Chem.* **10,** 579-594 (July 21, 1967).

Key words: Arc discharge; excitation sources; fuel-rich flames; high-frequency torch; laser probe; plasma jet; spark discharge; spectrochemical analysis.

Recent developments are reviewed in methods of exciting spectra, with emphasis on sources for spectrochemical analysis. The subjects discussed include fuel-rich flames, the high-frequency torch, the plasma jet, arc and spark discharges in controlled atmospheres, and the laser probe.

10709. Sengers, J. V., **Triple collision contribution to the transport coefficients of gases,** (Lectures presented at the Theoretical Physics Institute, University of Colorado, Boulder, Colo., Summer 1966), Chapter in *Lectures in Theoretical Physics,* **Vol. IXC,** *Kinetic Theory,* E. E. Brittin, ed., pp. 335-374 (Gordon and Breach, New York, N.Y., 1967).

Key words: Dense gases; diffusion; rigid disks; rigid spheres; thermal conductivity; transport properties; triple collisions; viscosity.

The effect of triple collisions on the transport coefficients of gases is discussed. In particular the triple collision integrals determining the first density correction to the viscosity and thermal conductivity of a gas of rigid spheres are derived and estimates are presented for these integrals. By applying the method to a two dimensional gas of rigid disks, an analysis is given of the logarithmic density dependence of the transport coefficients.

10710. Simmons, J. H., Macedo, P. B., **High temperature shear ultrasonic interferometer using sensitive phase-lock detection system,** *J. Acoust. Soc. Am.* **43,** No. 6, 1295-1301 (June 1968).

Key words: High temperature ultrasonic interferometer; lock-in amplifier system; measurements in molten glasses; phase-lock detection system; shear relaxation; ultrasonic interferometer.

A high temperature (up to 1600 °C) ultrasonic (3 to 23 MHz) interferometer having two single-crystal molybdenum transmission lines was used to study the propagation properties of shear waves through molten glasses. Shear velocity and absorption of the transmitted echoes were measured in a temperature range which covered the major part of the relaxation region of a molten glass. The highest value of absorption per wave length for which measurements were still possible was 5.4 nepers/cycle; over twice the value from previously reported equipment.

A feature which made this work possible was the use of a lock-in amplifier in the video circuit. This method of handling the transmitted echoes not only suppressed noise by 25 dB, but also permitted measurements of pulse heights to better than 0.1 dB. The video circuit is independent of the r.f. and can be used with most existing pulsed ultrasonic systems.

10711. Spokas, O. E., **The NBS linac master control and personnel protection system,** *IEEE Trans. Nucl. Sci.* **NS-14,** 1016 (June 1967).

Key words: Linear accelerator safety; linear accelerator utilization; personnel and equipment protection system.

The operation of the NBS linear accelerator and its beam handling equipment has been integrated with personnel and equipment protection safeguards and with the occupancy requirements of the linac complex. A mode switch is used to select beam direction and experimental area, and to program the requirements for personnel protection interlocks, beam handling system conditions, building mechanical services, experimental area services, and linac operation. The system includes visual and audible devices to indicate degree of readiness, hazards, faults, interlock information, zone of operation and emergency situations. A forced inspection of potentially dangerous zones, programmed cued taped warning announcements, key interlocks, and flexibility are built-in features. It offers the capability of providing maximum protection to personnel against environmental radiation hazards, and allows utilization of a maximum of laboratory space for varied beam conditions.

10712. Stern, J., **Aspect systems,** *Encyclopedia of Library and Information Science* **1,** 669-671 (1967).

Key words: Aspect systems; index organization; information retrieval systems; inverted index organization; inverted systems; Peek-a-Boo.

This encyclopedia entry defines the term aspect systems and describes briefly the type of index organization that characterizes these systems and some of the techniques applicable to them. The reader is referred to a number of other entries for more detailed information.

10713. Sukle, D. J., Wells, J. S., **An EPR sample servo,** *Rev. Sci. Instr. Notes* **39,** No. 4, 604-605 (Apr. 1968).

Key words: Crystal alignment; electron paramagnetic resonance; EPR sample orientation.

A device which permits one to change the orientation of an EPR sample with respect to the cavity without removing either from the spectrometer is described.

The sample orienter is essentially a mechanical servo comprised of two ball and socket joints which are constrained by four lengths of cotton thread to move together.

10714. Tighe, N. J., Hyman, A., **Transmission electron microscopy of alumina ceramics,** (Proc. Intern. Symp. Anisotropy in Single-Crystal Refractory Compounds, Dayton, Ohio, June 13-15, 1967), Chapter in *Anisotropy in Single-Crystal Refractory Compounds,* F. W. Vahldiek and S. A. Mersol, eds., **2,** 121-136 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Alumina; defects; dislocations; electron microscopy; ionic bombardment; polycrystalline Al_2O_3.

Transmission electron microscopic studies have been carried out on two samples of sintered alumina having different density (3.99g/cm^3 and 3.78g/cm^3), composition and grain size. Specimens were thinned by an ionic-bombardment method which preserved the grain boundaries and allowed observation of relatively large areas. The sample of nearly full density Al_2O_3 had very few dislocations or small angle boundaries. It did have grains of second phase material (spinel) and these grains contained faults. The sample of lower density, had many small angle boundaries, pores and extensive dislocation networks. A number of the networks were composed of dislocations with Burgers vectors: 1/3 $\langle 1120\rangle$ and 1/3 $\langle 1011\rangle$.

10715. Tisone, G. C., Branscomb, L. M., **Detachment of electrons from H^- and O^- negative ions by electron impact,** *Phys. Rev.* **170,** No. 1, 169-183 (June 5, 1968).

Key words: Crossed-charged beams; electron collisions; hydrogen negative ion; ionization cross section; negative oxygen ion.

The energy range for the electron detachment cross section for H^- has been extended from 500 eV down to 8.4 eV. The absolute cross section for detachment of electrons from atomic oxygen negative ions has been measured in the energy range of 7.1 to 487.1 eV. Results of these measurements are compared with Bethe-Born calculations of the cross section. This calculation with the semiclassical Coulomb correction is in qualitative agreement with the experimental results above 20 eV electron energy for both H^- and O^-, although the energy dependence of the H^- cross section from 100 to 500 eV is not consistent with the slope predicted theoretically for the high energy limit.

10716. VanderHart, D. L., Gutowsky, H. S., Farrar, T. C., **Dipole-dipole interactions of a spin 1/2 nucleus with a quadrupole-coupled nucleus,** *J. Am. Chem. Soc.* **89,** No. 19, 5056-5057 (Sept. 13, 1967).

Key words: Bond-distance; frequency-dependent proton NMR line shapes; indirect quadrupole interaction; solids.

Line shapes for two-spin (1/2, 7/2) system having axial symmetry along the internuclear vector and quadrupole coupling at the spin 7/2 nucleus are calculated as a function of the ratio of the Zeeman to quadrupole interaction energies. It is shown that the spin-1/2 NMR line shape is frequency dependent and that the second moment of the spin-1/2 NMR spectrum may be as much as 1.84 times its value in the absence of quadrupole coupling. Reported values for M-H bond distances via NMR studies in transition-metal carbonyl hydrides may be too small.

10717. Vriens, L., Kuyatt, C. E., Mielczarek, S. R., **Tests of Born approximations; differential and total cross sections for elastic scattering of 100- to 400-eV electrons by helium,** *Phys. Rev.* **170,** No. 1, 163-169 (June 1968).

Key words: Born approximation; differential and total cross sections; elastic scattering; electrons; exchange; helium.

The angular dependence for elastic scattering of 100 to 400 eV electrons by helium atoms has been measured with a high resolution electron spectrometer. The angular range in the present measurement extends from 5° to 30°. The relative differential cross sections were put on an absolute basis using measured ratios of elastic and 2^1P scattered currents and known 2^1P cross sections. The differential cross sections were integrated to get total elastic scattering cross sections. Large deviations from the Born approximation are found, especially for small incident energies and small scattering angles. The agreement with more sophisticated calculations of Khare and Moiseiwitsch is better, but not yet satisfactory. Our results are in reasonable qualitative agreement with results of earlier experiments, but are quantitatively quite different and extended to smaller scattering angles.

10718. Wachtman, J. B., Jr., Brower, W. S., Farabaugh, E. N., **Elastic constants of single crystal calcium molybdate ($CaMoO_4$),** *J. Am. Ceram. Soc.* **51,** No. 6, 341-344 (June 1968).

Key words: Calcium molybdate; compressibility; Debye temperature; elastic constants; shear modulus; Young's modulus.

The seven elastic compliances (and seven elastic constants) of single crystal calcium molybdate were determined by a resonance method. The compliance s_{16}, which is zero for higher symmetry tetragonal crystals, need not be zero for crystals of lower tetragonal symmetry and contributes significantly to the orientation dependence of the elastic moduli of calcium molybdate. The values of the compliances and their standard errors (based on 41 measurements) in units of $10^{-11}m^2/N(10^{-12}cm^2/dyn)$ are $s_{11}=.974\pm.005$, $s_{33}=.958\pm.004$, $s_{44}=2.720\pm.009$, $s_{55}=2.276\pm.024$, $s_{12}=-.308\pm.009$, $s_{13}=-.249\pm.009$, and $s_{18}=.418\pm.\ .011$.

10719. Wassink, H. W., **Cyclotron harmonic emission along the field from a plasma,** *Phys. Fluids* **11,** No. 3, 629-637 (Mar. 1968).

Key words: Electron cyclotron frequency; emission; harmonic; magnetic field; plasma.

Electron cyclotron harmonic (ECH) radiation from an abnormal negative glow plasma has been measured along the magnetic field with the following results: Single peaks of ECH radiation were observed at the harmonic frequencies which slowly decreased in amplitude with increasing harmonic number; these peaks were almost completely circularly polarized with a polarization opposite to that of an electron; a large peak was observed near the fundamental in the electron polarization only; ECH emission appeared only in the presence of the hot electrons produced by electron beams; the difference in the emission between the two polarizations indicated that most of the ECH radiation came from the interior of the plasma. A theory proposed by Persson, Johnson, and Uhlenbrock showed detailed agreement with these measurements.

10720. Watson, T. H., Flynn, D. R., **Thermal conductivity and electrical resistivity of beryllium copper foil,** *Trans. Met. Soc. AIME* **242,** 876-880 (May 1968).

Key words: Beryllium copper; conductivity; copper alloys; electrical conductivity; heat conductivity; Lorenz function; resistivity; thermal conductivity.

Measurements have been made of the thermal conductivity and electrical resistivity of two specimens of 0.005 cm (2 mil) beryllium copper strip over the temperature range −140 to +200 °C. The thermal conductivity of beryllium copper Alloy 125 was found to be significantly higher that that of Alloy 25, which had a higher impurity content. The thermal conductivity and electrical resistivity values obtained were in concordance with the Smith and Palmer relation for copper alloys which states that $\lambda = 0.0239\ (T/\rho) + 0.075$ where λ is thermal conductivity (W $\text{cm}^{-1}\text{deg}^{-1}$), ρ is electrical resistivity ($\mu\Omega$ cm), and T is absolute temperature (°K), indicating that the Smith and Palmer relation can be used to predict the thermal conductivity of this type of beryllium copper alloy over the temperature range −140 to + 200 °C to within an accuracy suitable for most engineering applications.

10721. Watson, T. W., Flynn, D. R., **Thermal conductivity of four heat-resistant alloys,** *Trans. Met. Soc. AIME* **242,** 844-846 (May 1968).

Key words: Conductivity; heat conductivity; heat-resistant alloys; heat transfer; stainless steel; temperature-resistant alloys; thermal conductivity.

Measurements are reported for the thermal conductivity of four heat-resistant alloys which were measured at the National Bureau of Standards. Data are given for two samples of AISI Type 316 stainless steel covering a combined temperature range from −150 to +800 °C. The thermal conductivities of three samples of AISI Type 347 were measured over the temperature range from −150 to +150 °C. Thermal conductivity values are given for Carpenter 20 stainless steel from 100 to 800 °C. Data are given for Inconel 702, in both the solution-annealed and the age-hardened condition, over the temperature range from −150 to + 800 °C.

10722. Wiederhorn, S. M., **The influence of water vapor on crack propagation in soda-lime glass,** *J. Am. Ceram. Soc.* **50,** No. 8, 407 (1967).

Key words: Cleavage; crack propagation; cracks; delayed failure; fracture; glass; static fatigue.

This paper presents the results of a new experimental approach to the subject of static fatigue of glass. Using the double-cantilever cleavage technique, it was possible to observe crack motion and to accurately measure crack velocities in glass. The measured crack velocity is observed to be a complicated function of stress and of water vapor concentration in the environment. Experimental results are discussed with reference to current theories of static fatigue.

10723. Wiese, W. L., **Transition probabilities for prominent Ar I lines,** (Proc. 8th Intern. Conf. Phenomena in Ionized Gases, Vienna, Austria, Aug. 27-Sept. 2, 1967), Chapter in *8th International Conference on Phenomena in Ionized Gases,* p. 447 (Springer Verlag, Vienna, Austria, Sept. 1967).

Key words: Ar I; intermediate coupling; lifetime measurements; local thermal equilibrium; spectra; transition probabilities.

The transition probabilities of the prominent Ar I lines have been the subject of numerous studies. Nevertheless, many discrepancies remain between the various results. It is the aim of this paper to clear these up. To this end, new measurements have been undertaken for three selected Ar I lines which seem to be particularly suited to shed light on the cause of the disagreements. With these and other very recent data at the disposal, all available material is then critically assessed and a set of best values is suggested.

10724. Winogradoff, N. H., Neill, A. H., **Band tailing effects and the temperature dependence of radiative recombination in compensated, epitaxial GaAs laser junctions,** *IEEE J. Quantum Elect.* **QE-4,** No. 4, 111-113 (Apr. 1968).

Key words: Band pinch effect; band tailing; Fermi level; GaAs laser; internal quantum efficiency; radiative recombination.

An increase in threshold current and decrease in power output of GaAs laser diodes has been observed. In highly doped material, an exponential density of states "tail" is formed at the nearest band edge. The nature of these tails and the temperature induced shift of the Fermi level may account for the temperature dependance of the spontaneous and stimulated spectra through a reduction in the internal quantum efficiency for radiative recombination. Three semi-logarithmic curves of the spontaneous emission are presented to confirm a narrowing of the spectrum and a decrease in light output with increasing temperatures. Pankove's model for the behavior of the Fermi level in highly degenerate GaAs can account for the shape and temperature dependance of spontaneous emission from highly doped p-n junctions. The temperature dependance of the Fermi level in the band tails of such materials results in a narrowing of the spontaneous spectrum with increasing temperatures.

10725. Wyckoff, J. M., **On-line transformations of high resolution spectra,** *IEEE Trans. Nucl. Sci.* **NS-14,** 634 (Feb. 1967).

Key words: Computer; gamma-ray; germanium-detector; on-line; pulse-height-distribution; spectra.

A new technique has been devised for transforming the pulse height distribution obtained from a lithium drifted germanium crystal used as a gamma-ray spectrometer into an energy, peak area vector. The computer operations required are simple enough to be performed by an on-line computer in about five seconds. The vector is generated from the raw pulse height distribution by the subtraction of a smoothed version of the raw vector. In order to remove the statistically insignificant portions of the difference, all values less than twice the square root of the original element of the data are set equal to zero. The only remanent of the Compton contribution to the raw data is a small peak at the Compton edge. The resulting vector may be plotted directly or further transformed to sum the area under each peak providing a convenient graphic or tabular means of presenting the gamma-ray energy and relative intensity information.

10726. Wyckoff, J. M., **Radioactivity produced by a linac,** *IEEE Trans. Nucl. Sci.* **NS-14,** 990 (June 1967).

Key words: Gamma rays; health physics; linac; radioactivity; relative yield.

Over 40 different materials have been irradiated in the 100 MeV bremsstrahlung beam from the NBS linac. The major contributions to the gamma ray spectrum from the radioactive products have been measured using a Ge(Li) detector. Measurements have been made of gamma rays of concern in the 30 minute to 30 day time interval but this includes in some cases gamma rays from nuclides with half lives as long as 30 years. Eighteen of the samples were pure materials and 25 were commonly used structural, shielding, electrical and mechanical components. In several important cases nuclides produced by multiple particle emission dominate the picture.

10727. Abrams, M. D., **A comparative sampling of the systems for producing computer-drawn flow charts,** *Proc. 1968 Association for Computing Machinery National Conf., Las Vegas, Nevada, Aug. 27-29, 1968,* pp. 743-750 (Brandon/Systems Press, Inc., Princeton, N.J., 1968).

Key words: Algorithmic languages; computer graphics; flowchart; graphical output; graphics.

Several programs which produce computer-drawn flowcharts from assembly language and algorithmic compiler language are compared. As a background, the applications, implementation, and information transferral properties of flowcharts are briefly treated. The strengths and restrictions of flowcharts as graphical communications media are also briefly discussed. Three programs to draw flowcharts of compiler language programs are directly compared; sample flowcharts and a tabular summary are provided.

10728. Ausloos, P., Lias, S. G., **Primary modes of decomposition of superexcited n-alkane molecules,** (Proc. Intern. Conf. Photochemistry, Munchen, Germany, Sept. 6-9, 1967), *Ber. deut. Gunsenges.* 72, No. 2, 187-195 (1968).

Key words: Alkanes; free radical reaction; ion-molecule reactions; photoionization; photolysis; primary processes; superexcited molecules.

Information is summarized concerning fragmentation of superexcited propane and n-butane molecules produced by photolysis of these compounds with 11.6-11.8 eV photons, which is about 0.5 and 1.0 eV above the ionization energies of the two compounds. The decomposition of the excited $[C_3H_8^+]^*$ and $[C_4H_{10}]^*$ ions which are formed either by direct ionization or by autoionization are quenched at pressures around 10 Torr. These ions can then be removed from the photolysis system through a charge transfer reaction with added NO or an H_2 transfer reaction with low concentrations of added ethylene. The modes of decomposition of the superexcited alkane molecules are derived from the isotopic analysis of the products formed upon irradiation of $CD_3CH_2CD_3$, $CH_3CD_2CH_3$, $CD_3CH_2CH_2CD_3$ and of the equimolar mixtures C_3H_8-C_3D_8 and C_4H_{10}-C_4D_{10}. Comparison of these results with studies at longer wavelengths demonstrates that although the modes of decomposition observed at the superexcitation energies are the same as those observed at excitation energies below the ionization energy, free radical producing processes occur with higher probability when the energy of the photon is increased.

10729. Ausloos, P., Rebbert, R. E., Lias, S. G., **Structure and reactivity of propyl ions in gas-phase radiolysis,** *J. Am. Chem. Soc.* **90,** No. 18, 5031-5033 (Aug. 28, 1968).

Key words: Ion-molecule reactions; hydrocarbons; radiolysis; reaction rates; structure of ions.

This is a preliminary report concerning the structure of the propyl ions formed in the radiolysis of alkanes. It is demonstrated that there are two distinct propyl isomers: the normal propyl ion and the secondary propyl ion. The normal propyl ion is shown to react with alkanes at a considerably higher rate than the secondary propyl ions. In the radiolysis of normal butane-NH_3 mixture the normal propyl ion reacts with NH_3 to form cyclopropane as a product.

10730. Averbuch, P., James, L. W., Mahler, R. J., **Nuclear ultrasonic fast passage,** *Appl. Phys. Letters* **11,** N. 11, 339-340 (Dec. 1, 1967).

Key words: Nuclear spin; ultrasonic.

An ultrasonic fast passage experiment is described and the small resulting 16 percent nuclear spin inversion is explained as an inability to obtain ideal experimental conditions.

10731. Bates, R. G., **Measurement of pH,** *Handbook of Biochemistry,* H. A. Sober, ed., pp. J190-J194 (Chemical Rubber Company, Cleveland, Ohio, 1967).

Key words: Acidity; glass electrode; indicators; pH; standardization.

The operational definition of pH, in the form endorsed by the International Union of Pure and Applied Chemistry, is presented. The preparation of standard reference solutions for pH measurements is described and the choice of electrodes and measurement techniques is discussed. The proper interpretation of pH numbers is set forth briefly, and procedures for pH measurement with indicators are described.

10732. Bechtoldt, C. J., Ogburn, F., Smit, J., **Structure and morphology of electrodeposited molybdenum dendrites,** *J. Electrochem. Soc.* **115,** No. 8, 814-816 (Aug. 1968).

Key words: Electrodeposition; molybdenum dendrites; twin growth; twinning; twin plane reentrant edge; x-ray diffraction.

Twin growth has not been reported previously in molybdenum dendrites nor has growth by the "twin plane reentrant edge" (TPRE) mechanism been reported for the body centered cubic lattice W-type structure. Electrodeposited molybdenum dendrites were examined using optical and x-ray diffraction techniques and found to be twinned. The dendrites were found to have been bounded by their closest packed {110} planes forming a hexagonal rod with extended growth in a ⟨111⟩ direction. The growth appeared to have been initiated by a TPRE mechanism with twin composition planes forming in two or three of the {112} planes which are parallel to the ⟨111⟩ growth direction. Although the two crystal parts were in an exact twin relation, the boundary appeared as a grain boundary except within the small region of TPRE growth. Crystal growth appears to be by means of a TPRE mechanism since it meets the requirements proposed by Faust and John.

10733. Bender, P. L., Alley, C. O., Currie, D. G., Faller, J. E., **Satellite geodesy using laser range measurements only,** *J. Geophys. Res.* **73,** No. 16, 5353-5358 (Aug. 15, 1968).

Key words: Continental drift; distance measurements; geodesy; geodetic satellite; geophysics; laser; worldwide geodetic network.

We have investigated the potential accuracy with which the distances between 12 observing stations spread fairly uniformly over the earth can be determined by using laser range measurements to a high altitude satellite equipped with optical retroreflectors. For each of 30 satellite positions, it was assumed that range measurements were made at about the same time from the 4 closest stations. For ideal distribution of the stations, the expected uncertainty in the distance between any two stations was found to be less than 45 cm, with little dependence on satellite altitude over the range of 20,000 to 110,000 km. With 12 stations chosen from the Pageos Worldwide Geometric Satellite Network, the expected accuracy for a satellite altitude of 110,000 km is 60 cm or better between any two stations.

10734. Bender, P. L., Branscomb, L. M., **Credit for gravity apparatus,** *Phys. Today Letter* **20,** No. 10, 17 (Oct. 1967).

Key words: Absolute gravity; gravity.

In his article on Geophysics Instrumentation in the July issue of Physics Today, J. N. Howard of the Air Force Cambridge Research Laboratories refers to an "absolute gravity apparatus developed jointly by AFCRL and NBS (which) uses a freely falling rotation-insensitive corner cube as one element of an optical interferometer." This project was initiated by Prof. James E. Faller while he was a NAS-NRC Research Associate at NBS and was a direct outgrowth of earlier absolute gravity measurements which he had made at Princeton Univ. (J. Geophys. Res. **70**, 4035; 1965). The experiments are now being carried out at Wesleyan Univ. by Prof. Faller and Mr. James A. Hammond.

10735. Bennett, J. A., **The initiation of fatigue microcracks under sequential bending and torsional loads,** *Trans. ASM* **61,** No. 2, 210-218 (June 1968).

Key words: Aluminum alloy; bending; fatigue strength; microcracks; shear stress; torsion.

Specimens of 6061-T6 aluminum alloy were stressed first in alternating torsion, then in reversed bending or vice versa. The development of cracks was observed by microscopic examination of replicas taken of the specimen surfaces at intervals during the tests. The results indicate that fatigue damage under uniaxial stress did not reduce the resistance to crack initiation in pure shear; the reverse was also true. Based on the number of cycles to initiate microcracks, the fatigue strength in terms of shear stress amplitude was 14 percent higher in torsion than in bending. Comparison of these results with earlier studies of environmental effects suggests that moisture influences the fatigue behavior of this alloy only after microcracks have formed.

10736. Bullis, W. M., Brewer, F. H., Kolstad, C. D., Swartzendruber, L. J., **Temperature coefficient or resistivity of silicon and germanium near room temperature,** *Solid-State Electron.* **11,** No. 7, 639-646 (July 1968).

Key words: Extrinsic exhaustion region; germanium; n-type; p-type; resistivity; silicon; temperature coefficients.

Temperature coefficients for the resistivity of n- and p-type germanium and silicon in the neighborhood of room temperature have been determined over a wide range of resistivity. Linear temperature coefficients have been found for the extrinsic exhaustion region (<5 Ω·cm for germanium and <5000 Ω·cm for silicon). The results are presented as plots of temperature coefficient against resistivity at 23 °C. The plots may be used in connection with measurements of resistivity on extrinsic germanium and silicon doped with the usual shallow impurities such as boron, aluminum, gallium, phosphorus, arsenic, and antimony. Accurate linear coefficients cannot be found for specimens doped with deep-lying impurities in sufficient amounts to affect the carrier density nor for specimens with resistivity in the transition region between extrinsic and intrinsic conduction.

10737. Burke, P. G., Cooper, J. W., Ormonde, S., **Electron-impact excitation of $n = 2$ states in He,** *Phys. Rev. Letters* **17,** No. 7, 345-348 (Aug. 15, 1966).

Key words: Close-coupling; electron excitation; multi-channel; polarization; resonance; threshold.

Calculations have been performed on the excitation of $n = 2$ states in He by electron impact at energies close to thresholds using close-coupling methods. The cross sections obtained for these processes are compared with experimental results and provide an explanation of resonance phenomena observed in 3 separate experiments. The excitation cross section $2^1S - 2^3S$ was also calculated and found to agree with experimental results. The calculations show that 3 separate resonances play an important role in the vicinity of the $n = 2$ thresholds and that, due to strong polarization effects, 2^3P and 2^1P states must be included in calculations of this type in order to obtain the resonance structure.

10738. Codling, K., Madden, R. P., **Structure in the $L_{II,III}$ absorption of aluminum and its oxides,** *Phys. Rev.* **167,** No. 3, 587-591 (Mar. 1968).

Key words: Absorption spectrum; aluminum; aluminum oxide; $L_{II,III}$ edges; soft x-ray.

The $L_{II,III}$ region of absorption has been observed for thin films of evaporated aluminum, for amorphous (anodized) Al_2O_3 and for crystalline (γ alumina) Al_2O_3. The spectra were obtained in high resolution (0.06 Å) using the NBS 180 MeV electron synchrotron as a background source. The $L_{II,III}$ absorption edges of Al are located with improved accuracy at 169.49 (±0.05)Å (estimated probable error) and 170.49(± 0.05)Å. Structure on the high energy side is compatible with other recent observations. The $L_{II,III}$ absorption edge in Al_2O_3 is not split in high resolution and is located at 162.11(± 0.15)Å for the amorphous form and 160.15(± 0.15)Å for the γ alumina. Both forms show considerable structure on the high energy side of the edge. That observed for the amorphous form is in agreement with other recent observations, while the absorption structure in γ alumina (showing maxima at 78.0, 78.6, 79.5, 84 and 99 eV) has been found to be more complex.

10739. Corliss, C. H., **Relative oscillator strengths for lines of TbI,** *J. Quant. Spectry, Radiative Transfer* **8,** 1185-1191 (1968).

Key words: Oscillator strengths; spectra, atomic; terbium; transition probabilities.

Relative oscillator strengths are derived for 250 lines of the first spectrum of terbium by using the relative intensities from the Tables of Spectral-Line Intensities by Meggers, Corliss and Scribner and the line classifications by Klinkenberg.

10740. Daniel, A. C., Bevan, A. W., Jr., Mahler, R. J., **Nuclear spin-lattice relaxation in the antiferromagnets $CoCl_2 \cdot O2H_2O$ and $FeCl_2 \cdot O2H_2O$,** *J. Appl. Phys.* **39,** No. 2, Part I, 496-497 (Feb. 1, 1968).

Key words: Antiferromagnetism; magnon energy gap; magnons; spin-lattice relaxation time.

Spin-lattice relaxation of protons in $CoCl_2 \cdot 2H_2O$ and $FeCl_2 \cdot 2H_2O$ has been measured over a temperature range of 1.3° to 12 °K in zero external magnetic field. The temperature dependence of the relaxation rate exhibits two relaxation processes, neither of which is adequately characterized by the T and T^8 laws previously reported for $CuCl_2 \cdot 2H_2O$. Additional T^{11} and $AT^2 \exp(-T_{AE}/T)$ dependences are required to fit our data which predicts a $T_{AE} = (42.8 \pm 1)$°K for $CoCl_2 \cdot 2H_2O$ and a $T_{AE} = (4.18 \pm 0.2)$°K for $FeCl_2 \cdot 2H_2O$.

10741. Dean, J. W., Richards, R. J., **Hydrostatic pressure effects in carbon and germanium thermometers,** (Proc. 1967 Cryogenic Engineering Conf., Stanford University, Stanford, Calif., Aug. 21-23, 1967), Chapter in *Advances in Cryogenic Engineering* **13,** 505-508 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Carbon; germanium; pressure effect; thermometer.

This work describes measurements of the hydrostatic pressure coefficient of electrical resistivity for carbon and germanium thermometers in the range of 4 to 295 °K with experimental pressures up to 1000 psig($7.0 \times 10^6 N/m^2$). Pressure coefficients were found to be independent of pressure but to vary with temperature from $-0.65)$ 10^{-5} to -1.1×10^{-5} psi^{-1} (-0.944×10^{-9} to -1.6×10^{-9} m^2/N) for germanium and from -1.2×10^{-5} to -1.5×10^{-5} psi^{-1} (-1.74×10^{-9} to -2.18×10^{-9} m^2/N) for carbon. These pressure coefficients result in resistance changes for a 1000 psig($7.0 \times 10^6 N/m^2$) pressure at 20 °K that may be interpreted as temperature errors of 0.3 °K for carbon and 0.03 °K for germanium.

10742. Dunn, G. H., **Photodissociation of H_2^+ and D_2^+: theory,** *Phys. Rev.* **172,** No. 1, 172-178 (Aug. 5, 1968).

Key words: Cross sections; D_2^+; H_2^+; photodissociation; theory; vibrational levels.

Theory is described and calculations made for photodissociation cross sections of H_2^+ (D_2^+) from each of the ion's 19 (27) vibrational levels. Cross sections are summed over an assumed Franck-Condon distribution of initial vibrational states to give a predicted cross section for comparison with experiment. Auxiliary calculations are made of some of the cross sections using the common δ function approximation to the continuum radial wave functions, and a comparison made with the results using more exact wave functions, shows very good agreement for photodissociation from the lowest vibrational levels, but very poor agreement for photodissociation from higher levels.

10743. Fano, U., **Introductory remarks,** *Proc. Intern. Conf. Radiation Research, Cortina, Italy, June 26, 1966,* pp. 13-19 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1967).

Key words: Chemical activation; degradation; ionization; radiation effects.

This symposium constitutes, in effect, the report of a study group. The group met last September to consider aspects particularly relevant at this time. Various questions have been reviewed in some detail following that meeting and calculations performed as needed, with a steady exchange of correspondence, consultation and visits.

10744. Fowler, H. A., **Experiments in electron scattering. 1,** (Proc. Symp. Quantitative Aspects of Electron Microscopy, Walter Reed Institute of Pathology, Washington, D.C., 1965), *Lab. Investigations* **14,** No. 6, Part 2, 9-16 (1965).

Key words: Electron scattering; solids.

This paper contains a review of National Bureau of Standards work on electron scattering in solids.

10745. Franklin, A. D., **NBS dedicates new laboratory,** *J. Am. Ceramic Soc.* **45,** No. 10, 841-842 (1966).

Key words: Complex; laboratory; standards.

General discussion of the plans of the National Bureau of Standards for the dedication of its Gaithersburg, Maryland laboratory complex on November 15, 1966.

10746. Gallagher, A., **Rubidium and cesium excitation transfer in nearly adiabatic collisions with inert gases,** *Phys. Rev.* **172,** No. 1, 88-96 (Aug. 5, 1968).

Key words: Alkali resonance; cesium; collisions; cross sections; line broadening; rubidium; velocity dependence.

The cross sections for rubidium $5^2P_{1/2} \leftrightarrow 5^2P_{3/2}$ and cesium $6^2P_{1/2} \leftrightarrow 6^2P_{3/2}$ excitation transfer due to inert gas collisions have been measured. The temperature of the collision vessel has been varied from 300 °K to partially establish the velocity dependence of these cross sections (the alkali resonance line optical depths were always much less than one). The various cross sections exhibit a systematic behavior that can be combined to find the general shape of a "universal" cross section that ranges across six orders of magnitude, starting just below the threshold for "sudden" collisions. The surprisingly large influence of line broadening on these excitation transfer measurements has been removed as a source of error.

10747. Gammon, W. H., **What educators can expect from the Center for Computer Sciences and Technology,** *Proc. Gen. Conf. Midwestern States Educational Information Project, Des Moines, Iowa, June 20, 1967,* **P.L. 89-10,** Title V, Sect. 505, pp. 30-45, (Department of Public Instruction, State of Iowa, Des Moines, Iowa, 1967).

Key words: Computer applications; computer instruction; data processing; education; standard data elements.

This presentation was made to the Midwestern States Educational Information Project (MSEIP)—a group working under contract from the U.S. Office of Education—in order to establish a dialogue with the group and to let them know what the Federal Government is doing in the area of data processing standards and how this may assist them in their work.

The computer is becoming a very important tool to educators since it is estimated that upwards of 1/4 of the teachers' and counselors' time is spent in clerical tasks involved in handling educational data. ADP standards resulting from development work done by the Center for Computer Sciences and Technology of NBS will be mandatory on the Federal Government only, but will be of benefit to MSEIP and similar educational groups. As an example, state school systems will have to determine items of information to be maintained and standards for uniform documentation within each of the thousands of local school districts. Such data will sometimes have to be fed from the individual school to the school district, and in some cases to the state and national level. In order to be able to exchange such information, there need to be agreed upon standards for documentation. NBS is presently working in the area of program documentation standards and will share its findings with MSEIP and others as they become available.

10748. Glasgow, A. R., Jr., **High-temperature value for corrosive gases,** *Anal. Chem.* **38,** 1104 (July 1966).

Key words: Fluoride; high-temperature; high-vacuum; metal; nickel-Monel; non-corrosive; value.

Alterations in a commercially available, bellows-type valve are described which extends its usage with fluorides to higher-temperatures (250 °F to 1000 °F). The altered valve of nickel and Monel parts only was tested with a helium-leak detector from room temperature to 1000 °F and found to be high-vacuum tight across the closed valve seat and at its bellows gasket. The valve has performed well in systems where beryllium fluoride vapors, or fluorine gas, or hydrogen fluoride gas have been present.

10749. Goldman, D. T., **Reactor physicists emphasize need for neutron data, Phys. Today 21,** No. 8, 85-89 (Aug. 21, 1968).

Key words: Cross sections; meeting; neutrons; nuclear technology; reactors; shielding.

This is a summary of the Neutron Cross Sections and Technology Conference written by the Conference Chairman. It summarizes the meeting and describes very briefly each of the eight sections of the Conference.

10750. Gross, D., Loftus, J. L., Lee, T. G., Gray, V. E., **Smoke and gases produced by burning aircraft interior materials,** *FAA NA-68-36 (DS-68-16)* 50 pages (Federal Aviation Agency, Washington, D.C., June 1968).

Key words: Aircraft materials; combustion products; fire tests; interior finish; smoke; thermal degradation; toxic gases.

Measurements are reported of the smoke produced during both flaming and smoldering exposures on nearly 150 aircraft interior materials. Smoke is reported in terms of specific optical density, a dimensionless attenuation coefficient which defines the photometric obscuration produced by a quantity of smoke accumulated from a specimen of given thickness and unit surface area within a chamber of unit volume. A very wide range in the maximum specific optical density was observed. For the majority of materials, more smoke was produced during the flaming exposure test. However, certain materials produced significantly more smoke in the absence of open flaming.

During the smoke chamber tests, indications of the maximum concentrations of CO, HCl, HCN and other selected potentially toxic combustion products were obtained using commercial colorimetric detector tubes. A study was made of the operation, accuracy and limitations of the detector tubes used. Measurements of the concentrations of HCı were also made using specific ion electrode techniques.

The elevated temperature thermal degradation of selected materials was studied in a number of ways including thermogravimetry and differential scanning calorimetry.

Qualitative identification of the major components of the original test materials was accomplished primarily by infrared absorption spectrophotometry.

Of the materials tested, a number were found to possess good heat stability properties, and did not generate large quantities of smoke or high concentrations of the combustion products selected for analysis.

10751. Haber, S., **A combination of Monte Carlo and classical methods for evaluating multiple integrals,** *Bull. Am. Math. Soc.* **74,** No. 4, 683-686 (July 1968).

Key words: Integral; integration; modified Monte Carlo; Monte Carlo; multiple integral; numerical analysis; numerical integration; quadrature.

This is a preliminary announcement, stating results without proof. A class of formulas for multiple integration, called "Stochastic Quadrature Formulas," is defined, and an error estimate given. Some constant-coefficient formulas of this class are described.

10752. Herber, R. H., Spijkerman, J. J., **Narrow-line source for ^{119}Sn Mössbauer spectroscopy,** *J. Chem. Phys.* **43,** No. 11, 4057-4059 (Dec. 1, 1965).

Key words: Isomeric state nuclide; Mössbauer spectroscopy; palladium matrix; spectroscopy.

Mössbauer spectroscopy with Sn^{119m} has usually involved either SnO_2 or Mg_2Sn as a host matrix for the 250 day isomeric state nuclide, although both of these materials have distinct disadvantages under normal applications.

A palladium matrix for Sn^{119m} was chosen after a correlation between the recoil free fraction and the chemical shift was noted. Such a prepared source was to be usable at room temperature with a recoil free fraction of 0.80 and a line width of 0.71 ± 0.07 mm-sec^{-1} compared to the natural line width 0.62 mm-sec^{-1}.

From the data presented it can be inferred that dilute solutions of tin in Pt, V, and Cu will constitute matrices which are suitable for use as Mössbauer sources at room temperature, while dilute solutions of tin in Ti, In, and Pb offer little advantage in such applications.

10753. Hertelendy, P., **An approximate theory governing symmetric motions of elastic rods of rectangular or square cross section,** *J. Appl. Mech. Paper No.* **68—APM-10,** pp. 333-341 (June 1968).

Key words: Longitudinal modes; theory of symmetric deformations of plates; thickness-shear modes; thickness-stretch modes; variational equations frequency as wave numbers; vibrations of square bars.

Variational equations of motion are developed for symmetric motions of linear elastic bars of rectangular cross-section. In the finite term approximation, sufficient terms are retained to allow a longitudinal mode, two thickness-stretch modes, and two thickness-shear modes of vibration in an infinite bar of square cross-section. Modes for complex wave numbers are also investigated. Adjustment factors in the strain energy and kinetic energy potentials are used to match exact and experimental solutions. Experimental frequency vs wave number results for four modes are reduced by Fourier synthesis and compared both to the approximate theory and to the exact solution for circular cylinders. Theory is intended to predict behavior of thick rectangular bars for which the plane stress solution is not accurate.

10754. Hiza, M. J., Heck, C. K., Kidnay, A. J., **Liquid-vapor and solid-vapor equilibrium in the system hydrogen-ethane,** (Proc. 1967 Cryogenic Engineering Conf., Stanford University, Stanford, Calif., Aug. 21-23, 1967), Chapter in *Advances in Cryogenic Engineering* **13,** 343-356 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Ethane; hydrogen; hydrogen-ethane system; liquid-vapor equilibrium; low temperature phase equilibrium; solid-vapor equilibrium; solubility of hydrogen in liquid ethane.

Equilibrium gas phase compositions in the system hydrogen-ethane were measured for nine isotherms from 83° to 190 °K up to 150 atmospheres; equilibrium liquid phase compositions were measured for six of the isotherms from 108° to 190 °K. Gas phase compositions up to 130 °K were measured in a single-pass solid-vapor apparatus using continuous analysis with a hydrogen flame ionization detector. The remainder of the measurements were made in a vapor-recirculating liquid-vapor apparatus using chromatographic analysis with a thermal conductivity detector.

Isobaric comparison of enhancement factors, $y_1\pi/p_{01}$, shows the gas phase data obtained by the two methods to be in excellent agreement. These data are in excellent agreement with the gas phase data of Williams and Katz at 185.93 °K. However, the only gas phase data of Williams and Katz below the normal boiling point of ethane (184.52 °K) at 144.26 °K appear to be as much as 25 percent too high in the concentration of ethane. The liquid phase data are generally higher in hydrogen concentration than the data of Williams and Katz by little more than the combined experimental errors. Very poor agreement was found with the older gas and liquid phase data of Levitskaya from 158.15° to 188.15 °K. The present investigation provides the only gas phase data in the region of the ethane triple point, 89.89 °K.

10755. Hummer, D. G., **Radiative transfer processes in planetary nebulae,** (Proc. Intern. Astronomical Union, Symp. No. 34, Tatranska Lomnica, Czechoslovakia, Sept. 4-8, 1967), Chapter in *Planetary Nebulae*, D. E. Osterbrock and C. R. O'Dell, eds., pp. 166-184 (D. Reidel Publ. Co., Dordrecht, Amsterdam, The Netherlands, 1968).

Key words: Balmer lines; Lyman continuum; non-coherent scattering; optical depth; planetary nebulae; radiative transfer; velocity gradients.

The physical aspects of radiative transfer processes that may be of importance in planetary nebulae are discussed and recent work on these problems is summarized.

10756. Ito, J., **Silicate apatites and oxyapatites,** *Am. Mineralogist* **53,** 890-907 (May-June 1968).

Key words: Condensation; field emission; hydrogen; molecular beam; tungsten.

Various synthetic compounds of the silicate apatite group which are isomorphous with the minerals abukumalite, beckelite, britholite and lessingite were investigated. Three different types were synthesized hydrothermally at temperatures from 550 °C to 720 °C under 2 kilobars pressure: $(Ca, Sr, Ba, Pb, Mn \text{ and } Cd)^{2+}{}_4\ (Ln, Y)_6{}^{3+}Si_6O_{24}(OH)_2$, $(Na, Li)_2\ (Ln, Y)^{3+}{}_8Si_6O_{24}(OH)_2$ and $Na_2Ca_X\ (Ln, Y)_{8-X}Si_{6-X}P_XO_{24}(OH)_2$, $X = 0$ to 6.

Complete solid solution exists between hydroxyapatite, $Ca_{10}P_6O_{24}(OH)_2$, and $Ca_4Y_6Si_6O_{24}(OH)_2$ (abukumalite). Unit cell dimensions of all compounds and indexed x-ray powder data of the typical end compounds are tabulated.

Anhydrous silicate apatite, oxyapatites with the probable formulae $M^{2+}{}_2\ (Ln, Y)^{3+}{}_8Si_6O_{26}$ and $M^{1+}{}_1\ (Ln, Y)^{3+}{}_9Si_6O_{26}$, and more generally $(M^{1+}, M^{2+}, Ln, Y \text{ and } Th^{3+})_{10}\ (Si, P \text{ and } B)_6O_{26}$ were prepared at temperatures from 950 °C to 1260 °C in air. The following solid solution systems of oxyapatite were established: $Ca_2La_8Si_6O_{26} \rightleftharpoons Ca_8La_2P_6O_{26}$, $Ca_2Y_8Si_6O_{26} \rightleftharpoons Ca_iY_2P_6O_{26}$, $Pb^{4+}{}_3Pb^{2+}{}_5Y_2Si_6O_{26} \rightleftharpoons Pb^{2+}{}_2Y_8Si_6O_{26}$, and $Mg_2Y_8Si_6O_{26} \rightleftharpoons Y_{10}Si_4B_2O_{26}$.

Results of the infrared spectroscopic analysis, water determination by two different methods and differential thermal analysis of selected compounds all agree well with the presence of OH in silicate apatite and its absence in oxyapatite.

$NaLa_9Si_6O_{26}$ was obtained as transparent needles up to ~0.2 mm by the slow cooling of the flux (Na_2WO_4) from 1,150 °C to 750 °C. Euhedral transparent crystals of $Na_2La_8Si_6O_{24}F_2$ up to 6 mm were grown by the combination of slow cooling and evaporation of the flux (NaF) at temperatures from 1350 °C to 900 °C.

New fluorescent yttrium and gadolinium analogues of oxyapatites, activated by europium and terbium, were prepared.

10757. Jackson, J. L., Coriell, S. R., **Transport coefficients of composite materials,** *J. Appl. Phys.* **39,** No. 5, 2349-2354 (Apr. 1968).

Key words: Composite material; dielectric constant; diffusion constant; electrical conductivity; eutectic; heat conductivity; magnetic permeability; transport coefficient.

The problem of the effective electrical conductivity of a composite material whose local conductivity is a function of position is treated. Using the analogy between this problem and the diffusion of ions in a periodic potential, upper and lower bounds are obtained for the effective conductivity. These bounds are shown to be the conductivities obtained in certain commonly used equivalent circuit approximations. Although the discussion in the paper is in terms of the electrical conductivity, the theory is equally applicable to many transport coefficients, e.g., the heat conductivity, magnetic permeability, dielectric constant, or diffusion constant.

10758. Johannesen, R. B., Candela, G. A., Tsang, T., **Jahn-Teller distortion: magnetic studies of vanadium tetrachloride,** *J. Chem. Phys.* **48,** No. 12, 5544-5549 (June 15, 1968).

Key words: Jahn-Teller distortion; ligand field; magnetic susceptibility; paramagnetic relaxation; paramagnetic resonance; vanadium tetrachloride.

Paramagnetic resonance of polycrystalline VCl_4 diluted with $TiCl_4$ has been observed near 9, 24, and 36 GHz below 9 °K. Both g-values and hyperfine A-tensors are axially symmetric and temperature independent with the same principal axes: $g_{\|}=1.920$, $g_{\perp}=1.899$, $|A_{\|}|=72$ G, $|A_{\perp}|=120$ G. The average g-value obtained from susceptibility data is in agreement with the resonance value. The paramagnetic relaxation time T_1 varies with temperature as shown by the relation $T_1 = 2 \times 10^{-9} \exp(25/T)$, indicating the presence of a potential barrier approximately 18 cm^{-1} in height. The results indicate a static Jahn-Teller distortion, but with large zero-point vibrations. This situation is in between Ballhausen-de Heer's ligand field and Ballhausen-Liehr's crystal field calculations.

10759. Kidnay, A. J., Hiza, M. J., Dickson, P. F., **The adsorption isotherms of methane, nitrogen, hydrogen and their mixtures on charcoal at 76 °K,** (Proc. 1967 Cryogenic Engineering Conf., Stanford University, Stanford, Calif., Aug. 21-23, 1967), Chapter in *Advances in Cryogenic Engineering* **13,** 397-408 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Adsorption; charcoal; hydrogen; isotherms; methane; mixture adsorption; nitrogen.

The pure component adsorption isotherms of nitrogen, methane, and hydrogen were measured at 76 °K and in the pressure range of 0.19 to 13.5 mm Hg, 0.082 to 6.808 mm Hg and 1.45 to 95.00 atm, respectively. Binary adsorption isotherms for mixtures of 340 ppm nitrogen, 1450 ppm nitrogen, 352 ppm methane, and 770 ppm methane in hydrogen were measured at 76 °K and in the pressure range of 5 to 82 atm. A ternary isotherm for a mixture of 415 ppm methane + 686 ppm nitrogen in hydrogen was also determined in the pressure range of 6 to 48 atm.

The empirical adsorption enhancement factor may be used in conjunction with the pure component isotherms to predict the adsorption of nitrogen and methane from the binary gas mixtures with an accuracy that should be sufficient for most engineering calculations. The adsorption of nitrogen and methane from the ternary gas mixtures can be predicted quite accurately through the use of the prediction technique proposed by Kidnay and Myers.

10760. Klein, R., **The deposition of hydrogen beams on tungsten,** *Surface Sci.* **11,** No. 2, 227-241 (July 1968).

Key words: Condensation; field emission; hydrogen; molecular beam; tungsten.

The deposition and chemisorption of hydrogen on tungsten have been investigated with a molecular beam apparatus to which a field emission microscope is attached. The FEM is operated immersed in liquid helium. The surface temperature of both the surface on which the deposition is made, and the beam, can be varied independently. Advantage is taken of the formation of a sharp boundary line after spreading on a shadowed emitter to evaluate the effect of beam temperature on the condensation process. There is a very marked effect which suggests that the deposition depends on a critical velocity for the hydrogen molecule in the beam. This effect is found only for the second layer where the adsorption forces are relatively weak. The course of the deposition in the first layer can be followed from the characteristics of the electron emission from the tip as coverage proceeds.

10761. Klemens, P. G., Jackson, J. L., **Diffusion of electrons on the Fermi surface. II. Longitudinal magnetoresistance of 1b metals,** *Physica* **31,** 1421-1427 (1965).

Key words: Fermi surface; high-field magnetoresistance; magnetoresistance.

Following Pippard the longitudinal high-field magnetoresistance is discussed in terms of belts on the Fermi sphere on which the deviation of the electron distribution from equilibrium must vanish. For the ideal resistance case the electron diffusion equation is solved with appropriate boundary conditions for a number of directions and neck radii, and the magnetoresistance is pointed out.

10762. Kopec, C. S., **Measurement of gears,** Chapter 15 in *Handbook of Industrial Metrology,* pp. 424-450 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Analytical inspection; composite inspection; gears; index; involute; lead; metrology; process control.

This chapter contains 26 pages of information on gear measuring methods, practices and basic definitions. The data presented cover only those practices and inspection methods which are recognized and accepted throughout the gear industry as being reliable. The methods described provide measurements which are accurate and repeatable to a degree compatible with the specified quality. Experienced personnel, using calibrated instruments in suitable environment, are required. Process control is the method by which gear accuracy is maintained through control of manufacturing equipment, methods, and processes. When analytical inspection of gear elements is required, methods are described for measuring the following tooth elements: runout, pitch, profile, lead, backlash, tooth thickness and composite method of gear inspection.

10763. Kokoszka, G. F., Allen, H. C., Jr., Gordon, G., **Electron paramagnetic resonance spectra of two zinc-doped and nickel-**

doped copper chloride pyridine-N-oxide complexes, *J. Chem. Phys.* **46,** No. 8, 3020-3024 (Apr. 15, 1967).

Key words: Copper chloride-pyridine-N-oxide; copper-nickel pairs; copper-zinc pairs; e.p.r. pair spectra; magnetic resonance.

The electron paramagnetic resonance spectra of zinc-doped dichlorobispyridine-N-oxidecopper(II) $[(C_5H_5NO)_2Cu(Zn)Cl_2]$ and zinc-doped dichloromonoaquopyridine-N-oxidecopper(II) $[C_5H_5NOCu(Zn)Cl_2 \cdot H_2O]$ have been observed at liquid nitrogen temperature. The data could be fit to the usual $S = 1/2$ Spin Hamiltonian. The g values obtained in this study for the copper-zinc pairs agree with the g values obtained for the copper-copper pairs in the pure material to within experimental uncertainty. Copper hyperfine splitting and chlorine superhyperfine splitting were also observed. The magnetic parameters for $(C_5H_5NO)_2Cu(Zn)Cl_2$ are $g_z = 2.332$, $g_x = 2.056$, $g_y = 2.080$, $A_z = 129 \times 10^{-4}$ cm^{-1}, $A_x = A_y < 10 \times 10^{-4}$ cm^{-1}, $A' = 25 \times 10^{-4}$ cm^{-1}, and $B' = 7 \times 10^{-4}$ cm^{-1}, while for $C_5H_5NOCu(Zn)Cl_2 \cdot H_2O$ we obtain $g_z = 2.306$, $g_x = 2.056$, $g_y = 2.083$, $A_z = 139 \times 10^{-4}$ cm^{-1}, and $A_x = A_y < 10 \times 10^{-4}$ cm^{-1}. An analysis of the data using a simple LCAO-MO approach suggests relatively strong metal-ligand bonds.

The data obtained from the study of nickel-doped $(C_5H_5NO)_2CuCl_2$ could be dit to an $S = 1/2$ Spin Hamiltonian with the following magnetic parameters: $g_z = 2.14$, $g_x = 2.54$, $g_y = 2.49$, $A_z = 35 \times 10^{-4}$ cm^{-1}, and $A_x = A_y < 7 \times 10^{-4}$ cm^{-1}. For nickel-doped $C_5H_5NOCuCl_2 \cdot H_2O$ we obtain $g_z = 2.15$, $g_x = 2.61$, $g_y = 2.50$, $A_z = 40 \times 10^{-4}$ cm^{-1}, and $A_x = A_y < 7 \times 10^{-4}$ cm^{-1}. These are the first reported magnetic parameters from dimers which contain exchange coupled dissimilar transition metal ions.

10764. Kruger, J., **The spectrum of corrosion research of the Corrosion Section of the National Bureau of Standards,** (Proc. 12th Annual Appalachian Underground Corrosion Short Course, West Virginia University, Morgantown, West Virginia, Oct. 1967), *West Virginia University Tech. Bull.* **86,** 11-13, (1967).

Key words: Corrosion; National Bureau of Standards.

A non-technical description of the research carried out in the Corrosion Section of the National Bureau of Standards is given.

10765. Lonie, M., **A report on body sizing for boys and students,** *Boys' and Young Men's Apparel Buyers' Assoc. J.*, p. 8 (1967).

Key words: Body sizing standards; boys' size standards; "student" boys'.

Body Sizing Standards are discussed in general and the program involving the development of such standards for "Student" Boys is discussed specifically. Reference is made to the participation of the Boys' and Young Men's Apparel Buyers' Association in the development of this and other standards.

10766. Macek, J. H., **Application of the Fock expansion to doubly excited states of the helium atom,** *Phys. Rev.* **160,** No. 1, 170-174 (Aug. 5, 1967).

Key words: Atomic physics; classification; levels; lifetimes; spectroscopy; theoretical physics.

The origin of the plus and minus character of the ^1P and ^3P doubly excited states of helium which converge to the $n = 2$ level is investigated in the close coupling approximation. It is found that the close coupling wave functions do exhibit the plus and minus character, and that the widths of these states are related to their plus and minus character in the case of the ^1P, but not for ^3P.

10767. Maeda, K., Young, J., **Propagation of the pressure waves produced by auroras,** *J. Geomagnetism Geoelectricity* **18,** No. 2, 275-299 (1966).

Key words: Acoustic modes; auroras; gravity (thermobaric) mode; pressure waves; propagation.

It is shown that the traveling pressure waves associated with auroral activity are not necessarily limited to the acoustic mode, but sometimes extend to the gravity (thermobaric) mode. This is partly due to the existence of large positive lapse rate (i.e. very stable) layers such as in the upper part of the stratosphere and in the thermosphere. As a consequence, clear sinusoidal oscillations which appear occasionally with periods of group velocity minimum (around 5 min) can be ascribed to the Airy phase. As an example, the data obtained at the NBS stations in Washington, D.C. on July 15, 1960 are shown with preliminary results of power spectrum analyses.

10768. Marezio, M., Remeika, J. P., Zocchi, M., **Cation distribution in the garnet $Eu_3Fe_{1.94}Ga_{3.06}O_{12}$,** *J. Chem. Phys.* **48,** No. 3, 1094-1096 (Feb. 1968).

Key words: Single crystal x-ray diffraction; study $Eu_3Fe_{1.94}Ga_{3.06}O_{12}$.

A single crystal x-ray diffraction study of the cation distribution in the garnet $Eu_3Fe_{1.94}Ga_{3.06}O_{12}$ has been made. The greater preference of the Ga^{+3} ions for the tetrahedral sites with respect to the one of the Fe^{+3} ions, already postulated from magnetic measurements, has been confirmed. The fraction of Ga^{+3} ions in tetrahedral site is $f_t = 0.91 \pm 0.03$.

10769. Mulroy, W. J., Kusuda, T., Phillips, C. W., **Survey on digital computer programs for heating and cooling load calculations,** *SICCAP Bull.* **2,** No. 2, 4-8 (May 1968).

Key words: Digital computer programs; energy-usage calculations for buildings; heating and cooling load calculations for buildings.

A summarization is made of findings obtained from a questionnaire sent out to ascertain the current state of activity in development and use of computer programs for calculating the heating and cooling loads of buildings. About 2500 questionnaries were sent out, and 489 replies were received. Sixty-one independently prepared computer programs were identified, the majority being based on the ASHRAE Guide and Data Book method. About 250 other replies came from people interested in such calculations but who have not developed a program for the purpose.

10770. Newman, M., **A bound for the number of cojugacy classes in a group,** *J. London Math. Soc.* **43,** 108-110 (1968).

Key words: Bounds; conjugacy classes; groups; matrix representations.

It is shown that if the group G is of order h and has k conjugacy classes, then $k \geqslant \log \log h / \log 4$.

10771. Odabasi, H., **Spectrum of doubly ionized lanthanum (La III),** *J. Opt. Soc. Am.* **57,** 1459-1463 (1967).

Key words: Fine-structure splitting; hyperfine structure; ionization energy; lanthanum; spectrum.

Sixty-five new spectral lines of doubly ionized lanthanum in the interval from 2000 to 12000 Å are reported. Four newly discovered terms (10s, 9p, 9d, 9f) are given. Fine-structure splittings of 5g, 6g, 7g, and 8g terms are determined, and their peculiar behavior discussed. The hyperfine structure of the $6s^2S_{1/2}$ level is observed to be 1.03 ± 0.10 cm^{-1}. By using the new terms, the previously reported ionization energy is corrected to 154664 ± 15 cm^{-1}. The theoretical values of spin-orbit coupling constants are calculated for the first three elements of the Cs isoelectronic sequence.

10772. Otto, E. M., **Rates of dissociation of Ag_2O_2,** *J. Electrochem. Soc.* **115,** No. 9, 878-881 (Sept. 1968).

Key words: Ag_2O; Ag_2O_2; aqueous potassium hydroxide; dissociation; rates; silver oxides.

The dissociation of Ag_2O_2 into Ag_2O and O_2 has been investigated over the temperature range from 22 to 100 °C for the dry material, for water slurries and for slurries in KOH of concentrations from 1 to 13 molar. The method consisted in measuring the O_2 volume while the dissociation was progressing, and in most cases very smooth curves were obtained when the volume of dry O_2 corrected to 0 °C, 760 torr, per gram of sample was plotted against time. Ag_2O_2 in water had the lowest rate of evolution, dry Ag_2O_2 had an intermediate rate and the high concentrations of KOH solution, such as are used in Ag-Cd cells, had the highest rate. The rates ranged from .0001 to 1.8 ml $hr^{-1}g^{-1}$.

10773. Penner, S., **Handling high-energy high-power electron beams,** *Record IEEE 9th Annual Symp. Electron, Ion and Laser Beam Technology, Berkeley, Calif., May 9-11, 1967,* No. F-79, pp. 50-61 (1967).

Key words: Beam handling; electron accelerators; high power beams.

Linear electron accelerators (linacs) produce high power pulsed electron beams at energies from a few MeV to 20 GeV. These machines are used in a wide variety of industrial and research applications including radiography, food processing, radiation chemistry, and nuclear physics. Linacs are in use which produce electron beam powers of hundreds of kilowatts and average currents of the order of one milliampere. Existing linacs operate as pulsed devices with peak currents in the ampere range and energy per pulse as high as 300 joules. In the larger laboratories multiple target areas are used. The electron beam is guided from the linac to the target areas by complex ion-optical systems employing numerous deflection and focussing magnets. The beam paths are often hundreds of feet long. Beam spot sizes at the target are often required to be as small as one square millimeter. The design of targets, collimators, transmission windows, and absorbers for these high energy beams is dominated by problems associated with the heat load. The most difficult aspects of these problems are the extremely high heat transfer rates required and the metal fatigue problem due to the pulsed nature of the beam.

10774. Rhodes, I., **The importance of the glossary storage in machine translation,** Chapter in *Machine Translation,* A. D. Booth, ed., pp. 431-449 (North-Holland Publ. Co., Amsterdam, The Netherlands, 1967).

Key words: Glossary storage; machine translation; mechanical translation.

It is imperative that the "blueprints" of the entire scheme for Mechanical Translation be completed, before venturing to embark upon the extremely time- and money-consuming task of constructing the accompanying Machine Glossary. Moreover, this gigantic undertaking needs the full cooperation of all competent workers in this field. A brief outline of the NBS scheme, as well as excerpts from the proposed Glossary, are given in order to highlight the reasons for the above assertions.

10775. Rhodes, I., **The mighty man-computer team,** *Blanch Anniversary Volume,* pp. 277-284 (Aerospace Research Laboratories, Office of Aerospace Research, U.S. Air Force, Arlington, Va., Feb. 1967).

Key words: Achievements of automators; automators; electronic machines; failings of automators; human mind; tyro coders.

With the aid of electronic machines, the unsurpassable human brain can attain sublime achievements. We, automators, must first purge ourselves of three failings: the usurpation of the million-dollar instruments by tyro coders; the scandalous waste of time and money by the use of artificial languages; and the mulcting of Government funds by spurious schemes.

10776. Robbins, C. R., **Synthetic $CaTiSiO_5$ and its germanium analogue ($CaTiGeO_5$),** *Mater. Res. Bull.* **3,** 693-698 (1968).

Key words: $CaTiGeO_5$; $CaTiSiO_5$; crystal; mineral; space group; synthetic sphene; x-ray.

Synthetic, anhydrous $CaTiSiO_5$ (sphene) and $CaTiGeO_5$ are monoclinic with lattice constants $a=6.567$, $b=8.723$, $c=7.454$ Å, $\beta=119°52'$ and $a=6.65$, $b=8.92$, $c=7.49$ Å, $\beta=119°45'$ respectively. There are four formula units per cell. Cell dimensions of the silicate are close to those of natural sphene. The space group is $P2_1/n$ as compared with space group $C2/c$ reported for natural minerals of variable composition and general formula $CaTiSiO_4(OH,F,Cl)$. Although x-ray intensities indicate a structural similarity, some of the low-order (h + k odd) reflections of the synthetic crystals are fairly strong, indicating appreciable shifts from the $C2/c$ structure.

10777. Robbins, R. F., Reed, R. P., **Tensile properties of neoprene below the glass transition temperature,** (Proc. 1967 Cryogenic Engineering Conf., Stanford University, Stanford, Calif., Aug. 21-23, 1967), Chapter in *Advances in Cryogenic Engineering* **13,** 252-258 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Glassy state; low temperature; mechanical property; modulus; neoprene; rubber; tensile strength; ultimate strength.

This paper describes tensile tests on two neoprene compounds at low temperatures. The neoprene compounds were chosen to determine the effect of carbon black filler material on the tensile properties below the glass transition temperature. Stress-strain curves were obtained at 4, 76, and 195 °K, and at strain rates between 0.01 and 10 inches per inch per minute. Results include the following: (1) Neoprene was ductile at temperatures 40 °K below the glass transition temperature (T_g); (2) The ultimate strength of the filled neoprene was less than the unfilled below T_g; (3) The ultimate strength of the filled neoprene was lower at 4 °K than at 76 °K; (4) The ultimate strength of neoprene at 195 °K was strain-rate dependent, and the ultimate strength of the filled neoprene showed a maximum at an intermediate strain rate.

10778. Rubin, R. J., **Momentum autocorrelation function of a heavy particle in a finite crystal,** *J. Am. Chem. Soc.* **90,** 3061-3063 (1968).

Key words: Brownian motion; correlation function; lattice dynamics.

The momentum autocorrelation function of a heavy particle in a finite one-dimensional crystal, $\rho_0^{(N)}(\tau)$, is compared with the same function in an infinite crystal, $\rho_0^{(\infty)}(\tau)$, by obtaining an explicit upper bound for the magnitude of the difference, $|\rho_0^{(N)}(\tau)-\rho_0^{(\infty)}(\tau)|$. The precise meaning of the statement that $\rho_0^{(\infty)}(\tau)$ is approximately a simple exponential is reviewed, and precise meaning is given to the statement that $\rho_0^{(N)}(\tau)$ decays exponentially.

10779. Ruch, R. R., DeVoe, J. R., **Radiochemical separation of copper by amalgam exchange,** *Anal. Chem.* **39,** No. 11, 1333-1335 (Sept. 1967).

Key words: Activation analysis; amalgam exchange; copper; radiochemical separation.

The technique of amalgam-exchange has been extended to and evaluated for the radiochemical separation of copper. The mercury phase is composed primarily of a finely divided suspension of electrodeposited copper in an extremely dilute solution of copper amalgam. Optimum conditions for separation are presented. The effect of some chemical interferences such as acids and salt have been observed. The evolved procedure has been evaluated for overall yield, precision, and decontamination. Generally recoveries greater than 98 percent may be obtained with better than 1 percent precision, accompanied by good decontamination ($> 10^5$) for most elements above copper in the electromotive series. This technique has been successfully applied to the activation analysis of low copper concentrations in NBS Standard Reference Material cast iron and magnesium alloy.

10780. Sadowski, W. L., **On some aspects of the eigenfunction expansion of the solution of the nonlinear Vlasov equation,** (Proc. Computer Simulation of Plasma and Many-Body Problems, Williamsburg, Va., Apr. 19-21, 1967), *Natl. Aeronaut. Space Agency Spec. Publ.* **153,** 433-440 (1967).

Key words: Eigenfunction; Landau damping; non-linear; numerical solution; plasma physics; truncation; Vlasov equation.

The non-linear Vlasov equation governing a one-dimensional periodic plasma was solved numerically. The solutions were expanded into a double set of eigenfunctions. The x-dependence of the distribution function was expressed by Fourier series, while Hermite polynomials were used to express the v-dependence. These two sets are eigenfunctions of the differential operators and the partial differential equation reduces to an ordinary differential equation on a matrix of expansion coefficients.

Some of the results are discussed as well as the closure problems arising from the attempts to represent an infinite expansion in terms of a finite matrix. The effect of the Fokker-Planck term or the detailed description of particle trapping and on Landau damping is also discussed.

10781. Schafft, H. A., **Avoiding second breakdown,** *Proc. XIII Intern. Scientific Congress on Electronics, Rome, Italy, June 1966,* pp. 119-130 (Rassegna Internazionale Elettronica Nucleare Teleradiocinematografica, Rome, Italy, 1966).

Key words: Electronics; failure mechanism; p-n junctions; reliability; second breakdown; transistors.

The problems that are encountered in avoiding second breakdown are discussed; they appear in three areas: (1) the design and fabrication of the transistor, (2) the specification of operations free of second breakdown, and (3) the interpretation of these specifications. In order to minimize the second breakdown problem in the transistor, it is vital that non-uniformities in the current density be minimized. The implications of this requirement to the design and fabrication of the transistor are considered. Generally the specifications that have appeared in data sheets are meant to apply to one of three types of operations: forward base drive operation, reverse base drive operation with a clamped inductive load, and reverse base drive operation with an unclamped inductive load. These specifications are examined to help the circuit designer to recognize the intent and limitation of a given specification and to interpret the specification for his particular application.

10782. Schindler, P. W., **Heterogeneous equilibria involving oxides, hydroxides, carbonates and hydroxide carbonates,** (Proc. Symp. Division of Water, Air, and Waste Chemistry, 151st Meeting of the American Chemical Society, Pittsburgh, Pa., Mar. 1966), Chapter in *Equilibrium Concepts in Natural Water Systems, Advances in Chemistry Series* **67,** 196-221 (American Chemical Society, New York, N.Y., 1967).

Key words: Carbonates; equilibria; hydroxide carbonates; hydroxides; oxides; sea water; solubility.

Part I discusses the experimental determination and graphical presentation of equilibrium data. . Some emphasis is placed on the connection between "thermodynamic" constants (referring to pure water as standard state) and "stoichiometric" constants relating to aqueous solutions of constant ionic strength. Part II compares equilibria in stable and metastable systems. Recent experimental work on the effect of particle size upon solubility is summarized, and the changes of solubility in the presence of metastable modifications is discussed. An attempt is made to classify some major and minor constituents of sea water with respect to a possible control of their concentrations by simple solubility equilibria.

10783. Schwerdtfeger, W. J., **Discussion of the paper "Method of estimating corrosion of highway culverts by means of polarization curves," by R. I. Lindberg,** *Highway Research Record No. 204, Metal Corrosion, Publ.* **1535,** p. 8 (Natl. Acad. Sci.—Natl. Res. Council, Washington, D.C., 1967).

Key words: Corrosion; corrosive soil; highway culverts; polarization curves; underground aluminum culverts.

The corrosion rate data obtained by Lindberg on actual underground aluminum culverts are evaluated on the basis of proven data obtained by the National Bureau of Standards upon which Lindberg's work is based. NBS polarization curves are also presented to show how a corrosive soil can be differentiated from a relatively non-corrosive soil.

Comments are made pertaining to the measuring circuit used in obtaining the polarization curves.

10784. Shapiro, J. T., Madden, R. P., **On the optical constants of polystyrene in the vacuum ultraviolet,** *J. Opt. Soc. Am.* **58,** No. 6, 771-775 (June 1968).

Key words: Optical constants; polystyrene; reflectance electron energy loss; vacuum ultraviolet.

The optical constants n and k for polystyrene in both thin film and bulk form have been measured by the reflectance vs angle of incidence technique in the wavelength region from 584 Å to 2000 Å. Four angles of incidence were used, and the effects of monochromator polarization were eliminated experimentally. The results differ from previously published data for the bulk form. The energy loss function $-\mathrm{Im}(1/\epsilon)$ was calculated from n and k determined for the thin films and compared with values obtained previously by characteristic electron energy loss techniques. These two methods yield the same structure in the energy loss function; however there remains some difference in the magnitude of the 6.9 eV loss relative to the background.

10785. Shideler, R. W., **Interfacing a teletypewriter to nuclear instruments used for computer-coupled activation analysis,** *Proc. 1965 Intern. Conf. Modern Trends in Activation Analysis, College Station, Texas, Apr. 1965,* pp. 236-242 (1965).

Key words: Digital instruments; digital multichannel pulse-height analyzer; multichannel analyzers; nuclear instruments; teletypewriter.

In performing activation analysis using modern digital instruments the volumes of numerical data dictate that an expedient data handling system be used.

The primary concern of this paper is to discuss the techniques and actual designs involved in the interfacing of a teletype to a digital multichannel pulse-height analyzer and to an automatic sample changer.

Two separate designs are discussed for interfacing to the multichannel analyzers. The first involves only minor changes to the analyzer. The second provides interfacing with no modification to the standard analyzer, and includes the additional capability of reading precursor data from external units including a time-of-year clock and programmed data groups. These additional data are included in the output format along with the analyzer data and serve to identify the data as well as to instruct the computer in its subsequent analysis.

Of primary importance in this paper is a discussion of the merits and advantages to be found in adopting the use of the teletype machine as an input-output device. As well as providing typed copy, it will punch and read a paper tape coded in the new ASCII code. The automatic inclusion of precursor data and an appropriate readout format brings on-line computer operation to a reality.

10786. Shimizu, A., **Calculations of the penetration of gamma rays through slabs by the method of invariant imbedding,** *Nucl. Sci. Eng.* **32,** 184-194 (May 1968).

Key words: Angular distributions; energy spectrum; gamma rays; invariant imbedding; shielding; transport.

The method of invariant imbedding has been applied to the penetration problem of gamma rays through slabs. The accuracy of the method was examined by comparison with other reliable calculations and proved to be competitive with other well developed methods. The method has the advantages that it is much more efficient than the Monte Carlo method and that it is readily applicable to the multi-layer problems. An extensive series of calculations on the transmission of gamma rays through homogeneous slabs was carried out. The energy and angular distributions of transmitted photons from mono-energetic and oblique sources were obtained for slab thickness up to fifteen mean free paths and for seven materials. The results of calculations were compared with experiments.

10787. Shimizu, A., **Calculation of the penetration of gamma rays through two-layer slabs,** *Nucl. Sci. Eng.* **32,** 385-391 (June 1968).

Key words: Dose transmission; gamma-rays; invariant imbedding; penetration; transport theory; two-layer slabs.

The method of invariant imbedding has been applied to the penetration problem of gamma rays through two-layer slabs, and turned out to be accurate and less time consuming than the Monte Carlo method. A series of calculations were made for two-layer slabs of water, iron and lead for plane oblique sources. An approximate formula for synthesizing the buildup factor of a composite slab from those of elementary layers is derived from numerical solutions by modifying the formula originally proposed by Kalos.

10788. Shuler, K. E., **Reaction cross sections, rate coefficients and nonequilibrium kinetics,** (Lecture, NATO Summer School on Theoretical Chemistry, Constance, Germany, Summer 1965), Chapter in *Chemische Elementarprozesse*, H. Hartmann, ed., pp. 1-22 (Springer-Verlag, Berlin, Germany, 1968).

Key words: Cross sections; nonequilibrium kinetics; rate coefficients; reaction cross sections.

The observed rate of a chemical reaction is usually expressed through an empirical equation involving the concentration of reactants and/or products and a proportionality constant k, the *rate coefficient*. This rate coefficient is determined experimentally from measurements of the change of concentration of reactants and/or products with time. If the empirical rate equation correctly describes, *in all aspects*, the reaction under investigation, the rate coefficient should be independent of the concentration of the reactants and/or products and of the time and should depend only upon the temperature of the (isothermal) reaction system.

Recent advances in experimental techniques permit the measurement of the "efficiency" of elementary chemical collision processes leading to product formation as a function of the energy of the reactants (kinetic and internal) and the geometry of the encounter. The results of these measurements are expressed as *reaction cross sections*, σ_R. It is the purpose of these lectures to explore the relation between the macroscopic rate coefficient k and the microscopic reaction cross section σ_R.

10789. Silverman, S., **Reflections on bioengineering,** (Proc. Symp. Engineering Significance of the Biological Sciences, Pittsburgh, Pa., Jan. 25-27, 1967), Chapter in *Bioengineering—An Engineering View,* pp. 103-106 (San Francisco Press Inc., San Francisco, Calif., June 1968).

Key words: Bioengineering; budgetary environment; social needs; technology; trends in science.

The role of Bioengineering in the contemporary scene is examined. The conviction is expressed that there is a real need for such an interdisciplinary development at this time. It is pointed out that Bioengineering must compete with other well-entrenched trends in science and technology in a budgetary environment that calls for thorough analysis and justification. There is, however, good evidence that the social needs should draw the necessary interest of gifted and competent people, and therefore sufficient Federal interest to support a growing program.

10790. Smith, G. W., Becker, D. A., **Preparation of an NBS biological standard reference material for trace elemental analysis,** *Proc. Nuclear Activation Techniques in the Life Sciences, Amsterdam, The Netherlands, May 8-12, 1967,* pp. 197-207 (International Atomic Energy Agency, Vienna, Austria, 1967).

Key words: Activation; analysis; biological; blood; bone; botanical; destructive; homogeneity; leaves; liver; neutron; non-destructive; reference; tissue; trace; variance.

A survey of leading U.S. biological, medical and forensic laboratories confirms the need for well characterized botanical, soft mammalian tissue, bone tissue and blood standards with elemental constituents at the 100 ppm level and below. The only sources of dried and sterilized tissue and blood known to the authors are certain U.S. drug concerns, whereas H. J. M. Bowen's kale has only been available since 1964 as a botanical comparison sample.

Before reliable analytical data can be obtained on a reference material, homogeneity must be established. Examples are given of this procedure, which is carried out routinely by the NBS on Standard Reference Materials. Homogeneity of Bowen's kale for chlorine (~4000 ppm), manganese (~14 ppm) and copper (~6 ppm) as well as for manganese in beef liver (~10 ppm) citrus leaf (~28 ppm) and oak leaf (~1000 ppm) are given. Measurements were made by neutron activation analysis both with and without chemical separation, using a Ge(Li) semiconductor detector. This technique was also used for the quantitative determination of the trace constituents chlorine and manganese, nondestructively. In addition, a destructive method was used for the elements arsenic and copper.

Analyses of variance, using the activation analysis data, indicate that all of the biological materials except the citrus leaves are homogeneous. Therefore, preparation under contract, of large lots of deciduous leaves and beef liver, will begin. Analyses for homogeneity and elemental content certification will be made by NBS activation analysis and other analytical competencies.

10791. Spijkerman, J. J., Ruegg, F. C., May, L., **The use of Mössbauer spectroscopy in iron coordination chemistry,** Chapter in *Mössbauer Effect Methodology* **2,** 85-93 (Plenum Press Inc., New York, N.Y., 1966).

Key words: Interpretation of chemical shift; iron coordination chemistry; Mössbauer spectroscopy; quadrupole splitting.

The application of Mössbauer Spectroscopy to the study of iron coordination chemistry is discussed. The chemical shifts of iron compounds are adjusted to the new standard, sodium nitroprusside, and this differential chemical shift is correlated with the 4s electron contribution to the bonding in the compounds. A new interpretation of the chemical shift—4s electron contribution diagram is proposed including the latest results of Molecular Orbital calculations. The quadrupole splitting is related to the total spin and structure of the compound. The asymmetry of the doublet intensities can be used to obtain additional information about the structure of the compound and the spin-spin relaxation time. The relationships between the Mössbauer parameters and the data from other spectroscopic measurements are discussed.

10792. Stevens, M. E., **Information scientist, H. P. Luhn,** Chapter in *H. P. Luhn: Pioneer of Information Science—Selected Works,* C. K. Schultz, ed., pp. 24-30 (Spartan Books, New York, N.Y., 1968).

Key words: Auto-encoding; automatic abstracting; automatic indexing; KWIC indexing; Luhn; selective dissemination systems.

The contributions of H. P. Luhn to information science and technology, in the development of KWIC *k*ey-*w*ords-*i*n-*c*ontext (KWIC) indexing and of selective dissemination of information (SDI) systems, in "auto-encoding" principles for both automatic indexing and abstracting, and in other ways, are reflected not only in selected papers but in experimental demonstrations and in reductions to practice. In addition, he provided leadership for the American Documentation Institute in such areas as novel techniques for the preparation and advance distribution of Conference papers and the establishment of Special Interest Groups.

10793. Suzuki, G., **Quantitative methods for decision making,** Chapter VIII in *Management: Concepts and Practices,* F. R. Brown, ed., pp. 155-193 (Industrial College of the Armed Forces, Washington, D.C., 1967).

Key words: Decision-making; education; management; operations research; quantitative analysis.

An elementary treatment of some of the better known and widely used analytical methods in operations research/systems analysis. The material is presented in a manner which attempts to indicate why quantitative methods are useful in managerial decision-making situations. Some basic references are provided.

10794. Truesdell, C., **The non-linear field theories of mechanics,** *Encyclopedia of Physics* **III,** Part 3, 602 pages (Springer-Verlag, Berlin, Germany, 1965).

Key words: Elastic strain; field theories; finite elastic strain; mechanical response; mechanics.

This treatise presents an organized development of theories of mechanical response of materials subject to large deformations. It contains as one of its chapters an exposition of everything now known about the general theory of finite elastic strain.

10795. Tschuikow-Roux, E., **Photolysis of propene at 1470 Å,** *J. Phys. Chem. Note* **71,** 2355 (1967).

Key words: Photolysis; propylene; vacuum ultraviolet.

The photolysis of propylene at 1470 Å has been reexamined with the following new results. (1) Evidence is presented for the reaction

$$C_3H_6^* \rightarrow 2H + C_3H_4$$

(2) The previously postulated, but unidentified intermediate, methylcyclopropane (from the reaction of CH_2 with propylene), has been identified in the reaction products. Some basic references are provided. (3) The molecular elimination of hydrogen from the methyl group in propylene produces allylidene which may either isomerize to form allene and propyne or cyclyze to form cyclopropene. The latter was shown definitely to be absent and that isomerization of allylidene dominates over cyclization.

10796. Ugiansky, G. M., Ellinger, G. A., **Corrosion of Monel 400 in high CO_2 well water,** *Corrosion* **24,** No. 5, 134-136 (May 1968).

Key words: Corrosion; dezincification; electron probe microanalysis; Monel.

The dezincification type corrosion of a Monel well screen in natural water is discussed in detail. The second phase present in the corroded grain boundaries was determined by electron probe microanalysis to be nearly pure copper with little or no nickel present. It is concluded that Monel may be susceptible to dezincification type corrosion when used in certain environments.

10797. Ugiansky, G. M., Skolnick, L. P., Kruger, J., Stiefel, S. W., **Rate-controlling step in stress corrosion cracking,** *Nature* **218,** No. 5147, 1156-1157 (June 22, 1968).

Key words: Aluminum alloys; crack initiation; crack propagation; rate-controlling step; stress corrosion.

Experimental evidence is reported which shows that crack propagation, rather than crack initiation, is the rate limiting step in the intergranular stress corrosion of the high strength aluminum alloy 7075-T651. The directional susceptibility of certain aluminum alloys is explained on the basis of the crack propagation in an elongated grain structure.

10798. Utech, H. P., Early, J. G., **On the presence of thermal convection in the kinetics experiments of Rigney and Blakely,** *Acta Met.* **15,** No. 7, 1238-1239 (1967).

Key words: Interface; kinetics; thermal convection; thermal wave; tin; turbulence.

An experiment was conducted to test for the presence of thermal convection in the horizontal tube system employed by Rigney and Blakely to determine the interface kinetics of tin by the thermal wave technique. Thermal convection was found to be present.

10799. Utech, H. P., Parker, R. L., Early, J. G., Coriell, S. R., **The cam equation for a thermal-wave generator,** *J. Appl. Phys.* **38,** No. 9, 3799-3800 (Aug. 1967).

Key words: Cam; equation; generator; sine wave; thermal diffusivity; thermal-wave.

The cam equation for sinusoidal thermal-wave generator is derived, correcting an equation previously reported in the literature by Abeles, Cody, and Beers.

10800. Waclawski, B. J., Hughey, L. R., Madden, R. P., **Effect of oxygen adsorption on the photoelectron yield from tungsten in the vacuum ultraviolet,** *Appl. Phys. Letters* **10,** No. 11, 305-307 (June 1968).

Key words: Oxygen adsorption; photoelectric effect; tungsten; vacuum ultraviolet.

The effect of adsorbedd oxygen on the photoelectron yield of bulk polycrystalline tungsten was studied at photon energies of 7.7, 10.2, 11.8, 16.9, and 21.2 eV. Use of ultra-high vacua $\sim 3 \times 10^{-10}$ torr ensured sample cleanliness prior to oxygen exposure. The photoelectron yield decreases with oxygen exposure because of the increase in the electronic work function of the tungsten photocathode. However, at $h\nu = 21.2$ eV, an increase in photoelectron yield with oxygen exposure also appears and is believed to be due to photoelectron emission from the adsorbed oxygen atoms.

10801. Wahsweiler, H. G., Greiner, W., Danos, M., **Continuum nuclear structure of O^{16} in the Eigenchannel Reaction Theory,** *Phys. Rev.* **170,** No. 4, 893-906 (June 20, 1968).

Key words: Continuum states; coupled channels; interacting continua; nuclear structure; O^{16}; photo absorption.

The total particle-particle S^J-matrix of O^{16} for spin $J = 1^-$ and excitation energies between 15 and 27 MeV has been calculated in the Eigenchannel Reaction Theory for several parameters of the Saxon-Woods potential and the two-body force. The many-body problem has been treated in the one-particle one-hole approximation. The photon channels have been included by perturbation theory. Surprisingly, the most important structure of the experimental cross sections is reproduced quite well in this simple approximation.

10802. Wang, F. E., DeSavage, B. F., Buehler, W. J., **The irreversible critical range in the TiNi transition,** *J. Appl. Phys.* **39,** No. 5, 2166-2175 (Apr. 1968).

Key Words: Covalent; delocalized; electronic conduction; Hall effect; localized; magnetic susceptibility; martensitic transition; order-disorder; phase transformation; resistivity.

Through an investigation of the transport and other related thermodynamic properties of TiNi at and around its "martensitic" transition temperature, the existence of a critical range extending over a 60 degree interval is characterized. Within this critical range, phase transition is second-order with anomalous heat capacity changes. Irreversibility of various properties within the critical range is interpreted in terms of irreversible shear movement of atoms.

By inference, based on transport data, the band structure of TiNi is a single or "nearly" single positive band within the temperature range investigated. The postulate that part of the valence electrons undergo a "covalent" ↔ "conduction" electronic state transformation, in the course of the 60 degree interval second-order transition, is consistent in large measure with experimental data.

10803. Weisman, H. M., **Information and the discipline of communication sciences,** (Proc. American Documentation Institute Annual Meeting, New York, N.Y., Oct. 22-27, 1967), Chapter in *Levels of Interaction Between Man and Information* **4,** 8-12 (Thompson Book Co., Washington, D.C., 1968).

Key words: Communication; communication sciences; documentation; information; information science.

This paper discusses the place of information in the field of communications. Documentation, information science, information, and communication are defined. The study of communication intersects many fields. Some of the significant fields within the communication sciences are identified. As a basic component of communication, information science has the major problems that have prevented cohesion and unification of the diverse fields that comprise communication. The happenstances that have created professional practitioners in information sciences are too haphazard to meet constantly growing requirements. Recommendations are made to develop a discipline of communication sciences through university academic programs.

10804. Weitzel, D. H., Sindt, C. F., Daney, D. E., **Hydrogen slush density reference system,** (Proc. 1967 Cryogenic Engineering Conf., Stanford University, Stanford, Calif., Aug. 21-23, 1967), Chapter in *Advances in Cryogenic Engineering* **13,** 523-533 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Densitometer; density reference system; liquid hydrogen; nuclear radiation attenuation; slush hydrogen.

A hydrogen slush density reference system has been designed for calibration of field-type instruments and/or transfer standards. The device is based on the buoyancy principle of Archimedes. The solids are weighed in a light-weight container so arranged that solids and container are buoyed by triple-point liquid hydrogen during the weighing process. Nuclear radiation attenuation is considered as the most likely candidate for a transfer standard, and preliminary results obtained with a NRA densitometer are presented. The densitometer was used as an aid to determine pressure drop data for various slush hydrogen concentrations.

10805. Winogradoff, N. N., Kessler, H. K., **Compensation and band tailing effects in high power room temperature GaAs lasers,** *Solid State Commun.* **5,** 155-158 (1967).

Key words: Compensation with donors; expitaxial gallium arsenide lasers; laser characteristics.

A reduction in the density of states of a two level system would facilitate the production of an inverted electron population. Such a low density of states system can be produced by the incorporation of shallow donors into p-type material in such concentrations that mergence of the impurity bands with the intrinsic bands result in the formation of "tails" of states at the bottom and top of the intrinsic conduction and valence bands respectively.

The low density of states in these tails results in low room temperature thresholds, negligible time delays between the leading edge of the current pulse and the onset of lasing and high peak power outputs.

The behaviour of a series of vapour phase, epitaxially formed, p-n junctions with and without compensation will be discussed and recent achievements in high power outputs with compensated lasers will be described and correlated with field effect experiments, the results of which show that the enhanced light output in compensated material is not due to radiative transitions between acceptor and donor impurity centers.

10806. Yakowitz, H., Vieth, D. L., Heinrich, F. J., Michaelis, R. E., **Homogeneity characterization of NBS spectrometric standards. II: Cartridge brass and low-alloy steel,** (Proc. 14th Annual Conf. Applications of X-ray Analysis, University of Denver, Denver Research Inst., Denver, Colo., Aug. 25-27, 1965), Chapter in *Advances in X-ray Analysis,* G. R. Mallett, M. Fay, and W. M. Mueller, eds., **9,** 289-303 (Plenum Press Inc., New York, N.Y., 1966).

Key words: Electron probe microanalyzer; homogeneity—standards; NBS cartridge brass; NBS low-alloy steel; optical metallography; solids mass spectrometer; standards of composition.

Most modern instrumental methods of analysis depend on the use of known standards of composition for calibration. Newer analytical techniques such as the solids mass spectrometer, laser probe and, especially, the electron probe microanalyzer have reduced the amount of a sample which can be analyzed quantitatively to a range of about 0.1 micrograms to as little as 0.00005 micrograms. Corollary to these microanalytical advances, homogeneity requirements have become severe for the analytical standards. This paper describes a continuation of the NBS effort to more fully characterize existing standards as to suitability for the new microanalytical techniques (1). An NBS cartridge brass sample in both the wrought (NBS-1102) and chill cast forms (NBS-C1102), as well as a low alloy steel sample (NBS-463), have been investigated by means of electron probe microanalysis and optical metallography. Some seventeen elements are contained in the brass while twenty-five elements are in the steel. Results for ten elements in the steel are presented while results for six elements in the brass are given. In the steel, Fe, Ni, Cu, and Si are essentially distributed homogeneously at micron levels while Mn, Ta, Nb, Zr, S, and Cr are not. In the brass, Cu and Zn are distributed homogeneously at micron levels while Pb, S, Al, and Si are not. Electron probe microanalyzer results indicate that both NBS-1102 and NBS-C1102 brass are suitable for use as a calibration standard for electron probe microanalysis as well as other microanalytical techniques such as the solids mass spectrometer. The results for brass have been corroborated by a number of laboratories using the electron probe analyzer.

10807. Yee, K. W., Deslattes, R. D., **Transistorized current stabilizer for x-ray tubes with directly heated cathodes,** *Rev. Sci. Instr.* **38,** No. 5, 637-638 (May 1967).

Key words: Controlled; current; emission; impedance; regulator; stabilizer; x-ray tube.

An instrument is described which stabilizes the emission current in x-ray tubes with directly heated cathodes. Transistors are used in the amplifier and loading circuits. Emission currents from 20 mA to 1 A are maintained constant to within 0.1 percent for periods of about a half-hour.

10808. Yolken, H. T., Kruger, J., **Thermal regeneration of oxide covered iron {100} and {110} surfaces,** *J. Electrochem. Soc.* **114,** No. 8, 796-799 (Aug. 1967).

Key words: Ellipsometer; iron; oxidation; thermal regeneration.

The effects of ultra-high vacuum annealing on thin oxide films grown to a limiting thickness at room temperature on {100} and {110} iron surfaces were studied using an ellipsometer. After vacuum annealing at 400 °C or above, these films grew when reexposed to 1×10^{-5} torr of oxygen at 25 °C. This process could be repeated several times, with the film each time exhibiting a greater limiting thickness until a thickness was reached which could not be appreciably increased by further annealing.

The thermal regeneration of oxide covered iron can be explained by a phase change of the oxide film from Fe_3O_4 to FeO on annealing at about 400 °C or above. Cooling to room temperature causes the reappearance of Fe_3O_4. Thin areas in the oxide film and some enrichment of iron in the film are the results of the phase changes. Concurrently, the adsorbed monolayer of oxygen anions is incorporated into the oxide during annealing.

10809. Yolken, H. T., Kruger, J., Calvert, J. P., **Hydrogen in passive films on Fe,** *Corrosion Sci.* 8, 103-108 (1968).

Key words: γ-Fe_2O_3; iron passivity; tritium.

The use of radiochemical techniques involving tritium has shown that when a passive potential is observed for iron passivated either by immersion in a 0.1N $NaNO_2$ aqueous solution or by anodic polarization in a $Na_2B_4O_7 - H_3BO_3$ aqueous solution (pH 8.4) hydrogen is found in the film formed. By potentiostatic reduction of this film it was found that most of the hydrogen was in the outer layer, which was reducible at potentials less negative than that required to reduce Fe_3O_4. Approximately 0.06 percent hydrogen was found in the outer layer. Besides cathodic reduction, hydrogen could be removed from the film by using chloride ions or lowering the pH.

10810. Younglove, B. A., **Polarizability, dielectric constant, pressure, and density of solid parahydrogen on the melting line,** *J. Chem. Phys.* **48,** No. 9, 4181-4186 (May 1, 1968).

Key words: Dielectric constant; melting pressure; parahydrogen; polarizibility; solid density.

Polarizibilities, calculated from measurements of the dielectric constant, are reported for solid parahydrogen on the melting line between 18 and 320 atmospheres (14.4 to 22.2 °K). Also new melting pressures below 17 °K are presented. Previously reported solid densities are adjusted slightly, using the new resulting pressure data. Liquid parahydrogen polarizibilities were determined over part of the density range of the solid and are seen to be slightly less than the solid polarizibilities.

10811. Zwanzig, R., Lauritzen, J. I., Jr., **Exact calculation of the partition function for a model of two-dimensional polymer crystallization by chain folding,** *J. Chem. Phys.* **48,** No. 8, 3351-3360 (Apr. 15, 1968).

Key words: Chain-folding: equilibrium statistical mechanics; partition function; phase transition; polymer crystals.

A model of two-dimensional polymer crystallization by chain folding is treated by equilibrium statistical mechanics. The Laplace transform of the partition function with respect to the length of the polymer chain is obtained in exact analytical form. The model leads to thermodynamically well defined chain folded crystals. Under certain circumstances in the limit of an infinitely long polymer chain, the model shows a second order phase transition from an "extended chain" crystal to the chain folded crystal.

10812. Weissberg, A., **Data handling systems,** (Proc. Second Conf. Technical Information Center Adminstration, St. David's, Pa., June 14-17, 1965), Chapter 7 in *TICA* **2,** A. W. Elías, ed., pp. 75-89 (Spartan Books, Washington, D.C., 1965).

Key words: Data systems; information handling experts; technical information.

The discussion emphasizes the intellectual organization of data systems and covers briefly the equipment used in such systems. It concentrates on the reason why a particular data system is needed, how it is defined and developed, and the organizational relationships in its development and operation.

The conclusions suggested are that the data system be adequately funded, established on the basis of a well understood need, organized and operated by subject matter specialists, have proper guidance from information handling experts, work within well defined subject and organizational boundaries, and be responsive to the continuing needs of the technical community.

10813. Acquista, N., Abramowitz, S., Lide, D. R., **Structure of the alkali hydroxides. II. The infrared spectra of matrix isolated CsOH and CsOD,** *J. Chem. Phys.* **49,** No. 2, 780-782 (July 15, 1968).

Key words: CsOH; high temperature; infrared: molecular geometry; vibrational assignment.

The infrared spectra of matrix isolated CsOH and CsOD have been observed. Both the CsO stretching mode and the bending mode have been assigned for each isotopic species. ν_1 of CsOH is at 335.6 cm^{-1}, while a value of 330.5 cm^{-1} is found for CsOD. ν_2 is found at 306 cm^{-1} for CsOH and at 226 cm^{-1} for CsOD. The isotope shift observed for ν_2 confirms the essentially linear structure which was indicated by the microwave spectrum.

10814. Ahearn, A. J., Paulsen, P. J., **Workshop on mass spectrometric analysis of solids at the National Bureau of Standards in Gaithersburg, Md., Nov. 18 and 19, 1968,** *Anal. Chem.* **41,** No. 2, 79A-81A (Feb. 1969).

Key words: Background; electrical detection; electrical discharge; ion probe; ion sensitive plates; mass spectrometry; pelletizing; precision: relative sensitivity; sample homogeneity; solids; statistics.

A Workshop on Mass Spectrometric Analysis of Solids was sponsored by and held at the National Bureau of Standards on Nov. 18, 19, 1968. The purpose of the workshop was to discuss problems and factors that influence the accuracy and precision of analysis of solids by mass spectrometric techniques.

The topics considered, each led by a discussion leader, were (1) accuracy and precision problems, (2) surface analysis, (3) sample problems, (4) electrical discharge type ion sources, and (5) ion sensitive plate problems.

Five committees of four people each met during the first evening or at the end of the workshop to summarize the treatment of the five topics. Abstracts of these summaries are presented.

10815. Altschuler, H. M., **Comments on "An improved method for measuring scattering parameters of nonreciprocal two-ports,"** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 4, 261-262 (Apr. 1968).

Key words: Measurement; microwave; network; nonreciprocal; scattering parameters; two-port.

This letter points out that part of work described as new by Hoffman and Willem was already published by this author five years ago and that the new aspect of their work most likely can be expected to reduce measurement uncertainty only if certain precautions are taken.

10816. Amano, T., Saito, S., Hirota, E., Morino, Y., Johnson, D. R., Powell, F. X., **Microwave spectrum of the ClO radical,** *J. Mol. Spectry.* **30,** No. 2, 275-289 (May 1969).

Key words: Chlorine monoxide; free radical; hyperfine structure; microwave spectrum; rotational transitions; Stark effect.

Rotational transitions in the $^2\Pi_{3/2}$ and $^2\Pi_{1/2}$ electronic states have been investigated for both the ^{35}ClO and ^{37}ClO radicals by means of Stark modulated microwave spectrometers. Improved values were obtained for the rotational constants, Λ-doubling parameter and hyperfine constants of both radicals. It was found necessary to consider the effect of centrifugal distortion in order to determine the dependence of the spin-orbit coupling constant A on the internuclear distance. The distortion constant D_e was found to be 0.077 ± 0.016 MHz and the value of $A' = (r\, dA/dr)$ at the equilibrium internuclear distance was 320 ± 60 cm^{-1}, assuming a value for A determined from electron-paramagnetic-resonance data.

The equilibrium internuclear distance r_e was calculated to be 1.569 ± 0.001 Å from the rotational constants B_0 for ^{35}ClO and ^{37}ClO. A detailed analysis of the second order Stark effect of the $F = 0 \leftarrow 1$ and $F = 1 \leftarrow 1$ components of the upper series of the $J = 3/2 \leftarrow 1/2$ rotational transition in the $^2\Pi_{1/2}$ state of ^{35}ClO was performed and the electric dipole moment was determined to be 1.239 ± 0.010 D. This value was confirmed for the $^2\Pi_{3/2}$ state of ^{35}ClO where the Stark effect is first-order for weak electric fields. The indicated uncertainties are three times the standard errors of the reported value.

10817. Ambler, E., Schooley, J. F., Colwell, J. H., Pfeiffer, E. R., Frederikse, H. R., Hosler, W. R., Thurber, W. R., **Transition temperatures and critical fields of $\mathrm{SrTiO_3}$ and mixed titanates,** *Proc. Xth Intern. Conf. Low Temperature Physics, Moscow, U.S.S.R., Aug. 31-Sept. 6, 1966,* **Vol. 2B,** *Superconductivity,* Paper S123, 142-148 (1968).

Key words: $(\mathrm{Ba}_x\mathrm{Sr}_{1-x})\mathrm{TiO_3}$; $(\mathrm{Ca}_y\mathrm{Sr}_{1-y})\mathrm{TiO_3}$; critical fields; magnetic moment; penetration depth; semiconducting systems; $\mathrm{SrTiO_3}$; superconducting; transition temperature.

The experimental investigation of the superconducting properties of the semiconducting systems $\mathrm{SrTiO_3}$, $(\mathrm{Ba}_x\mathrm{Sr}_{1-x})\mathrm{TiO_3}$, and $(\mathrm{Ca}_y\mathrm{Sr}_{1-y})\mathrm{TiO_3}$ is reviewed. The studies of a.c. magnetic susceptibility, which yields transition temperature and penetration depth; of heat capacity, which yields the electronic density of states and transition temperature; and of magnetic moment, which yields first and second critical fields and transition temperature, are discussed briefly. Tables of experimental values of the parameters mentioned above are included.

10818. Anderson, H. J., Brenner, A., **Preparation of rhenium hexafluoroacetylacetonate,** *J. Electrochem. Soc.* **116,** No. 4, 513 (Apr. 1969).

Key words: Hexafluoroacetylacetonate; rhenium; vapor deposition.

A brief account is given of the work now in progress on methods of preparing the rhenium derivative of hexafluoroacetylacetone. This compound can be vaporized without decomposition.

10819. Arenhovel, H., **General formulas for describing the absorption of polarized photons by oriented nuclei,** *Phys. Rev.* **171,** No. 4, 1212-1216 (July 20, 1968).

Key words: Electromagnetic transition; matrix elements; nuclear orientation; orientation parameter; photo absorption; photon polarization; polarizabilities.

The absorption cross section of polarized photons by oriented nuclei is given in terms of the nuclear orientation parameters and the photon polarization parameters for linear and circular polarization. All quantities are given in terms of the nuclear polarizabilities which contain the electric and magnetic transition matrix elements.

10820. Arenhovel, H., Danos, M., **Baryon resonances in nuclei: Magnetic moment anomaly in ^{3}H and ^{3}He,** *Physics Letters* **28B,** No. 5, 299-301 (Dec. 23, 1968).

Key words: Exchange currents; magnetic moment anomaly; nuclear magnetic moments; nuclear structure baryon resonances; resonance photoproduction.

The exchange current contributions to the static magnetic moments of ^{3}H and ^{3}He are described by the admixture of baryon resonance to the ground state. It is found that the dominant contribution comes from the admixture of the N*(1470) in a spatial symmetric $^2S_{1/2}$ states by means of the magnetic photon-production matrix element. An admixture of about 1 percent would be sufficient to account for the magnetic moment anomaly.

10821. Arp, V., **Properties and preparation of high-purity aluminum,** *Proc. 1968 Summer Study on Superconducting Devices and Accelerators, Brookhaven National Laboratory, Upton, N.Y., June 10-July 19, 1968,* Part III, **BNL 50155 (C-55),** pp. 1095-11144 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., Apr. 1969, $3.00).

Key words: Aluminum; impurity; resistivity; skin effect; thermal conductivity.

The potential economy of using aluminum magnets operating at cryogenic temperatures was suggested by Post and Taylor in 1959, before the advent of high field superconductivity. A liquid hydrogen-cooled aluminum magnet was built and operated not long thereafter (Purcell and Payne, 1963), but by this time superconducting magnets seemed to be generally more attractive. Nevertheless, a small effort was carried on, since for some low duty cycle conditions aluminum appears to be more attractive than superconductors (Arp, 1965). We have continued a study of the properties of aluminum which are related to this type of application, and a major part of this paper summarizes this study and knowledge in a tutorial fashion. The final and minor section of the paper reports the current status on the availability of high-purity aluminum in technologically useful quantities.

10822. Arp, V. D., Kasen, M. B., Reed, R. P., **Magnetic energy storage and cryogenic aluminum magnets,** *Tech. Rept.* **AFAPL-TR-68-87** 122 pages (Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, Feb. 1969).

Key words: Aluminum; cryogenics; magnetic energy storage; magnets; metallurgy.

Factors pertaining to aluminum magnet technology have been investigated. Industrial competence and capacity to produce super-purity aluminum have been improved. Methods of analyzing super-purity aluminum have been studied; in particular, the eddy-current decay technique of measuring electrical resistivity ratios between 4 and 295 K have been improved and used extensively. New devices used to sensitively measure stress, strain, and resistivity at 4 K have been developed.

Two major experimental programs were conducted. One pertains to the effects of internal defects, particularly grain boundaries and impurity elements, on the residual resistance ratio. It was found that no one process can be ascribed to the linear relationship between increasing grain size and decreasing resistance ratio. One significant mechanism proposed is that, in super-purity aluminum, grain boundary motion acts to sweep away impurity elements in solid solution, thus having a purifying effect.

The second program involved the relationships between applied stress, plastic strain, and electrical resistivity changes due to the introduction of dislocations and vacancies at 4 K. It was found that the change in resistivity at 4 K is related to $\epsilon^{1.19}$ where ϵ is the plastic strain.

10823. Ausloos, P., Rebbert, R. E., Lias, S. G., **Gas-phase photolysis of cyclohexane in the photoionization region,** *J. Phys. Chem.* **72,** No. 11, 3904-3914 (Oct. 1968).

Key words: Cyclohexane; free radicals; ions; photoionization; photolysis; superexcited molecules.

The photolysis of cyclohexane (I.P. = 9.88 eV) has been studied in the gas phase using 1470 Å(8.4 eV), 1236 Å(10.03 eV), and 1067-48 Å(11.6-11.8 eV) radiation. At the latter two wavelengths, ions and superexcited molecules are formed. Emphasis is placed on the measurement of accurate quantum yields at all three wavelengths through both chemical actinometry and saturation current measurements. The primary decomposition of the excited cyclohexane molecule: cyclo-$C_6H_{12}^* \rightarrow C_6H_{10} + H_2$ reported earlier for the photolyses at 8.4 eV and 10.03 eV, is also seen to occur at 11.6-11.8 eV. In addition, evidence is presented for ring opening, and rearrangement of the excited hexamethylene intermediate, followed by decomposition of excited intermediates are readily quenched by an increase in pressure, the quenching being more effective for deuterated than for non-deuterated species. On the other hand, little or no pressure effect on product formation is observed in the photolysis at 1067-48 Å. In the photolysis at 1067-48 Å, although the parent cyclohexane ions have sufficient energy to undergo fragmentation processes, it is demonstrated that fragmentation is negligible at pressures above 1 torr. Using the photoionization results, it also demonstrated that in the radiolysis, $M(C_6H_{12}^+)/N_i$ is 0.3 at 13 torr and 0.34 at 90 torr. Assuming that the fragmentation of the excited cyclohexane molecule observed in the photolysis at 11.6-11.8 eV is roughly representative of the superexcited molecule dissociation which occurs in the radiolysis, the 1067-48 Å photolysis product yields are used to derive a value of N_{ex}/N_i of 0.1-0.3 for the radiolysis.

10824. Bach, R. L., Caswell, R. S., **Energy transfer to matter by neutrons,** *Radiation Res.* **35,** N. 1, 1-25 (July 1968).

Key words: Energy transfer coefficient; first collision dose; kerma; neutron dosimetry; neutron energy transfer; nuclear reactions.

Calculations of energy transfer (kerma) for neutrons from thermal to 18 MeV energy have been carried out for hydrogen, carbon, nitrogen, and oxygen and for ten compounds or mixtures including tissue. All pertinent nuclear reaction processes are included. The calculation demonstrates the importance of (n,charged particle) reaction processes which have been neglected in nearly all previous calculations. These processes dominate the energy transfer process in carbon, nitrogen, and oxygen above roughly ten MeV.

10825. Barber, D. J., Tighe, N. J., **Neutron damage in single crystal aluminum oxide,** *J. Am. Ceram. Soc.* **51,** No. 11, 611-617 (Nov. 1968).

Key words: Aluminium oxide; defects; electron microscopy; neutron damage dislocations; sapphire.

Synthetic aluminium oxide crystals were irradiated with fast neutrons to a dose of 1.8×10^{20} nvt and examined by transmission electron microscopy. As-irradiated crystals contained damage on a fine scale, revealed by diffraction contrast and showed a 28 percent increase in Knoop diamond hardness compared with un-irradiated material. Annealing above 600 °C, which decreased the hardness, caused the small defect clusters to grow, forming dislocation loops on {1010} planes, with ⟨1010⟩ Burgers vectors. Vacancy and interstitial loops occurred. High temperature annealing caused the loops to interact to give dislocation segments; these tended to align with the ⟨1010⟩ and ⟨1120⟩ directions. Grown-in dislocations also began to climb at high temperatures but showed evidence of impurity pinning. Isolated platelike precipitates on {1010} planes were also observed in samples annealed at high temperatures. Possible effects of the observed damage on physical properties are considered and there is qualitative agreement between predictions and existing data.

10826. Barger, R. L., Hall, J. L., **Pressure shift and broadening of methane line at 3.39μ studied by laser-saturated molecular absorption,** *Phys. Rev. Letters* **22,** No. 1, 4-8 (Jan. 6, 1969).

Key words: Laser; methane; pressure broadening; saturated molecular absorption; wavelength standard.

We study broadening and shift of a rotation-vibration line of methane at millitorr pressures. Saturation by the laser intracavity field allows investigation of the *very* sharp natural linewidth, without Doppler broadening. Two lasers were independently locked to this transition with an offset of less than 3 kc/s, a reproducibility of $3{:}10^{11}$!

10827. Bates, R. G., **Equilibrium properties of acids and bases in amphiprotic mixed solvents,** (Proc. Symp. Equilibria and Reaction Kinetics in Hydrogen Bonded Solvent Systems, University of New Castle, Upon Tyne, England, Jan. 10-12, 1968), Chapter in *Hydrogen-Bonded Solvent Systems,* A. K. Covington and P. Jones, eds., pp. 49-86 (Taylor and Francis, London, England, 1968).

Key words: Acidity; medium effects; mixed solvents; solvation of ions; solvent effect; transfer energy.

Binary mixed solvents which contain water as one component possess the capacity to react protolytically both with hydrogen acids and with their conjugate bases. Although the acid-base behaviour of many of these solvent mixtures resembles that of water in kind, wide differences of degree are observed. Futhermore, there is evidence that solute-solvent interactions become more complex as the dielectric constant of the mixed medium is lowered. The effect of adding an organic constituent to aqueous solutions of acids and bases is examined through summaries of data for standard electromotive forces, equilibrium constants, medium effects, and thermodynamic functions for the transfer from water to mixed solvents of various compositions. Systems consisting of strong and weak electrolytes in mixed solvents are considered. An attempt is made to identify the factors on which the observed solvent effect depends. In particular, the roles of dielectric constant, solvent basicity, hydrogen bonding, sorting of the two types of solvent molecules by the ions, and the formation of ion pairs and higher aggregates are discussed. Recent proposals for the establishment of a useful scale of individual ionic transfer energies for mixed solvents are reviewed.

10828. Bay, Z., Luther, G. C., **Locking a laser frequency to the time standard,** *Appl. Phys. Letters* **13,** No. 9, 303-304 (Nov. 1, 1968).

Key words: Electrooptic modulation; optical frequencies; velocity of light.

On the basis of high frequency modulation experiments and well known locking techniques, a scheme is described for stabilizing a visible laser frequency and simultaneously determining that frequency in terms of the time standard. The importance of this method for a refined determination of the velocity of light and the possibility of establishment of reference lines for spectroscopy and for length measurements, throughout the spectrum wherever laser lines are available, is discussed.

10829. Beatty, R. W., **Discussion of effect of realizability conditions upon estimated limits of mismatch error in the calibration of fixed attenuators,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 11, 976 (Nov. 1968).

Key words: Attenuation; microwave; mismatch error; realizability; 2-ports.

The effect or realizability conditions for 2-ports upon the estimation of mismatch error is discussed. Only the case of the insertion of fixed, symmetrical, reciprocal 2-ports is considered. It is shown that the effect of realizability conditions needs to be considered only for certain ranges of attenuation and VSWR. Most attenuators encountered in practice do not fall within those ranges so that the conventional method of estimating mismatch error limits is usually satisfactory.

10830. Beatty, R. W., Fentress, G. H., **An attenuation and phase shift divider circuit,** *Proc. IEEE* **56,** No. 11, 2063-2064 (Nov. 1968).

Key words: Attenuation; circuit; rotary vane attenuator.

An attenuation divider circuit is described. The theory is presented for accurate division of small attenuation changes by arbitrarily selected ratios, and the procedure for adjusting the circuit is described. The circuit is useful for accurately producing small attenuation changes such as 0.0001 decibel, which is outside the capability of most attenuators.

10831. Beckett, C. W., Cezairliyan, A., **High-speed thermodynamic measurements and related techniques,** Chapter 14 in *Experimental Thermodynamics,* J. P. McCullough and D. W. Scott, eds., **Vol. I,** *Calorimetry of Non-reacting Systems,* 551-585 (Butterworth and Co., London, England, 1968).

Key words: Experimental thermodynamics; high-speed thermodynamic measurements; shock wave techniques; thermodynamic measurements; thermodynamic properties.

The needs and requirements of high-speed measurement of thermodynamic properties and related high-speed techniques in millisecond and microsecond time domain are presented. High-speed generation of heat by electrical pulse methods is reviewed. The technique of the measurement of heat through the measurement of electrical quantities is discussed and the factors causing error are summarized. High-speed temperature measurement methods, both photoelectric and photographic, are discussed. Other related subjects, such as high-speed photography, dynamic pressure measurements, fast x-ray and interferometry, are reviewed briefly. Applications of high-speed measurements to the determination of properties, such as specific heat, thermal diffusivity, electrical conductivity, are presented. Measurement of thermodynamic properties by shock wave techniques is reviewed. Other applications of high-speed measurement techniques in the areas of exploding conductors and high-temperature sources are also discussed.

10832. Bekkedahl, N., **Crystallization of natural rubber,** *Rev. Gen. Caoutchouc Plastiques* **45,** No. 3, 341-6—463-9 (1968).

Key words: Chain folding; contractility; crystallization; dilatometry; heat engine; melting; polymers; rubber; stark rubber.

This review article presents a resume of the research work that has been done at the National Bureau of Standards during the past thirty-five years in the field of crystallization of polymeris materials, with special emphasis on natural rubber. It contains only information on results of research work that has already been published.

10833. Bennett, H. S., **Diffuse and propagating modes in the Heisenberg paramagnet,** *Phys. Rev.* **174,** No. 2, 629-639 (Oct. 10, 1968).

Key words: Brillouin component; dynamic scaling theory; Heisenberg paramagnet; pair correlations; Rayleigh component; spectral weight function.

The spectral weight function for pair correlations is studied as a function of frequency ω and wave vector q within the framework of the Heisenberg model for magnetism. The frequency regions $\omega\tau(q) \ll 1$ and $\omega\tau(q) \gg 1$ are examined for both the ferromagnet and the antiferromagnet in the paramagnetic state. The quantity $\tau(q)$ is a characteristic time of the system. It is shown that when $\omega\tau \ll 1$ a diffuse mode (Rayleigh component) dominates the spectral weight function and that when $\omega\tau \gg 1$ a propagating mode (Brillouin component) dominates the spectral weight function. A critical wave vector q_c which separates these two regions is computed from microscopic theory and is found to scale according to the square root of the static susceptibility near the critical point. This latter microscopic result is identical in form to the result for the critical wave vector which separates the hydrodynamic and critical domains of dynamic scaling theory when the critical exponents are $\gamma = (413)$ and $\eta = 0$.

10834. Bennett, H. S., **Magnet scattering of neutrons from Heisenberg antiferromagnets,** *J. Appl. Phys.* **40,** No. 3, 1552-1553 (Mar. 1, 1969).

Key words: Heisenberg magnets; longitudinal diffusivity; longitudinal spectral weight function; moments; neutron scattering; $RbMnF_3$; sum rules.

The magnetic scattering of neutrons from Heisenberg antiferromagnets in the paramagnetic state is discussed within the rigorous framework of a spectral representation for the longitudinal spectral weight function, low order moments of this function, and sum rules. The longitudinal spectral weight function is expressed as a functional of the longitudinal diffusivity. The exact framework leads naturally to a phenomenological description of the neutron scattering cross section in Heisenberg antiferromagnets. It is shown that replacing the longitudinal diffusivity by the sum of a Gaussian function and a resonating function, which satisfies the sum rules, gives the essential features for neutron scattering in the Heisenberg antiferromagnet $RbMnF_3$.

10835. Bennett, H. S., **Phenomenology of neutron scattering in Heisenberg systems,** *Phys. Rev.* **176,** No. 2, 650-654 (Dec. 10, 1968).

Key words: Critical magnetic scattering; diffusivity; Heisenberg magnets; neutron cross section.

The critical magnetic scattering of neutrons from Heisenberg systems is discussed within the rigorous framework of spectral representations for the longitudinal and transverse spectral weight functions, low order moments of these functions, and their sum rules. The spectral weight functions are expressed as functionals of longitudinal and transverse diffusivities. This exact framework leads naturally to a two parameter phenomenological description of the neutron scattering cross section in Heisenberg ferromagnets. It is shown that replacing the diffusivities by two parameter Gaussian functions, which satisfy the first two sum rules, gives reasonable values for the neutron scattering cross section in ferromagnets.

10836. Bennett, L. H., **Nuclear magnetism,** Chapter 14 in *Magnetism and Magnetic Materials 1968 Digest,* H. Chang and T. R. McGuire, eds., pp. 201-221 (Academic Press, Inc., New York, N.Y., 1968).

Key words: Magnetic materials; Mössbauer effect; nuclear magnetic resonance; nuclear magnetism; nuclear specific heat; perturbed angular correlation.

This chapter reviews the 1967 literature that was devoted to the study of magnetism and magnetic materials taking advantage of the atomic nucleus as a probe. The bulk of the experimental papers utilize nuclear magnetic resonance (NMR or FNR) or recoilless-ray absorption, i.e. the Mössbauer effect (ME), as in previous years. Most of the NMR papers reviewed here are for ferromagnetic materials in the ordered state, for which we use the special abbreviation FNR. Other techniques for determining hyperfine (hf) magnetic fields (H_{hf}) include nuclear specific heat and perturbed angular correlation.

10837. Bennett, L. H., Mebs, R. W., Watson, R. E., **Solute Knight shifts in noble metals,** *Phys. Rev.* **171,** No. 3, 611-626 (July 15, 1968).

Key words: Ag; Al; alloys; Au; Cd; Cu; Ga; Hg; hyperfine fields; In; Knight shift; noble metals; P; Sn; susceptibility; Zn.

Knight shifts of Cu, Cd, Al, In, Sn and Ga as dilute solutes in Au/Hg and Al as dilute solutes in Ag; In as a dilute solute in Cu; and Sn as a dilute solute in Ag-Au alloys, are reported. These data are considered together with all other Knight shift data on dilute solutes in the 3 noble metals. Assuming the solute atom to be situated most nearly in a free conduction electron state when dissolved in Ag, the changes in Knight shift when dissolved in Cu or Au indicate a valence effect which is opposite in sense for these latter 2 noble metals. The Cd resonance linewidths for Au-Cd alloys show appreciable broadening with increase in alloy content or test frequency. Values of hyperfine fields for the free atom are presented together with alternative values of the paramagnetic spin susceptibility of the host. The problem of exchange enhancement of the spin susceptibility is discussed. Values for Knight's parameter ξ usually considered as a measure of the amount of s-character in the metal are tabulated and discussed. The valence effects found in the Knight shifts, are also evident in the ξ values. The requirement of orthogonalization of the conduction electron states to the metallic ion cores leads to a reconsideration of the origin of the solvent Knight shifts in noble metal alloys.

10838. Bennett, L. H., Swartzendruber, L. J., **Some comments on "The corrosion of materials in desalination plants,"** *Desalination* **4,** 389-390 (1968).

Key words: Alloys; copper; corrosion; desalination; iron; nickel.

The implications to testing and use of cupro-nickel alloys for desalination are described.

10839. Berger, M. J., Seltzer, S. M., Chappell, S. E., Humphreys, J. C., Motz, J. W., **Response of silicon detectors to monoenergetic electrons with energies between 0.15 and 5.0 MeV,** *Nucl. Instr. Methods* **69,** No. 2, 181-193 (Apr. 1969).

Key words: Detector response function; electron absorption; electron backscattering; electron transmission; silicon transmission detector.

By means of measurements as well as Monte Carlo calculations, response functions have been obtained which describe the pulse-height distributions produced by monoenergetic electrons incident perpendicularly on silicon detectors. Generally good agreement has been found between experimental and Monte Carlo results at energies of 0.25, 0.50, 0.75, and 1.00 MeV for detectors with thicknesses of 0.061, 0.105, 0.191, 0.530, 1.0, and 3.0 mm. Additional calculated results have been obtained as follows: (1) response functions at fifteen energies between 0.15 and 5.0 MeV for detectors with ten thicknesses between 0.05 and 10.0 mm; (2) response functions for arrangements in which the silicon detector is shielded partially or completely by other detectors operating in anticoincidence; (3) reflection, transmission and absorption coefficients of electrons for plane-parallel silicon targets.

10840. Berman, H. A., West, E. D., **Heat capacity of liquid nitromethane from 35° to 200 °C,** *J. Chem. Eng. Data* **14,** No. 1, 107-109 (Jan. 1969).

Key words: Heat capacity; nitromethane.

The heat capacity of saturated liquid nitromethane (under its own vapor pressure) has been determined in an adiabatic calorimeter to a precision of 0.1 percent between 35 and 200 °C, and may be represented in this range by the polynomial: $C_{sat} = 104.4_4 + 6.381_1 \times 10^{-2}t + 3.175_3 \times 10^{-4}t^2 - 8.131_8 \times 10^{-7}t^3 = 4.073_9 \times 10^{-9}t^4$, where C_{sat} is in J/mol-deg C and t is in °C.

10841. Birmingham, B. W., ed., **A Report on the 1967 Applied Superconductivity Conference,** *Cryogenics* 8, No. 3, 176-179 (June 1968).

Key words: Cryogenic refrigeration; superconducting electronics; superconducting magnets; superconducting materials; superconducting phenomena; superconducting power transmission; superconductivity.

The 1967 Applied Superconductivity Conference met at the University of Texas in Austin in response to a growing need for improved communications between researchers in superconductivity and potential users of new knowledge from industry, government, private and national laboratories, and universities. Invited papers presented the U.S. Bureau of Mines helium program, U.S. government programs in superconductivity, and superconductivity in Europe. Subjects covered in contributed papers included magnets and materials, computer devices, and phenomena and other devices. Two panel discussions highlighted superconducting power transmission and refrigeration. An exhibition of apparatus demonstrated superconducting phenomena and applications in addition to the latest cryogenic refrigerator developments and high field magnet materials and designs.

10842. Birmingham, B. W., Flynn, T. M., **National programs and the compressed gas industry,** (Proc. 55th Annual Meeting of the Compressed Gas Association, New York, N.Y., Jan. 1968), Chapter in *The Future of the Compressed Gas Industry,* pp. 39-49 (Compressed Gas Assoc. Inc., New York, N.Y., 1969).

Key words: Agriculture; compressed gases; conservation; cryogenics; education; health; national goals; space; transportation.

The object is to discuss a segment of the compressed gas industry, namely the cryogenic industry, and its relation to selected national programs, such as space, health, agriculture, transportation, conservation, and education.

10843. Blandford, J. M., Bensing, P. L., *Testing Programs for the Apparel Industry. Evaluation of Material and Components,* Part I, 31 pages; Part II, 222 pages (Apparel Research Foundation, Inc., Washington, D.C., Oct. 1, 1968).

Key words: Apparel materials; equipment, textile testing; fabric defects; physical properties, fabrics; programs, textile testing; test methods, textile; testing equipment, textile; textile testing.

This publication presents the details of minimum, intermediate, and advanced textile testing programs for evaluating the appearance and performance properties of materials and components used by the apparel industries. Tabulations give testing equipment, properties its use may determine, testing procedures and evaluation materials employed, and sources of supply and approximate prices of the equipment and evaluation materials.

Included are: (1) sections on the significance of a textile testing program, conditioning for testing textiles, performance requirements for textile fabrics ((USA) Standard L22), and the availability of short laboratory training courses for apparel company employees; (2) reprints of the fifty-nine referenced test methods.

10844. Blandford, J. M., **NBS-ARF apparel materials testing and evaluation project,** *Second Annual Conf. Apparel Research Foundation, Washington, D.C., Oct. 7-9, 1968,* 4 pages (Apparel Research Foundation, Washington, D.C., 1968).

Key words: Apparel materials; equipment, textile testing; physical properties, fabrics; programs, textile testing; test methods, textile; testing equipment, textile.

This address is a summary and final progress report of the Apparel Materials Evaluation Project on which the NBS and the Apparel Research Foundation, Inc. (ARF) collaborated. It presents a discussion of the development and accomplishments of the Project with especial emphasis on its achievements which are two "firsts" for the apparel industry: (1) publication of the book "Testing Programs for the Apparel Industry—Evaluation of Materials and Components" (published by the Apparel Research Foundation, Inc.); and (2) making available to the apparel industry (through nationally-recognized educational, research, and testing organizations) a short laboratory training program for apparel company employees. The book and training course complement one another.

10845. Botter, R., Rosenstock, H. M., **Franck-Condon factors for NH_3 and H_2O,** Chapter in *Advances in Mass Spectrometry* **4,** 579-589 (Institute of Petroleum, London, England, 1968).

Key words: Bond angle; bond length; Franck-Condon factors; H_2O; NH_3 ion; photo-electron; photo-ionization; spectroscopy.

10846. Boutillon, M., Henry, W. H., Lamperti, P. J., **Comparison of exposure standards in the 10–50 kV x-ray region,** *Metrologia* **5,** No. 1, 1-11 (Jan. 1969).

Key words: Air attenuation; analysis of uncertainties; correction factors; direct comparison; exposure standards; low-energy x rays.

Direct comparisons of the low-energy x-ray exposure standards of the International Bureau of Weights and Measures (BIPM) and the National Research Council of Canada (NRC), the BIPM and the National Bureau of Standards of the U.S.A. (NBS), were made, using x rays generated by 10, 30, and 50 kilovolts. The half-value layers for these qualities of radiation were 0.03_6, 0.17_6, and 2.25_7 mm aluminum respectively. The results indicate that a direct comparison between two free-air chambers, in the low-energy x-ray region, can be precise to better than 0.3 percent. The uncertainties and errors in the geometric and correction factors used for the comparison measurements, as well as other systematic and statistical errors, were examined in detail and are reported. The results of preliminary work on the definition of the quality of radiation, air attenuation correction, diaphragm comparisons and saturation correction are included.

10847. Bowen, R. L., Cleek, G. W., **X-ray-opaque reinforcing fillers for composite materials,** *J. Dental Res.* **48,** No. 1, 79-82 (Jan-Feb. 1969).

Key words: Barium fluoride; composite materials; dental restorations; refractive index; reinforcing fillers; x-ray-opaque.

Clear, colorless glasses designed for use as part of the reinforcing fillers for composite dental restorative materials were prepared. They were formulated by melting together materials such as silica, boric oxide, alumina, barium oxide, and barium fluoride. Barium made the glasses radiopaque, fluoride lowered the refractive index, and alumina tended to stabilize the glasses.

10848. Bowen, R. L., Paffenbarger, G. C., Mullineaux, A. L., **A laboratory and clinical comparison of silicate cements and a direct-filling resin: A progress report,** *J. Prosthetic Dentistry* **20,** No. 5, 426-437 (Nov. 1968).

Key words: Clinical research; composites; color stability; dental materials; reinforced resins; silicate cements; solubility.

Two silicate cements showing a difference of about 0.7 percent solubility and disintegration in distilled water for 24 hours, showed approximately the same durability in clinical service during a four-to-six year period. There was more disintegration in the interproximal areas of the silicate restorations than there was in the self-cleansing areas.

An experimental reinforced resin gave sufficiently good results to warrent further clinical investigations of more recent and perhaps better composite formulations. Both unreinforced and reinforced resin materials appear to benefit from the use of a primer or "cavity seal."

10849. Bowen, R. L., Mullineaux, A. L., **Adhesive restorative materials,** *Dental Abstr.* **14,** No. 80, 80-82 (Feb. 1969).

Key words: Adhesion; alkylboron; coupling agents; cyanoacrylates; dental restorative materials; expoxy resins; isocyanates.

Available dental literature on adhesive dental restorative materials is reviewed.

10850. Branscomb, L. M., **Joint Institute for Laboratory Astrophysics of the National Bureau of Standards and the University of Colorado, Boulder, Colorado, observatory report,** *Bull. Am. Astron. Soc.* **1,** No. 1, 27-33 (Jan. 1969).

Key words: Annual summary; astrophysics; JILA.

This is an annual report of work accomplished in laboratory astrophysics at JILA (Joint Institute for Laboratory Astrophysics). No original technical material is presented.

10851. Branscomb, L. M., **Physics and the nation in a crystal ball,** *Phys. Today* **21**, No. 8, 23-28 (Aug. 1968).

Key words: Public policy in science.

This paper was prepared for presentation as part of a symposium on "The Coupling of Physics and Society in the Seventies" at a Special Joint Session of the American Physical Society and the American Association of Physics Teachers, Chicago, 30 January 1968.

10852. Brauer, G. M., McLaughlin, R., Huget, E. F., **Aluminum oxide as a reinforcing agent for zinc oxide-eugenol-o-ethoxybenzoic acid cements,** *J. Dental Res.* **47**, No. 4, 622-628 (July-Aug. 1968).

Key words: Alumina as a reinforcing agent; Al_2O_3 reinforced cements; crown and bridge; dental cements; EBA cements; zinc oxide-eugenol-EBA cements.

Aluminum oxide is a very effective reinforcing agent for *o*-ethoxybenzoic acid (EBA) cements. Addition of Al_2O_3 increases the amount of powder that can be incorporated into the mix. The compressive strength of the hardened cement is increased up to 1055 kg/cm^2 (15,000 psi) and the ADA film thickness decreased to 26μ. The materials adhere to tooth structure as well as zinc phosphate cements and are suitable as crown and bridge cements. With higher powder-liquid ratios their high 10-minute compressive strength and excellent tissue tolerance suggests their use as bases under metallic restorations. These materials may also be employed as temporary restoratives. Mixes of Al_2O_3 and eugenol or glycerine may be of interest as a temporary non-hardening crown and bridge cement. Incorporation of Al_2O_3 whiskers did not improve the physical properties of these cements.

10853. Brinckman, F. E., Gordon, G., **Energetic intermediates in inorganic synthesis: characterization of transport species in electric discharge,** *Proc. Intern. Symp. Decomposition of Organometallic Compounds to Refractory Ceramics, Metals, and Metal Alloys, Dayton, Ohio, Nov. 1967*, pp. 29-46 (University of Dayton Press, Dayton, Ohio, Oct. 1968).

Key words: Boron; electric discharge; germanium; oxyfluorides; reactive intermediates; silicon; time-of-flight mass spectrometry; transport species.

Commercial processes involving energetic chemical transport and deposition reactions are poorly understood with respect to the identity and mechanistic behavior of their intermediates. Work is presented resulting from recent development of a facility for *in situ* sampling of electric discharge reactions by time-of-flight mass spectrometry. With use of single or mixed reactant gases to sustain a microwave discharge plasma, both homogeneous and heterogeneous reactions have been examined for synthetic potential under conditions of optimized energy input. A number of new compounds thereby have been identified with aid of computerized polyisotopic mass spectral analyses, but also by independent syntheses where known. Several important cases are presented with emphasis on oxyfluorides since both hetero- and homo-μ-oxy-metalloid products form. These systems include Si-O-Si, Si-O-B, B-O-B, Si-O-Ge, Ge-O-Ge, and Ge-O-B species for which some relative stability data can be derived. Extension of these findings to analogous carbon-containing materials (derived from organometals or organometalloids) is also discussed.

10854. Broadhurst, M. G., **The dielectric properties of leaves, sticks, and dirt at radio and microwave frequencies,** *Proc. 1968 Annual Report Conf. Electrical Insulation and Dielectric Phenomena, Oct. 21-23, 1968, Buck Hill Falls, Pa.*, pp. 146-152 (Natl. Acad. Sci.—Natl. Res. Council, Washington, D.C., 1969).

Key words: Dielectric constant; dielectric loss; dielectric measurements; soil; vegetation.

The dielectric constant and loss of a variety of fresh leaves were measured at room temperature from 0.1 MHz to 4.2 GHz. A water displacement method was used with a single thickness of leaf in a coaxial line. Capacitance and conductance were determined with a bridge up to 250 MHz and a slotted line above 250 MHz. The leaf is a high admittance shunt in the line and both the real and imaginary components of the admittance could be measured within a few percent accuracy. The accuracy of the dielectric constant and loss values is limited to about 10 percent mainly by uncertainties in the sample thickness measurements. The main features of the data are a Maxwell-Wagner type relaxation at about 10 MHz with a tan δ maximum of about 2. Both κ' and κ'' rise to about 10,000 at 0.1 MHz with a second relaxation at lower frequencies apparent in the tan δ curve. Above 100 MHz, κ' levels off at about 50 and above 10^9 Hz a third relaxation—presumably due to the dipolar relaxation in water—appears. The results are surprisingly consistent among all varieties of leaves measured. Measurements were also made with reduced precision on twigs and clay at various moisture contents. The measurement techniques, and evaluation of errors of the method will be described together with the data.

10855. Brockman, J. F., **Popular science writing,** *Proc. 1967 Inst. Technical Industrial Communications, Colorado State University, Ft. Collins, Colo., June 12-16, 1967*, pp. 96-100 (1967).

Key words: Image of science; lead paragraphs; popular science writing; science writers; science writing; science writing goals.

The term popular science writing carries connotations of superficiality and inaccuracy. But, if we are to convey understanding of science to the public—and I think it critically important that we do so—we must make the efforts required to reverse this concept. I believe that this requires thoughtful consideration of our basic goals and of the images which we create of our organization, of its staff, and of science in general. Thus, it requires clear understanding on our part of what we want to say, of what we actually say, and of why we handle a particular subject in a certain fashion.

The development of our material must, of course, be clear, and it must be interesting. The interesting features which we emphasize, however, must be valid. They must grow from the subject matter and not be artificially imposed by the writer. This must be true not only of the story as a whole but also of the lead paragraphs where the pressure to gain attention is greatest.

In conveying understanding of science, there is room for improvement in all groups involved in the process, but the greatest burden of responsibility is our own as science writers.

10856. Brooks, R., Horton, A. T., Torgesen, J. L., **Occlusion of mother liquor in solution-growth crystals,** *J. Crystal Growth* **2**, 279-283 (1968).

Key words: Ammonium dihydrogen phosphate; crystal defects; crystal growth; crystal-growth forms; mother-liquor inclusions; occlusions in crystals; sodium chlorate; solution-grown crystals.

Inclusions of mother liquor, comprising major defects in crystals grown from solution, are sometimes formed when the level of the supersaturation increases. The change in crystallization driving force can cause irregular growth or hopper growth, particularly on fast growing faces if they are present, even when the solution is strongly stirred and when the change of supersaturation is relatively slight; and inclusions can be formed by overgrowth of the irregularities either by faces contiguous to the affected face, or, if supersaturation is diminished, by development of a new face of the kind that was originally present. When ammonium dihydrogen phosphate crystals or sodium chlorate crystals are grown under such conditions that their habits are characterized by several forms, those faces which grow most rapidly provide the primary sites for occlusion of mother liquor when supersaturation is increased.

The results can be explained if formation of growth centers on crystal faces is sensitive to supersaturation so that location of these centers is dictated by considerations of solute supply if supersaturation rises above a limiting value.

10857. Brown, P. J., **Human factors research in motor vehicle occupant restraint systems,** *IEEE Trans. Man-Machine Systems* **MMS-9,** No. 3, 88-89 (Sept. 1969).

Key words: Highway safety; human factors research; motor vehicle restraint systems.

The national program in highway and motor vehicle safety has provided a new stimulus to human factors research by agencies of the Federal Government. An important area included in their list was the protection of occupants of a motor vehicle from injury during a crash. This paper will describe some results of human factors research in motor vehicle occupant restraint systems by the Office of Vehicle Systems Research in the National Bureau of Standards.

10858. Bullis, W. M., **Measurement problems in microcircuit processing,** (Proc. Government Microcircuit Applications Conference, Gaithersburg, Md., Oct. 1-3, 1968), *GOMAC Digest* **1,** 215-217 (Office of Naval Research, Washington, D.C., Oct. 1968).

Key words: Microelectronics; monolithic microcircuits; reliability; semiconductor devices; silicon; test methods.

Attempts to meet reliability and interchangeability requirements for microcircuits solely by post-fabrication testing have proven to be extremely expensive and, at the same time, not completely successful. Since variations in materials and processing cause a given type of circuit to have a range of characteristics, both reliability and interchangeability are affected. With suitable measurement procedures, these variations could be better controlled. The first step is the establishment of procedures with adequate sensitivity and reproducibility at all stages of microcircuit fabrication from specification and evaluation of the starting materials through the final processing steps. In many cases this can be accomplished with only incremental improvements in existing procedures although in other cases new methods or even new tests must be developed. Once such procedures are available, tests for relevance can be undertaken and then the specification, evaluation, and process control sequence can be refined. A broad program intended to assist in the development of improved test methods is now in progress at the National Bureau of Standards. This program will be discussed briefly in order to indicate the scope of problems encountered and the approach being employed to solve them.

10859. Bur, A. J., Roberts, D. E., **Rodlike and random coil behavior of poly(n-butyl isocyanate) in dilute solution,** *Proc. 1968 Annual Report Conf. Electrical Insulation and Dielectric Phenomena, Oct. 21-23, 1968, Buck Hill Falls, Pa.,* pp. 17-21 (Natl. Acad. Sci.—Natl. Res. Council, Washington, D.C., 1969).

Key words: Dielectric constant; dielectric relaxation time; dipole moment; molecular relaxation in dilute solution; poly(n-butyl isocyanate); rodlike molecules.

Measurements of the complex dielectric constant $\epsilon^* = \epsilon' - i\epsilon''$ have been made on dilute solutions of fractionated poly(n-butyl isocyanate) (PBIC) in CCl_4. The measurements, which were carried out at 23 °C and over a frequency range 0.05 Hz to 1 mHz, yielded relaxation times and dipole moments of PBIC as a function of molecular weight where M_w varied from 2.0×10^4 to 10×10^6. For low M_w ($< 250{,}000$) the relaxation time data indicate that the molecule is in a rigid rod conformation. As M_w increases this rodlke conformation can not be sustained and the effects of chain flexibility accumulate with the addition of each monomer unit to the chain. Finally at high M_w ($> 10^6$) the dominant mode of relaxation is a long-range Rouse-Zimm normal mode and the conformation of the molecule is random coil. For these two conformations of PBIC, rigid rod and random coil, the molecular dimensions and dipole moments are calculated.

10860. Cahill, K. E., **Pure states and the P representation,** *Phys. Rev.* **180,** No. 5, 1239-1243 (Apr. 25, 1969).

Key words: Coherent states; density operator; distribution theory; electromagnetic field; photon statistics; P representation; pure states; quantum optics; representation theory.

The coherent-state P representation for the density operator of the electromagnetic field is studied for the case in which the density operator represents a pure state, $\rho = |\psi\rangle\langle\psi|$. An exact and complete characterization is given of the states for which the P representation exists with a weight function $P(\alpha)$ that is a tempered distribution. These states $|\phi\rangle$ form an exceedingly narrow class: each may be generated from a particular coherent state $|\alpha\rangle$ by the application of a finite number of creation operators, i.e., $|\phi\rangle = [c_0 + c_1 a^+ + \ldots + c_n (a^+)^n]|\alpha\rangle$, where α and the c_n are arbitrary complex numbers. For them the weight function $P(\alpha)$ is a linear combination of the two-dimensional delta function and a finite number of its derivatives. For other pure states the function $P(\alpha)$ has singularities that are not compatible with the form of the P representation.

10861. Cameron, J. M., **The statistical consultant in a scientific laboratory,** *Technometrics* **11,** No. 2, 247-254 (May 1969).

Key words: Consulting; statistical consultation; statistics.

The responsibilities of the statistical consultant who is a regular staff member of a scientific institution are discussed. The effects of the continuing nature of his association with the organization, and of the fact that extended collaboration with the individual scientists is the rule, not the exception, are described. The importance of the statistician's educational role in providing lectures, courses, manuals, etc., which are tailor made for the needs of his organization is emphasized, along with the duty to provide computer aids for statistical analysis and data handling designed for the convenience of the using scientist.

10862. Campbell, W. H., **Aurora,** *Encyclopedia of Atmospheric Sciences and Astrogeology,* R. W. Fairbridge, ed., pp. 105-106 (Reinhold Publ. Co., New York, N.Y., 1967).

Key words: Atmospheric physics; aurora; solid-earth geophysics.

This "Aurora" article is a brief description, designed for mature scientists with no upper atmospheric physics background.

5. INDEXES

5.1. HOW TO USE THE INDEXES

In addition to the usual author index, a subject index is provided in the form of a permuted key word index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is thus able to locate papers of interest to him through the subject-related words he finds in the key word index.

The index symbols used in the author and key word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

Table A. Symbols for the Periodicals

NBS Journal of Research	Index Symbol			Issue Date	Page Number
	Vol.	Sec.	No.		
Section A	J72	A	1	January-February 1968	1
	J72	A	2	March-April 1968	2
	J72	A	3	May-June 1968	4
	J72	A	4	July-August 1968	5
	J72	A	5	September-October 1968	6
	J72	A	6	November-December 1968	8
	J73	A	1	January-February 1969	10
	J73	A	2	March-April 1969	11
	J73	A	3	May-June 1969	13
	J73	A	4	July-August 1969	14
	J73	A	5	September-October 1969	15
	J73	A	6	November-December 1969	16
Section B	J72	B	1	January-March 1968	17
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	J72	B	4	October-December 1968	19
	J73	B	1	January-March 1969	21
	J73	B	2	April-June 1969	21
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	J73	B	4	October-December 1969	23
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	J72	C	3	July-September 1968	26
	J72	C	4	October-December 1968	27
	J73	C	1	January-June 1969	28
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Table B. Symbols for the Nonperiodicals

NBS Nonperiodical Series	Index Symbol	Page Number
Monographs	Monogr.	30
Handbooks	H	33
Miscellaneous Publications	M	34
Special Publications	SP	35
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5.2. AUTHOR INDEX

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Creatinine SRM; D-glucose (clinical SRM); Organic trace analysis; SRM's for clinical analysis; Urea SRM; Uric acid SRM; 6-amino-6-deoxy-D-glucose-6-^{15}N; Bilirubin analysis; Calcium carbonate SRM; *TN507.*

Creative engineering; Engineering education; Innovation; Invention; Technological change; *10536.*

Creep; Creep activation energy; Dental amalgam; Silver amalgam; Amalgam; **J.72C** *No. 3, 215-218 (1968).*

Creep; Crystal growth; Diffusion; Enthalpy; Evaporation; Fracture; Glass band structure; High temperature materials; Mass transport; Materials properties; Mechanical relaxation; Oxides; Polymers; Pyrolytic graphite; Transition metal borides; Copper; *TN494.*

Creep; Dental; Steady-state creep; Stress-strain; Transient creep; Viscoelastic; Amalgam; **J.72C** *No. 3, 203-213 (1968).*

Creep; Elastic fluid; Elastic strain energy function; Finite strain; Non-linear behavior; Non-Newtonian fluids; Normal stresses; Pure shear; Simple extension; Simple shear; Stress relaxation; Time effects; Uniaxial strain; Viscoelasticity; BKZ theory; *9583.*

Creep; Elastic fluid; Nonlinear behavior; Polyisobutylene; Polyvinylchloride; Recovery; Stress relaxation; BKZ theory; Constant rate of strain; *10144.*

Creep; Engineering design; High temperatures; Phase changes; Rupture; Titanium alloy; **J.72C** *No. 2, 167-174 (1968).*

Creep; Loss of prestress; Prestressed concrete; Relaxation; Shrinkage; Variable prestress; *BSS13*.

Creep activation energy; Dental amalgam; Silver amalgam; Amalgam; Creep; **J.72C** *No. 3, 215-218 (1968)*.

Criminology; Data handling; Geochemistry; Industry; Neutron; Nuclear reactions; Photons; Radiation detectors; Radiochemical separation; Activation analysis; Applications; Archaeology; Biology; Charged particles; Computation; *SP312, Volumes I and II*.

Critical aperture; Relative contrast; Resolving power; Chromatic aberration; *10121*.

Critical configurational entropy; Glass transformations; Molecular configurational relaxation; Configurational entropy; *9631*.

Critical data; Ethylene; Hydrogenation; Metallic catalysts; Reaction mechanisms; Reaction rates; *NSRDS-NBS13*.

Critical density; Experimental measurement; Helium gas; Parallel plate method; Thermal conductivity; Capacitance method; *10705*.

Critical distance; Illumination; Light projectors; Photometric distance; Photometry; Signal lighting; *9682*.

Critical energy; Generating function; Lattice model; Partition function; Random walk; Adsorption; Chain polymer; *10031*.

Critical evaluation; Gases; Graphites; Metallic elements; Metals; Recommended values; Standard reference data; Thermal conductivity; *NSRDS-NBS16, Part 2*.

Critical evaluation; Information centers; Information services; NSRDS; Physical properties; Standard reference data; *10318*.

Critical exponents; Critical isotherm; Critical region; Density gradients; Equation of state; Gases; Gravity effect; Scaling law; Compressibility; *9757*.

Critical field; Critical temperature; Crystallographic data; Low temperature; Superconductivity; Bibliography; Compilation of data; Composition; *TN482*.

Critical field; Field dependence; Nickel pellets; Nickel powder; Nuclear resonance; Permeability; *9575*.

Critical fields; Magnetic moment; Penetration depth; Semiconducting systems; SrTiO$_3$; Superconducting; Transition temperature; (Ba$_x$Sr$_{1-x}$)TiO$_3$; (Ca$_y$Sr$_{1-y}$)TiO$_3$; *10817*.

Critical indices; Equation of state; Scaling-laws; *10522*.

Critical isotherm; Critical region; Density gradients; Equation of state; Gases; Gravity effect; Scaling law; Compressibility; Critical exponents; *9757*.

Critical magnetic scattering; Diffusivity; Heisenberg magnets; Neutron cross section; *10835*.

Critical mixtures; Critical opalescence; Light scattering; Phase separations; Binary mixtures; Coexistence curves; *10271*.

Critical opalescence; Critical phenomena; Isooctane; Low angle x-ray scattering; Perfluoroheptane; Correlation function; *10461*.

Critical opalescence; Critical phenomena; Density fluctuations in fluids; Light scattering; Volume viscosity; Brillouin scattering; **J.73A** *No. 6, 593-598 (1969)*.

Critical opalescence; Electric field effect and light scattering; Relaxation time; Binary mixture; Concentration fluctuations; *10523*.

Critical opalescence; Electric field effect; Excess concentration; Van der Waals; Binary mixture; *10630*.

Critical opalescence; Gas liquid transition; Laser light scattering; Magnets; Superfluids; Transport processes; Critical phenomena in: binary alloys; Binary liquid mixture; *10602*.

Critical opalescence; Light scattering; Phase separations; Binary mixtures; Coexistence curves; Critical mixtures; *10271*.

Critical phenomena; Critical scattering; Scattered intensity; Small angle x-ray scattering; Correlation function; *9593*.

Critical phenomena; Density fluctuations in fluids; Light scattering; Volume viscosity; Brillouin scattering; Critical opalescence; **J.73A** *No. 6, 593-598 (1969)*.

Critical phenomena; Fluctuation and time correlation function; Heat capacity; Shear viscosity; Thermal conductivity; Van der Waals gas; Volume viscosity; *10696*.

Critical phenomena; Isooctane; Low angle x-ray scattering; Perfluoroheptane; Correlation function; Critical opalescence; *10461*.

Critical phenomena in: binary alloys; Binary liquid mixture; Critical opalescence; Gas liquid transition; Laser light scattering; Magnets; Superfluids; Transport processes; *10602*.

Critical phenomena in liquid vapor systems; Liquid vapor systems; Statistical mechanics; Thermodynamics of phase changes; *9755*.

Critical point; Density fluctuations in fluids; Landau-Placzek intensity ratio; Negative dispersion; Non-local hydrodynamics; Thermal diffusivity; Brillouin scattering; Carbon dioxide-light scattering; *9959*.

Critical point; Equation; Formula; Liquid; Nitrogen; Nonanalytic; Oxygen; Vapor pressure; **J.73A** *No. 5, 487-491 (1969)*.

Critical point; Equation of state; Hydrogen; Parahydrogen; Specific heats; Thermodynamic properties; **J.73A** *No. 6, 585-591 (1969)*.

Critical point parameters; Critical region; Fluids; He^4; Scaling laws; Specific heat; Thermodynamic properties; Vapor pressure; Xenon; CO$_2$; Chemical potential; **J.73A** *No. 6, 563-583 (1969)*.

Critical region; Density gradients; Equation of state; Gases; Gravity effect; Scaling law; Compressibility; Critical exponents; Critical isotherm; *9757*.

Critical region; Fluids; He^4; Scaling laws; Specific heat; Thermodynamic properties; Vapor pressure; Xenon; CO$_2$; Chemical potential; Critical point parameters; **J.73A** *No. 6, 563-583 (1969)*.

Critical region; Lattice gas; Scaling law; Specific heat; Thermodynamic anomalies; Vapor pressure; Chemical potential; *10603*.

Critical review; Electron impact; Multiply charged ions; Relative cross sections; Absolute cross sections; *9843*.

Critical scattering; Scattered intensity; Small angle x-ray scattering; Correlation function; Critical phenomena; *9593*.

Critical temperature; Crystallographic data; Low temperature; Superconductivity; Bibliography; Compilation of data; Composition; Critical field; *TN482*.

Critically evaluated data; Equilibrium electrochemical cells; Excess entropies; Excess Gibbs free energies; Gibbs free energies; Molten salt mixtures; Molten salts; Surface tension; Thermodynamics of molten salts; *NSRDS-NBS28*.

Cross section; Cryostat; Helium-3; Helium-4; Neutrons; Photodisintegration; Bremsstrahlung; *9739*.

Cross section; Dielectric constant; Oscillator strength; Plasmon; Aluminum oxide; Characteristic energy loss; *10439*.

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Cross section; Dipole-quadrupole interaction; Giant resonances; *9790*.

Cross section; Electron; Excitation threshold; Helium; Inelastic scattering; Negative ion; Resonance; *9630*.

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ture; Ultra-pure reagents; Urea; Uric acid; Analytical distillation; Clinical standards; *TN459.*

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Crystallization; Kinetics; Multicomponent chains; Polymer crystallization; *10340.*

Crystallization; Single-crystal growth; Crystal growth; *10102.*

Crystallization-oriented; Lamella thickness; Logarithmic-decrement; Modulus; Polyethylene; Relaxations; Shear; Temperature; Torsion pendulum; *a, c* face of cell; Compliance; *9689.*

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Crystallography; Silver iodide; Site-occupation; Structure; Structure memory; Alpha-phase; *10322.*

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$Cs_2ZnCl_4(Cu)$; Tetrachlorocuprate ion; Single crystals; Band assignments; Charge transfer spectra; Cs_2CuCl_4; *10068.*

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Curved bar analysis; Discrete variables; Elastic; Force transducer; Minimum weight; *n*-degree elliptical ring; Nonlinear programming; Nonrandom complex method; Optimization; Rib-stiffened plate; Structural analysis; *J.***72C** *No. 4, 249-258 (1968).*

Curved bar analysis; Elasticity; Force transducer; *n*-degree elliptical ring; Nonlinear programming; Optimization; Proving ring; Structural design; Theory; *J.***72C** *No. 2, 139-160 (1968).*

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Data systems; Information handling experts; Technical information; *10812*.

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D-C amplifier; Design equations; Differential amplifier; Dual regulator; Integrated circuit; Output resistance; Power dissipation; Power supply; Preregulator; Regulation factor; Ripple voltage; Transistor; Voltage regulation; Zener diode; *TN371*.

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DCN; Emission; Far infrared; HCN; Lasers; Spectra; *10491*.

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Thermometry; Tunnel junctions; Josephson effect; Superconductivity; *TN381.*

Thermophysical properties; Bibliography, high temperature; Chemistry, high temperature; High temperature chemistry; Materials properties; Research at high temperatures; *SP315-1.*

Thermophysical properties; Bibliography, high temperature; Chemistry, high temperature; High temperature chemistry; Materials properties; Research at high temperatures; *SP315-2.*

Thermophysical properties; Bibliography, high temperature; Chemistry, high temperature; High temperature chemistry; Materials properties; Research at high temperatures; *SP315-3.*

Thermophysical properties; Conductance; Conductivity; Contact conductance; Contact resistance; Electrical conductivity; Electrical resistivity; Heat transfer; Lorenz function; Resistivity; Temperature; Thermal conductivity; Thermal diffusivity; *SP302.*

Thermophysical properties; Cryogenic temperature; Metals; *9995.*

Thermopile; Absolute radiometry; Detectors; Extreme ultraviolet; Ionization chamber; Monochromator; *10469.*

Thermoviscoelasticity; Cylinder; Neumann series; **J.73B** *No. 1, 31-40 (1969).*

Theta alumina; Alpha alumina; Alumina; Amorphous alumina; Delta alumina; Gamma alumina; Intermediate aluminas; Metastable aluminas; Phase transitions; *10298.*

Thick target bremsstrahlung; Efficiencies; Low energy; Monte Carlo predictions; Photon emission angles; *9991.*

Thickness of graphs; Conjectures; Connectivity; Cut-set; Graph

Traditional property-rights; Unrestricted copying; Useful service; Anti-trust violations; Better products; Copiers; Developer-producer's; Dormant patents; Higher productivity; Improvements; Industrial stimulus; Industrial trade associations; *9780*.

Traffic allocation; Transportation; Algorithm; Least cost; **J.73B** *No. 2, 91-118 (1969)*.

Traffic flow; Transportation theory; Allocation; Queueing theory; Scheduling; Switching theory; **J.72B** *No. 3, 215-227 (1968)*.

Training; Weights; Laboratory; Measure; Standards; States; *10086*.

Trajectory calculations; Transport processes; Chemical kinetics; Cross sections; Rate theory; Scattering theory; *10604*.

Transducer; Acceleration; Calibrator; Dual centrifuge; Dynamic; Inter-agency Transducer Project; Life-cycling; Pressure; Shock tube; Thermal transient; *10483*.

Transducer; Calibration; Dynamic calibration; Electro-mechanical; Performance; Pressure; Telemetering; Test method; *10666*.

Transducer; Dynamic calibration; Evaluation; InterAgency Transducer Project; Performance characteristics; Telemetry; *TN469*.

Transducer; High temperatures; Information services; Instrumentation; *10496*.

Transducer activities; Transducer instrumentation; Transducers; *10479*.

Transducer instrumentation; Transducers; Transducer activities; *10479*.

Transducer workshop; NBS; *10455*.

Transducers; Transducer activities; Transducer instrumentation; *10479*.

Transducers; Uncertainty; Weighing; Calibration; Force; Load cells; Proving rings; *TN436*.

Transfer; AC; DC; Operation; Precision; Rectifier; **J.73C** *Nos. 3 and 4, 47-55 (1969)*.

Transfer energy; Acidity; Medium effects; Mixed solvents; Solvation of ions; Solvent effect; *10827*.

Transfer function; Deflector; Drift space; Oscilloscope; Standard; Strip-line; **J.72C** *No. 2, 117-125 (1968)*.

Transfer of technology; Technological measurements; *10487*.

Transfer standard; AC; Calibration; DC; Intercomparison; Thermoelement; *10107*.

Transfer standard; Transverse motion; Vibration pickups; Accelerometer; Axial motion; Ceramic; Comparison calibration; *9813*.

Transfer standards; Ac-dc transfer standards; Alternating current and voltage; Thermal converters; *9783*.

Transfer standards; Voltage comparator; Voltage measurements; Audio-frequency; Comparator; Standards; Thermal convectors; Thermoelements; *9782*.

Transference numbers; Batteries; Debye-Hückel-Onsager theory of conductance; Electrochemical thermodynamics; Electrode mechanisms; Electrolytic conductivity; Fuel cells; Ionic charge; Ionization; Standard cells; *10559*.

Transformation algorithm; Wiswesser; Acyclic; Benzene; Chemical structure notations; Connection tables; Contractions; Ring system; Syntax analysis; *TN432*.

Transformation algorithm; Wiswesser; Acyclic; Benzene; Chemical structure notations; Connection tables; Contractions; Ring system; Syntax analysis; *10550*.

Transformation coefficients; Angular momentum; Asymmetric rotor; Eigenfunction; Microwave spectra; Rotational spectrum; *NSRDS-NBS12*.

Transformer; Two-stage voltage transformer; Voltage divider; Voltage ratio; Calibration; In-phase deviation; Inductive voltage divider; Measurements; Quadrature deviation; Ratio calibration; **J.72C** *No. 1, 49-59 (1968)*.

Transient creep; Viscoelastic; Amalgam; Creep; Dental; Steady-state creep; Stress-strain; **J.72C** *No. 3, 203-213 (1968)*.

Transistor; EDP system; Patent; Patent information retrieval; Patent search; *9644*.

Transistor; Variable; Current; Generator; Magnetic; Stable; *10127*.

Transistor; Voltage regulation; Zener diode; D-C amplifier; Design equations; Differential amplifier; Dual regulator; Integrated circuit; Output resistance; Power dissipation; Power supply; Preregulator; Regulation factor; Ripple voltage; *TN371*.

Transistor reliability; Transistors; Circuit reliability; Diodes; Failure mechanisms; Failure modes; Review; Second breakdown; Semiconductor devices; Thermal breakdown; *10230*.

Transistors; Breakdown; Diodes; Reliability; Second breakdown; Thermal instability; *10048*.

Transistors; Circuit reliability; Diodes; Failure mechanisms; Failure modes; Review; Second breakdown; Semiconductor devices; Thermal breakdown; Transistor reliability; *10230*.

Transistors; Diodes; Failure mechanisms; Internal current distributions; Second breakdown; Semiconductors; Temperature sensitive phosphors; *10050*.

Transistors; Electronics; Failure mechanism; P-n junctions; Reliability; Second breakdown; *10781*.

Transistors; X-ray diffraction microscopy; Dislocations; Failure mechanisms; Second breakdown; Semiconductors; *10051*.

Transit time; Ultrasonic pulses; Fluid range; Measure pressures; Pressure gages; Pressure-sensitive components; Regenerating circuits; *10563*.

Transition; Hot-wire anemometry; Instability; Laminar boundary layer; Roughness; *9847*.

Transition; Vibrational; Acetylene probability; Franck-Condon factors; Photoionization; *10027*.

Transition array; Calculated line strengths; Configuration interaction; Intermediate coupling; Ti II; $3d^3$, $3d^24s$, $3d^24p$ configurations; **J.73A** *No. 1, 51-64 (1969)*.

Transition metal borides; Copper; Creep; Crystal growth; Diffusion; Enthalpy; Evaporation; Fracture; Glass band structure; High temperature materials; Mass transport; Materials properties; Mechanical relaxation; Oxides; Polymers; Pyrolytic graphite; *TN494*.

Transition metals; A15-type phase; Atomic packing; Beta-tungsten phase; Electronic structure; Order-disorder transformation; Ordering of atoms; Phase stability; Sigma phases; *10498*.

Transition pressure; High pressure; Piston gauge; Pressure measurement; *10159*.

Transition pressure; Volume change; Bismuth; Free piston gage; High pressure; Polymorphic phase transition; *9785*.

Transition probabilities; Allowed and forbidden transitions; Aluminum; Argon; Calcium; Chlorine; Magnesium; Oscillator strengths; Phosphorus; Potassium; Silicon; Sodium; Sulfur; *NSRDS-NBS22*.

Transition probabilities; Ar I; Intermediate coupling; Lifetime measurements; Local thermal equilibrium; Spectra; *10723*.

Transition probabilities; Atomic spectra; Rare-earth spectra; Solar spectrum; *9949*.

Transition probabilities; CO; CO^+; Electronic transition moment integrals; Franck-Condon factors; Franck-Condon principle; **J.72A** *No. 5, 495-503 (1968)*.

Transition probabilities; Oscillator strengths; Spectra, atomic; Terbium; *10739*.

Transition probabilities; Triple commission for spectroscopy; Ultraviolet atomic spectra; Atomic spectra; Rare-earth spectra; *9951*.

Transition probabilities; Ultrasonic (paramagnetic) resonance; Ultrasonic transition probabilities; Wave functions of Fe^{+++}; Energy levels of Fe^{+++} in Al_2O_3; **J.73A** *No. 2, 241-268 (1969)*.

Transition probabilities; Ultraviolet spectra; Atomic spectra;

Lanthanon spectra; Molecular spectra; Rare earth spectra; *10406*.

Transition probabilities; Wall-stabilized arc; Line strength; Nickel-carbonyl; Ni I and Ni II; Oscillator strength; Relative measurements; *9573*.

Transition probabilities; Wavelength standards; Laboratory spectra; Molecular spectra; Solar spectrum; Standards, wavelength; *10588*.

Transition probabilities in Fe I; Fe I; Iron; Oscillator strengths; Spectrum; Spectrum of neutral iron; *Monogr. 108*.

Transition probabilities of spectral lines; Wavelength standards; Standard wavelengths; *9952*.

Transition probability; Allowed; Atomic; Discrete; Forbidden; *M278 Supplement*.

Transition probability; Arc; Atomic spectroscopy; Plasma; Stark broadening; Sulfur; *10209*.

Transition probability; Argon; Plasma; Spectroscopy; *10071*.

Transition probability; Density of states; Emission spectrum; Linear detection; Nickel; Oxide free; Paramagnetic; Soft x-ray; *10334*.

Transition probability; Einstein A coefficient; Hydroxyl; Radical; *9891*.

Transition probability; Velocity average; Atomic beam; Frequency shift; Rabi spectrometer; Schrödinger equation; *10430*.

Transition temperature; $(Ba_xSr_{1-x})TiO_3$; $(Ca_ySr_{1-y})TiO_3$; Critical fields; Magnetic moment; Penetration depth; Semiconducting systems; $SrTiO_3$; Superconducting; *10817*.

Transition temperature; Cerous magnesium nitrate; Curie-Weiss constant; Dipole-dipole interaction (pure); Entropy; Lattice sums; Magnetic susceptibility; *10264*.

Transition temperatures; Semiconductors; $SrTiO_3$; Superconductivity; *10381*.

Transitions; Triple point; Dilatometry; Enthalpy; Entropy; Helical molecule; Low pressure; Phase diagram; Polytetrafluoroethylene; **J.72A** *No. 5, 467-470 (1968)*.

Transmission curves; Beta absorption; Beta-particle energy; Beta-particle transmission; Half-thickness; Infinitely-thick sources; Low-level; Synthetic beta sources; *10421*.

Transmission electron microscopy; Alloys; Dislocation; Dislocation nodes; Stacking faults; *9804*.

Transmission line; Digital computer program; Distributed networks; Inverse Laplace Transformation; Lumped networks; Rosenbrock cursor; Step response; **J.73B** *No. 2, 163-176 (1969)*.

Transmission line; Waveguide; Air lines; Coaxial; Impedance; Measurements; Standards; *9809*.

Transmission-line voltages; Voltage measurements; Current measurement; Measurement voltages; Microwave current; Microwave voltages; **J.72C** *No. 1, 61-79 (1968)*.

Transmittance; Luminance; Luminous flux; Luminous intensity; Photometric brightness; Photometry; Reflectance; *9549*.

Transmittance; Ultraviolet; X-rays; Absorption; Films; Spectra; Tin; *9639*.

Transport; Angular distributions; Energy spectrum; Gamma rays; Invariant imbedding; Shielding; *10786*.

Transport; Diffraction; Inelastic; Interaction; Materials; Neutron; Properties; Reaction; Scattering; Structure; *10553*.

Transport (effects); Cold neutrons; D_2O(ice); (leakage) spectra; Neutron; (neutron) flux; (neutron) moderation; (neutron) spectra; Neutron temperature; (neutron) thermalization; *10042*.

Transport coefficient; Composite material; Dielectric constant; Diffusion constant; Electrical conductivity; Eutectic; Heat conductivity; Magnetic permeability; *10757*.

Transport coefficients; Isothermal susceptibility; Nonlinear response theory; Nonlinear transport theory; Response functions; *9987*.

Transport phenomena; Viscous flow; Continuous systems; Diffusion flow; Discontinuous systems; Membranes; Nonequilibrium thermodynamics; Porous media; Thermal transpiration; *10362*.

Transport problems; Diffusion theory; Exponential integral; Indefinite integrals; Quantum mechanics; Radiative equilibrium; Special functions; **J.73B** *No. 3, 191-210 (1969)*.

Transport processes; Chemical kinetics; Cross sections; Rate theory; Scattering theory; Trajectory calculations; *10604*.

Transport processes; Critical phenomena in: binary alloys; Binary liquid mixture; Critical opalescence; Gas liquid transition; Laser light scattering; Magnets; Superfluids; *10602*.

Transport properties; Argon; Kinetic theory; Phase studies; Potential functions; Special functions; Thermodynamics; *9767*.

Transport properties; BBGKY hierarchy; Bogolyubov's functional assumption; Chapman-Enskog method; Dense gases; *9756*.

Transport properties; Bibliography; Equation of state; Low temperature; Mechanical properties; Methane; Thermodynamic properties; *TN367*.

Transport properties; Triple collisions; Viscosity; Dense gases; Diffusion; Rigid disks; Rigid spheres; Thermal conductivity; *10709*.

Transport properties; Validity range; Viscosity; Dilute gas; Dilute limit; Low pressure; Mean-free-path; *10520*.

Transport properties; Viscosity; Collision integrals; Diffusion; Potential; Thermal conductivity; Thermal diffusion; **J.72A** *No. 4, 359-424 (1968)*.

Transport species; Boron; Electric discharge; Germanium; Oxyfluorides; Reactive intermediates; Silicon; Time-of-flight mass spectrometry; *10853*.

Transport theory; Two-layer slabs; Dose transmission; Gamma-rays; Invariant imbedding; Penetration; *10787*.

Transportable ten picofarad capacitor; Unit of capacitance; Volume dependence; Capacitance standards; Fused silica dielectric; Picofarad capacitor; Shock sensitivity; Stability of value; Ten picofarad capacitor; *9653*.

Transportation; Agriculture; Compressed gases; Conservation; Cryogenics; Education; Health; National goals; Space; *10842*.

Transportation; Algorithm; Graph; Network; Optimization; Shortest-path; *10552*.

Transportation; Algorithm; Least cost; Traffic allocation; **J.73B** *No. 2, 91-118 (1969)*.

Transportation; Conservation; Cryoelectronics; Cryogenics; Cryopumping; Helium; Liquefaction; Magnets; Purification; Refrigeration; Safety; Storage; Thermodynamic properties; *Monogr. 111*.

Transportation; Transportation technology; Urban transportation; Future transportation; Regional transportation; Technology; *10342*.

Transportation planning; Travel forecasting; Urban transportation; Modal choice; Systems analysis; *10429*.

Transportation planning; Urban transportation; Data processing; Systems analysis; *10164*.

Transportation systems; Computer simulation model; Network-simulation; Railroad freight transportation systems; *10150*.

Transportation technology; Urban transportation; Future transportation; Regional transportation; Technology; Transportation; *10342*.

Transportation theory; Allocation; Queueing theory; Scheduling; Switching theory; Traffic flow; **J.72B** *No. 3, 215-227 (1968)*.

Transportation vehicle; Utility functions; Computer algorithm; Iterative equation; Optimal scheduling; Parametric analysis; *10185*.

Transverse displacement; Vector solution; Approximation errors; Complex dielectric constant; Convergence confidence interval; Contour diagrams; Dielectric liquid; Diffraction; Ex-

Vacuum techniques; Capture coefficient; Cryocondensation; Cryogenically cooled surfaces; Cryopump; Partial pressure measurements; Pressure calibration with vapor pressures; Pressure anisotropy; Pumping efficiency; Pumping speed; Speed factor measurements; *10265*.

Vacuum ultraviolet; Energy transfer; Excited species; Fluorescence; Gas phase; N_2O; Photolysis; *10208*.

Vacuum ultraviolet; Adsorption; Excited NH; Excited NH_2; Fluorescence; NH_3; Photodissociation; *10411*.

Vaccum ultraviolet; Autoionization; CO_2; COS; CS_2; Electronic; Excited states; Heats of formation; Ionization thresholds; Ions; Mass spectrometry; O_2; Photoionization; Radicals; Rydberg series; *10274*.

Vacuum ultraviolet; Bond dissociation; Heats of formation; Ionization energies; *10538*.

Vacuum ultraviolet; CF_4; C_2F_6; C_3F_8; C_4F_{10}; CF_3H; CF_3Cl; CF_3Br; CF_3I; Heats of formation; Ionization energies; **J.72A** *No. 5, 479-485 (1968)*.

Vacuum ultraviolet; CH; Flash photolysis; Hydrogen; Kinetic spectroscopy; Methane; Nitrogen; Rate constant; *9597*.

Vacuum ultraviolet; Absorption; Analysis; Gas; Photochemistry; Spectroscopy; *TN476*.

Vacuum ultraviolet; Free radical; Infrared; Matrix isolation; Methyl; Methylene; Photolysis; Rotation; Spectrum; Ultraviolet; *10404*.

Vacuum ultraviolet; Optical constants; Polystyrene; Reflectance electron energy loss; *10784*.

Vacuum ultraviolet; Oxygen adsorption; Photoelectric effect; Tungsten; *10800*.

Vacuum ultraviolet; Oxygen adsorption; Photoelectric effect; Tungsten; *10115*.

Vacuum ultraviolet; Photolysis; Propylene; *10795*.

Vacuum ultraviolet; Photolysis; Propane chain decomposition; *9878*.

Vacuum ultraviolet; Wavelength; Energy levels; Silicon; Spectroscopy; Standards; *10001*.

Vacuum ultraviolet; Wavelengths; Energy levels; Interaction parameters; Praseodymium; Third spectrum; **J.73A** *No. 3, 333-381 (1969)*.

Vacuum ultraviolet nitrosyl chloride; Absorption spectra; Fluorescence excited states; Nitrogen dioxide; Photodissociation; *10669*.

Vacuum ultraviolet photolysis; Acetylene; C_2; HC_2; Infrared spectrum; Mulliken bands of C_2; Swan bands of C_2; Ultraviolet spectrum; *10246*.

Vacuum ultraviolet photolysis; CN free radical; Cyanogen; Cyanogen bromide; Cyanogen chloride; Cyanogen fluoride; Halogen isocyanides; Hydrogen cyanide; Hydrogen isocyanide; Infrared spectrum; Matrix isolation technique; Ultraviolet spectrum; *10233*.

Vacuum ultraviolet photolysis; C atom reaction; CN reaction; HN_3 photolysis; Infrared spectrum; Matrix isolation; NCO free radical; NO reaction; O^3 atom reaction; Ultraviolet spectrum; *10405*.

Vacuum ultraviolet spectroscopy; Dissociation energies; HCl; Ionization; Mass spectrometry; Methyl halides; **J.72A** *No. 4, 281-293 (1968)*.

Vacuum uv monochromator; Autoionization; BrCN; C_2N_2; ClCN; FCN; Heats of formation; ICN; Mass spectrometer; Photoionization; Rydberg levels; *10338*.

Validity range; Viscosity; Dilute gas; Dilute limit; Low pressure; Mean-free-path; Transport properties; *10520*.

Value; Fluoride; High-temperature; High-vacuum; Metal; Nickel-Monel; Non-corrosive; *10748*.

Values of Faraday; Coulometers; Faraday; Inclusions in silver coulometers; **J.72A** *No. 4, 435-439 (1968)*.

Van der Waals; Binary mixture; Critical opalescence; Electric field effect; Excess concentration; *10630*.

Van der Waals gas; Volume viscosity; Critical phenomena; Fluctuation and time correlation function; Heat capacity; Shear viscosity; Thermal conductivity; *10696*.

Van der Waals mixtures; Viscosity; Heat capacity; Solution critical point; *9671*.

Van Hove G(r,t); Convolution approximation; *9967*.

Vanadium, the fourth and fifth spectra of; Atomic spectra, V IV and V V; Classified lines, V IV and V V spectra; Spectra V IV and V V; **J.72A** *No. 4, 295-308 (1968)*.

Vanadium hydride; Vibration spectra; Crystal structure; Frequency distribution; Hydrogen positions; Hydrogen vibration; Metal hydride; Neutron inelastic scattering; Phase transformation; *10598*.

Vanadium tetrachloride; Jahn-Teller distortion; Ligand field; Magnetic susceptibility; Paramagnetic relaxation; Paramagnetic resonance; *10758*.

Vapor; Cylindrical and spherical shapes; Solution or vapor; Spherical shapes; *9643*.

Vapor and density pressure; Density and vapor pressure; Nitromethane density; Nitromethane vapor pressure; *9582*.

Vapor content; Wet-bulb; Adiabatic saturation; Gas mixtures; Humidity; Hygrometer; Mixing ratio; Moist gas; Psychrometer; Psychrometric factor; Saturation; Thermodynamic wet-bulb temperature; **J.72C** *No. 1, 33-47 (1968)*.

Vapor deposition; Crystal growth; Epitaxy; Fe-W alloying; Field emission microscopy; *10165*.

Vapor deposition; Deposition of tungsten; Hydrogen reduction; Investigation of variables; Tungsten hexafluoride; *9579*.

Vapor deposition; Hexafluoroacetylacetonate; Rhenium; *10818*.

Vapor dimerization; Vapor pressure; Aluminum fluoride; Entrainment method; Heat of sublimation; Temperature; *10382*.

Vapor phase failure; Methanol; Stress corrosion; Titanium; Titanium 8-1-1; *10503*.

Vapor pressure; Activity coefficient; Calcium chloride; Isopiestic measurements; Mixed salt solutions; Osmotic coefficients; Potassium chloride; **J.72A** *No. 3, 239-245 (1968)*.

Vapor pressure; Aluminum fluoride; Entrainment method; Heat of sublimation; Temperature; Vapor dimerization; *10382*.

Vapor pressure; Carbon dioxide; Fixed point; Hypsometer; Pressure standard; Purification; **J.72C** *No. 1, 27-32 (1968)*.

Vapor pressure; Chemical potential; Critical region; Lattice gas; Scaling law; Specific heat; Thermodynamic anomalies; *10603*.

Vapor pressure; Critical point; Equation; Formula; Liquid; Nitrogen; Nonanalytic; Oxygen; **J.73A** *No. 5, 487-491 (1969)*.

Vapor pressure; Vapor pressure of water; Water; Manometer; Precision manometer; Pressure; *p-t* relation; *p-t* relation of water; Standard resistance thermometers; Temperature; **J.73A** *No. 5, 493-496 (1969)*.

Vapor pressure; Virial coefficient; Argon; Compressibility factor; Enthalpy; Entropy; Equation of state; Internal energy; Joule-Thomson coefficient; *P-V-T*; Specific heat; *NSRDS-NBS27*.

Vapor pressure; Water in alumina; Water vapor; Alumina; Arc-image furnace; Heat of vaporization; Molten alumina; Temperature measurement; Vaporization; *9675*.

Vapor pressure; Xenon; CO_2; Chemical potential; Critical point parameters; Critical region; Fluids; He^4; Scaling laws; Specific heat; Thermodynamic properties; **J.73A** *No. 6, 563-583 (1969)*.

Vapor pressure of water; Water; Manometer; Precision manometer; Pressure; *p-t* relation; *p-t* relation of water; Standard resistance thermometers; Temperature; Vapor pressure; **J.73A** *No. 5, 493-496 (1969)*.

Vaporization; Vapor pressure; Water in alumina; Water vapor; Alumina; Arc-image furnace; Heat of vaporization; Molten alumina; Temperature measurement; *9675*.

Vapors; High temperature chemistry; High temperatures; Kilodegree range; Thermodynamic properties; *10456*.

Variability; Colorimetry; Propagation of errors; Uncertainty in chromaticity coordinates; Uncertainty in spectral tristimulus

APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

Alexander City: Alexander City State Junior College Library (1967).
Auburn: Auburn University, Ralph Brown Draughon Library (1907).
Birmingham:
  Birmingham Public Library (1895).
  Birmingham-Southern College, M. Paul Phillips Library (1932).
  Samford University, Harwell G. Davis Library (1884).
Enterprise: Enterprise State Junior College Library (1967).
Florence: Florence State College, Collier Library (1932).
Gadsden: Gadsden Public Library (1963).
Huntsville: University of Alabama, Huntsville Campus Library (1964).
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
Maxwell A. F. Base: Air University Library (1963).
Mobile:
  Mobile Public Library (1963).
  Spring Hill College, Thomas Byrne Memorial Library (1937).
  University of South Alabama Library (1968).
Montgomery:
  Alabama State Department of Archives and History Library (1884).
  Alabama Supreme Court Library (1884).
Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
St. Bernard: St. Bernard College Library (1962).
Troy: Troy State College Library (1963).
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
University:
  University of Alabama Law Library (1967).
  University of Alabama Library (1860)—REGIONAL.

ALASKA

Anchorage:
  Anchorage Community College Library (1961).
  Anchorage Methodist University Library (1963).
College: University of Alaska Library (1922).
Juneau: Alaska State Library (1964).

ARIZONA

Flagstaff: Northern Arizona University Library (1937).
Phoenix:
  Department of Library and Archives (unknown)—REGIONAL.
  Phoenix Public Library (1917).
Prescott: Prescott College Library (1968).
Tempe: Arizona State University, Matthews Library (1944).
Thatcher: Eastern Arizona Junior College Library (1963).
Tucson: University of Arizona Library (1907)—REGIONAL.
Yuma: Yuma City-County Library (1963).

ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).
Batesville: Arkansas College Library (1963).
Clarksville: College of the Ozarks Library (1925).
College Heights: Arkansas Agricultural and Mechanical College Library (1956).
Conway: Hendrix College, O. C. Bailey Library (1903).
Fayetteville: University of Arkansas Library (1907).
Little Rock:
  Arkansas Supreme Court Library (1962).
  Little Rock Public Library (1953).
Magnolia: Southern State College, J. M. Peace Library (1956).
Russellville: Arkansas Polytechnic College, Tomlinson Library (1925).
Searcy: Harding College, Beaumont Memorial Library (1963).
State College: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcata: Humboldt State College Library (1963).
Bakersfield: Kern County Library.
Berkeley:
  University of California, General Library (1907).
  University of California, Law Library, Earl Warren Legal Center (1963).
Chico: Chico State College Library (1962).
Claremont: Pomona College Documents Collection, Honnold Library (1913).
Culver City: Culver City Library (1966).
Davis: University of California Library (1953).
Downey: Downey City Library (1963).
Fresno:
  Fresno County Free Library (1920).
  Fresno State College Library (1962).
Fullerton: California State College at Fullerton Library (1963).
Gardena: Gardena Public Library (1966).
Hayward: California State College at Hayward Library (1963).
Inglewood Public Library (1963).
Irvine: University of California at Irvine Library (1963).
La Jolla: University of California, San Diego, University Library (1963).
Lancaster: Lancaster Regional Library (1967).
Long Beach:
  California State College at Long Beach Library (1962).
  Long Beach Public Library (1933).
Los Angeles:
  California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
  Los Angeles County Law Library (1963).
  Los Angeles Public Library (1891).
  Loyola University of Los Angeles Library (1933).
  Occidental College, Mary Norton Clapp Library (1941).
  Pepperdine College Library (1963).
  University of California at Los Angeles Library (1932).
  University of California, School of Law Library (1958).
  University of Southern California Library (1933).
Lynwood: Lynwood Library (1966).
Marysville: Yuba College Library (1963).
Menlo Park: Department of the Interior, Geological Survey Library (1962).
Montebello: Montebello Library (1966).
Monterey: Naval Postgraduate School Library (1963).
Monterey Park: Bruggemeyer Memorial Library (1964).
Newhall: Newhall Library of Los Angeles County Public Library System (1967).
Northridge: San Fernando Valley State College Library (1958).

Oakland:
  Mills College Library (1966).
  Oakland Public Library (1923).
Orange: Orange County Public Library (1963).
Pasadena:
  California Institute of Technology Library (1933).
  Pasadena Public Library (1963).
Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
  Riverside Public Library (1947).
  University of California at Riverside Library (1963).
Sacramento:
  California State Library (1895)—REGIONAL.
  Sacramento City Library (1880).
  Sacramento County Law Library (1963).
  Sacramento State College Library (1963).
San Bernardino: San Bernardino County Free Library (1964).
San Diego:
  San Diego County Library (1966).
  San Diego Public Library (1895).
  San Diego State College Library (1962).
  University of San Diego Law Library (1967).
San Francisco:
  Mechanics' Institute Library (1889).
  San Francisco Public Library (1889).
  San Francisco State College, Social Science and Business Library (1955).
  University of San Francisco, Richard A. Gleeson Library (1963).
San Jose: San Jose State College Library (1962).
San Leandro: San Leandro Community Library Center (1961).
Santa Ana: Santa Ana Public Library (1959).
Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz Library (1963).
Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
Stanford: Stanford University Libraries (1895).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Public Library (1969).
Turlock: Stanislaus State College Library (1964).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

COLORADO

Alamosa: Adams State College Library (1963).
Boulder: University of Colorado Libraries (1879)—REGIONAL.
Colorado Springs: Colorado College, Charles Leaming Tutt Library (1880).
Denver:
  Colorado State Library (unknown).
  Denver Public Library (1884)—REGIONAL.
  Department of Interior, Bureau of Reclamation Library (1962).
  Regis College, Dayton Memorial Library (1915).
  University of Denver, Mary Reed Library (1909).
Fort Collins: Colorado State University Library (1907).
Golden:
  Colorado School of Mines, Arthur Lakes Library (1939).
  Jefferson County Public Library (1968).
Greeley: Colorado State College Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Pueblo:
  McClelland Public Library (1893).
  Southern Colorado State College Library (1965).
U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).
Danbury: Western Connecticut State College Library (1967).
Hartford:
  Connecticut State Library (unknown)—REGIONAL.
  Hartford Public Library (1945).
  Trinity College Library (1895).
Middletown: Wesleyan University, Olin Library (1906).
Mystic: Mystic Seaport Library (1964).
New Haven:
  Southern Connecticut State College Library (1968).
  Yale University Library (1859).
New London:
  Connecticut College Library (1926).
  U.S. Coast Guard Academy Library (1939).
Pomfret: Pomfret School Library (1968).
Storrs: University of Connecticut, Wilbur Cross Library (1907).
Thompsonville: Enfield Public Library (1967).
Waterbury: Silas Bronson Library (1869).

DELAWARE

Dover:
  Delaware State College, William C. Jason Library (1962).
  State Law Library in Kent County (unknown).
Georgetown: Delaware Technical and Community College, Southern Branch Library (1968).
Newark: University of Delaware, Morris Library (1907).
Wilmington: Wilmington Institute Free Library (1861).

DISTRICT OF COLUMBIA

Washington:
  Bureau of the Budget Library, Executive Office of the President (1965).
  Civil Service Commission Library (1963).
  Department of Commerce Library (1955).
  Department of Health, Education, and Welfare Library (1954).
  Department of the Interior Central Library (1895).
  Department of the Interior, Geological Survey Library (1962).
  Department of Justice, Main Library (1895).
  Department of State Library (1895).
  Department of State, Office of Legal Advisor, Law Library (1966).
  Department of Transportation, National Highway Safety Bureau Library (1968).
  District of Columbia Public Library (1943).
  Georgetown University Library (1969).
  Indian Claims Commission Library (1968).
  National Agricultural Library (1895).
  National War College Library (1895).
  Navy Department Library (1895).

  - Navy Department, Office of Judge Advocate General Library (1963).
  - Post Office Department Library (1895).
  - Treasury Department Library (1895).
  - Veterans Administration, Medical and General Reference Library (1967).

FLORIDA

- Boca Raton: Florida Atlantic University Library (1963).
- Coral Gables: University of Miami Library (1939).
- Daytona Beach: Volusia County Public Libraries (1963).
- De Land: Steston University, DuPont-Ball Library (1887).
- Fort Lauderdale:
  - Fort Lauderdale Public Library (1967).
  - Nova University Library (1967).
- Gainesville: University of Florida Libraries (1907)—REGIONAL.
- Jacksonville:
  - Haydon Burns Library (1914).
  - Jacksonville University, Swisher Library (1962).
- Lakeland: Lakeland Public Library (1928).
- Leesburg: Lake-Sumter Junior College Library (1963).
- Melbourne: Florida Institute of Technology Library (1963).
- Miami:
  - Miami Dade Junior College, North Campus Library (1967).
  - Miami Public Library (1952).
- Milton: Aeronautical Systems Library (1969).
- Opa Locka: Biscayne College Library (1966).
- Orlando: Florida Technological University Library (1966).
- Palatka: St. Johns River Junior College Library (1963).
- Pensacola: University of West Florida Library (1966).
- St. Petersburg: St. Petersburg Public Library (1965).
- Tallahassee:
  - Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
  - Florida State Library (1929).
  - Florida State University, R. M. Strozier Library (1941).
- Tampa:
  - Tampa Public Library (1965).
  - University of South Florida Library (1962).
  - University of Tampa Library (1953).
- Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

- Albany: Albany Public Library (1964).
- Americus: Georgia Southwestern College, Wade Lott Memorial Library (1966).
- Athens: University of Georgia Libraries (1907).
- Atlanta:
  - Atlanta Public Library (1880).
  - Atlanta University, Trevor Arnett Library (1962).
  - Emory University, Asa Griggs Candler Library (1928).
  - Emory University, School of Law Library (1968).
  - Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
  - Georgia State Library (unknown).
- Augusta: Augusta College Library (1962).
- Brunswick: Brunswick Public Library (1965).
- Carrollton: West Georgia College, Sanford Library (1962).
- Dahlonege: North Georgia College Library (1939).
- Gainesville: Chestatee Regional Library (1968).
- Macon: Mercer University Library (1964).
- Marietta: Kennesaw Junior College Library (1968).
- Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
- Savannah: Savannah Public and Chatham-Effingham-Liberty Regional Library (1857).
- Statesboro: Georgia Southern College, Rosenwald Library (1939).
- Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

- Agana: Nieves M. Flores Memorial Library (1962).

HAWAII

- Hilo: University of Hawaii, Hilo Campus Library (1962).
- Honolulu:
  - Chaminade College of Honolulu Library (1965).
  - Hawaii Medical Library, Inc. (1968).
  - Hawaii State Library (1929).
  - Municipal Reference Library of the City and County of Honolulu (1965).
  - University of Hawaii Library (1907).
- Laie: Church College of Hawaii Library (1964).
- Lihue: Kauai Public Library (1967).
- Pearl City: Leeward Community College Library (1967).
- Wailuku: Maui Public Library (1962).

IDAHO

- Boise:
  - Boise State College Library (1966).
  - Boise Public Library (1929).
  - Idaho State Law Library (unknown).
- Caldwell: College of Idaho, Terteling Library (1930).
- Moscow: University of Idaho Library (1907)—REGIONAL.
- Pocatello: Idaho State University Library (1908).
- Rexburg: Ricks College, David O. McKay Library (1946).

ILLINOIS

- Bloomington: Illinois Wesleyan University Libraries (1964).
- Carbondale: Southern Illinois University Library (1932).
- Carlinville: Blackburn College Library (1954).
- Champaign: University of Illinois Law Library, College of Law (1965).
- Charleston: Eastern Illinois University, Booth Library (1962).
- Chicago:
  - Chicago Natural History Museum Library (1963).
  - Chicago Public Library (1876).
  - Chicago State College Library (1954).
  - John Crerar Library (1909).
  - Loyola University, E. M. Cudahy Memorial Library (1966).
  - Newberry Library (1890).
  - Northeastern Illinois State College Library (1961).
  - University of Chicago Law Library (1964).
  - University of Chicago Library (1897).
  - University of Illinois, Chicago Circle Campus Library (1957).
- Decatur: Decatur Public Library (1954).
- De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).
- Edwardsville: Southern Illinois University, Lovejoy Memorial Library (1959).
- Elsah: Principia College, Marshall Brooks Library (1957).
- Evanston: Northwestern University Library (1876).
- Freeport: Freeport Public Library (1905).
- Galesburg: Galesburg Public Library (1896).
- Jacksonville: MacMurry College, Henry Pfeiffer Library (1929).
- Kankakee: Olivet Nazarene College, Memorial Library (1946).

Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: St. Procopius College Library (1911).
Lockport: Lewis College of Science and Technology Library (1952).
Macomb: Western Illinois University Memorial Library (1962).
Monmouth: Monmouth College Library (1860).
Normal: Illinois State University, Milner Library (1877).
Oak Park: Oak Park Public Library (1963).
Peoria:
  Bradley University Library (1963).
  Peoria Public Library (1883).
River Forest: Rosary College Library (1966).
Rock Island: Rock Island Public Library (1950).
Rockford: Rockford Public Library (unknown).
Springfield: Illinois State Library (unknown)—REGIONAL.
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington: Indiana University Library (1881).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
  Evansville and Vanderburgh County Public Library (1928).
  Indiana State University, Evansville Campus Library (1969).
Fort Wayne:
  Indiana-Purdue Universities, Regional Campus Library (1965).
  Public Library of Fort Wayne and Allen County (unknown).
Gary:
  Gary Public Library (1943).
  Indiana University, Northwest Campus Library (1966).
Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
  Butler University, Irwin Library (1965).
  Indiana State Library (unknown)—REGIONAL.
  Indiana University, Law Library (1967).
  Indianapolis Public Library (1906).
Jeffersonville: Indiana University, Southeastern Campus Library (1965).
Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
  Ball State University Library (1959).
  Muncie Public Library (1906).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
  Earlham College, Lilly Library (1964).
  Morrison-Reeves Library (1906).
South Bend: Indiana University, South Bend-Mishawaka Campus Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

Ames: Iowa State University of Science and Technology Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs: Free Public Library (1885).
Denison: Midwestern College Library (1967).
Des Moines:
  Drake University, Cowles Library (1966).
  Iowa State Traveling Library (unknown).
  Public Library of Des Moines (1888).
Dubuque:
  Carnegie-Stout Public Library (unknown).
  Loras College Wahlert Memorial Library (1967).
Fairfield: Parsons College Library Branch of Fairfield Public Library (1862).
Grinnell: Grinnell College Library (1874).
Iowa City:
  University of Iowa, Law Library (1968).
  University of Iowa Library (1884)—REGIONAL.
Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: St. Benedict's College, the Abbey Library (1965).
Baldwin City: Baker University Library (1908).
Colby: Colby Community Junior College Library (1968).
Emporia: Kansas State Teachers College, William Allen White Library (1909).
Hays: Fort Hays Kansas State College, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence: University of Kansas, Watson Library (1869).
Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Kansas State College of Pittsburg, Porter Library (1952).
Salina: Kansas Wesleyan University Library (1930).
Topeka:
  Kansas State Historical Society Library (1877).
  State Libraries of Kansas (unknown).
Wichita: Wichita State University Library (1901).

KENTUCKY

Ashland: Ashland Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Margie Helm Library (1934).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
  Kentucky Department of Libraries (1967).
  State Law Library (unknown).
Lexington:
  University of Kentucky, Law Library (1968).
  University of Kentucky, Margaret I. King Library (1907)—REGIONAL.
Louisville:
  Louisville Free Public Library (1904).
  University of Louisville Library (1925).
Morehead: Morehead State University, Johnson Camden Library (1955).
Murray: Murray State University Library (1924).
Owensboro: Kentucky Wesleyan College Library (1966).
Pikeville: Pikeville College Library (1947).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:
  Louisiana State University Law Library (1929).
  Louisiana State University Library (1907)—REGIONAL.
  Southern University Library (1952).
Eunice: Louisiana State University at Eunice, LeDoux Library (1969).
Hammond: Southeastern Louisiana College, Sims Memorial Library (1966).
Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State College, Frazar Memorial Library (1941).
Monroe: Northeast Louisiana State College, Sandel Library (1963).
Natchitoches: Northwestern State College of Louisiana, Russell Library (1887).
New Orleans:
  Isaac Delgado College, Moss Technical Library (1968).
  Law Library of Louisiana (unknown).
  Louisiana State University in New Orleans Library (1963).
  Loyola University Library (1942).
  New Orleans Public Library (1883).
  Southern University in New Orleans Library (1962).
  Tulane University, Howard-Tilton Memorial Library (1942).
Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).
Ruston: Louisiana Polytechnic Institute Library (1896)—REGIONAL.
Shreveport:
  Louisiana State University at Shreveport Library (1967).
  Shreve Memorial Library (1923).
Thibodaux: Francis T. Nicholls State College, Leonidas Polk Library (1962).

MAINE

Augusta: Maine State Library (unknown).
Bangor: Bangor Public Library (1884).
Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).
Lewiston: Bates College Library (1883).
Orono: University of Maine, Raymond H. Fogler Library (1907)—REGIONAL.
Portland:
  Portland Public Library (1884).
  University of Maine Law Library (1964).
Springvale: Nasson College Library (1961).
Waterville: Colby College Library (1884).

MARYLAND

Annapolis:
  Maryland State Library (unknown).
  U.S. Naval Academy Library (1895).
Baltimore:
  Enoch Pratt Free Library (1887).
  Johns Hopkins University, Milton S. Eisenhower Library (1882).
  Morgan State College Library (1940).
Bel Air: Harford Junior College Library (1967).
Bethesda: Montgomery County Department of Public Libraries (1951).
Chestertown: Washington College, George Avery Bunting Library (1891).
College Park: University of Maryland, McKeldin Library (1925)—REGIONAL.
Frostburg: Frostburg State College, Jerome Frampton Library (1967).
Germantown: Atomic Energy Commission Library (1963).
Patuxent River: Naval Air Station Library (1968).
Salisbury: Salisbury State College, Blackwell Library (1965).
Towson: Groucher College, Julia Rogers Library (1966).
Westminster: Western Maryland College Library (1896).

MASSACHUSETTS

Amherst:
  Amherst College Library (1884).
  University of Massachusetts, Goodell Library (1907).
Belmont: Belmont Memorial Library (1968).
Boston:
  Boston Athenaeum Library (unknown).
  Boston College, Bapst Library (1963).
  Boston Public Library (1859).
  Northeastern University, Dodge Library (1962).
  State Library of Massachusetts (unknown)—REGIONAL
Brookline: Public Library of Brookline (1925).
Cambridge:
  Harvard College Library (1860).
  Massachusetts Institute of Technology Libraries (1946).
Chicopee: Our Lady of the Elms College Library (1969).
Lowell: Lowell Technological Institute Library (1952).
Lynn: Lynn Public Library (1953).
Medford: Tufts University Library (1899).
New Bedford: New Bedford Free Public Library (1858).
North Dartmouth: Southeastern Massachusetts Technological Institute Library (1965).
North Easton: Stonehill College, Cushing-Martin Library (1962).
Springfield: Springfield City Library (1966).
Waltham: Brandeis University, Goldfarb Library (1965).
Wellesley: Wellesley College Library (1943).
Wenham: Gordon College, Winn Library (1963).
Williamstown: Williams College Library (unknown).
Worcester:
  American Antiquarian Society Library (1814).
  Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).
Allendale: Grand Valley State College Library (1963).
Alma: Alma College, Monteith Library (1963).
Ann Arbor: University of Michigan, General Library (1884).
Battle Creek: Willard Library (1876).
Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Granbrook Institute of Science Library (1940).
Dearborn: Henry Ford Community College Library (1957).
Detroit:
  Detroit Public Library (1868)—REGIONAL.
  Marygrove College Library (1965).
  Mercy College of Detroit Library (1965).
  University of Detroit Library (1884).
  Wayne County Public Library (1957).
  Wayne State University Library (1937).
East Lansing: Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).
Flint:
  Charles Stewart Mott Library (1959).
  Flint Public Library (1967).
Grand Rapids:
  Grand Rapids Public Library (1876).
  Knollcrest Calvin Library (1967).

Houghton: Michigan Technological University Library (1876).
Jackson: Jackson Public Library (1965).
Kalamazoo:
  Kalamazoo Library System (1907).
  Western Michigan University, Dwight B. Waldo Library (1963).
Lansing: Michigan State Library (unknown)—REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

Bemidji: Bemidji State College Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State College Library (1962).
Minneapolis:
  Minneapolis Public Library (1893).
  University of Minnesota, Wilson Library (1907)—REGIONAL.
Moorhead: Moorhead State College Library (1956).
Morris: University of Minnesota at Morris Library (1963).
Northfield:
  Carleton College Library (1930).
  St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State College Library (1962).
St. Paul:
  Minnesota Historical Society Library (1867).
  Minnesota State Law Library (unknown).
  St. Paul Public Library (1914).
Saint Peter: Gustavus Adolphus College Library (1941).
Stillwater: Stillwater Public Library (1893).
Wilmar: Kandiyohi County-Willmar Library (1958).
Winona: Winona State College, Maxwell Library (1969).

MISSISSIPPI

Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1929).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
  Jackson State College Library (1968).
  Millsaps College, Millsaps-Wilson Library (1963).
  Mississippi Library Commission (1947).
  Mississippi State Law Library (unknown).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
  University of Mississippi Library (1883).
  University of Mississippi, School of Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State College, Kent Library (1916).
Columbia: University of Missouri Library (1862).
Fayette: Central Methodist College Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Hannibal: Hannibal Free Public Library (1909).
Jefferson City:
  Lincoln University, Inman E. Page Library (1944).
  Missouri State Library (1963).
  Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
  Kansas City Public Library (1881).
  Rockhurst College Library (1917).
  University of Missouri at Kansas City, General Library (1938).
Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).
Liberty: William Jewell College Library (1900).
Rolla: University of Missouri at Rolla Library (1907).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
  St. Louis Public Library (1866).
  St. Louis University, Law Library (1967).
  St. Louis University, Pius XII Memorial Library (1866).
  University of Missouri at St. Louis Library (1966).
  Washington University, John M. Olin Library (1906).
Springfield:
  Drury College Library (1874).
  Southwest Missouri State College Library (1963).
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
  Montana Historical Society Library (unknown).
  Montana State Library (1966).
Missoula: University of Montana Library (1909)—REGIONAL.

NEBRASKA

Blair: Dana College Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
  Nebraska State Library (unknown).
  University of Nebraska, Don L. Love Memorial Library (1907).
Omaha:
  Creighton University, Alumni Library (1964).
  Omaha Public Library (1880).
  University of Omaha, Gene Eppley Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).

NEVADA

Carson City: Nevada State Library (unknown).
Las Vegas: Nevada Southern University, James R. Dickinson Library (1959).
Reno: University of Nevada Library (1907)—REGIONAL.

NEW HAMPSHIRE

Concord: New Hampshire State Library (unknown).
Durham: University of New Hampshire Library (1907).
Hanover: Dartmouth College, Baker Library (1884).
Henniker: New England College Library (1966).

Manchester:
  Manchester City Library (1884).
  St. Anselm's College, Geisel Library (1963).

NEW JERSEY

Atlantic City: Atlantic City Free Public Library (1908).
Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Free Public Library of Bloomfield (1965).
Bridgeton: Cumberland County Library (1966).
Camden: Rutgers Library in South Jersey (1966).
Convent Station: College of St. Elizabeth, Santa Maria Library (1938).
East Orange: East Orange Public Library (1966).
Elizabeth: Free Public Library of Elizabeth (1895).
Glassboro: Glassboro State College, Savitz Library (1963).
Hackensack: Johnson Free Public Library (1966).
Irvington: Free Public Library of Irvington (1966).
Jersey City:
  Jersey City Free Public Library (1879).
  Jersey City State College, Forrest A. Irwin Library (1963).
Madison: Drew University, Rose Memorial Library (1939).
Mount Holly: Burlington County Area Library (1966).
New Brunswick:
  Free Public Library (1908).
  Rutgers University Library (1907).
Newark:
  Newark Public Library (1906)—REGIONAL.
  Rutgers—The State University, John Cotton Dana Library (1966).
Passaic: Passaic Public Library (1964).
Princeton: Princeton University Library (1884).
Rutherford: Fairleigh Dickinson University, Periodicals Library (1953).
Shrewsbury: Monmouth County Library (1968).
South Orange: Seton Hall University Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
Toms River: Ocean County College Library (1966).
Trenton:
  New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
  Trenton Free Public Library (1902).
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
West New York: West New York Free Public Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

Albuquerque: University of New Mexico, Zimmerman Library (1896)—REGIONAL.
Hobbs: New Mexico Junior College, Pannell Library (1969).
Las Cruces: New Mexico State University Library (1907).
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
Portales: Eastern New Mexico University Library (1962).
Santa Fe:
  New Mexico State Library (1960)—REGIONAL.
  Supreme Court Law Library (unknown).

NEW YORK

Albany:
  New York State Library (unknown)—REGIONAL.
  State University of New York at Albany Library (1964).
Binghamton: State University of New York at Binghamton Library (1962).
Brockport: State University of New York, Drake Memorial Library (1967).
Bronx: Herbert H. Lehman College Library (1967).
Bronxville: Sarah Lawrence College Library (1969).
Brooklyn:
  Brooklyn College Library (1936).
  Brooklyn Public Library (1908).
  Polytechnic Institute of Brooklyn, Spicer Library (1963).
  Pratt Institute Library (1891).
  State University of New York, Downstate Medical Center Library (1958).
Buffalo:
  Buffalo and Erie County Public Library (1895).
  State University of New York at Buffalo, Lockwood Memorial Library (1963).
Canton: St. Lawrence University, Owen D. Young Library (1920).
Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).
Cortland: State University of New York, College at Cortland, Memorial Library (1964).
Elmira: Elmira College, Hamilton Library (1956).
Farmingdale: State University of New York at Farmingdale Library (1917).
Flushing: Queens College, Paul Klapper Library (1939).
Garden City:
  Adelphia University, Swirbul Library (1966).
  Nassau Library System (1965).
Geneseo: State University College, Milne Library (1967).
Greenvale: C. W. Post College Library (1964).
Hamilton: Colgate University Library (1902).
Hempstead: Hofstra University Library (1964).
Huntington: Huntington Public Library (1966).
Ithaca:
  Cornell University Library (1907).
  New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).
Jamaica:
  Queens Borough Public Library (1926).
  St. John's University Library (1956).
Kings Point: U.S. Merchant Marine Academy Library (1962).
Mount Vernon: Mount Vernon Public Library (1962).
New Paltz: State University College Library (1965).
New York City:
  City University of New York, City College Library (1884).
  College of Insurance, Ecker Library (1965).
  Columbia University Libraries (1882).
  Cooper Union Library (1930).
  Fordham University Library (1937).
  New York Law Institute Library (1909).
  New York Public Library (Astor Branch) (1907).
  New York Public Library (Lenox Branch) (1884).
  New York University Libraries (1967).
  New York University, University Heights Gould Memorial Library (1902).
  State University of New York, Maritime College Library (1947).
Newburgh: Newburgh Free Library (1909).
Oakdale: Dowling College Library (1965).
Oneonta: State University College, James M. Milne Library (1966).
Oswego: State University College, Penfield Library (1966).
Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).
Potsdam:
  Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
  State University College Library (1964).
Poughkeepsie: Vassar College Library (1943).

Purchase: State University of New York, College at Purchase Library (1969).
Rochester:
  Rochester Public Library (1963).
  University of Rochester Library (1880).
St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).
Saratoga Springs: Skidmore College Library (1964).
Schenectady: Union College, Schaffer Library (1901).
Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).
Stony Brook: State University of New York at Stony Brook Library (1963).
Syracuse: Syracuse University Library (1878).
Troy: Troy Public Library (1869).
Utica: Utica Public Library (1885).
West Point: U.S. Military Academy Library (unknown).
Yonkers: Yonkers Public Library (1910).

NORTH CAROLINA

Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).
Boone: Appalachian State University, Dauphin Disco Dougherty Library (1963).
Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
Chapel Hill: University of North Carolina Library (1884)—REGIONAL.
Charlotte:
  Public Library of Charlotte and Mecklenburg County (1964).
  Queens College, Everett Library (1927).
  University of North Carolina at Charlotte, Atkins Library (1964).
Cullowhee: Western Carolina University, Hunter Library (1953).
Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).
Durham: Duke University Library (1890).
Greensboro:
  North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
  University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).
Greenville: East Carolina University, J. Y. Joyner Library (1951).
Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).
Mars Hill: Mars Hill College, Memorial Library (1967).
Murfreesburo: Chowan College Library (1963).
Pembroke: Pembroke State College Library (1956).
Raleigh:
  North Carolina State Library (unknown).
  North Carolina State University, D. H. Hill Library (1923).
Rocky Mount: North Carolina Wesleyan College Library (1969).
Salisbury: Catawba College Library (1925).
Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).
Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).
Winston-Salem:
  Forsyth County Public Library System (1954).
  Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:
  North Dakota State Historical Society Library (1907).
  North Dakota State Law Library (unknown).
  Veterans Memorial Public Library (1967).
Dickinson: Dickinson State College Library (1968).
Fargo:
  Fargo Public Library (1964).
  North Dakota State University Library (1907)—REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.
Grand Forks: University of North Dakota, Chester Fritz Library (1890).
Minot: Minot State College, Memorial Library (1925).
Richardton: Assumption College, Abbey Library (1965).
Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
Akron:
  Akron Public Library (1952).
  University of Akron Library (1963).
Alliance: Mount Union College Library (1888).
Ashland: Ashland College Library (1938).
Athens: Ohio University Library (1886).
Bluffton: Bluffton College, Musselman Library (1951).
Bowling Green: Bowling Green State University Library (1933).
Chillicothe: Ohio University at Chillicothe Library (1968).
Cincinnati:
  Public Library of Cincinnati and Hamilton County (1884).
  University of Cincinnati Library (1929).
Cleveland:
  Case Western Reserve University, Freiberger Libary (1913).
  Cleveland Public Library (1886).
  Cleveland State University Library (1966).
  John Carroll University, Grasselli Library (1963).
Columbus:
  Capital University Library (1968).
  Columbus Public Library (1885).
  Ohio State Library (unknown)—REGIONAL.
  Ohio State University Library (1907).
Dayton:
  Dayton and Montgomery County Public Library (1909).
  University of Dayton, Albert Emanuel Library (1969).
  Wright State University Library (1965).
Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
Elyria: Elyria Public Library (1966).
Findlay: Findlay College, Shafer Library (1969).
Gambier: Kenyon College Library (1873).
Granville: Denison University Library (1884).
Hiram: Hiram College, Teachout-Price Memorial Library (1874).
Kent: Kent State University Library (1962).
Mansfield: Ohio State University, Mansfield Campus Library (1969).
Marietta: Marietta College, Dawes Memorial Library (1884).
New Concord: Muskingum College Library (1966).
Oberlin: Oberlin College Library (1858).
Oxford: Miami University, Alumni Library (1909).
Portsmouth: Portsmouth Public Library (unknown).
Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).
Springfield: Warder Public Library (1884).
Steubenville: Public Library of Steubenville and Jefferson County (1950).
Tiffin: Heidelberg College, Beeghly Library (1964).
Toledo:
  Toledo Public Library (1884).
  University of Toledo Library (1963).
Van Wert: Brumback Library of Van Wert County (1900).
Westerville: Otterbein College, Centennial Library (1967).

Wooster: College of Wooster, the Andrews Library (1966).
Youngstown: Public Library of Youngstown and Mahoning County (1923).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).
Alva: Northwestern State College Library (1907).
Bartlesville: Bureau of Mines, Petroleum Research Center Library (1962).
Durant: Southeastern State College Library (1929).
Edmond: Central State College Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Norman: University of Oklahoma Libraries (1893).
Oklahoma City:
    Oklahoma City University Library (1963).
    Oklahoma Department of Libraries (1893)—REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907).
Tahlequah: Northeastern State College, John Vaughan Library (1923).
Tulsa:
    Tulsa City-County Library Commission (1963).
    University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern State College Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene: University of Oregon Library (1883).
Forest Grove: Pacific University Library (1897).
La Grande: Eastern Oregon College Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Oregon College of Education Library (1967).
Portland:
    Department of the Interior, Bonneville Power Administration Library (1962).
    Lewis and Clark College Library (1967).
    Library Association of Portland (1884).
    Portland State College Library (1963).
    Reed College Library (1912).
Salem:
    Oregon State Library (unknown).
    Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College Library (1939).
Bethlehem: Lehigh University Library (1876).
Bradford: Carnegie Public Library (1909).
Carlisle: Dickinson College Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College Library (1963).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: Pennsylvania State Library (unknown)—REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
    Drexel Institute of Technology Library (1963).
    Free Library of Philadelphia (1897).
    Temple University Library, Serials Records Unit (1947).
    University of Pennsylvania Library (1886).
Pittsburgh:
    Bureau of Mines, Pittsburgh Research Center Library (1962).
    Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
    Carnegie Library of Pittsburgh (1895).
    University of Pittsburgh, Hillman Library (1910).
Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College Library (1949).
Williamsport: James V. Brown Library of Williamsport and Lycoming County (1922).
York: York Junior College Library (1963).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
    Brown University, John D. Rockefeller, Jr. Library (unknown).
    Providence College Library (1969).
    Providence Public Library (1884).
    Rhode Island College Library (1965).
    Rhode Island State Library (before 1895).
Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).

SOUTH CAROLINA

Charleston:
    Baptist College at Charleston Library (1967).
    College of Charleston Library (1869).
    The Citadel Memorial Library (1962).
Clemson: Clemson University Library (1893).

Columbia:
  Benedict College, Starks Library (1969).
  Columbia College Library (1966).
  South Carolina State Library (before 1895).
  University of South Carolina, McKissick Memorial Library (1884).
Due West: Erskine College, McCain Library (1968).
Florence: Florence County Library (1967).
Greenville:
  Furnam University Library (1962).
  Greenville County Library (1966).
Greenwood: Lander College Library (1967).
Orangeburg: South Carolina State College Library (1953).
Rock Hill: Winthrop College Library (1896).
Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).
Brookings: South Dakota State University, Lincoln Memorial Library (1889).
Rapid City:
  Rapid City Public Library (1963).
  South Dakota School of Mines and Technology Library (1963).
Sioux Falls:
  Augustana College, Mikkelsen Library and Learning Resources Center (1969).
  Carnegie Free Public Library (1903).
Spearfish: Black Hills State College Library (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

Chattanooga: Chattanooga Public Library (1907).
Clarksville: Austin Peay State University Library (1945).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College, Maples Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville: University of Tennessee Library (1907).
Martin: University of Tennessee at Martin Library (1957).
Memphis:
  Cossitt Reference Library (1896).
  Memphis State University, John W. Brister Library (1966).
Murfreesboro: Middle Tennessee State University Library (1912).
Nashville:
  Fisk University Library (1965).
  Joint University Libraries (1884).
  Public Library of Nashville and Davidson County (1884).
  Tennessee State Library and Archives, State Library Division (unknown).
Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene: Hardin-Simmons University Library (1940).
Arlington: University of Texas at Arlington Library (1963).
Austin:
  Texas State Library (unknown)—REGIONAL.
  University of Texas Library (1884).
  University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
  University of Texas, School of Law Library (1965).
Beaumont: Lamar State College of Technology Library (1957).
Brownwood: Howard Payne College, Walker Memorial Library (1964).
Canyon: West Texas State University Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corsicana: Navarro Junior College Library (1965).
Dallas:
  Bishop College, Zale Library (1966).
  Dallas Baptist College Library (1967).
  Dallas Public Library (1900).
  Southern Methodist University, Fondren Library (1925).
Denton: North Texas State University Library (1948).
Edinburg: Pan American College Library (1959).
El Paso:
  El Paso Public Library (1906).
  University of Texas at El Paso Library (1966).
Fort Worth:
  Fort Worth Public Library (1905).
  Texas Christian University, Mary Couts Burnett Library (1916).
Freeport: Brazosport Junior College Library (1969).
Galveston: Rosenberg Library (1909).
Houston:
  Houston Public Library (1884).
  Rice University, Fondren Library (1967).
  University of Houston Library (1957).
Huntsville: Sam Houston State College, Estill Library (1949).
Kingsville: Texas Arts and Industries University Library (1944).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Technological College Library (1935)—REGIONAL.
Marshall: Wiley College, Cole Library (1962).
Nacogdoches: Stephen F. Austin State College, Paul L. Boynton Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
San Angelo: Angelo State University Library (1964).
San Antonio:
  San Antonio Public Library, Business and Science Department (1899).
  St. Mary's University Library (1964).
  Trinity University Library (1964).
San Marcos: Southwest Texas State College Library (1955).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana College Library (1963).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College Library (1963).
Logan: Utah State University Library (1907)—REGIONAL.
Ogden: Weber State College Library (1962).
Provo: Brigham Young University Library (1908).
Salt Lake City:
  University of Utah, Law Library (1966).
  University of Utah Library (1893).
  Utah State Library Commission, Documents Library (unknown).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Johnson: Johnson State College, John Dewey Library (1955).
Middlebury: Middlebury College, Egbert Starr Library (1884).

Montpelier: Vermont State Library (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): St. Thomas Public Library (1968).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
  University of Virginia, Alderman Library (1910)—REGIONAL.
  University of Virginia Law Library (1964).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College (1884).
Fairfax: George Mason College of the University of Virginia Library (1960).
Fredericksburg: Mary Washington College of the University of Virginia, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
  Virginia Military Institute, Preston Library (1874).
  Washington and Lee University, Cyrus Hall McCormick Library (1910).
Norfolk:
  Armed Forces Staff College Library (1963).
  Norfolk Public Library (1895).
  Old Dominion College, Hughes Memorial Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico: Marine Corps Schools, James Carson Breckinridge Library (1967).
Richmond:
  University of Richmond, Boatwright Memorial Library (1900).
  Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College (1936).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia: Washington State Library (unknown)—REGIONAL.
Port Angeles: Port Angeles Public Library (1965).
Pullman: Washington State University Library (1907).
Seattle:
  Seattle Public Library (1908).
  University of Washington Library (1890).
  University of Washington, School of Law Library (1969).
Spokane: Spokane Public Library (1910).
Tacoma:
  Tacoma Public Library (1894).
  University of Puget Sound, Collins Memorial Library (1938).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Pênrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Charleston:
  Kanawha County Public Library (1952).
  West Virginia Department of Archives and History Library (unknown).
Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University Library (1925).
Institute: West Virginia State College Library (1907).
Morgantown: West Virginia University Library (1907)—REGIONAL.
Salem: Salem College Library.
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Samuel Appleton Library (1869).
Beloit: Beloit College Libraries (1888).
Eau Claire: Wisconsin State University, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).
Green Bay: University of Wisconsin at Green Bay Library (1968).
La Crosse:
  La Crosse Public Library (1883).
  Wisconsin State University, Florence Wing Library (1965).
Madison:
  Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).
  Madison Public Library (1965).
  State Historical Society Library (1870)—REGIONAL, in cooperation with University of Wisconsin, Memorial Library.
  University of Wisconsin, Memorial Library (1939).
  Wisconsin State Library (unknown).
Milwaukee:
  Milwaukee County Law Library (1934).
  Milwaukee Public Library (1861)—REGIONAL.
  Mount Mary College Library (1964).
  Oklahoma Neighborhood Library (1965).
  University of Wisconsin-Milwaukee Library (1960).
Oshkosh: Wisconsin State University, Forrest R. Polk Library (1956).
Platteville: Wisconsin State University, Elton S. Karrmann Library (1964).
Racine: Racine Public Library (1898).
River Falls: Wisconsin State University, Chalmer Davee Library (1962).
Stevens Point: Wisconsin State University Library (1951).
Superior:
  Superior Public Library (1908).
  Wisconsin State University, Jam Dan Hill Library (1935).
Waukesha: Waukesha Public Library (1966).
Whitewater: Wisconsin State University, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).
Cheyenne: Wyoming State Library (unknown).
Laramie: University of Wyoming, Coe Library (1907).
Powell: Northwest Community College Library (1967).
Riverton: Central Wyoming College Library (1969).
Rock Springs: Western Wyoming College Library (1969).
Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

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Ext. 2151

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Straus Building
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