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

United States Department of Commerce
National Bureau of Standards
Miscellaneous Publication 240

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($1.50), available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

UNITED STATES DEPARTMENT OF COMMERCE • Frederick H. Mueller, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

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

(With Subject and Author Indexes)

Betty L. Arnold

National Bureau of Standards Miscellaneous Publication 240
To Accompany National Bureau of Standards C460, and Supplement—1901 to June 30, 1957

Issued April 3, 1961

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.
Price $2.25

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FOREWORD

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government agencies on scientific and technical problems, invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. The program is carried out in the following technical divisions and offices: Electricity, metrology, heat, radiation physics, analytical and inorganic chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building research, applied mathematics, data processing systems, atomic physics, instrumentation, physical chemistry, weights and measures, cryogenic engineering, ionosphere research and propagation, radio propagation engineering, radio standards, radio systems, upper atmosphere and space physics.

The results of the Bureau's work take the form of either actual equipment and devices or published papers, which appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau publishes three periodicals, available from the Government Printing Office: The Journal of Research, the Technical News Bulletin, and Basic Radio Propagation Predictions. There are also five series of nonperiodical publications: Monographs, Handbooks, Applied Mathematics Series, Miscellaneous Publications, and Technical Notes.

This publication provides a complete list, with brief abstracts, of Bureau publications issued during the period July 1, 1957 to June 30, 1960. It also includes a list of those papers by Bureau authors that have appeared in non-National Bureau of Standards Journals from 1950 through 1959. Circular 460 (for the period 1901 to June 30, 1957) and its Supplement (July 1, 1947 to June 30, 1957) remain in effect.

A. V. Astin, *Director.*

Supplementary List of Publications of the National Bureau of Standards July 1, 1957, to June 30, 1960

This Supplement lists the publications of the National Bureau of Standards from July 1, 1957, to June 30, 1960. A brief abstract for each publication is given. It also includes a list of those papers by Bureau authors that have appeared in non-National Bureau of Standards Journals from 1950 through 1959. Subject and author indexes are included, and general publication information is furnished. This catalog and previous lists (see page 2) give reference to the publications printed by the Bureau during the period 1901 to June 30, 1957. Over 8,000 papers have been issued.

Reprints of papers published in outside journals are available only from the authors themselves or from the outside journal.

1. GENERAL INFORMATION

1.1. PURCHASE PROCEDURES

The publications of the Bureau are distributed principally by the Superintendent of Documents, United States Government Printing Office, Washington 25, D.C., who sells them, as long as copies are available, at the prices given in this Circular.

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 25, D.C., by coupon, postal money express order, or check. Publications cannot be mailed in advance of receipt of remittance. Currency may be sent at sender's risk. Foreign remittances should be made either by international money order or draft on an American bank.

Foreign money, defaced or smooth coins, will not be accepted. Do not send postage stamps.

The letter symbol with each publication number and the full title of the publication must be given when ordering. If 100 copies or more of any publication are ordered, a discount of 25 percent is allowed.

For the convenience of the general public, coupons in the denomination of 5 cents that are good until used in exchange for Government publications sold by the Superintendent of Documents, may be purchased from his office. Address order to Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of $10 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 handling of the order has been completed, it will be 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 forwarded to points in United States and possessions, or to Canada, Cuba, 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.

1.2. ANNOUNCEMENTS OF BUREAU PUBLICATIONS

There are several official sources of information as to new publications of the National Bureau of Standards. The following announcements are issued regularly by governmental agencies. In addition, many of the technical journals carry notices of new Bureau publications of interest in their respective fields.

Technical News Bulletin. Issued monthly by the National Bureau of Standards. Announces all new publications by members of the staff, including those appearing in outside journals. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Annual subscription, $1.50; $2.25 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 25, D.C. Annual subscription, with consolidated annual index, $3; $4.50 foreign.

Price Lists. Publication lists prepared by the Superintendent of Documents on special subjects. These will be furnished free, on application, if the subject concerning which information is desired is stated.

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 announcements 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 for $1.50 a year domestic; $3.50 foreign.

1.3. CATALOGS OF BUREAU PUBLICATIONS

Previous catalogs and this Circular give a complete list of the titles and brief abstracts of the Bureau's publications up to June 30, 1960. Where the price is given the publication is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., or they may be available for consultation in libraries maintaining sets of Bureau Circulars.

Price

Circular C24, 7th edition: Publications of the Bureau of Standards 1901 to 1925. 271 pages, including brief abstracts and subject index . . .

Circular C24 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, 1942, to June 30, 1947 . . . . . $1. 25

Supplementary List of Publications of the National Bureau of Standards, July 1, 1947, to June 30, 1957. 373 pages, including subject and author indexes $1. 50

* Out of print.

Price

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

1.4. MAILING LISTS

Names of individuals are not placed on the Bureau's mailing lists. The principal distribution is by the Superintendent of Documents on a sales basis. A limited edition of each paper is printed for Bureau administrative needs and for official distribution to cooperating laboratories, technical organizations, Government agencies, and to leading public and educational institutions libraries. In addition, the Superintendent of Documents distributes copies of selected Bureau publications to the Government depository libraries listed below.

1.5. 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 below are now receiving certain selected publication series of the National Bureau of Standards for general reference use. Whether or not a given library has a copy of any particular publication can only be determined by inquiry at the library.

ALABAMA

Auburn: Alabama Polytechnic Institute Library.
Birmingham:
  Howard College Library.
  Birmingham Southern College, M. Paul Phillips Library.
  Public Library.
Florence: State Teachers College Library.
Jacksonville: State Teachers College Library.
Mobile (Spring Hill): The Thomas Bryne Memorial, Spring Hill College.
Montgomery:
  Department of Archives and History Library.
  State and Supreme Court Library.
Tuskegee Institute: Hollis Burke Frissell Library.
University: University of Alabama Library.

ALASKA

College: University of Alaska Library.
Juneau: Alaska Historical Library and Museum.

ARIZONA

Flagstaff Arizona State Teachers College Library.
Phoenix:
  Department of Library and Archives.
  Phoenix Public Library.
Tempe: Matthews Library.
Tucson: University of Arizona Library.

ARKANSAS

Clarksville: College of the Ozarks Library.
College Heights: Arkansas Agricultural and Mechanical College Library.
Conway: Hendrix College Library.
Fayetteville: University of Arkansas Library.
Little Rock: Little Rock Public Library.
Magnolia: Southern State College, J. M. Peace Library.
Russellville: Arkansas Polytechnic College Library.
State College: Arkansas State College Library.

CALIFORNIA

Bakersfield: Kern County Free Library.
Berkeley: University of California Library.
Claremont: Pomona College, Honnold Library.
Davis: University of California Library.
Eureka: Eureka Free Library.
Fresno: Fresno County Free Library.
Long Beach: Public Library.
Los Angeles:
  University of Southern California Library.
  Los Angeles Public Library.
  Los Angeles State College Library.
  Loyola University Library.
  Occidental College Library.
  University of California at Los Angeles Library.
Northridge: San Fernando Valley State College Library.
Oakland: Oakland Public Library.
Pasadena: California Institute of Technology Library.
Redding: Shasta County Free Library.
Redlands: University of Redlands Library.
Richmond: Richmond Public Library.
Riverside: Riverside Public Library.
Sacramento:
  California State Library.
  City Free Library.
San Diego: San Diego Public Library.
San Francisco:
  Mechanics Mercantile Library.
  San Francisco Public Library.
  San Francisco State College, Social Science and Business Library.
Santa Barbara: Santa Barbara Public Library.
Stanford Univ.: Stanford University Library.
Stockton: Stockton Free Public Library.

COLORADO

Boulder: University of Colorado Library.
Colorado Springs: Colorado College, Coburn Library.
Denver:
  Colorado State Library.
  Public Library.
  Regis College Library.
  U.S. Air Force Academy.
  University of Denver, Mary Reed Library.
Fort Collins: Colorado State University Library.
Golden: Colorado School of Mines Library.
Gunnison: Western State College Library.
Pueblo: McClelland Public Library.

CONNECTICUT

Bridgeport: Bridgeport Public Library.
Hartford:
- Connecticut State Library.
- Hartford Public Library.
- Trinity College Library.

Middletown: Wesleyan University, Olin Library.
New Haven: Yale University Library.
New London:
- Connecticut College, Palmer Library.
- U.S. Coast Guard Academy Library.

Storrs: University of Connecticut Library.
Waterbury: Silas Bronson Library.

DELAWARE

Newark: University of Delaware Library.
Wilmington: Wilmington Institute Free Library.

DISTRICT OF COLUMBIA

Washington:
- Department of Agriculture Library.
- Department of Commerce Library.
- Department of Health, Education, and Welfare Library.
- Department of Interior Central Library.
- Department of Justice Main Library.
- Department of State Library.
- National War College Library.
- Navy Department Library.
- Post Office Department Library.
- Public Library.
- Treasury Department Library.

FLORIDA

Coral Gables: University of Miami Library.
De Land: Sampson Library of John B. Stetson University.
Gainesville: University of Florida Library.
Jacksonville: Jacksonville Public Library.
Lakeland: Lakeland Public Library.
Miami: Miami Public Library.
Tallahassee:
- Florida Agricultural and Mechanical College Library.
- Florida State Library.
- Florida State University Library.

Tampa: University of Tampa Library.
Winter Park: Rollins College, Mills Memorial Library.

GEORGIA

Athens: University of Georgia General Library.
Atlanta:
- Atlanta Public Library.
- Emory University: Asa Griggs Candler Library.
- Georgia State Library.

Augusta: Library of Richmond County Academy and Junior College of Augusta.
Collegeboro: Georgia Teachers College Library.
Dahlonega: North Georgia College Library.
Milledgeville: Georgia State College for Women Library.
Savannah: Savannah Public Library.
Valdosta: Valdosta State College Library.

HAWAII

Honolulu:
- Library of Hawaii.
- University of Hawaii Library.

IDAHO

Boise:
- Boise Public Library.
- Idaho State Law Library.

Caldwell: Strahorn Memorial Library.
Moscow: University of Idaho Library.
Pocatello: Idaho State College Library.
Rexberg: Ricks College Library.

ILLINOIS

Carbondale: Southern Illinois University Library.
Carlinville: Blackburn College Library.
Chicago:
- Amundsen Junior College Library.
- Chicago Public Library.
- Chicago Teachers College Library.
- John Crerar Library.
- Newberry Library.
- University of Chicago Libraries.
- University of Illinois Library.

Decatur: Decatur Public Library.
Elsah: Prinicipia College, Marshall Brooks Library.
Evanston: Northwestern University Library.
Freeport: Freeport Public Library.
Galesburg: Galesburg Public Library.
Jacksonville: MacMurray College Library.
Joliet: Public Library.
Kankakee: Olivet Nazarene College Library.
Lisle: St. Procopius College Library.
Lockport: Lewis College of Science and Technology Library.
Monmouth: Monmouth College Library.
Normal: Illinois State Normal University Library.
Peoria: Peoria Public Library.
Rock Island: Rock Island Public Library.
Rockford: Public Library.
Springfield: Illinois State Library.
Urbana: University of Illinois Library.

INDIANA

Bloomington: Indiana University Library.
Crawfordsville: Wabash College Library.
Evansville: Evansville Public Library.
Fort Wayne: Public Library.
Gary: Gary Public Library.
Greencastle: De Pauw University Library.
Hanover: Hanover College Library.
Indianapolis:
- Indiana State Library.
- Indianapolis Public Library.

Lafayette: Purdue University Library.
Muncie: Public Library.
Notre Dame: University of Notre Dame Library.
Richmond: Morrison-Reeves Library.
Terre Haute: Indiana State Teachers College Library.
Valparaiso: Valparaiso University Library.

IOWA

Ames: Iowa State College Library.
Cedar Falls: Iowa State Teachers College Library.
Council Bluffs: Free Public Library.
Des Moines:
- Iowa State Traveling Library.
- Public Library.

Dubuque: Carnegie Stout Free Public Library.
Fairfield: Fairfield Free Public Library.
Grinnell: Grinnell College Library.
Iowa City: State University of Iowa Library.
Lamoni: Graceland College Library.
Mount Vernon: Cornell College Library.
Sioux City: Public Library.

KANSAS

Baldwin City: Baker University Library.
Emporia: William Allen White Library, Kansas State Teachers College.
Hays: Forsyth Library of Fort Hays Kansas State College.
Highland: Highland Junior College Library.
Lawrence: University of Kansas Library.
Manhattan: Kansas State College Library.
Pittsburg: Porter Library, Kansas State Teachers College.
Salina: Kansas Wesleyan University Library.
Topeka:
- Kansas State Historical Society Library.
- Kansas State Library.

Wichita: University of Wichita Library.

KENTUCKY

Ashland: Ashland Public Library.
Barbourville: Union College, Abigail E. Weeks Library.

Bowling Green: Western Kentucky State Teachers College Library.
Danville: Centre College Library.
Frankfort: State Law Library.
Lexington: University of Kentucky Library.
Louisville:
Louisville Free Public Library.
University of Louisville Library.
Morehead: Johnson Camden Library, Morehead State College.
Murray: Murray State Teachers College Library.
Pikeville: Pikeville College Library.

LOUISIANA

Baton Rouge:
Louisiana State University Law Library.
Louisiana State University Library.
Southern University Library.
Lafayette: Southwestern Louisiana Institute Library.
Lake Charles: McNeese State College Library.
Natchitoches: Northwestern State College of Louisiana.
New Orleans:
Law Library of Lousiana.
Loyola University Library.
New Orleans Public Library.
Tulane University, Howard-Tilton Memorial Library.
Ruston: Lousiana Polytechnic Institute Library.
Shreveport: Shreve Memorial Library.

MAINE

Augusta: Maine State Library.
Bangor: Bangor Public Library.
Brunswick: Bowdoin College Library.
Lewiston: Bates College Library.
Orono: University of Maine Library.
Portland: Portland Public Library.
Waterville: Colby College Library.

MARYLAND

Annapolis:
Maryland State Library.
U.S. Naval Academy Library.
Baltimore:
Enoch Pratt Free Library.
Johns Hopkins University Library.
Morgan State College Library.
Peabody Institute Library.
Chestertown: Washington College, George Avery Bunting Library.
College Park: University of Maryland Library.
Gaithersburg: Montgomery County Department of Public Libraries.
Westminster: Western Maryland College Library.

MASSACHUSETTS

Amherst:
Amherst College Library.
University of Massachusetts, Goodell Library.
Boston: Boston Athenaeum Library.
Boston Public Library.
State Library of Massachusetts.
Brookline: Public Library.
Cambridge:
Harvard College Library, Serials Division.
Massachusetts Institute of Technology Library.
Lowell: Lowell Textile Institute Library.
Lynn: Lynn Public Library.
New Bedford: Public Library.
Tufts College: Tufts College Library.
Wellesley: Wellesley College Library.
Williamstown: Williams College Library.
Worcester:
American Antiquarian Society Library.
Free Public Library.

MICHIGAN

Ann Arbor: General Library of University of Michigan.
Battle Creek: Willard Library.
Benton Harbor: Benton Harbor Public Library.
Bloomfield Hills: Cranbrook Institute of Science Library.
Dearborn: Henry Ford Community College Library.
Detroit:
Detroit Public Library.
University of Detroit Library.
Wayne County Public Library.
Wayne State University Library.
East Lansing: Michigan State College of Agriculture and Applied Science Library.
Flint: Robert N. Mandeville High School Library.
Grand Rapids: Grand Rapids Public Library.
Houghton: Michigan College of Mining and Technology Library.
Kalamazoo: Public Library.
Lansing: Michigan State Library.
Mount Pleasant: Central Michigan College Library.
Muskegon: Hackley Public Library.
Port Huron: Port Huron Public Library.
Saginaw: Hoyt Public Library.

MINNESOTA

Collegeville: St. Johns University Library.
Duluth: Duluth Public Library.
Minneapolis:
Public Library.
University of Minnesota Library.
Moorhead: State Teachers College Library.
Northfield:
Carleton College Library.
St. Olaf College Library.
Saint Peter: Gustavus Adolphus College Library.
St. Paul:
Minnesota Historical Society Library.
Minnesota State Law Library.
St. Paul Public Library.
Stillwater: Stillwater Public Library.

MISSISSIPPI

Cleveland: W. B. Roberts Memorial Library, Delta State Teachers College.
Columbus: J. C. Fant Memorial Library of Mississippi State College for Women.
Hattiesburg: Mississippi Southern College Library.
Jackson:
Mississippi Library Commission.
Mississippi State Library.
State College: Mississippi State College, Mitchell Memorial Library.
University: University of Mississippi Library.

MISSOURI

Cape Girardeau: Kent Library, Southeast Missouri State College.
Columbia: University of Missouri Library.
Fulton: Westminster College Library.
Hannibal: Free Public Library.
Jefferson City:
Lincoln University Library.
Missouri Supreme Court Library.
Kansas City:
Kansas City Public Library.
Rockhurst College Library.
University of Kansas City Library.
Liberty: William Jewell College Library.
Rolla: School of Mines & Metallurgy Library.
St. Joseph: St. Joseph Public Library.
St. Louis:
St. Louis Public Library.
St. Louis University Library.
Washington University Library.
Springfield: Drury College Library.
Warrensburg: Central Missouri State College Library.

MONTANA

Bozeman: Montana State College Library.
Butte: Montana School of Mines Library.
Helena:
Helena Public Library.
Historical Society of Montana Library.
Missoula: State University of Montana Library.

NEBRASKA

Blair: Dana College Library.
Crete: Whitin Library of Doane College.
Fremont: Midland College Library.
Lincoln:
  Nebraska State Library.
  University of Nebraska Library.
Omaha:
  Municipal University of Omaha Library.
  Omaha Public Library.
Scottsbluff: Scottsbluff Public Library.

NEVADA

Carson City: Nevada State Library.
Hawthorne: Mineral County Public Library.
Reno: University of Nevada Library.

NEW HAMPSHIRE

Concord: New Hampshire State Library.
Dover: Dover Public Library.
Durham: University of New Hampshire Library
Hanover: Dartmouth College Library.
Laconia: Laconia Public Library.
Manchester: City Library.

NEW JERSEY

Atlantic City: Free Public Library.
Bayonne: Free Public Library.
Camden: Camden Free Public Library.
Convent Station: Santa Maria Library of College of St. Elizabeth.
Elizabeth: Public Library.
Jersey City: Free Public Library.
Madison: Rose Memorial Library.
New Brunswick:
  Free Public Library.
  Rutgers University Library.
Newark: Public Library.
Princeton: Princeton University Library.
Rutherford: Fairleigh Dickinson College Library.
South Orange: Seton Hall University Library.
Trenton:
  Division of State Library, Archives and History—Department of Education.
  Free Public Library.

NEW MEXICO

Albuquerque: University of New Mexico.
Hobbs: Hobbs Public Library.
Las Vegas: New Mexico Highlands University, Rodgers Library.
Santa Fe: New Mexico State Law Library.
Silver City: New Mexico State Teachers College Library.
State College: New Mexico College of Agriculture and Mechanic Arts Library.

NEW YORK

Albany: New York State Library.
Brooklyn:
  Brooklyn College Library.
  Brooklyn Public Library.
  Pratt Institute Library.
Buffalo:
  Buffalo and Erie County Public Library.
  Grosvenor Library.
Canton: St. Lawrence University Library.
Elmira: Elmira College Library.
Farmingdale: Long Island Agricultural and Technical Institute Library.
Flushing: Queens College Library.
Glens Falls: Crandall Library.
Hamilton: Colgate University Library.
Ithaca:
  Albert R. Mann Library, New York State Colleges of Agriculture and Home Economics.
  Cornell University Library.
Jamaica:
  Queens Borough Public Library.
  St. Johns University Library.
New York City:
  College of the City of New York Library.
  Columbia University Library.
  Cooper Union Library.
  Fordham University Library.
  New York Law Institute Library.
  New York Public Library (Astor Branch).
  New York Public Library (Lenox Branch).
  New York State Maritime College Library.
  New York University General Library.
Newburgh: Newburgh Free Library.
Potsdam: Clarkson College of Technology Library.
Poughkeepsie: Vassar College Library.
Rochester:
  Rochester Public Library, Edgerton Branch.
  University of Rochester Library.
St. Bonaventure: St. Bonaventure College Library.
Schenectady: Union College Library.
Staten Island: Wagner College Library, Grymes Hill.
Syracuse: Syracuse University Library.
Troy: Troy Public Library.
Utica: Utica Public Library.
West Point: U.S. Military Academy.
Yonkers: Yonkers Public Library.

NORTH CAROLINA

Chapel Hill: University of North Carolina Library.
Charlotte: Queens College Library.
Cullowhee: Western Carolina College Library.
Davidson: Library of Davidson College.
Durham: Duke University Library.
Greensboro: Agricultural and Technical College Library.
Greenville: East Carolina College Library.
Pembroke: Pembroke State College Library.
Raleigh:
  D. H. Hill Library of North Carolina State College.
  North Carolina State Library.
Salisbury: Catawba College Library.
Wilson: Atlantic Christian College, Clarence L. Hardy Library.
Winston-Salem:
  Public Library of Winston-Salem and Forsyth County.
  Wake Forest College Library.

NORTH DAKOTA

Bismarck:
  State Historical Library.
  State Law Library.
Fargo: North Dakota Agricultural College and Experiment Station Library.
Grand Forks: University of North Dakota Library.
Minot: State Teachers College Library.
Valley City: State Teachers College Library.

OHIO

Akron: Akron Public Library.
Alliance: Mt. Union College Library.
Ashland: Ashland College Library.
Athens: Ohio University Library.
Bluffton: Musselman Library of Bluffton College.
Bowling Green: Bowling Green State University Library.
Bucyrus: Bucyrus Public Library.
Cincinnati:
  Public Library.
  University of Cincinnati Library.
Cleveland:
  Adelbert College Library of Western Reserve University.
  Cleveland Public Library.
Columbus:
  Columbus Public Library.
  Ohio State Library.
  Ohio State University Library.
Dayton: Dayton Public Library.

Delaware: Charles Slocum Library of Ohio Wesleyan University.
Gambier: Kenyon College Library.
Granville: Denison University Library.
Hiram: Hiram College Library.
Marietta: Marietta College Library.
Oberlin: Oberlin College Library.
Oxford: Miami University Library.
Portsmouth: Free Public Library.
Springfield: Warder Public Library.
Steubenville: Carnegie Library.
Toledo: Toledo Public Library.
Van Wert: Brumback Library of Van Wert County.
Youngstown: Youngstown Public Library.

OKLAHOMA

Ada: East Central State Teachers College Library.
Alva: Northwestern State Teachers College Library.
Durant: Southeastern Teachers College Library.
Edmond: Central State College Library.
Enid: Carnegie Public Library.
Langston: Langston University Library.
Norman: University of Oklahoma Library.
Oklahoma City: Oklahoma State Library.
Shawnee: Oklahoma Baptist University Library.
Stillwater: Oklahoma State University Library.
Tahlequah: Northeastern State Teachers College Library.
Tulsa: University of Tulsa Library.
Weatherford: Southwestern State College Library.

OREGON

Ashland: Southern Oregon College of Education Library.
Corvallis: Oregon State College Library.
Eugene: University of Oregon Library.
Forest Grove: Pacific University Library.
La Grande: Eastern Oregon College of Education Library.
Portland:
  Library Association of Portland.
  Reed College Library.
Salem: Oregon State Library.

PENNSYLVANIA

Allentown: Muhlenberg College Library.
Bethlehem: Lehigh University Library.
Bradford: Carnegie Public Library.
Carlisle: Dickinson College Library.
Erie: Erie Public Library.
Harrisburg: Pennsylvania State Library.
Haverford: Haverford College Library.
Huntingdon: Juniata College Library.
Lancaster: Franklin and Marshall College, Fackenthal Library.
Meadville: Allegheny College Library.
Philadelphia:
  Free Library of Philadelphia.
  Philadelphia Commercial Museum Library.
  Temple University, Sullivan Memorial Library.
  University of Pennsylvania Library.
Pittsburgh:
  Allegheny Regional Branch Library.
  Carnegie Library of Pittsburgh.
  University of Pittsburgh Library.
Reading: Reading Public Library.
Scranton: Scranton Public Library.
State College: Pennsylvania State University Library.
Swarthmore: Swarthmore College Library.
Warren: Warren Library Association.
Washington: Memorial Library of Washington and Jefferson College.
Wilkes-Barre: Kings College Library.
Williamsport: James V. Brown Library.

PUERTO RICO

Mayaguez: University of Puerto Rico, College of Agriculture and Mechanical Arts Library.
Rio Piedras: University of Puerto Rico General Library.

RHODE ISLAND

Kingston: University of Rhode Island Library.
Providence:
  Brown University Library.
  Providence Public Library.
  Rhode Island State Library.
Westerly: Westerly Public Library.

SOUTH CAROLINA

Charleston: Charleston College Library.
Clemson: Clemson College Library.
Columbia:
  South Carolina State Library.
  University of South Carolina Library.
Orangeburg: State Agricultural and Mechanical College.
Rockhill: Carnegie Library of Winthrop College.

SOUTH DAKOTA

Brookings: Lincoln Memorial Library of South Dakota State College.
Mitchell: Dakota Wesleyan University Library.
Pierre: South Dakota Free Library Commission.
Sioux Falls: Carnegie Free Public Library.
Spearfish: Black Hills Teachers College Library.
Vermillion: University of South Dakota Library.
Yankton: Yankton College Library.

TENNESSEE

Chattanooga: Chattanooga Public Library.
Clarksville: Austin Peay State College Library.
Johnson City: East Tennessee State College Library.
Knoxville: University of Tennessee Library.
Martin: University of Tennessee Library, Martin Branch.
Memphis: Cossitt Library.
Murfreesboro: Middle Tennessee State College Library.
Nashville:
  Joint University Libraries.
  Nashville Public Library.
  State Library Division, Tennessee State Library and Archives.
Sewanee: University of the South Library.

TEXAS

Abilene: Hardin Simmons University Library.
Austin:
  Texas State Library.
  University of Texas Library.
Beaumont: Lamar State College of Technology Library.
Canyon: West Texas State Teachers College Library.
College Station: Agriculture and Mechanical College of Texas Library.
Commerce: East Texas State Teachers College Library.
Dallas:
  Dallas Public Library.
  Southern Methodist University Library.
Denton: North Texas State Teachers Library.
El Paso: El Paso Public Library.
Fort Worth:
  Fort Worth Public Library.
  Texas Christian University Library.
Galveston: Rosenberg Library.
Houston:
  Houston Public Library.
  University of Houston Library.
Huntsville: Sam Houston State Teachers College, Estill Library.
Kingsville: Texas College of Arts and Industries Library.
Lubbock: Texas Technological College Library.
Marshall: Bishop College Library.
San Antonio: Public Library (La Villita Annex).
San Marcos: Southwest Texas State Teachers College Library.
Waco: Baylor University Library.

UTAH

Ephraim: Snow College Library.
Logan: Utah State Library of Agriculture and Applied Science Library.
Ogden: Carnegie Free Library.
Provo: Brigham Young University Library.
Salt Lake City:
University of Utah Library.
Utah State Library.

VERMONT

Burlington: University of Vermont Library.
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Montpelier: Vermont State Library.
Northfield: Norwich University Library.

VIRGINIA

Blacksburg: Virginia Polytechnic Institute Library.
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Emory: Emory and Henry College Library.
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Hampden Sydney: Hampden Sydney College Library.
Lexington:
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Washington and Lee University Library.
Norfolk: Norfolk Public Library.
Petersburg: Virginia State College Library.
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Salem: Bittle Memorial Library of Roanoke College.
University: University of Virginia Library.
Univ. of Richmond, P.O.: University of Richmond Library.
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University of Washington Library.
Spokane: Spokane Public Library.
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Tacoma Public Library.
Walla Walla: Whitman College Library.

WEST VIRGINIA

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Department of Archives and History, State Library.
Kanawha County Public Library.
Elkins: Davis and Elkins College Library.
Fairmont: Fairmont State College Library.
Huntington: Marshall College Library.
Institute: West Virginia State College Library.
Morgantown: West Virginia University Library.
Salem: Salem College Library.

WISCONSIN

Appleton: Lawrence College Library.
Beloit: Beloit College Library.
Eau Claire: Wisconsin State College Library.
La Crosse: Public Library.
Madison:
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University of Wisconsin Library.
Wisconsin State Library.
Milwaukee:
Law Library of Milwaukee County.
Milwaukee Public Library.
Oshkosh: Oshkosh State College Library.
Racine: Racine Public Library.
Stevens Point: Wisconsin State College Library.
Superior:
Superior Public Library.
Curran Library, Wisconsin State College.

WYOMING

Casper: Natrona County Public Library.
Cheyenne: Wyoming State Library.
Laramie: University of Wyoming Library.

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

Department of Commerce Field Offices are maintained in the cities listed below. 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 material.

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Rm. 321, Post Office Bldg.

ATLANTA 3, GA.
604 Volunteer Bldg.
66 Luckie St., N.W.

BOSTON 9, MASS.
Rm. 232, Post Office & Courthouse

BUFFALO 3, N.Y.
504 Federal Bldg.
117 Ellicott St.

CHARLESTON 4, S.C.
Area 2, Sergeant Jasper Bldg.
West End Broad St.

CHEYENNE, WYO.
207 Majestic Bldg.
16th St. & Capitol Ave.

CHICAGO 6, ILL.
Rm. 1302
226 West Jackson Blvd.

CINCINNATI 2, OHIO
915 Fifth Third Bank Bldg.
36 E. Fourth St.

CLEVELAND 1, OHIO
4th Floor
Federal Reserve Bank Bldg.
E. 6th St. & Superior Ave.

DALLAS 1, TEX.
Rm. 3–104 Merchandise Mart
500 South Ervay St.

DENVER 2, COLO.
142 New Custom House
19th & Stout Street

DETROIT 26, MICH.
438 Federal Bldg.

GREENSBORO, N.C.
Rm. 407, Post Office Bldg

HOUSTON 2, TEX.
610 Scanlan Bldg.
405 Main St.

JACKSONVILLE 1, FLA.
425 Federal Bldg.
311 West Monroe St.

KANSAS CITY 6, MO.
Room 2011
911 Walnut St.

LOS ANGELES 15, CALIF.
Rm. 450, Western Pacific Bldg.
1031 S. Broadway

For local telephone listing, consult section devoted to U.S. Government.

MEMPHIS 3, TENN.
212 Falls Bldg.
22 N. Front St.

MIAMI 32, FLA.
316 Post Office Bldg.
300 N.E. First Ave.

MINNEAPOLIS 1, MINN.
319 Metropolitan Bldg.
2nd Ave. South & 3rd St.

NEW ORLEANS 12, LA.
1508 Masonic Temple Bldg.
333 St. Charles Ave.

NEW YORK 1, N.Y.
61st Fl. Empire State Bldg.
350 Fifth Ave.

PHILADELPHIA 7, PA.
Jefferson Bldg.
1015 Chestnut St.

PHOENIX, ARIZ.
419 Ellis Bldg.
137 N. 2nd Ave.

PITTSBURGH 22, PA.
817 Fulton Bldg.
107 Sixth Street

PORTLAND 4, OREG.
217 Old U.S. Courthouse
520 S.W. Morrison St.

RENO, NEV.
1479 Wells Ave.

RICHMOND 19, VA.
Rm. 309, Parcel Post Bldg.
11th and Main Streets

ST. LOUIS 1, MO.
910 New Federal Bldg.
1114 Market St.

SALT LAKE CITY 1, UTAH
Room 105
222 S.W. Temple St.

SAN FRANCISCO 11, CALIF.
Rm. 419 Customhouse
555 Battery St.

SAVANNAH, GA.
235 U.S. Courthouse and Post Office Bldg.
125–29 Bull St.

SEATTLE 4, WASH.
809 Federal Office Bldg.
909 First Ave.

2. PERIODICALS OF THE NATIONAL BUREAU OF STANDARDS

2.1. 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 four 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 measurement, fundamental constants, and properties of matter. Issued six times a year.

B. MATHEMATICS AND MATHEMATICAL PHYSICS

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 programing of computers and computer systems are covered, together with short numerical tables. Issued quarterly.

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.

D. RADIO PROPAGATION

This section reports research in radio propagation, communications, and upper atmospheric physics. Topics covered include propagation in ionized media, scattering by turbulence, effect of irregular terrain on propagation, diffraction and scattering by solid obstacles, propagation through time-varying media, surface waves, and antennas. Issued six times a year.

2.2. TECHNICAL NEWS BULLETIN

This monthly publication summarizes the current research development, and test activities of the Bureau. The articles are brief, with emphasis on the results of research and their significance, chosen for their importance to other scientists, engineers, and to industry. Résumés of longer research reports, important national and international conferences on fundamental science in which the Bureau has represented the Nation, and a bibliography of all publications by members of the staff as published are included. The Bulletin is designed to give a succinct account of the current work of the Bureau.

2.3. BASIC RADIO PROPAGATION PREDICTIONS

This is a monthly publication for those concerned with radio communication in determining the best sky-wave frequencies over any path at any time of day for average conditions for the month of prediction, which are made three months in advance. Charts of extraordinary-wave critical frequency for the F2 layer and of maximum usable frequency for a transmission distance of 4,000 km, of highest frequency of sporadic–E in excess of 15 MC are included. In addition, there are various maps, charts, diagrams, and nomograms needed to make practical application of the world-contour charts, together with examples of their use.

ANNUAL SUBSCRIPTION	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. 00	$4. 75
Bound volume (1 volume per year), blue buckram	(3)	(3)
Section B. Mathematics and Mathematical Physics, issued quarterly, paper covers	2. 25	2. 75
Bound volume (1 volume per year), green buckram	(3)	(3)
Section C. Engineering and Instrumentation, issued quarterly, paper covers	2. 25	2. 75
Bound volume (1 volume per year) salmon buckram	(3)	(3)
Section C. Radio Propagation, issued six times a year, paper covers	4. 00	4. 75
Bound volume (1 volume per year) tan buckram	(3)	(3)
Technical News Bulletin, 12 monthly issues[4]	1. 50	2. 25
Basic Radio Propagation Predictions, 12 monthly issues[4]	1. 50	2. 00

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

[1] United States and its possessions, Canada, Cuba, 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 two monthly periodicals may be obtained on a 1-, 2-, 3-year subscription basis (although no reduction in rates can be made).

3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS

The prices of the publications are shown in "Price list of available publications" on page 161. The publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (The only exception is the Technical Note Series, see page 165.) If the price is omitted, the publication is out of print, but may be consulted in libraries maintaining reference sets of Bureau publications. Abstracts of publications issued prior to July 1, 1957, are included in Circulars 24, 460, and 460 supplement.

The letter-symbol designations given below are used in this Circular for the publication series indicated, and these letters should be included with the serial number in all requests and references to Bureau publications:

J, Journal of Research
A. Physics and Chemistry
B. Mathematics and Mathematical Physics
C. Engineering and Instrumentation
D. Radio Propagation
C, Circulars.

Mono., Monographs.
H, Handbooks.
MP, Miscellaneous Publications.
BMS, Building Materials and Structures Reports.
AMS, Applied Mathematics Series.
TN, Technical Note Series (use PB number).

3.1. RESEARCH PAPERS

Research Papers are reprints of individual articles that appeared in Volumes 1–62 of the monthly Journal of Research. They were made available in this form primarily to serve the needs of research workers and technical groups. In July 1959 the Bureau began publishing the Journal in four separate sections (page 34) and Research Papers were discontinued.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 59, JULY–DECEMBER 1957

RP2768. Thermal length changes of some refractory castables, S. J. Schneider and L. E. Mong

The changes in length exhibited by a variety of refractory castables during complete heating and cooling cycles were determined. The tests consisted of determinations on castable specimens that had been heat treated at either 110°, 1,050°, or 1,300° C. A detailed description of the apparatus is given, especially that of the dilatometer assemblies. These assemblies incorporated differential transformers to give a record of length changes as they occurred. The data suggested that the same general length-change characteristics were exhibited by castables that had received the same curing and heat treatment. Length-change curves of all three groups illustrated silica inversions. Curves of the 110° C group indicated contractions associated with cement reactions, namely, the loss of water of hydration and the conversion of amorphous alumina to γ alumina. 8 p.

RP2769. Precise intercomparison of acids by differential potentiometric titration with hydrogen electrodes, R. G. Bates and E. Wichers

The purity of two preparations of benzoic acid, three of oxalic acid, and three of potassium hydrogen phthalate has been compared by a precise determination of the equivalence of each substance with the same solid reference base, sodium carbonate, the only requirements for which were that its composition be uniform and remain constant throughout the series of measurements. The inflection point in each titration was determined by a differential potentiometric method utilizing two hydrogen electrodes. The procedure, which gives a degree of precision greater than has previously been reported for acidimetric determinations, is described in detail. When about 0.06 equivalent of acid was used in each titration, the reproducibility attainable was better than 0.002 percent. The failure of the inflection point and the equivalence point to coincide exactly has been considered in evaluating the reliability of the procedure.

The purity of one of the samples of benzoic acid, as determined independently from accurate measurements of the freezing point, was 99.997 mole percent. Single crystals of benzoic acid grown from a melt of this material were selected as a reference acid and were regarded to have a purity of 100.000 percent. In terms of this reference, a preparation of potassium hydrogen phthalate consisting of optically perfect crystals was found to have a purity of 100.000 percent. The method is adaptable to a variety of acids and bases and, hence, provides an additional criterion of purity for these substances. 9 p.

RP2770. Mixed-path ground-wave propagation: 2. Larger distances, J. R. Wait and J. Householder

The theoretical results given in part 1 (NBS Research Paper 2687) for ground wave propagation over a mixed path on a flat earth are generalized to a spherical earth. The problem is formulated in terms of the mutual impedance between two vertical dipoles which are located on either side of the boundary of separation. Extensive numerical results are given in graphical form for a mixed land-sea path at frequencies of 10, 20, 50, 100, and 200 kilocycles per second. 8 p.

RP2771. A spectroscopic study of oils used in oil-extended rubber, F. J. Linnig and J. E. Stewart

Knowledge of the composition of oils used in oil-extended rubber is useful in specifying oil types and in understanding the properties of the oil-rubber master batches. In this work, elucidation of structure has been attempted by a comparison of infrared spectra between 2 and 15 microns of two series of oil fractions obtained by basically different methods. Fractions of a number of different oils or oil distillates were studied. The spectra were compared with reference to the method of separation and in some cases to the physical and chemical properties of the fractions. There are marked similarities between certain of the

fractions separated by the two methods. However, the study indicates a variability of structural types from one oil to another. This is especially true for the more polar fractions. It is suggested that this varability, especially with respect to polar groups and other structures leading to active hydrogens, could account for the observed variability in the aging properties of master batches containing different oils or oil fractions.

Spectra were also obtained of a few typical fractions in the ultraviolet range between 210 and 340 millimicrons and in the far infrared between 15 and 40 microns. 14 p.

RP2772. Infrared spectra of sugar acetates in solution, H. S. Isbell, F. A. Smith, E. C. Creitz, H. L. Frush, J. D. Moyer, and J. E. Stewart

Infrared absorption spectra are reported for a group of structurally and configurationally related carbohydrate derivatives. The conformation of the pyranose ring and other structural features of the compounds are discussed in relation to the spectra. Most of the absorption that is characteristic of the cyclic carbohydrate structure occurs in the region of 8.4 to 15 μ. Although the spectra are complex and difficult to interpret, they show features from which a number of provisional conclusions have been drawn.

It was found that fully acetylated monosaccharides with an axial glycosidic acetate group give a moderately strong absorption band at 8.63 ± 0.04 μ, and at most a weak band at 8.87 ± 0.06 μ; whereas compounds having an equatorial glycosidic acetate group absorb weakly at 8.63 μ, and give a moderately strong band at 8.87 μ. The spectra for the acetates having the *gulo-*, *ido-*, or *talo*-configurations appear to indicate the presence of the C'2, or less common chair conformation, or a mixture of conformations.

Acetylated methyl glycosides with the methoxyl group in the axial position give characteristic absorption at 8.33 ± 0.02 μ and at 8.80 ± 0.05 μ; none of the compounds with the methoxyl group in the equatorial position shows absorption in these regions. Absorption at 8.80 μ is enhanced further by the presence of axial acetyl groups on the ring. On the basis of this generalization, an acetylated methyl glycoside with the *β-gulo* structure gives evidence for the presence of the C'2 conformation.

Overlapping bands in the region of 8.0 to 8.2 μ arise from acetyl groups of diverse character, with the result that spectra in this region show characteristic features for some compounds. Thus the pyranose acetates of the pentoses and of rhamnose give a sharp, well-defined band at 8.0 μ, but the acetates of the hexoses and higher sugars give a poorly defined band that seems to include an overlapping component with a maximum at higher wavelength. This characteristic may serve to distinguish acetates that do, or do not, have a primary acetyl group 38 p.

RP2773. A problem in self-heating of a spherical body, S. M. Genensky

An analytic steady-state solution is developed for a spherical body in which heat is generated according to a first-order unimolecular-reaction law, and lost at the surface in accordance with Newton's law of cooling. The temperature within the sphere depends chiefly on the radial distance from the center, but also on the ambient temperature, the surface heat-loss coefficient, and the material properties, which are assumed constant. 3 p.

RP2774. Properties of arsenic sulfide glass, F. W. Glaze, D. H. Blackburn, J. S. Osmalov, D. Hubbard, and M. H. Black

Samples of arsenic sulfide glass were investigated to determine their chemical and physical properties. Among the properties reported are the hygroscopicity, chemical durability, hydrogen electrode function, expansivity, elastic moduli, modulus of rupture, hardness, transmittance, and indices of refraction.

The main interest in arsenic sulfide glass, for the present, is for its transmittance in the infrared. It is transparent to infrared energy out to approximately 13 microns. Although its physical properties are inferior to those of ordinary silicate glasses, they are superior to those of some of the available materials used in infrared optics. 10 p.

RP2775. Thermal conductivity of beryllium oxide from 40° to 750° C, D. A. Ditmars and D. C. Ginnings

The thermal conductivity of beryllium oxide has been measured by an absolute method from 40° to 750° C. The apparatus employed steady-state longitudinal heat flow along a rod of high-fired beryllium oxide, surrounded by a tube with matching temperature gradient to minimize radial heat loss. The estimated accuracy of the measurements is about 3 percent. However, the values of thermal conductivity of the ideal beryllium oxide crystal are probably considerably higher than the values given because of the lower density (87 percent theoretical) of the sample used. 7 p.

RP2776. A self-balancing direct-current bridge for accurate bolometric power measurements, G. F. Engen

Until recently, the most accurate microwave power measurements of the bolometric type have required the use of a manual d-c bridge. A self-balancing d-c bridge has been developed that preserves the inherent accuracy of the manual bridge, extends the dynamic range of operation, and greatly simplifies the operating procedure. A general description of the equipment and operating techniques is given, followed by a comprehensive survey of the sources of error accompanying the method and the accuracy achieved. 5 p.

RP2777. Some observations on hydrated monocalcium aluminate and monostrontium aluminate, E. T. Carlson

Monocalcium aluminate hydrate, probably having the composition $CaO.Al_2O_3.10H_2O$, was prepared by precipitation from calcium aluminate solutions at 1° C, and by hydration of pastes of monocalcium aluminate or aluminous cement. It was obtained as hexagonal prisms, very weakly birefringent, with mean index 1.471. Three molecules of water were expelled by drying over $CaCl_2$, without apparent change in crystal structure; however, the structure was destroyed by heating to 175° C. Monostrontium aluminate hydrate was obtained by analogous methods in the form of minute needles or prisms with mean index 1.478. The maximum degree of hydration was not successfully determined, as the compound underwent decomposition to $3SrO.Al_2O_3.6H_2O$ and gibbsite. X-ray diffraction powder patterns indicate a close similarity in structure between the monocalcium and monostrontium aluminate hydrates. 5 p.

RP2778. Turbidity and viscosity measurements on some cationic detergents in water and in sodium chloride solutions, L. M. Kushner, W. D. Hubbard, and R. A. Parker

Light-scattering and viscosity measurements were made on solutions of three cationic detergents in distilled water and in various solutions of sodium chloride. The detergents were dodecylamine hydrochloride, dodecyltrimethylammonium chloride, and tetradecyltrimethylammonium chloride. The first of these was investigated at 30° C and the others at 23° C. The micellar weight and the intrinsic viscosity of the micelles of each detergent were calculated, and the dependence of these quantities on the concentration of sodium chloride is discussed. 7 p.

RP2779. Relative stress-optical coefficients of some National Bureau of Standards optical glasses, R. M. Waxler and A. Napolitano

The relative stress-optical coefficients of 27 optical glasses made at the National Bureau of Standards have been determined. The glasses were loaded in compression, and the amount of birefringence was measured with a polarimeter, using a quarter-wave plate compensator. The stress-optical coefficients determined for the crown glasses ranged between +2.95 and +1.82 brewsters. For the flint glasses, a regular variation of the stress-optical coefficient with weight percent of lead oxide was found with values ranging from +3.18 to −1.16 brewsters. 5 p.

RP2780. Physicochemical studies of the destructive alkali-aggregate reaction in concrete, R. G. Pike and D. Hubbard

In a further study of the alkali-aggregate reaction in high-alkali cements, 11 reactive and nonreactive experimental aggregates were examined by several procedures. On comparing the results of each method with the standard expansion-bar test, it appears that each property studied has some bearing on the expansion characteristics of each aggregate. For example (1) The chemical durability as determined by the interferometer procedure was poor for the aggregates that showed excessive expansion, but not all aggregates that are shown to be chemically reactive by this procedure will cause expansion, (2) all aggregates are sufficiently hygroscopic to attract the water necessary for the reaction if other properties are also favorable, (3) surface electrical-resistance measurements confirm the hygroscopicity determinations; however, free ions in glasses may have considerably more effect on the surface resistance of certain glasses than do their hygroscopic properties, and (4) the uneven distribution of migratable ions between the aggregate surface and the outer phase offers a mechanism for the osmotic swelling of individual aggregate grains, with accompanying expansion in concrete members. 6 p.

RP2781. Insulated loop antenna immersed in a conducting medium, J. R. Wait

A solution is given for the fields of a circular loop in a conducting medium. The loop is assumed to have a uniform current, and it is enclosed by a spherical insulating cavity. The impedance of the loop is also considered. It is shown that the power radiated from the loop varies approximately as the reciprocal of the radius of the cavity for a specified loop current. Furthermore, if the cavity is electrically small, relative to the external medium, the radiation field is not significantly affected by the presence of the cavity. 5 p.

RP2782. Noncrystal ionic model for silica glass, L. W. Tilton

A model was constructed of pentagonal rings of symmetrical tetrahedra so connected that all five silicons lie in one plane and all angles Si—O—Si approximate 180°. From an initial tetrahedron the rings extend in six directions to include its six edges, and in the resulting three-dimensionable network each ring forms a common interface between dodecahedral cages which necessarily have fivefold symmetry. Such symmetry is incompatible with formation of a crystal lattice and thus the structure can be extended in three dimensions only to a very limited degree and with unavoidable stress and distortional strain. A stressed network cluster of such dodecahedral cages is here called a VITRON.

If the scale in this model for silica glass is taken as 1.6 A, from silicon to oxygen, the model is found to be in accord with other radial distances computed from diffraction data and the density is correct within 10 percent. The apertures of the pentagonal interfaces are of suitable size to explain data on the diffusion of noble gases through silica. Shared penta faces and intermittent oxygen bridges connect neighboring vitrons and constitute an interstitial tissue of relatively weakened structure that accounts for the observed low tensile strengths of silica glass and provide channels for viscous flow.

The proposed cages would be less pliable at low temperatures and so the interstitial tissues between vitrons should expand in volume on cooling. This "negative" expansion would counter the normal expansion and account for the known extremely small (net) expansivity of silica glass. The accompanying changes in strength and volume of the glass at its weakest places, the interstitial tissues, can account for a number of known "anomalies" in thermal behavior of silica glass with respect to its volume, compressibility, elastic moduli, and viscous flow.

The vitron concept reconciles the crystallite and the network theories of glass by proposing nuclei that cannot grow extensively and a distribution of localized stresses that may constitute an acceptable degree of randomness and provide effective modulations in continuity. This concept of definite but limited microregularity in structure suggests that other noncrystal symmetries should be studied for possible interest in other fields such as liquids and high polymers. 16 p.

RP2783. A computation of cyclic cubic units, H. Cohn and S. Gorn

The paper is a report on a tabulation of units performed on the EDVAC at the U.S. Army Proving Grounds in Aberdeen, Maryland. The algebraic number fields involved were 45 cyclic cubic fields of discriminant l^2, where l is one of the primes of form $3m+1$ from 7 through 499. The object of the search was the discovery of units through a specific method, an algorithm based on Minkowski's geometric number theory but particularly amenable to a stored-program computer. In the computation, combined use was made of integral arithmetic and decimal arithmetic but with careful error analysis. 14 p.

RP2784. Estimation of the frequencies of thin elastic plates with free edges, T. Kato, H. Fujita, Y. Nakata, and M. Newman

A variational method is proposed for calculating the frequencies of thin elastic plates with free edges, with rigorous error estimates. As a numerical example, the fundamental frequency of a square plate with the Poisson ratio 0.225 is calculated with a satisfactory result, the possible relative error being less than 1/2000. Generalization to more complicated boundary conditions is straightforward. 18 p.

RP2785. A thermochemical study of the reaction of calcium hydroxide, silica gel, and water, E. S. Newman

The heat of reaction of calcium hydroxide, silica gel, and water was measured by a heat-of-solution method. The reaction was carried out at 25° C in pastes having a water solid ratio of about 1.0. The heat of reaction, $-\Delta H$ at 25° C, for the reaction

$$Ca(OH)_2 + SiO_2 \cdot nH_2O = CaO \cdot SiO_2 \cdot nH_2O$$

was found to be about 10.3 kilocalories. The heat of the reaction

$$CaO \cdot SiO_2 \cdot nH_2O + mCa(OH)_2 = (1+m)CaO \cdot SiO_2 \cdot (n+m)H_2O$$

is about 1.6 kilocalories per mole of added $Ca(OH)_2$. About half of the total measured heat of reaction represents the heat of wetting of the reaction products. Differential thermal analyses and drying experiments indicated that $3CaO \cdot 2SiO_2 \cdot 2H_2O$ was formed in some of the pastes. 10 p.

RP2786. On some expansions for Bessel integral functions, F. Oberhettinger

Investigations by van der Pol and Humbert concerning the Bessel integral function of order zero are extended to Bessel functions of other kinds and to functions related to Bessel functions. 5 p.

RP2787. Table of the first moment of ranked extremes, J. Lieblein and H. E. Salzer

Let a sample of n independent random values from the extreme-value distribution, with c.d.f. $\Phi(y)=\exp(-e^{-y})$, be arranged in decreasing order and denoted by $y_1, y_2, \ldots, y_m, \ldots, y_n$. The table gives the expected values for all these order statistics for sample size not exceeding 25. For the larger samples, up to $n=100$, the expected values are given only for the first 26 largest values. 4 p.

RP2788. An approximate expression for gamma-ray degradation spectra, U. Fano and A. T. Nelms

The equation for gamma-ray degradation spectra is reduced to a form suitable for a simple approximation. The approximation is valid in a wavelength range between two Compton wavelengths larger than the wavelength of the source and the region where photoelectric absorption becomes very intense; this range is wide for low Z materials. Input data are provided for application to various materials and source energies. The results of sample calculations are shown and compared with those obtained by standard numerical calculation. 4 p.

RP2789. Some infrared bands of deuterium sulfide, H. C. Allen, Jr., E. K. Plyler, and L. R. Blaine

Two regions of the D^2S spectrum have been observed, 5 and 3.6 μ. An analysis of the absorption in the 3.6 μ region attributes it to two overlapping bands with excited states $(v^1,v^2,v^3)=(1,1,0)$ and $(0,1,1)$. The band center of the $(0,1,1)$ band is found to be some 50 cm^{-1} lower than the previously accepted value while the $(1,1,0)$ band center is found some 60 cm^{-1} higher than the previous determination. The absorption near 5 μ seems to arise from the $(0,0,1)$ band centered near 1906 cm^{-1}. Overlapping atmospheric absorption makes a detailed analysis impossible at this time. This band center is almost 100 cm^{-1} lower than previously reported. The excited state constants for the two bands near 3.6 μ are

$(1,1,0)$ $\nu_0=2742.77$ $A^*=5.478$ $B^*=4.512$ $C^*=2.395$

$(0,1,1)$ $\nu_0=2754.44$ $A^*=5.531$ $B^*=4.521$ $C^*=2.405$.

4 p.

RP2790. Some effects of low temperatures and notch depth on the mechanical behavior of an annealed commercially pure titanium, G. W. Geil and N. L. Carwile

Unnotched and notched specimens (60° notch angle, 0.05-inch root radius and various notch depths) of an annealed commercially pure titanium were slowly strained to fracture in tension at +150° or +100° to −196° C, to reveal the combined effects of temperature and notch geometry on the tensile behavior of the metal. Impact tests were made on Charpy V-notch specimens at +300° to −196° C for a determination of the impact notch-toughness of the titanium. True stress-true strain relations were determined for the titanium in tension and a study was made of the effects of test temperature, stress system, and interstitial content on the mechanism of deformation and work-hardening characteristics of the metal. 12 p.

RP2791. Determination and use of the sag point as a reference point in the heating of glasses, S. Spinner, G. W. Cleek, and E. H. Hamilton

Glasses, when heated, undergo a gradual continuous change from solids to liquids over a rather wide temperature range. As a consequence, it has been found necessary to define certain temperature reference points in this transition range so that different glasses may be compared with each other. These points are chosen to correspond to established stages in the annealing or forming process. A new reference point, designated as the sag point, is described. The experimental determination of this point is rapid and simple. Also, it gives useful information concerning the annealing temperatures and ease of formation of glasses of widely varying compositions.

The sag point is defined as the temperature at which a glass fiber 0.5 to 0.8 millimeter in diameter, horizontally supported at ½-inch intervals, will sag under its own weight in 25±5minutes. 5 p.

RP2792. Formulas for inverse osculatory interpolation in the complex plane, H. E. Salzer

Improved formulas for inverse osculatory interpolation in the complex plane are obtained by inversion of Hermite's formula and the use of appropriate grid point configurations. They cover the cases for $n=2(1)7$, where n is the number of points required in direct osculatory interpolation. The formulas provide an improved means for inverse interpolation in the complex plane where the first derivative is either tabulated alongside the function or is easily obtained. 6 p.

RP2793. An x-ray study of textural stresses in two-phase alloys, C. J. Newton and H. C. Vacher

Internal or residual stresses of the textural stress class are discussed, with special attention to that type resulting from a difference in thermal expansion of two phases present in an alloy. X-ray stress measurements were made on various brasses and steels, and the results were found to be in reasonable agreement with the quantitative theory of F. Lászlό. 5 p.

RP2794. Dissociation of 4-chloro-4′-aminodiphenylsulfone, E. E. Sager and F. C. Byers

The ultraviolet absorption spectra of 4-chloro-4′-aminodiphenylsulfone has been determined. The dissociation may be considered as the acidic dissociation of the ammonium ion which is formed with the addition to the base of hydrogen ion from an acid such as hydrochloric acid. Spectrophotometric measurements of several concentrations of 4-chloro-4′-aminodiphenylsulfone at various known hydrogen-ion concentrations were made at 25° C, from which the values pK_c, based upon the concentrations, were determined. From these, the value of pK_a was derived. At 25° C, pK_a is 1.38, which corresponds to a value of 0.042 mole per liter for K_a. The activity coefficient terms may be expressed simply as a linear function of the ionic strength. Spectrophotometric measurements were also made at 15°, 20°, 25°, 30°, and 35° C on certain solutions in order to calculate the heat of dissociation. It was found to be 21,000 joules deg^{-1} $mole^{-1}$. The basic dissociation constant, K_b, is 2.4×10^{-13}, or pK_b is 12.62. 4 p.

RP2795. Speed of sound in water by a direct method, M. Greenspan and C. E. Tschiegg

The speed of sound in distilled water was measured over the temperature range 0° to 100° C with an accuracy of 1 part in 30,000. The results are given as a fifth-degree polynomial and in tables. The water was contained in a cylindrical tank of fixed length, terminated at each end by a plane transducer, and the end-to-end time of flight of a pulse of sound was determined from a measurement of the pulse-repetition frequency required to set the successive echoes into time coincidence. 6 p.

RP2796. Pattern of a flush-mounted microwave antenna, J. R. Wait

The numerical results for the far zone radiation from an axial slot on a circular cylinder of perfect conductivity and infinite length are discussed. It is shown that the results

or large diameter cylinders can be expressed in a universal orm that is suitable for pattern calculations for arrays of lots on a gently curved surface. The work is compared with a related diffraction problem considered by Fock. 5 p.

RP2797. Standards for *p*H measurements from 60° to 95° C, V. E. Bower and R. G. Bates

The NBS standard *p*H scale is defined in terms of several reference solutions whose *p*H values (pH_s) have heretofore been assigned only in the range 0° to 60° C. Recent measurements of the standard potential of the silver—silver-chloride electrode at temperatures above 60° now permit this scale to be extended to 95° C.

Electromotive-force measurements of cells with hydrogen and silver—silver-chloride electrodes and containing buffer-chloride solutions are reported in this paper for the range 60° to 95° C. The assignment of *p*H$_s$ values to the following five reference solutions is described: 0.05-*m* potassium tetroxalate; potassium hydrogen tartrate (saturated at 25° C); 0.05-*m* potassium hydrogen phthalate; 0.025-*m* potassium dihydrogen phosphate; 0.025-*m* disodium hydrogen phosphate; and 0.01-*m* borax. 4 p.

RP2798. A numerical study of Dedekind's cubic class number formula, H. Cohn

In this paper an analytic formula of Dedekind is used to compute class numbers for a sample of pure cubic fields, employing the National Bureau of Standards electronic computer, the SEAC. The computation is one of major magnitude, and it illustrates the usefulness of combining integral and decimal arithmetic. The class numbers obtained are of much greater magnitude than those of pure cubic fields previously studied by means of hand computer methods. 7 p.

RP2799. Impact properties of slack-quenched alloy steels, M. R. Meyerson and S. J. Rosenberg

A method was developed for slack quenching impact specimens so as to produce uniform and accurately controlled hardnesses and microstructures at any location in the cross section. Steels of the 81xx type, without and with boron, and varying in hardenability, were studied to evaluate the effect of slack quenching upon the impact properties.

Slack quenching was shown to be detrimental to the impact properties of the steels. The injurious effects were found to be dependent on the carbon and alloy content of the steels, the degree of slack quenching, and the amount of tempering.

When any two steels were slack quenched to the same hardness, the higher carbon lower alloy steel had impact properties inferior to those of the lower carbon higher alloy steel. Tempering usually improved the properties of both and reduced the differences between them.

The higher the hardness to which any steel was slack quenched, the lower were its impact properties. When tempered to the same hardness, however, the steel originally slack quenched to the higher hardness had the better impact properties. 16 p.

RP2800. Synthesis of C^{14}-labeled L-sorbose and L-ascorbic acid, H. L. Frush and H. S. Isbell

A method is presented for preparing C^{14}-labeled L-ascorbic acid (vitamin C) from labeled barium D-gluconate or D-glucose. The process is adapted from the commercial synthesis of vitamin C through sorbitol, L-sorbose and potassium di-*O*-isopropylidene-2-*keto*-L-gulonate. In the cyanohydrin synthesis of labeled D-glucose, barium D-gluconate is used as an intermediate. For preparing labeled L-ascorbic acid, the gluconate is converted to the lactone. This is efficiently reduced, by means of sodium borohydride, directly to sorbitol, obviating the intermediate preparation of D-glucose.

If labeled D-glucose is more readily available than the corresponding gluconic acid (as for instance D-glucose-6-C^{14} or randomly labeled D-glucose), the sugar is reduced to sorbitol by the sodium borohydride method; the yield is nearly quantitative.

In a preparation of L-ascorbic acid-6-C^{14} from barium D-gluconate-1-C^{14} the yield was 41.5 percent, based on the gluconate, or 67.8 percent, based on the intermediate L-sorbose. A mixture of Methyl Cellosolve, ethylene dichloride, and hydrogen chloride was found to be effective in converting potassium di-*O*-isopropylidene-2-*keto*-L-gulonate to L-ascorbic acid. 4 p.

RP2801. A determination of the gamma-ray emission of radium, F. H. Attix and V. H. Ritz

Measurements of the γ-ray emission of radium (roentgens per milligram-hour at 1 centimeter) have been made by means of a graphite cavity ionization chamber. An auxiliary experimental examination of the stopping-power correction for the non-air-equivalence of the cavity wall is also described. The resulting average value for the γ-ray emission of radium (enclosed in an 0.5-millimeter platinum capsule) is 8.26 $\pm$0.05 roentgens per milligram-hour at 1 centimeter, which is based upon the conclusion that the stopping-power data of Bakker and Segre are consistent with the results of the auxiliary experiment. 13 p.

RP2802. Radiation from slots on dielectric-clad and corrugated cylinders, J. R. Wait and A. M. Conda

An approximate formula is derived for the radiation pattern of an axially slotted cylinder with a thin dielectric coating. The accuracy of the formula is shown to be sufficient for practical purposes. Using a similar method, the pattern function for a slot on a corrugated cylinder is derived. Extensive numerical results are presented for both dielectric-clad and corrugated cylinders. 10 p.

RP2803. Infrared emission spectrum of methane at 3.3 microns, E. K. Plyler and L. R. Blaine

The emission spectrum of methane from the flame of a Bunsen burner has been observed in the region from 2,820 to 3,180 cm^{-1}. Many lines have been measured in the *P*-, *Q*-, and *R*-branches. The *P*-branch was observed to *P*-28 and the *R*-branch to *R*-17.

The spectrum was observed from the inner cone of the flame and with a rich fuel mixture the *P*-12 line was most intense. This intensity distribution indicated a temperature of about 1,200° K for the heated gas. 2 p.

RP2804. Term analysis of the first spectrum of rhenium (Re 1), P. F. A. Klinkenberg, W. F. Meggers, R. Velasco, and M. A. Catalán

With the aid of new data on wavelengths, intensities, and the Zeeman effect, the structural analysis of the first spectrum of rhenium (Re 1) has been extended to include 2,764 lines that are explained as transitions among 282 atomic energy levels. This analysis accounts for 90 percent of the total observed intensity, although only 64 percent of the total number of lines has been classified. From the Zeeman effect, magnetic splitting factors have been derived for 75 percent of the levels, and nearly 40 percent of these have been grouped into designated spectral terms ascribed to specific configurations of electrons. The normal state of neutral Re atoms is $5d^5\,6s^2\,^6S_{2\frac{1}{2}}$ and the ionization limit is approximately 63530 kaysers or 7.87 electron volts. 30 p.

RP2805. An apparatus for measurement of thermal conductivity of solids at low temperatures, R. L. Powell, W. M. Rogers, and D. O. Coffin

A description is given of an apparatus used for determining the thermal conductivities of solids in the temperature range 4° K to 300° K. The apparatus is especially suited to the determination of thermal conductivity over a large temperature interval, enabling coverage of the

temperatures between the normal boiling points of liquefied gases. Illustrative results are given for an insulator, polytetrafluoroethylene, and for a high-conductivity commercial coalesced copper. The thermal conductivity of the insulator increases monotonically from 0.56 milliwatt per centimeter per degree K at 5° K, to 2.32 at 80° K. The thermal conductivity of the copper has a maximum of 24.9 watts per centimeter per degree K at 21° K, and a value of 8.15 at 5° K. The methods of data analysis and estimation of errors are given. 7 p.

RP2806. Some factors affecting the surface area of hydrated portland cement as determined by water-vapor and nitrogen adsorption, L. A. Tomes, C. M. Hunt, and R. L. Blaine

Brunauer-Emmett-Teller (BET) surface areas of hydrated portland cement have been calculated from water-vapor and nitrogen-adsorption data. The adsorption and desorption of water vapor caused measurable decreases in specific surface areas by both water-vapor and nitrogen adsorption. Changes were also produced by wetting and drying. The adsorption and desorption of nitrogen at the boiling point of liquid nitrogen did not produce similar effects.

The specific surface and nonevaporable-water content of a hydrated cement are also somewhat dependent on the initial drying treatment. The effect of measuring water-vapor surface and nonevaporable water with specimens dried for different periods of time is also considered. 8 p

RP2807. Excitation of surface waves on conducting, stratified, dielectric-clad, and corrugated surfaces, J. R. Wait

An expression for the field of an electric dipole located over a flat surface with a specified surface impedance Z is derived from the formal integral solution by a modified saddle-pcint method. Using the value of Z appropriate for a homogeneous conducting ground, the general expressions reduce to those given by Norton. In this case the phase of Z lies between 0 and 45°. When the phase exceeds 45°, as it may for a stratified ground, the radiated wave of the dipole becomes partially trapped to the interface. This effect is most pronounced for an inductive surface where the phase of Z is 90°, in which case the energy of the wave is confined within a small distance from the surface. Such inductive surfaces are a metallic plane with a thin dielectric film or a corrugated surface.

This unifying treatment provides a link between the surface waves of Zenneck, Sommerfeld, Norton, and Goubau, and indicates that the phase angle of Z controls the extent to which these waves may exist for a dipole excitation. 13 p.

RP2808. Cunife wire magnets of small size, I. L. Cooter and R. E. Mundy

A ductile permanent-magnet alloy, having a composition of 60 percent of copper, 20 percent of nickel, and 20 percent of iron, was cold-drawn from wire, 25 mils in diameter to 5 mils in diameter. Demagnetization curves were obtained for several sizes of the wire in the cold-drawn state. These wires were then given a heat treatment and again demagnetization curves were obtained. Values of coercivity, retentivity, and maximum energy product are compared for various wire diameters. Although the magnetic properties were adversely affected by the cold-working, they were substantially improved by the heat treatment. 4 p.

RP2809. Interpretation of mass spectra of condensates from urban atmospheres, E. R. Weaver, E. E. Hughes, S. M. Gunther, S. Schuhmann, N. T. Redfearn, and R. Gorden, Jr.

A method of interpreting the mass spectra of the very complex mixtures of substances that condense from an urban atmosphere at the temperature of liquid oxygen is described. The number of individual chemical compounds in such a mixture is greatly in excess of the number of masses recorded, and it is accordingly impossible to identify all the compounds present. However, the significant sources of pollutants are much less numerous, and if the products from each source are of substantially constant composition it is possible to obtain a representative pattern of each and to proceed thereafter to make a fairly good estimate of the character and amount of pollutants in terms of their sources. The greatest simplification is made by treating the gases associated with motor traffic as a unit. 22 p.

RP2810. Infrared emission spectrum of silicon carbide heating elements, J. E. Stewart and J. C. Richmond

A method for determining the spectral emittance of a silicon carbide heating element (Globar) was devised and data were obtained over the wavelength range 1.25 to 15.25 μ for four different temperatures. The spectral emittance at all four temperatures, 482°, 649°, 816°, and 982° C (900°, 1,200°, 1,500°, and 1,800° F), was found to be approximately constant except for a gradual rise in emittance from 1.25 to about 4 μ and two minimums in the curves at longer wavelengths. The first of these minimums, which occurred at about 9 μ, was ascribed to minor amounts of SiO_2 present on the surface of the silicon carbide heating element, whereas the second at about 12.5 μ corresponds to one of the strong Raman lines for SiC. 5 p.

RP2811. Increased chemical reactivity of the surface compared with that in the bulk volume of Britton-Robinson universal buffers, R. G. Pike and D. Hubbard

A direct comparison of the chemical reactivity at the surface with that in the bulk volume of buffer solutions over the range pH 7 to pH 11.8 was made, using Corning 015 glass as the indicator. By observing interferometrically the surface alterations of optically flat specimens brought about by exposures to aqueous buffer solutions under controlled conditions of time, temperature, and pH it was possible to evaluate, at least semiquantitatively, the difference between the chemical reactivity of the surface and the bulk volume of the solutions. For the buffer at pH 7 the surface reactivity appeared to correspond to a hydrogen ion activity of pH 9.4. The apparent concentration differential between the surface and bulk volume falls off sharply for buffers of increased pH, amounting to only 0.2 pH unit for the buffer at pH 11.0, and becomes nondetectable at pH 11.8. Unfortunately the chemical durability characteristics of the glass were such that no differentiation could be made between the hydrogen ion activity of the surface and the bulk volume in solutions more acid than pH 7. 4 p.

RP2812. Photometric determination of tungsten in steel and titanium alloys with dithiol, L. A. Machlan and J. L. Hague

A method is described for the direct photometric determination of tungsten in steels. The sample, 0.1 to 0.2 g in weight, is dissolved in aqua regia, and a sulfuric-phosphoric-perchloric acid mixture is added. The solution is evaporated to fumes of sulfuric acid and diluted to volume with diluted sulfuric acid (1+3). An aliquot portion of the solution is treated with dithiol in diluted sulfuric acid solution (1+3) containing sulfur dioxide, and molybdenum and certain other potential interferences are removed by extraction with chloroform. Copper and other elements forming insoluble dithiolates are removed by filtration. The tungsten-dithiol complex is then formed, after the addition of hydrochloric acid, stannous chloride, and dithiol, and extracted with butyl acetate. The absorbancy of the tungsten complex is determined at approximately 635 mμ. An accuracy of 0.005 percent of tungsten, or better, is indicated in the range 0.05 to 0.50

percent of tungsten, and of about 0.001 percent for amounts of less than 0.05 percent of tungsten. The application of the method to titanium alloys is described in an appendix section. 6 p.

RP2813. On the most general form of the compatibility equations and the conditions of integrability of strain rate and strain, E. H. Brown

The most general forms of the equations of compatibility are derived by a very simple analysis in terms of the material strain rate tensor and the rate of change of the Riemann-Christoffel curvature tensor during the defermations. It is shown that recent statements on the significance of the compatibility equations, essentially that their satisfaction is equivalent to the condition that the space be locally Euclidean, are misinterpretations based on restricted forms of the equations. In addition, a new form of the conditions of integrability of strain is derived in terms of the rate of change of the curvature tensor. 6 p.

RP2814. An apparatus for measuring the piezoresistivity of semiconductors, R. F. Potter and W. J. McKean

A detailed description is given of an apparatus and procedure designed to measure the piezoresistive effect in semiconductors over an extended temperature range. A tensile force up to 1 kilogram can be applied to the sample by means of a calibrated beam balance. The apparatus has been used for measurements on indium antimonide over the range 78° K to 300° K, and tensile stresses of the order of 5×10^7 dynes per square centimeter can be applied to samples that are cut in a special manner. 4 p.

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RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 60, JANUARY—JUNE 1958

RP2815. The condition of certain matrices, III, J. Todd

The condition-numbers of certain matrices associated with various discretizations of the two-dimensional Laplacian operator are estimated. The condition-number gives an estimate of the error obtained by solving the corresponding systems of simultaneous linear equations. 7 p.

RP2816. Infrared study of some structural changes in natural rubber during vulcanization, F. J. Linnig and J. E. Stewart

A knowledge of the structure of vulcanized rubber is essential to the interpretation of vulcanization and oxidation studies and the physical properties of the material.

In the present work an infrared study has been made of structures resulting from a number of different methods of vulcanization. Sulfur vulcanizates show the presence of a shifted double bond, originally observed by Sheppard and Sutherland. The presence of conjugated double bonds is also indicated. Accelerators such as tetramethylthiuram disulfide and zinc dibutyl dithiocarbamate increase the rate of the double-bond shift and reduce the amount of conjugated double bonds. Neither the double-bond shift nor conjugation is observed as a result of vulcanization with tetramethylthiuram disulfide alone, hydrogen sulfide and sulfur dioxide (Peachey process), a peroxide, or gamma rays. These result in a possible decrease in carbonyl structures, and in the case of the last three, possible increased absorption due to OH and ionized carboxyl groups.

Apparently, the double-bond shift and conjugation are primarily phenomena related to the use of elemental sulfur. The other vulcanization systems studied evidently involve different mechanisms. An implication of the present work is that there may be a relationship between the reported ease of oxidation of sulfur vulcanizates, accelerated vulcanizates, and sulfurless vulcanizates (tetramethylthiuram disulfide alone), which decreases in the order named, and the probable amount of conjugation in the compound, which decreases in the same order. 13 p.

RP2817. Crystal structure of barium hydrogen orthophosphate, G. Burley

The structure of anhydrous $BaHPO_4$ was determined from three Fourier projections. The unit cell is orthorhombic with the space group $Pn2_1a$—No. 33. The cell dimensions are $a=14.12$, $b=17.15$, and $c=4.59$ A, and it contains twelve formula units. Each Ba atom has a coordination polyhedron of ten oxygen atoms, being bonded to four phosphate tetrahedra by edge sharing and to two more by corner sharing of oxygen atoms. The phosphate groups are in separate tetrahedra, linked by hydrogen bonding to form continuous chains. 5 p.

RP2818. A study of sampling of flame gases, C. Halpern and F. W. Ruegg

A study of sampling of hot combustion gases by means of water-cooled probes of internal diameter of 0.027 to 0.070 cm has been made. Effect of conditions of sampling on concentrations of CO, CO_2, H_2, and H_2O was the primary interest in this study. The probes were unable to quench reactions completely and were unable to preserve the original composition of the gas, but small probes were more effective than larger probes. Sample composition was unaffected by sampling velocity, except that at the higher rates of sampling it appears that gradients of composition and temperature caused the effectiveness of quenching to decrease. Probe material and configuration had little effect on sample composition. 9 p.

RP2819. Pyrolysis of polyamides, S. Straus and L. A. Wall

Thermal decompositions of various nylon samples having different molecular weights and composition were investigated by several procedures: (1) The rate of volatilization at temperatures between 310° and 380° C; (2) the analysis of the volatile products by mass spectrometry; and (3) a direct measurement of volatilizing material obtained by carrying out the pyrolysis within the ionization chamber of a mass spectrometer.

Activation energies based on the rates of volatilization for the various samples varied from 15 to 42 kilocalories. The rate behavior, i.e., the observation of maxima in the rate-versus-conversion plots, is close to that given by theory for random decomposition. The different activation energies appear to be the result of a hydrolytic mechanism which is sensitive to trace polymerization catalysts. Increases in rates were obtained when sulfuric and phosphoric acids were added to nylon. The fluctuations found in activation energies, and the production of CO_2 indicates that a hydrolytic decomposition mechanism may be contributing to the over-all process. It appears evident that, compared to a pure hydrocarbon chain, the polyamides are much more susceptible to thermal decomposition. 7 p.

RP2820. Some thermodynamic properties of the systems polybutadiene-benzene and polyisobutene-benzene, R. S. Jessup

Experimental data are reported on densities at 26.9° C of solutions of polyisobutene in benzene covering the composition range from 0 to 10 percent by weight of polyisobutene, and on relative vapor pressures of solutions of polybutadiene and of polyisobutene in benzene covering the range from 0 to 50 percent of benzene. Values of apparent specific volume of polyisobutene in benzene were calculated from the densities of solvent and solutions. The results of the vapor pressure measurements were compared with the Flory-Huggins equation. The deviations from this equation for the polyisobutene-benzene system are much greater than for the polybutadiene-benzene system. The following equations represent the

activities of the solvent for the polybutadiene-benzene and polyisobutene-benzene systems, respectively.

$$\ln a_1 = \ln v_1 + v_2 + 0.27v_2^2 + 0.06v_2^3,$$

$$\ln a_1 = \ln v_1 + \left(1 - \frac{1}{m}\right) v_2 + 0.50v_2^2 + 0.388v_2^3 + 0.184v_2^{12},$$

where a_1 represents activity of the solvent, v_1 and v_2 are volume fractions of solvent and polymer, respectively, and m is the ratio of molal volumes of polymer and solvent. 7 p.

RP2821. Infrared measurements with a small grating from 100 to 300 microns, E. K. Plyler and L. R. Blaine

Good resolution has been obtained with a small grating in the region from 100 to 300 microns. A high-pressure mercury lamp, having a quartz inner envelope, was used as a source and a Golay cell as a detector. The radiation was reflected from three filtering plates before passing through the entrance slit. This filtering served to reduce the stray radiation to about 5 percent. 3 p.

RP2822. A low-frequency annular-slot antenna, J. R. Wait

The radiation characteristics of an annular slot cut in an ideally conducting ground plane are discussed. The voltage impressed between the concentric edges is assumed to be constant around the slot. The annular slot is backed by a hemispherical cavity which has imperfectly conducting walls. For a specified voltage, the power radiated in the upper half-space and the power absorbed by the hemispherical cavity are calculated. It is indicated that the power absorbed can be reduced greatly by lining the walls of the cavity with a wire mesh. A flush-mounted antenna of this type at low frequencies may have certain practical advantages over the more conventional monopole. 6 p.

RP2823. Relation between the absorption spectra and the chemical constitution of dyes: XXIX. Interaction of direct azo dyes in aqueous solution, M. N. Inscoe, J. H. Gould, M. E. Corning, and W. R. Brode

Interaction of dyes in aqueous solution results in differences in the spectrum of the mixture when compared with the sum of the spectra of the individual dyes. A general survey, chiefly with azo dyes, was made to determine the effect of dye structure on this interaction.

The effect of other factors on the interaction of direct azo dyes was investigated. The addition of alcohol or non-ionic detergent prevents this interaction, while the presence of inorganic salts or an increase in dye concentration appears to increase the extent of interaction. The effect of acids and bases is dependent upon the nature of the dyes in the mixture.

The results obtained are consistent with the assumption that the forces involved in the interaction of direct azo dyes in mixtures are the same as those causing the aggregation of individual dyes and those binding these dyes to fibers. 19 p.

RP2824. Energy spectra of cascade electrons and photons, C. A. Olson and L. V. Spencer

The equations for the energy spectra of electrons and photons in a cascade shower are written in a form suitable for numerical applications with accurate cross sections. Trial calculations were carried out to check the feasibility of a step-by-step numerical integration procedure similar to that used successfully at low energies in noncascade problems. Numerical results were obtained for lead by using a monoenergetic source of electrons at 360 mc^2 and extreme relativistic cross-sectional forms, which assume complete screening. The method was designed to permit the determination of cascade-shower spectra, spatial distributions, and directional distributions that are exact in the sense that the main limiting factor is the accuracy with which the cross sections are known. The numerical results of the trial calculations were found to agree with previously published results based on more restrictive methods of analysis. 12 p.

RP2825. Observer differences in color-mixture functions studied by means of a pair of metameric grays, K. L. Kelly

The Granville metameric gray panels have served to characterize the color vision of observers in an approximate but useful way. Thus, the 39 observers studied, and the four color-mixture functions were classed into five groups according to their indicated amounts of ocular pigmentation. These panels were also used to measure the correlation of lens and macular pigmentations with observer age, sex, and eye and hair colors. Of the three sets of color-mixture functions intended to refer to 2° field observation, the 1931 Commission Internationale de L'Éclairage standard observer agrees best. These data thus afford no basis for supplanting the 1931 Commission Internationale de L'Éclairage standard observer with either the Judd "i" or the 1955 Stiles' 2° color-mixture functions. The 1955 Stiles' 10° functions, however, agree fairly well. 7 p.

RP2826. Precise evaluation of surface area with indirectly calculated dead space, W. V. Loebenstein

The determination of surface area from nitrogen adsorption data obtained at low temperature by volumetric methods is subject to several errors. One error that becomes especially serious when the surface area is small is associated with the calibration of the dead space with helium. This error is large because the volume of adsorbed gas is calculated as a small difference between two comparatively large quantities.

A statistical method of successive approximations has been developed for calculating the dead space. The latter is obtained as that quantity necessary to yield the best agreement with the known isotherm equation. This procedure fixes the value of V_m (directly proportional to the surface area). The procedure also provides an estimate of the experimental error associated with the over-all determination. 4 p.

RP2827. Sample calculations of gamma-ray penetration into shelters: Contributions of sky shine and roof contamination, M. J. Berger and J. C. Lamkin

An approximate method is presented for calculating the penetration of gamma radiation in shelters. Sample calculations, for an assumed source energy of 1 million electron volts, are given for the following problems: (1) Dose rate inside houses and underground shelters whose roofs are covered with radioactive fallout, and (2) dose rate in open holes due to reflected radiation (sky shine) from fallout contamination on the surrounding ground. A detailed examination is made of the dependence of the dose rate in a shelter on the shape of the shelter, and on the position of the detector within the shelter. The estimated accuracy of the calculations is ± 30 percent. 8 p.

RP2828. Heat content of sodium borohydride and of potassium borohydride from 0° to 400° C, T. B. Douglas and A. W. Harman

The heat content of sodium borohydride, $NaBH_4$, and of potassium borohydride, KBH_4, was measured, relative to that at 0° C, at 50-degree intervals from 0° to 400° C. The so-called "drop" method was used with a precision Bunsen ice calorimeter and a silver core furnace. Preliminary tests showed that spontaneous decomposition of these compounds is very slow at temperatures up to 400° C. Measurements were made on two samples of each compound, those of sodium borohydride having been obtained

from different sources. Smoothed values of the heat-content function, heat capacity, entropy, and the Gibbs free-energy function were derived from the data. These values were increased by 0.5 percent to correct for the presence of an estimated 1 percent of the corresponding *meta*borate in each sample. The heat capacity of sodium borohydride increases monotonically with temperature in the range investigated; that of potassium borohydride passes through a point of inflection, which suggests that there may be a broad second-order transition in the neighborhood of room temperature. 8 p.

RP2829. Infrared spectra of crystalline polyphenyls, J. E. Stewart and M. Hellmann

Infrared absorption spectra of sixteen selected polyphenyls ranging from biphenyl to *m*-octaphenyl are presented for the 5- to 38-micron region. The observed vibration bands are discussed in terms of a pseudo-symmetry approximation in which the individual rings are assumed to vibrate separately. Indications of interactions between rings are seen in the C–H out-of-plane bending vibrations of ortho- and meta-substituted rings. Evidence is given for the existence of two rotational isomers of *m*-quatraphenyl with a free energy difference of about 250 calories per mole. 12 p.

RP2830. On the application of steam-driven water jets for propulsion purposes, J. M. Burgers and A. Ghaffari

Calculations have been made concerning the momentum that can be given to a jet of water by mixing it with a jet of high-speed steam. Apart from an application of the equations of momentum and enthalpy, this raises questions concerning the speed of condensation and the acceleration of the water. 5 p.

RP2831. Mass spectra and relative sensitivities of some polyphenyls, P. Bradt and F. L. Mohler

Mass spectra have been measured by evaporating polyphenyls from a tube furnace into the ionization chamber of a 60° mass spectrometer operated at constant ion accelerating voltage. Mass spectra of pure tetraphenyl, hexaphenyl, and octaphenyl are reported. A synthetic mixture of terphenyl, tetraphenyl, pentaphenyl, hexaphenyl, and octaphenyl in known proportions was evaporated as the temperature was increased step by step from 125° to 290° C and time integrals of the five molecule ion currents were recorded over the time required to completely evaporate the sample. The relative sensitivity increases rapidly with increasing molecular weight. 3 p.

RP2832. Infrared spectra of thermally degraded poly (vinyl chloride), R. R. Stromberg, S. Straus, and B. G. Achhammer

The changes in chemical structure occurring in poly (vinyl chloride) as a result of heating in a vacuum in the range 100° to 400° C were studied using infrared spectrophotometry. The principal changes occurring in the residue during pyrolysis in a vacuum were the formation of unsaturated structures and a change from an aliphatic spectrum to one showing aromatic absorption. The data are used to support a previously proposed mechanism of decomposition for poly(vinyl chloride). 6 p.

RP2833. Current and potential relations for the cathodic protection of steel in salt water, W. J. Schwerdtfeger

A laboratory investigation was made pertaining to the cathodic protection of steel specimens that were exposed for 60 days to both stagnant and aerated city water, to which was added 3 percent by weight of sodium chloride.

Major consideration was given to the significance of potential as a criterion for protection. Optimum protection was achieved when specimens were controlled at −0.77 volt with reference to the saturated calomel half cell. Although a good degree of protection was obtained at controlled potentials more noble than −0.77 volt, that is, at the potentials associated with the breaks in cathodic polarization curves, this lesser degree of protection could not be obtained at lower mean current densities. 7 p.

RP2834. Joule-Thomson process in the liquefaction of helium, E. H. Brown and J. W. Dean

A dimensionless, normalized, correlating function is introduced for the specific enthalpy of helium. Using this function, the consistency of various enthalpy data is determined. These data are then used to obtain curves of helium liquefaction yield in the region of variable specific heat in terms of heat-exchanger efficiency. 8 p.

RP2835. Changes in the properties of an asphalt during the blowing operation, L. R. Kleinschmidt and H. R. Snoke

The physical characteristics and component distribution of an asphalt flux and of asphalt products taken at six two-hour intervals during the conversion, by air blowing, of the flux to a coating-grade asphalt, were determined. The softening point and asphaltene content of the asphalt products increased linearly with time during the blowing operation. There was essentially no change in percentage, refractive index, and viscosity of the water-white oils during blowing. The percentage and refractive index of the dark oils decreased progressively during the blowing operation. 4 p.

RP2836. Creep of annealed nickel, copper, and two nickel-copper alloys, W. D. Jenkins and C. R. Johnson

Creep tests were made in tension under constant loads at temperatures of 300°, 700°, and 900° F on initially annealed specimens of nickel, copper, and 70-percent-nickel–30-percent-copper and 30-percent-nickel–70-percent-copper alloys. Tests at 1,200° F were also made on the nickel and the two alloys, but not on the annealed copper as the resistance to creep of copper is relatively low at this temperature. The investigation included a study of the influence of rate of loading on the creep stress and of prior thermal-mechanical history on the creep behavior of the alloys at several selected temperatures. Contour and hardness surveys and metallographic examinations were also carried out on some of the fractured specimens to ascertain the effect of creep on the necking characteristics, hardness, and structures of the metals. 19 p.

RP2837. Stress-strain relation of pure-gum rubber vulcanizates in compression and tension, L. A. Wood

The stress-strain curve in tension for a typical pure-gum rubber vulcanizate after a given period of creep, according to Martin, Roth, and Stiehler, can be represented by an empirical equation

$$F = M(L^{-1} - L^{-2})\exp A(L - L^{-1})$$

where F is the stress based on the original-cross sectional area, and L is the ratio of stressed to unstressed length, M is the slope of the stress-strain curve at $L = 1$ and A normally has a value close to 0.38. The present paper shows by an examination of data published by Sheppard and Clapson, Treloar, and Rivlin and Saunders that the equation is also valid in the region of compression for values of L as small as 0.5 (50 percent compression). The features of the empirical equation are discussed, and comparisons are made with the equation predicted by the statistical theory of rubber elasticity and the equation derived by assuming Hooke's law for the stressed cross section. The consequences of the validity of the empirical equation in terms of the Mooney-Rivlin presentation of the strain energy function are pointed out. The equation

predicted by the statistical theory represents observed data very well in the compression region from $L=0.5$ to $L=1.0$. The Mooney equation is approximately valid from $L=1.5$ to $L=3.5$. Neither of these equations is satisfactory in the important intermediate region from $L=1.0$ to $L=1.5$. The empirical equation represents the observed data over all three of these regions. It is concluded that Young's modulus M can best be obtained from the intercept of a plot of log $F/(L^{-1}-L^{-2})$ against $(L-L^{-1})$. For $0.75<L<2.00$ it is thoroughly satisfactory to determine M as the intercept of a plot of $F/(L^{-1}-L^{-2})$ against $(L-1)$. 7 p.

RP2838. Tables for diagonalizing second-order matrices, R. E. Trees and C. D. Coleman

Sets of tables are given to facilitate the evaluation of the eigenvalues and eigenvectors of second-order matrices. 14 p.

RP2839. Effects of capillary shape on flow characteristics and degradation of polymer solutions, H. S. White and H. V. Belcher

Flow data were obtained using a tapered capillary, a chamfered capillary, and a uniform-bore capillary in a McKee worker consistometer. With polyisobutene-cetane solutions, degradation occurred at lower rates of flow and persisted for a greater number of passes with flow entering the smaller end compared to flow entering the larger end of the tapered capillary. When degradation occurred in both directions at high rates of flow the pressure was larger for flow entering the larger end though after degradation ceased the pressure (used to overcome viscous resistance) was less for flow in this direction, compared to flow entering the smaller end in each case. Errors which might arise in the use of single pass instruments with nonuniform capillaries are pointed out. 5 p.

RP 2840. Ortho-para catalysis in liquid-hydrogen production, D. H. Weitzel, W. V. Loebenstein, J. W. Draper, and O. E. Park

A series of selected or specially prepared catalysts were studied for their ability to accelerate the ortho to para conversion of hydrogen. The results of this study are presented, and the performance of various catalysts are compared with that of chromic oxide on alumina pellets. An outstanding catalyst, unsupported hydrous ferric oxide granules, was selected for further study and used in the liquefiers of the National Bureau of Standards Cryogenic Engineering Laboratory. One and one-half liters of this catalyst has now been used to convert more than 100,000 liters of liquid hydrogen to 90 to 95 percent para at an average rate of about 235 liters of liquid per hour. There is to date no evidence of decrease in efficiency with continued use. 7 p.

RP 2841. Degradation of cellulose in a vacuum with ultraviolet light, J. H. Flynn, W. K. Wilson, and W. L. Morrow

Dried, purified, cotton cellulose sheets were irradiated in a vacuum at 40° C with light of 2537 A wavelength. Hydrogen, carbon monoxide, and carbon dioxide were evolved, the degree of polymerization (D. P.) decreased, and CHO and COOH groups were produced. The evolution of hydrogen has not been reported previously. The rate of hydrogen evolution followed a parabolic rate law indicating inhibition by a product. The rate of evolution of carbon monoxide plus carbon dioxide increased slightly during irradiation. The initial quantum yield was 10^{-2} for hydrogen and 10^{-3} for carbon monoxide and carbon dioxide. A mechanism is proposed in which alcohol groups are photolyzed to carbonyl with the liberation of hydrogen. 5 p.

RP 2842. Cavity ionization as a function of wall material, F. H. Attix, L. DeLa Vergne, and V. H. Ritz

A study has been made of the ionization within a flat cavity chamber under irradiation by X- and gamma rays in the energy region 38 to 1,250 kilovolts effective (kev). Chamber walls were made of carbon, aluminum, copper, tin, and lead, and the wall separation was varied from 0.5 to 10 millimeters. Results are compared with cavity theory. 9 p.

RP 2843. Fragmentation of waterdrops in the zone behind an air shock, O. G. Engel

Observations made on the fragmentation of two waterdrop sizes, after collision with air shocks that were moving at three different supersonic velocities, are reported. The possible mechanisms of various aspects of the fragmentation process are discussed. The experimental observations indicate that high-speed-rain-erosion damage should not be observed on spheres having a diameter as large as 4 feet and moving with a Mach number in the range of 1.3 to 1.7 in rain that has a drop diameter of 1.4 millimeter. Waterdrops of this size should be reduced to mist in the zone of separation between the detached shock and the surface of the sphere according to the results that are reported. A means to extend this protection to spheres of smaller diameter or to rain of larger size is pointed out. The need for further experimental observation of the time required for the fragmentation of waterdrops using shocks moving at higher Mach numbers is indicated to verify and extend the information. 36 p.

RP 2844. Transient radio-frequency ground waves over the surface of a finitely conducting plane earth, J. R. Johler

The complete transient signal is reconstructed after propagation via the ground-wave mode over a finitely conducting plane earth in which the displacement currents are neglected. The theory is illustrated by computations that have been made on formulas derived by the method of the inverse Laplace transformation. The results of this analysis indicate that current sources with sinusoidal form in the time domain could be used to simulate sferics. The methods employed in this analysis can be also used to reconstruct propagated signals of pulsed radio-navigation systems. 5 p.

RP 2845. Measurement of current with a Pellat-type electrodynamometer, R. L. Driscoll

The value of an electric current has been determined in absolute measure by means of an electrodynamometer, and simultaneously by standard cells and standard resistors as currently maintained. The electrodynamometer used was of the Pellat type, and featured a fused silica balance beam and single layer helical coils.

The relation of the NBS ampere to the absolute ampere, from this determination, may be expressed as

1 NBS ampere = 1.000013 absolute amperes.

The uncertainty in this result from all known sources is estimated to be eight parts per million. 10 p.

RP2846. Measurement of current with the National Bureau of Standards current balance, R. L. Driscoll and R. D. Cutkosky

Prior to the adjustment of the electrical units in 1948, the value of a current had been determined in absolute units by means of a current balance and simultaneously measured in NBS amperes by comparison with standard resistors and standard cells. This work was reported in RP1449. Similar measurements made recently with an electrodynamometer indicate a possible change in the values of the standards. The present paper reports a repetition of the work described in RP1449. The purpose of this remeasurement was to determine whether or not the standards had changed. Only minor changes were made in the equipment in order that factors which might have introduced small systematic errors in the results would remain unchanged.

According to the work described in this paper, 1 NBS ampere = 1.000008 absolute amperes. Recent work with the Pellat electrodynamometer gave the result 1 NBS ampere = 1.000013 absolute amperes. The weighted mean of these two values is

1 NBS ampere-1.000010 ± 0.000005 absolute amperes

The results given above for the current balance differ by 6 ppm from those obtained in 1942. This indicates, in view of the uncertainties of measurement, that any change in the ampere as maintained by standard resistors and standard cells does not exceed a few parts in a million. 9 p.

RP2847. Radial distribution of the center of gravity of random points on a unit circle, F. Scheid

This paper describes some Monte Carlo computations carried out on the Standards Electronic Automatic Computer (SEAC) which are related to the problem of random walks. 2 p.

RP2848. An adiabatic calorimeter for the range 30° to 500° C, E. D. West and D. C. Ginnings

An adiabatic calorimeter accurate to 0.1 percent and suitable for heat capacity measurements of solids and liquids over the temperature range 30° to 500° C is described. Factors affecting the design and accuracy are discussed. Automatic controls permit one-man operation of the apparatus. Measurements of the heat capacity of Al_2O_3 agree to 0.1 percent with earlier measurements made with other calorimeters at the National Bureau of Standards. 8 p.

RP2849. An evaluation of the luminous-transmittance requirements for railroad-signal glassware in terms of standard source A of the International Commission on Illumination, F. C. Breckenridge

As an extension of Research Paper 1688, an estimate has been made of the transmittance for illuminant A of signal glassware having the minimum transmittance acceptable under the specifications of the Signal Section of the Association of American Railroads, which are formulated in terms of tests at 2,360° K. 4 p.

RP2850. Random notes on matrices, K. Goldberg

Three matrix problems are considered in this paper: Bessel functions as limits of determinants, finding all optimal strategies of a matrix game with nonzero value, and conditions for matrices to have equal principal minors. 6 p.

RP2851. Range finders using projected images, R. E. Stephens

Two optical range finders of six-inch base length have been designed and constructed for making measurements to arbitrary points on a model. One measures distances from 2.5 feet to 10 feet, the other from 9.7 feet to 25 feet. The accuracy of all distances is plus or minus one-quarter inch or better. Because of unusual requirements of use these range finders operate by projecting two images of a bright cross upon the target, which may be fused into a single image by adjustment of the range knob. 7 p.

RP2852. Effect of rib flexibility on the vibration modes of a delta-wing aircraft, W. D. Kroll

A systematic study was made to determine whether decreasing the number of ribs or making the ribs more flexible would have any appreciable effect on the vibration modes and frequencies of a delta-wing aircraft. The modes and frequencies were computed for the basic wing and for the following modifications of the basic wing: (1) One rib outboard of the fuselage removed, (2) two ribs removed, (3) stiffness of ribs outboard of fuselage reduced one-half, and (4) rib stiffness reduced nine-tenths. The results indicated that the frequencies and mode shapes of the modified wings differed little from those of the basic wing and, therefore, that changes similar to these modifications would not appreciably affect the vibration characteristics of delta wings. 7 p.

RP2853. Thermal degradation of cellulosic materials, S. L. Madorsky, V. E. Hart, and S. Straus

Fortisan, cellulose triacetate, and NO_2-oxidized cellulose were pyrolyzed in a vacuum in the temperature range 180° to 465° C. Cotton cellulose and cellulose triacetate were also pyrolyzed in nitrogen at atmospheric pressure. The tar yields were in the decreasing order from: Cotton, Fortisan, cellulose triacetate, and oxidized cellulose. The other volatiles consisted mainly of acetic acid, carbon dioxide, and carbon monoxide, from the triacetate; and water, carbon dioxide, and carbon monoxide from the other celluloses. In all cases there was a carbonaceaus residue (volatilization end point), the amount depending on the nature of the cellulose and the temperature of pyrolysis. When pyrolyzed in nitrogen at atmospheric pressure, cotton cellulose and cellulose triacetate yielded less tar than when pyrolyzed in a vacuum. The tar from cellulose triacetate consisted of a compound whose infrared spectrum resembled that of the original triacetate. Cotton cellulose, Fortisan, and cellulose triacetate do not differ much in their initial rates and activation energies of thermal degradation. Oxidized cellulose has very high initial rates of thermal degradation. 7 p.

RP2854. Role of vitrons in alkali silicate binary glasses, L. W. Tilton

Applications of vitron theory to analyses of properties of R_2O silicate binary glasses indicate that changes in slope on the property-composition curves may occur where there are integral numbers of cations per dodecahedral cavity or cage of the network. From geometrical considerations it is found that 1 or 2 oxygens and 6 sodiums can be accommodated inside a cage, and similarly not more than 1 oxygen and 4 potassiums can be inclosed in a cage.

Data on chemical attack and on solubility losses in water suggest for alkali silicate glasses a maximal average inclosure of oxygen inside the cavities at 16.7-mole percent for K_2O, 23.1 percent for Na_2O, and probably 28.6 percent for Li_2O. These compositions correspond to 1, 1.5, and 2 oxygens per cage. These compositions mark the begining deterioration of the net, possibly because of nonbridging oxygen. Changes in rate of volatilization occur at 28.6-, 37.5-, and 50.0-percent R_2O for potash, soda, and lithia silicate glasses, repectively. These critical compositions are considered those for which the cavities in the glasses are completely saturated with the modifier oxides, R_2O, and with additional cations, R.

Detailed analyses of curves of molar volume versus composition show that the critical points for oxide saturation are evident and that changes in slope may occur at other critical compositions corresponding to integral numbers of cations per cage. It is found that the percentage of 16.7-percent Na_2O at high temperatures and the saturation point of 37.5 percent at low temperatures are critical in curves for specific (electrical) resistance. The "deep-well" point at 16.7-percent Na_2O critically separates soda silicate glasses that are very readily devitrified from those that contain more oxide modifier and are more stable. 14 p.

RP2855. Elastic problem for a ring of uniform force in an infinite body, W. H. Pell

Kelvin has given an integral representation for the displacements in an infinite elastic body produced by a body force acting in an arbitrary portion of this body. By a limit procedure, solutions have been found for point and line singularities acting in the interior of such a body. A similiar method is used in this paper to obtain the

displacements produced by a uniform force applied along, and normal to, a circle lying in the interior of an infinite elastic body. 9 p.

RP2856. Description and analysis of the second spectrum of molybdenum, Mo II, C. C. Kiess

Wavelengths and estimated intensities are presented for 3,800 lines of Mo II in the spectral range from 6100 A in the red to 1550 A in the ultraviolet. For approximately 970 of these lines, Zeeman patterns have been measured. Analysis of these spectral data shows that about 70 percent of the lines can be accounted for as transitions between levels of the even terms in the electron configurations $4d^5$ and $4d^4\ 5s$, and levels of the odd terms in the configuration $4d^4\ 5p$. No series have been found from which an ionization potential can be derived. 48 p.

RP2857. Forces on cylinders and plates in an oscillating fluid, G. H. Keulegan and L. H. Carpenter

The inertia and drag coefficients of cylinders and plates in simple sinusoidal currents are investigated. The mid-section of a rectangular basin with standing waves surging in it is selected as the locale of currents. The cylinders and plates are fixed horizontally and below the water surface. The average values of the inertia and drag coefficients over a wave cycle show variations when the intensity of the current and the size of the cylinders or plates are changed. These variations, however, can be correlated with the period parameter $U_m T/D$, where U_m is the maximum intensity of the sinusoidal current, T is the period of the wave and D is the diameter of the cylinder or the width of the plate. For the cylinders $U_m T/D$ equaling 15 is a critical condition yielding the lowest value of the inertia coefficient and the largest value of the drag coefficient. For the plates the higher values of the drag coefficient are associated with the smaller values of $U_m T/D$ and the higher values of the mass coefficient with the larger values of $U_m T/D$. The variation of the coefficients with the phase of the wave is examined and the bearing of this on the formula for the forces is discussed. The flow patterns around the cylinders and plates are examined photographically, and a suggestion is advanced as to the physical meaning of the parameter $U_m T/D$. 18 p.

RP2858. Reaction of portland cement with carbon dioxide, C. M. Hunt, V. Dantzler, L. A. Tomes, and R. L. Blaine

The reaction of portland cement with carbon dioxide was found to be greatly influenced by the moisture environment of the cement. Reaction with carbon dioxide and water also affected the subsequent hydration of the cement. 6 p.

RP2859. Average energy of sulfur-35 beta decay, H. H. Seliger, W. B. Mann, and L. M. Cavallo

The rate of energy emission in an approximately 400-millicurie source of sulfur-35 was measured by means of a "radiation-balance" microcalorimeter. This value and the disintegration rate of an accurate dilution of the sample measured by means of $4\pi\beta$-gas-proportional counting yield a mean energy for sulfur-35 beta decay of 50.4 $(^{+0.2}_{-1.2})$ kev. The half-life has been determined to be 87.16 ± 0.1 days. 4 p.

RP2860. Effect of structure on the thermal decomposition of polymers, L. A. Wall and R. E. Florin

During recent years a considerable number of theoretical and experimental studies have been published on the kinetics and mechanism of the thermal decomposition of polymers. The treatment of depolymerization as a free-radical chain reaction involving the four basic steps of initiation, propagation, transfer, and termination seems adequate for a fairly complete understanding of the process in a large number of cases. Rate data now available are discussed from this point of view. It is shown that most of the characteristics of the thermal decomposition rate curves are a result of their basic structure and not of trace impurities. The magnitude of the rates and activation energies are, however, sensitive to trace structures or impurities. It is shown that intermolecular transfer will account for the rate behavior in a large number of polymers. In a relatively few other cases intramolecular transfer is indicated to be of more importance. 8 p.

RP2861. Comparison of theoretical and empirical relations between the shear modulus and torsional resonance frequencies for bars of rectangular cross section, S. Spinner and R. C. Valore, Jr.

The relations between the modulus of elasticity in shear and the fundamental torsional resonance frequency, mass, and dimensions for bars of rectangular cross section have been evaluated experimentally. The empirical relation was found to be less than the theoretical approximation given by Pickett by an amount increasing to about 1¾ percent as the cross-sectional width to depth ratio of the bars approached 10.

In addition to the fundamental torsional resonance frequency, the first overtone of the specimens was also determined. The overtone was found not to be an exact multiple of the fundamental; it increased more than 5 percent over double the value of the fundamental as the width to depth ratio increased to 10. 6 p.

RP2862. Specific volume and degree of crystallinity of semicrystalline poly(chlorotrifluoroethylene), and estimated specific volumes of the pure amorphous and crystalline phases, J. D. Hoffman and J. J. Weeks

The specific volume of poly(chlorotrifluoroethylene) has been measured from $-40°$ to $+260°$ C. Both quenched and well-crystallized specimens prepared by reproducible procedures were studied. Well-defined glass transitions were found close to 52° C in both specimens. Hence the glass temperature of this polymer is essentially independent of the degree of crystallinity. The quasi-equilibrium melting point of the particular type of crystallized specimen used in the investigation was 216° C. The equilibrium melting temperature is undoubtedly somewhat higher, and probably lies between 220° and 225° C.

The degree of crystallinity of the crystallized and quenched specimens was calculated at T_g from specific-volume measurements alone, using a straightforward thermodynamic procedure. The method avoids a long "unguided" extrapolation of the liquid data to low temperatures, and does not involve the inexact approximation that the volume-temperature derivative of the glassy and crystalline states are the same. It has the further advantage of not requiring a pure crystal density from another source, such as a unit-cell determination from X-ray data. It was found that the quenched sample was 39 percent crystalline and the well-crystallized one 82 percent. A simple extension of the theory permits the degree of crystallinity to be computed as a function of temperature. The results are compared with those obtained in earlier investigations.

The specific volumes and volume-temperature derivatives of the pure supercooled liquid, glassy, and crystalline phases are estimated over a wide range of temperature. Certain quantities related to the free volume of the glassy state are discussed.

The methods outlined may be of utility in analyzing specific-volume-temperature data on other semicrystalline polymers where the rapid onset of crystallization interferes with a direct study of the supercooled liquid and glassy states, and where independent data on the properties of the pure crystalline phase are not available. 15 p.

RP2863. Heat and ultraviolet aging of poly(vinyl chloride), C. F. Bersch, M. R. Harvey, and B. G. Achhammer

Four poly(vinyl chloride) polymers prepared with different initiators were exposed to ultraviolet radiant energy

and to heat, in a vacuum and in air. The gaseous products evolved were analyzed by mass spectrometry. Changes in chemical structure were followed by infrared spectrophotometry. Benzene was among the products evolved in most cases, and acetone was produced during exposure to heat in air. Catalyst fragments or other incorporated impurities affected initiation at very mild conditions. Susceptibility to degradation increased with increasing oxygen content and unsaturation of the untreated polymer. Pyrolysis studies indicated a two stage degradation: (1) dehydrochlorination, and (2) decomposition of the resultant polyene chain. Color formation was attributed to both oxidation and conjugated unsaturation because exposure in air following exposure in a vacuum, and vice versa, caused bleaching of the degraded polymer. 8 p.

RP2864. Determination of water vapor from the change in electrical resistance of a hydroscopic film, E. R. Weaver, E. E. Hughes, and A. W. Diniak

The electrical conductivity of a thin film of such a material as phosphoric acid changes over a wide range with changes in the concentration of water in the atmosphere with which it is in contact. By adjusting the pressures of a sample of gas of known composition and one of unknown composition, they can be made to have the same concentration of water (more accurately the same fugacity) shown by the production of equal resistances of the detecting film. Modifications of the apparatus, procedures, and calculations described in an earlier publication are presented and numerous applications of the method are discussed. The method has the merits of simplicity, speed, and great sensitivity. Only small samples are needed, and few substances interfere. 20 p.

RP2865. Improved bridge method for the measurement of core losses in ferromagnetic materials at high flux densities, W. P. Harris and I. L. Cooter

Accurate core-loss measurements at high flux densities can be made by bridge methods if the power dissipated in the primary circuit at harmonic frequencies is measured and subtracted from the apparent power dissipated in the ferromagnetic material at fundamental frequency. The determination of this harmonic power term is inconvenient, and must be done with greater accuracy than that required in the final result. An amplifier having negative output resistance was devised and is used in a manner that automatically allows accurate compensation for the harmonic power dissipation. 8 p.

RP2866. Stress-strain relationships in yarns subjected to rapid impact loading: 5. Wave propagation in long textile yarns impacted transversely, J. C. Smith, F. L. McCrackin, and H. F. Schiefer

The behavior of an infinitely long flexible filament after transverse impact is treated theoretically. The filament is assumed to have a tension-strain curve that is always concave downward, and to have no short-time creep or stress-relaxation effects. Under most conditions the impact initiates a variable strain that propagates down the filament between an "elastic wave" front and a "plastic wave" front. A transverse wave, shaped like an inverted V, then travels in the constant-strain region behind the plastic-wave front. Under special conditions the transverse-wave front may propagate faster than the plastic-wave front, but the shape of the transverse wave remains the same. The theory for both cases is worked out in detail, and some illustrative examples are given. 18 p.

RP2867. Measurement of flame speeds by a nozzle burner method, C. Halpern

The literature records a great many measurements, using stationary flames on burners, of the speed with which flame moves through combustible mixtures of gases. Despite the fact that the method itself seems reasonably simple, the results obtained by various investigators often are not in good agreement. One of the phases of a program of research on combustion has been a study of some of the reasons for the differences among recorded values of flame speed measured by the burner method. The primary objective of this task has been to develop the precautions that should be observed in applying the method, rather than to evolve numerical values of flame speed. This paper describes progress that has been made since the apparatus was described originally in 1951, and presents values of flame speeds of methane-air mixtures obtained since then, together with comparisons of these values with those obtained by two flame theories. 12 p.

RP2868. Growth of preferentially oriented aluminum single crystals, T. H. Orem

Monocrystalline aluminum specimens having both a preferential orientation and a specified cross-sectional shape are very difficult to produce. Such specimens must be grown in a vertical furnace, a condition which, while permitting the choice of cross-sectional shape in the specimen, makes it extremely difficult to obtain specimens of preferred orientation. It is fairly easy to grow preferentially oriented monocrystalline aluminum specimens when a horizontal furnace is used, but the use of such a furnace limits the choice of cross-sectional shapes in the finished crystal. Crystals of circular cross-sectional shape are practically impossible to grow in a horizontal furnace.

The method described herein can be used to grow monocrystalline aluminum crystals with any desired orientation or cross-sectional shape. 3 p.

RP2869. Marginal performance of corrected ophthalmic lenses, F. E. Washer and W. R. Darling

The measured values of the departures of the marginal meridional and cylindrical powers from the corresponding measured values of the axial powers for 311 corrected ophthalmic lenses are reported. The spherical refractive powers of the lenses studied range from $+7.00$ to -20.00 diopters with cylindrical powers of 0.00 to 4.00 diopters. The probable errors of measurement are discussed. A set of tolerance values is suggested, and the degree of compliance with these suggested tolerances is shown. 12 p.

RP2870. Enthalpy and heat capacity from 0° to 900° C of three nickel-chromium-iron alloys of different carbon contents, T. B. Douglas and A. W. Harman

The enthalpy relative to 0° C of three alloys was measured at nine temperatures from 100° to 900° C by a precise "drop" method. The alloys contained approximately 76 percent of nickel, 15 percent of chromium, and 8 percent of iron, with carbon contents of 0.02, 0.07, and 0.11 percent, respectively. The results are almost independent of the several variations in prior heat treatment investigated, and the heat-capacity-temperature curves of the three alloys are almost coincident, but there is a marked shift in each curve within the interval 500° to 600° C. 6 p.

RP2871. Relative strengths of forty aromatic carboxylic acids in benzene at 25° C., M. M. Davis and H. B. Hetzer

The relative strengths of benzoic acid, 31 of its monosubstituted derivatives, 7 disubstituted derivatives, and one trisubstituted derivative have been measured in terms of the equilibrium constants (K'') for association with the reference base 1,3-diphenylguanidine in benzene at 25° C. The measurements were performed spectrophotometrically, using the indicator acid bromophthalein magenta E (tetrabromophenolphthalein ethyl ester) as the reference acid, the equilibrium constant K' for association

of the indicator with diphenylguanidine being known from previous work. Equilibrium constants for *p*-orsellinic (2,6-dihydroxy-*p*-toluic) acid and 2,4,6-trinitrobenzoic acid could not be measured, as these acids appear to associate completely with diphenylguanidine under the conditions of the experiments.

Plotting log K' values against the corresponding pK values for aqueous solutions of the acids gives an essentially linear relationship in the case of acids with *meta*- and *para*-substituents only, but the line for *para*-substituted acids has a slightly different slope from the line for *m*-substituted acids. Similar comparisons were made with published data on relative strengths in alcohols or dioxane-water mixtures. *ortho*-Substituted acids show marked solvent effects. Explanations of the solvent effects have been suggested, and various theoretical implications and possible applications of the results are discussed. The theoretical discussion includes evaluation of constants of the Hammett equation. 24 p.

RP2872. Shape of the liquidus surface as a criterion of stable glass formation, E. H. Hamilton and G. W. Cleek

The slope of the liquidus curve or surface at a point in a phase diagram representing a specific chemical composition has been found to be a reliable indication of the glass-forming tendency of that composition. The observed effect is interpreted in terms of the structure of the glass. 4 p.

RP2873. Twinned epitaxy of copper on copper, T. H. Orem

A study of the X-ray diffraction patterns of copper electrodeposited on copper monocrystals having surfaces parallel to the cubic, dodecahedral, and octahedral planes shows an interesting relationship between electrodeposit and base crystal. At the current density used for electrodeposition, the electrodeposit on the surface parallel to the dodecahedral plane was a monocrystalline continuation of the orientation of the base crystal in every respect. The electrodeposit on the surface parallel to the octahedral plane was a highly preferentially oriented polycrystalline electrodeposit made of microcrystals, some of which continued the orientation of the base crystal, whereas others were twinned with respect to the surface plane of the base crystal. In the case of electrodeposition on the surface parallel to the cubic plane, the electrodeposit was also a highly preferentially oriented polycrystalline electrodeposit made up of microcrystals, some of which continued the orientation of the base crystal, whereas others bore a twin relationship to the close-packed planes of the base crystal. 12 p.

RP2874. Dielectric constant of deuterium oxide, C. G. Malmberg

An equal ratio-arm, capacitance-conductance bridge operated at frequencies below 100 kilocycles per second was used to measure the dielectric constant of deuterium oxide with an accuracy of 0.1 percent or better in the range 4° to 100° C. A value of 77.94 was found for the dielectric constant at 25° C. The data fit the relation

$$\epsilon = 87.48_2 - (0.40509)t + (9.638 \times 10^{-4})t^2 - (1.333 \times 10^{-6})t^3,$$

with a maximum deviation of less than 0.01 unit in dielectric constant. These values were obtained by using a sample having a deuterium oxide content of 99.38 mole percent. Deviation of these values from those for pure deuterium oxide, as a result of isotopic contamination, is estimated to be less than 0.005 unit. Some aspects of the temperature dependence of the dielectric constant and of that of a macroscopic polarization are discussed. 4 p.

RP2875. Additional abscissas and weights for Gaussian quadratures of high order: values for $n=64$, 80, and 96, P. Davis and P. Rabinowitz

Abscissas and weights for Gaussian quadratures of orders $n=64$, 80, and 96 are given to twenty decimal places. 2 p.

RP2876. Mass spectra of aromatic hydrocarbons filtered from smoky air, F. L. Mohler, P. Bradt, and V. H. Dibeler

Public health service chemists collected particulate matter from smoky air and separated aliphatic and aromatic hydrocarbons from this material. These samples have been analyzed by two methods. In one method the sample is slowly evaporated from a tube furnace directly into the mass spectrometer and spectra recorded as the temperature is increased step by step. In the other method the sample is completely vaporized in a heated reservoir and the vapor passed through a leak into the mass spectrometer. Mass spectra of the aliphatic compounds are not reported in detail. Mass spectra of the aromatic fractions evaporated from the tube furnace show sharply defined fractionation with molecule ions of fused-ring aromatics predominant. Compounds containing three to seven fused rings are tentatively identified. The mass spectrum from the reservoir mass spectrometer was recorded at ionizing voltages of 70 v and at a low voltage, which gives predominantly molecule ions. The fused-ring aromatics include compounds that are carcinogenic. 4 p.

TITLE PAGE AND CONTENTS TO VOLUME 60. 6 p.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 61, JULY-DECEMBER 1958

RP2877. The system lime-alumina-water at 1° C, E. T. Carlson

A study was made of phase equilibria in the system CaO-Al_2O_3-H_2O at 1° C. The stable phases are believed to be gibbsite, tetracalcium aluminate hydrate, and $Ca(OH)_2$, but no solubility curve was established for gibbsite because of extreme slowness of reaction. The compound $3CaO \cdot Al_2O_3 \cdot 6H_2O$ appears to be metastable, being very slowly transformed to one or the other of the hexagonal hydrates. Metastable equilibrium curves were established for $CaO \cdot Al_2O_3 \cdot 10H_2O$ and $2CaO \cdot Al_2O_3 \cdot 8H_2O$. The concentration at their intersection (a metastable invariant point) is about 0.10 g of Al_2O_3 and 0.38 g of CaO per liter. The dicalcium compound can readily be dried to a $6H_2O$ stage, giving a characteristic X-ray pattern. During the long storage period required to approach equilibrium, most of the reaction mixtures picked up a little CO_2, apparently by absorption through the polyethylene containers, with formation of a carboaluminate, probably $3CaO \cdot Al_2O_3 \cdot CaCO_3 \cdot 11H_2O$. 11 p.

RP2878. Heat content of zirconium and of five compositions of zirconium hydride from 0° to 900° C, T. B. Douglas and A. C. Victor

Using a precise Bunsen ice calorimeter, a "silver core" furnace, and a "drop" method, the heat content (enthalpy) of zirconium metal and five samples of zirconium hydride (24 to 52 atomic percent hydrogen) was measured over the range 0° to 900° C. Thermal hysteresis of the hydrides was investigated in several cases, and corrections were applied for the impurities in the samples. At each temperature up to 550° C the heat contents of the hydrides relative to 0° C were found to vary linearly with composition, a fact in accord with the phase diagram of the system. The effective heat capacity of each hydride sample reached its maximum value between 550° and 600° C, a behavior that can be interpreted as due to the endothermic formation of the high-temperature beta phase. 11 p.

RP2879. Uniform transient error, E. L. R. Corliss

The economy of transient error is discussed. Equations describing error in power-level measurements of transients can be used to compute the design of analyzers so as to distribute transient error in a way compatible with experimental requirements. In addition, consideration of a limiting power-discrimination factor provides a measure of the largest number of bandpass filters that can be over-

lapped on adjacent channels to yield meaningful information about a rapidly changing signal. A scanning filter can be compared with a set of bandpass filters by calculating the effective number of overlapped bandpass filters providing the same resolution as the scanning filter. The results are applicable to autocorrelation analyzers. Restrictions on rapid signal analysis also are considered for the special case in which power-level discrimination is limited by noise. 6 p.

RP2880. Optical T-bench method of measuring longitudinal spherical aberration, F. E. Washer

A method of measuring longitudinal spherical and chromatic aberration by visual means is described. The method employs an especially constructed optical T-bench equipped with nodal slide and an angle-measuring telescope. The underlying theory of the method is presented, together with a brief description of the apparatus used. The results of measurement on a few typical lenses and an analysis of the sources of error are included. 9 p.

RP2881. Mass spectrometric study of the rate of thermal decomposition of hydrazoic acid, J. L. Franklin, V. H. Dibeler, and P. P. Morris, Jr.

Hydrazoic acid vapor at low pressures (0.15 mm Hg or less), has been decomposed thermally and the rate of reaction studied mass spectrometrically at 265° to 325° C. Nitrogen and ammonia are the only reaction products, and no intermediates were observed. The disappearance of HN_3 is first order and the reaction occurs on the walls of the glass reaction vessel. The experimental activation energy is 31 kilocalories per mole. The activation energy for the reaction $HN_3 \rightarrow NH + N_2$ must be at least 39 kilocalories per mole. 6 p.

RP2882. Erosion damage to solids caused by high-speed collision with rain, O. G. Engel.

The stresses that are produced when a liquid drop collides with the planar surface of a solid are discussed. These are a result of the impact pressure and the consequent radial flow of the drop. It is concluded that a rain-erosion resistant material may be either soft and rubbery or hard and rigid. If it is soft and rubbery it mitigates the applied stresses but it must be able to withstand the mitigated stresses. If it is hard and rigid it does not mitigate the applied stresses and it must be able to withstand the unmitigated stresses. 6 p.

RP2883. Emission spectrum of carbon monoxide from 2.3 to 2.5 microns, E. K. Plyler, H. C. Allen, Jr., and E. D. Tidewell

The 2–0, 3–1, 4–2, 5–3, and 6–4 emission bands of carbon monoxide have been measured in the region from 4000 to 4360 cm^{-1} with a grating spectrometer. A 10,000 line per inch grating used in the second order resolved lines separated by 0.08 cm^{-1}. Several sets of measurements were made on the 2–0 band and the molecular constants were calculated. The constants in cm^{-1} are $B_0 = 1.922511 \pm 0.000025$ $D_0 = 6.13 \pm 0.02 \times 10^{-6}$. Using these values and the B_0 from 1–0 band in conjunction with the microwave constant a new determination of the speed of light is obtained, $c = 299{,}794 \pm 3$ kilometers per second. 4 p.

RP2884. Further studies of the influence of a ridge on the low-frequency ground wave, J. R. Wait and A. Murphy

Computations are presented in graphical form for the perturbation of a plane wave by a semicylindrical boss on an otherwise flat ground plane of perfect conductivity. The height of the ridge is comparable to the wavelength. This is an extension of earlier work on the semielliptical boss. 4 p.

RP2885. Infrared studies on polymorphs of silicon dioxide and germanium dioxide, E. R. Lippincott, A. Van Valkenburg, C. E. Weir, and E. N. Bunting

The infrared spectra of coesite, low-temperature tridymite, low-temperature cristobalite-low-temperature quartz, vitreous silica, hexagonal GeO_2, tetragonal GeO_2, and vitreous germania are reported from 4,000 to 300 cm^{-1}. Wherever possible an assignment of frequencies has been made on the basis of the selection rules for the crystal symmetry. Three characteristic group frequencies near 1,100, 800, and 480 cm^{-1} are common to all the polymorphs of SiO_2. These frequencies respectively correspond to a stretching mode involving displacements associated primarily with the oxygen atoms, a stretching mode involving displacements associated primarily with the silicon atoms, and a Si-O bending mode. The presence of these group frequencies in coesite indicates that the coordination of silicon in coesite is tetrahedral and that its high density is associated with the packing of tetrahedral units at an angle approximating 120 degrees. The tetragonal and hexagonal GeO_2 polymorphs show a marked difference in spectra due in part to the change from sixfold to fourfold coordination. The assignment of observed frequencies in hexagonal GeO_2 is consistent with that made for low-temperature quartz if allowance is made for the heavier mass of the Ge atom. 10 p.

RP2886. Carbon-14 carboxy-labeled polysaccharides, J. D. Moyer and H. S. Isbell

Procedures are given for the preparation of C^{14} carboxy-dextran and C^{14} carboxyinulin. These materials have C^{14}-labeled carboxyl groups in place of the reducing end groups present in the parent polysaccharides. The substances can be prepared cheaply and should find many applications as tracers in biological and chemical research. 3 p.

RP2887. Heat of formation of sodium calcium aluminate, E. S. Newman

The compounds $3CaO \cdot Al_2O_3$, Na_2SO_4 V (Thenardite), $Na_2O \cdot 8CaO \cdot 3Al_2O_3$, and $CaSO_4$ anhydrite, were prepared, and their heats of solution in HCl, $26.61H_2O$ were determined. The heat of solution of Na_2SO_4 V in water to form Na_2SO_4 $1000H_2O$ was also measured. From these and other data in the literature the heats of formation of $Na_2O \cdot 8CaO \cdot 3Al_2O_3$ and $NaSO_4$ V were calculated to be -2567 and -330.92 kcal/mole, respectively. 2 p.

RP2888. Thermal degradation of polyacrylonitrile, polybutadiene, and copolymers of butadiene with acrylonitrile and styrene, S. Straus and S. L. Madorsky

Polybutadiene and a copolymer consisting of 76.5 percent butadiene and 23.5 percent of styrene were investigated as to the rates of their thermal degradation. The rates for polybutadiene indicated an activation energy of 60 kilocalories per mole. The copolymer had very high initial rates of degradation, followed by a rapid drop, so that it was not possible to obtain a reliable activation energy.

Polyacrylonitrile and a copolymer consisting of 31 percent of acrylonitrile and 69 percent of butadiene were investigated with regard to the nature and distribution of volatile products, as well as to the rates of their thermal degradation. The rates were very high initially, but dropped rapidly so that it was not possible to determine accurately the activation energy. The acrylonitrile-butadiene copolymer showed a decomposition pattern similar to that of polybutadiene. Here, too, the activation energy could not be deduced accurately from the rate curves. Comparative thermal stability in terms of temperature, at which half of the polymer sample is evaporated in 35 minutes of heating, is as follows: 407° C for poly-

butadiene, 374° C for SBR, 364° C for polystyrene, 360° C for NBR, and 316° C for polyacrylonitrile. 5 p.

RP2889. On the motion of two cylinders in an ideal fluid, L. H. Carpenter

The complex potential of two cylinders moving in an infinite liquid is determined by the method of image doublets, and the solution is expressed as an infinite series in rectangular coordinates. Approximate solutions in finite form are given for various cases. A method for generalizing the solution for the case of more than two cylinders is indicated. Applications to the flow induced by a cylinder moving in the presence of plane boundaries are given and the stream lines are illustrated in certain cases. 5 p.

RP2890. Properties of sodium titanium silicate glasses, E. H. Hamilton and Given W. Cleek

The glass-forming area of the Na_2O-TiO_2-SiO_2 system was surveyed. Glasses were made with refractive indices from 1.5184 to 1.8005, nu values from 51.5 to 23.2, and densities from 2.42 to 3.06. The glasses have higher dispersions and have considerably lower densities than the PbO glasses with comparable refractive indices. 6 p.

RP2891. Wavelengths from thorium-halide lamps, W. F. Meggers and R. W. Stanley

The present system of international secondary standards of wavelength for spectroscopic measurements is based on interferometric determinations of wavelengths emitted at atmospheric pressure by an electric are between iron electrodes. Because of the poor quality and uneven distribution of these iron standards they are not suitable for accurate measurement of wavelengths in the spectra of heavier elements, most of which are more complex and consist of much sharper lines that the standards. Quartz-tube lamps containing a small quantity of a thorium halide, when excited by microwaves, emit thousands of uniformly sharp and evenly distributed lines whose wavelengths, or positions in a spectrum, can be determined with about one-tenth the error of locating iron-arc lines. Preliminary values of 222 vacuum wavelengths emitted by a thorium-iodide lamp have been measured relative to 5462.2705 and 4047.7144 A emitted by a similar lamp containing mercury-198. Fabry-Perot interferometers with plate separations of 25, 40, or 50 millimeters were used with a stigmatic grating spectrograph in making these measurements. The thorium wavelengths range from 3288.7356 to 6991.5839 A in vacuum and from 3287.7885 to 6989.6562 A in standard air. The accuracy in relative value of 27 classified thorium lines is tested by means of the combination principle, which indicates that the average error is less than 1 part in 20 million. 9 p.

RP2892. An electrical-analog method for transient heat-flow analysis, A. F. Robertson and D. Gross

An electronic instrument is described which permits solution of transient heat-flow problems by use of direct analogy to electrical networks. The instrument is of the so-called "fast-time" type, simulating the transient involved in times of the order of 10^{-6} that of the thermal prototype. A photoformer type of input-signal generation is used and this, together with a variable-frequency master oscillator, permits flexibility of input-signal waveform and time scale.

Some applications of the instrument to the field of fire research are described. The discussion of errors includes consideration of those resulting from the lumping of circuit elements. 11 p.

RP2893. Effect of crystal field and spin-orbit coupling on magnetic susceptibility of systems with f electron configuration, C. M. Herzfeld and D. B. Levine

The effects of a crystal field of octahedral symmetry and of spin-orbit coupling on an ion with f^2 electron configuration are considered. Only fourth-degree terms in the crystal-field potential are taken into account. The eigenvalues and eigenvectors of the resulting 33×33 secular determinant are determined numerically on the 704 electronic computer at the National Bureau of Standards for eight values of D/ζ, where D is a crystal-field parameter, and ζ the spin-orbit coupling constant of the ion. Perturbations by an external magnetic field are computed using second-order perturbation theory. All eigenvalues are tabulated for $D/\zeta = -10^{-4}$, -2×10^{-4}, -5×10^{-4}, -10^{-3}, -2×10^{-3}, -5×10^{-3}, -10^{-2}, -10^{-1}. They can be adapted directly to any finite nonzero positive value of ζ and, by interpolation, for values of D/ζ not tabulated. The magnetic susceptibility of a powder is calculated and displayed as a function of temperature and D/ζ, for $\zeta = \infty$, 10^3 cm^{-1}, and 5×10^2 cm^{-1}. The relation of the results of the calculations to measurements on compounds of U^{+4} is discussed. 5 p.

RP2894. Vibration-rotation bands of ammonia: 1. The combination bands $\nu_2+(\nu_1,\ \nu_3)$, W. S. Benedict, E. K. Plyler, and E. D. Tidwell

A general discussion is given of methods used in the analysis of NH_3 vibration-rotation spectra, including the derivation of molecular constants and the determination of line strengths and line widths. Results are given for the region 2.15 to 2.48 μ (4,060 to 4,700 cm^{-1}), in which more than 800 lines have been measured. These have been analyzed into the inversion-doubled perpendicular combination band $\nu_2+\nu_3$ (ν_0=4416.908 and 4434.610 cm^{-1}; band strength=19.7 cm^{-2} atm^{-1}) and the inversion-doubled parallel combination band $\nu_1+\nu_2$ (ν_0=4293.716 and 4320.060 cm^{-1}; band strength=2.9 cm^{-2} atm^{-1}). Complete energy levels for these bands have been found up to $J=12$ and 10, respectively, permitting determinations of molecular constants, which include numerous higher-order effects involving the interaction of rotation, vibration and inversion. The line widths range from a maximum of 0.57 cm^{-1} atm^{-1}, when $K=J$ to a minimum of <0.2 cm^{-1} atm^{-1}, when $K\ll J$. 25 p.

RP2895. Evaluation of tensile, compressive, torsional, transverse, and impact tests and correlation of results for brittle cermets, M. J. Kerper, L. E. Mong, M. B. Stiefel, and S. F. Holley

Static tests were studied for the determination of mechanical properties of brittle materials. Specimens of brittle materials, represented by cermets having five different compositions, were subjected to tensile, compressive, torsional, transverse, and impact tests. The designs of specimens and apparatus suitability of the tests to the materials, refinements in test procedures, and the variability of results and their correlation were studied. The elastic properties were obtained from tensile, compressive, and transverse tests, and the modulus of rigidity calculated from the results of these tests agreed with that from the torsional test. Tensile strength was obtained from the tensile, torsional, and transverse tests on specimens of comparable sizes in accordance with a limiting tensile strain. Shear strengths were obtained in the compressive tests. The correlation of impact values with mechanical properties was unsatisfactory. 21 p.

RP2896. Redetermination of mass spectra of deuteromethanes, F. L. Mohler, V. H. Dibeler, and E. Quinn

Mass spectra of the four deuteromethanes have been remeasured using samples of improved isotopic purity. The relative abundances of fragment ions involving loss of H or D atoms from the molecules CH_3D, CH_2D_2, and CHD_3 are not proportional to the a priori probabilities of removing H or D atoms but have been expressed in terms of the a priori probability times a weighting factor. The weighting factor for removing one H or D atom from these molecules can be roughly expressed as positive and negative powers of a single constant 1.19 ± 0.015 and the same

power law holds for the relative abundances of H^+ and D^+. Weighting factors for removing two or more hydrogenic atoms are not consistent with this power law. 2 p.

RP2897. Effect of strain-temperature history on the tensile behavior of titanium and a titanium alloy, G. W. Geil and N. L. Carwile

This study was made to determine the effect of prestraining specimens in tension under uniaxial and multiaxial stresses at a selected temperature on their tensile behavior at a different temperature. Unnotched and notched cylindrical specimens of initially annealed, commercially pure titanium and initially annealed 4-percent-aluminum, 4-percent-manganese, titanium alloy were extended at selected temperatures to various true strains and then extended to fracture at another temperature. The ductility retained by the prestrained specimens decreased with increase in the prestrain, whereas the strength indices generally were nearly independent of the amount of the prestraining. However, strength indices obtained on some of the deep-notched specimens of the alloy at −196° C were decreased by prestraining at +25° C as a direct result of the very low retained ductility of the prestrained specimens. 14 p.

RP2898. Propagation of very-low-frequency pulses to great distances, J. R. Wait

A theoretical study is presented for the propagation of electromagnetic pulses at very low frequencies to large distances. The space between the earth and the ionosphere is represented as a wave guide with sharply bounded and concentric spherical boundaries. The concept of phase and group velocity and its application to the present problem is discussed in some detail. The influence of the propagation medium on the shape of the envelope of a quasi-monochromatic pulse is also considered. Using an alternative approach, the response of an impulsive source is also calculated and is shown to be a damped oscillatory function of time with a quasi-half-period varying in a predictable manner with distance of travel in agreement with the observations of Norinder and Hepburn. 17 p.

RP2899. Transmission and reflection of electromagnetic waves in the presence of stratified media, J. R. Wait

A general analysis is presented for the electromagnetic response of a plane stratified medium consisting of any number of parallel homogeneous layers. The solution is first developed for plane-wave incidence and then generalized to both cylindrical and spherical-wave incidence. Numerical results for interesting special cases are presented and discussed. The application of the results to surface-wave propagation over a stratified ground is considered in some detail. 28 p.

RP2900. Pseudoternary system calcium oxide-monocalcium aluminate ($CaO \cdot Al_2O_3$)-dicalcium ferrite ($2CaO \cdot Fe_2O_3$), T. F. Newkirk and R. D. Thwaite

The system $CaO\text{-}CaO \cdot Al_2O_3\text{-}2CaO \cdot Fe_2O_3$ is of importance to portland cement chemistry because it provides information on the composition of the iron-bearing phase in cement clinker.

Iron-bearing solid solutions in the system were found to exist as a continuous narrow band extending from $2CaO \cdot Fe_2O_3$ to $6.45CaO \cdot 2.31Al_2O_3 \cdot F_2O_3$. Additional tie lines were established to show the composition of the iron-bearing solid solution phase (Fss) and liquid phases during the course of crystallization of mixtures within the system. Isotherms have been located for the regions of principal interest. Compatibility relations differ somewhat from those reported by previous investigators. The composition of the iron-bearing phase in equilibrium with CaO and $3CaO \cdot Al_2O_3$ at the ternary invariant point proved to be lower in Fe_2O_3 than that reported by Swayze. Other results are in general agreement with the work of Swayze and of Yamauchi. 13 p.

RP2901. Heats of formation of diborane and pentaborane, E. J. Prosen, W. H. Johnson, and F. Y. Pergiel

The heats of formation of diborane and pentaborane have been determined by measurements of the heats of decomposition into amorphous boron and hydrogen in a calorimeter. The heats of formation at 25° C, from amorphous boron and hydrogen, are 6.73 ± 0.52 kcal/mole for diborane (gas) and 12.99 ± 0.39 for pentaborane (gas). 4 p.

RP2902. Temperature of the inversion in cristobalite, R. F. Walker, S. Zerfoss, S. F. Holley, and L. J. Gross

The inversion temperature of cristobalite prepared from pure precipitated silica gel was compared with that of less pure cristobalite, including material derived from quartz. All materials showed a variability in their inversion temperature which was dependent on their thermal history. However, evidence suggested that a sufficiently extended heat treatment at high temperatures would in each case produce a uniform product with invariant inversion temperatures attributable to the low-high and high-low inversions. It is proposed that the variability of the inversion temperature can be rationalized in terms of three rate processes dependent on the temperature of heat-treatment, viz., nucleation, ordering, and crystal growth. The effect of all other factors known to influence the inversion temperature is either to accelerate or retard the rate of one or more of these processes. 11 p.

RP2903. Infrared emission spectra of flames under high resolution, E. K. Plyler and E. D. Tidwell

The spectrum of a hydrogen-oxygen flame and an oxy-acetylene flame has been measured in the near infrared region with a high-resolution grating spectrometer. In the region from 3.7 to 4.1 μ many lines are observed which have not been classified. They may arise from transitions belonging to the ν_2 or ν_3 bands of water vapor. The intensity of the first overtone band of CO was increased when a high-frequency discharge was passed through the flame and the infrared CN band was increased in intensity when N_2O was mixed with the acetylene. The results are shown in five figures of the observed spectra. 6 p.

RP2904. Improved description of hafnium spectra, C. H. Corliss and W. F. Meggers

Earlier descriptions of atomic hafnium spectra, from conventional arcs or sparks, have been handicapped by the absence of pure samples and by the presence of a strong background of molecular spectra. Recent availability of highly purified hafnium metal, and the development of a new light source, removed these handicaps. This improved description of hafnium spectra was made by employing electrodeless metal-halide lamps excited, at relatively low pressure and temperature, by microwaves. Lamps of hafnium iodide, hafnium bromide, and hafnium chloride were compared to recognize the spectra of halogens or their compounds and thus arrive at the atomic hafnium lines common to different lamps. The number of lines now ascribed to hafnium spectra exceeds 6,200 as compared with about 2,400 heretofore. The wavelengths range from 1284.88 to 12043.08 A, and estimated relative intensities in different light sources (including arcs, sparks, and electrodeless lamps) indicate which lines belong to Hfi, Hfii, Hfiii, and Hfiv. The splitting of spectral lines in magnetic fields (Zeeman effect) has also been improved by using magnetic fields of higher intensity, and greater spectrographic resolving power than before. The number of lines for which Zeeman patterns have been observed has been increased from 280 to 1,030, and the types of complex

patterns invariably confirm the assignments of lines to HfI or HfII. 56 p.

RP2905. Dielectric constant of hydrogen-bonded liquids, F. Buckley

A simple extension is presented of Onsager's electrostatic theory of dielectric polarization to take account of the "excess" polarization due to hydrogen bonding. Dielectric data for a number of liquid mixtures are analyzed and the deviations from ideal behavior expressed in terms of an excess polarization. A method is developed for calculating the excess polarization and certain related molecular parameters. Tentative values of these parameters have been determined for some particularly simple structures. 18 p.

RP2906. On the diffraction and reflection of waves and pulses by wedges and corners, F. Oberhettinger

Various problems arising in the theory of the excitation of a perfectly reflecting wedge or corner by a plane, cylindrical, or spherical wave, are dealt with. The incident wave is represented by a line source (acoustic or electromagnetic) parallel to the edge. The spherical wave is emitted by an acoustic point source or by a Hertz dipole with its axis parallel to the edge. The case of an incident plane wave field is obtained as the limiting case (for large distances of the source from the edge) of the cylindrical or spherical wave excitation. 23 p.

RP2907. A liquid-helium cold cell for use with an X-ray diffractometer, I. A. Black, L. H. Bolz, F. P. Brooks, F. A. Mauer, and H. S. Peiser

A liquid-helium cold cell for use with the General Electirc X-ray goniometer has been designed and constructed. It is used to obtain X-ray diffraction patterns of polycrystalline solids deposited from the gaseous phase on a helium-cooled surface. This work is part of the program for studying the stabilization of free radicals. 5 p.

RP2908. The second spectrum of ruthenium (Ru II), A. G. Shenstone and W. F. Meggers

Wavelengths and estimated intensities of 2,227 spectral lines characteristic of singly ionized ruthenium atoms are presented. The wavelengths range from 1054.684 to 6371.29 A. The Zeeman effect has been investigated for 488 lines ranging from 2323 to 4010 A. Analysis of these basic data of Ru II has resulted in the classification of 1,633 lines as transitions between 68-even, and 140-odd energy levels. All but three of these levels have been grouped into designated spectral terms and assigned to electron configurations. The low-even terms arise from $4d^7$, $4d^6\ 5s$, and $4d^6\ 5s^2$. All the terms from the $4d^7$ configuration have been found, and $4d^7\ a^4F$ represents the ground state of Ru II. From two members of the $4d^6$ $^{7}s^6D$ series a limit, 135200 cm^{-1}, has been calculated which indicates a principal ionization potential (I. P.) of 16.76 electron volts for Ru^+ ions. 39 p.

RP2909. Self-ignition temperatures of materials from kinetic-reaction data, D. Gross and A. F. Robertson

Results of experimental determinations of the kinetic constants of the self-heating reaction are presented for wood fiberboard, cotton linters, sugar pine, cork, crepe rubber, GRS rubber, natural, synthetic, and blended foam rubber (with and without additive), various oils (raw linseed, cottonseed, rapeseed, sperm, olive, castor, and neatsfoot) applied to cotton gauze in a ratio of 1 part of oil to 6 parts of cotton by weight, ammonium perchlorate, and nitrocellulose plastic. Under the assumption that self-heating follows a first-order reaction, these constants were used to calculate the critical radii of spherical piles for each of four surface temperatures likely to be experienced in long-period storage. Calculated self-ignition temperatures of piles of ½-inch-diameter to 22-inch-diameter spheres of wood fiberboard and ½-inch-diameter to 2-inch-diameter spheres of cotton linters were in reasonable agreement with previous measurements by N. D. Mitchell (National Fire Protection Association Quarterly **45:** 162, 1951). 5 p.

RP2910. Some studies of atmospheric transmittance on Mauna Loa, R. Stair and R. G. Johnston

Studies are described of the spectral intensity of solar radiation and its transmission through the atmosphere above a new 11,140-foot-altitude station on Mauna Loa, Hawaii, during May and June 1957. The spectral measurements covered the region from 300 millimicrons to 2.5 microns for different air masses from about 3.0 to 1.0. The amounts of ozone and of water vapor which were present in the upper atmosphere were calculated from spectral data obtained on several different days. 7 p.

RP2911. Central notations for the revised ISCC-NBS color-name blocks, K. L. Kelly

Nickerson and Newhall published, in 1941, the central notations of the original ISCC-NBS (Inter-Society Color Council-National Bureau of Standards) color-name blocks which were used in the preparation of the soil and rock color-name charts. In 1955, the ISCC–NBS color-name blocks were revised to accord more closely with usage in the textile and other fields (NBS Circular 553). The central notations of these revised color-name blocks have been computed and are given in the present paper in tabular form. A color chart showing the central colors of the 267 ISCC–NBS color-name blocks would serve for rapid determination of the ISCC–NBS color designation, especially in field work where speed and ease of operation are more important than high accuracy. 5 p.

RP2912. Viscosity of *n*-hexadecane, R. C. Hardy

Attempts to prepare high-purity *n*-hexadecane from commercial cetane by simple laboratory procedures were unsuccessful. Fractional distillation at reduced pressure, of material previously treated with silica gel, produced a few small fractions of about 99.5-mole-percent purity. The kinematic viscosities of the original material and of the fraction of highest purity, 99.63-mole percent, were found to be the same, 4.4635 centistokes at 20°. All other fractions had lower viscosities. The viscosity of NBS standard sample of *n*-hexadecane, 99.94-mole percent, was found to be 4.4642 centistokes or 3.4540 centipoises at 20°C. *n*-Hexadecane is not likely to be suitable for use as a second calibration standard for viscometry until a simple, easily defined routine of purification is developed. 4 p.

RP2913. Revision of the phase equilibrium diagram of the binary system calcia-titania, showing the compound $Ca_4Ti_3O_{10}$, R. S. Roth

The compound $Ca_4Ti_3O_{10}$ has been found to be a stable phase in the system CaO-TiO_2. It melts incongruently at about $1755 \pm 10°$ C, presumably to $CaTiO_3$ plus liquid. This compound is shown in a revision of the phase diagram for the system CaO-TiO_2. 4 p.

RP2914. Term analysis of the second spectrum of rhenium (Re II), W. F. Meggers, M. A. Catalán, and M. Sales

Wavelengths and estimated intensities of approximately 2,000 spectral lines emitted by singly ionized rhenium atoms were available for this analysis. Observed Zeeman patterns for 220 Re II lines facilitated finding and interpreting the first energy levels. The analysis continued until 49 low-even, and 85 high-odd levels were found. Transitions between these groups of levels account for 1,014 Re II lines including about 70 percent of the total observed intensity. The ground state of Re^+ is described by the spectral term $5d^5(a^6S)6s\ a^7S_3$. 21 p.

RP2915. Density formula for alkali silicate glasses from annealing to glass-processing temperatures, L. W. Tilton

An additive formula is given for the computation of specific volumes of molten and compacted alkali silicate binary glasses with modifiers up to 50-mole percent and from annealing temperatures (400° or 500° C) to 1,400° C. The effective partial volumes, v_s, for the silica are postulated as

$$(1/v_S) = 2.198 + r_m C_S(1723 - t),$$

where r_m is the mole fraction of nonsilica and C_S is a constant to be evaluated from glass-density data. This is based on the idea that silica networks can contract in volume as temperatures are lowered provided, and in proportion as, modifier ions are present in the glass. The effective partial volumes of R_2O, the nonsilica, are assumed as linear functions of temperature but not of the fraction of silica present.

Computed and observed densities agree within approximately 1 percent. The effective volumes of nonsilica are somewhat smaller than published estimates for the oxides themselves, as should be expected because of interpenetrations. 5 p.

RP2916. Thermodynamic properties of gases at high temperature: 1. Chemical equilibrium among molecules, atoms, and atomic ions considered as clusters, H. W. Woolley

The equilibrium thermodynamic properties of gaseous mixtures at high temperatures are treated by an extension of the cluster theory of Ursell, omitting the assumption of additivity of pair energies. An effective partition function is introduced, which is a convenient function in expressing the increase of the partition function for the entire gas due to the joining together of the parts of the cluster. The law of mass action and the dependence of second and third virial coefficients upon the cluster integrals for pairs and triples of molecules in a mixture have been obtained therefrom. Extension to a partially ionized gas is made by incorporating Mayer's cluster-based extension of the Debye-Hückel theory. 22 p.

RP2917. Parallel testing interferometer, J. B. Saunders

The conventional methods of testing the parallelism of opaque bodies, such as gage blocks, by interferometry require wringing of the body to an optical flat. This operation disturbs the temperature equilibrium, necessitating long periods between tests, especially for long blocks. It often injures the surfaces of both the optical flat and the test body. Also, if the body is a standard gage block, repeated wringings during use ultimately change the dimension. This paper describes an interferometer for measuring the parallelism of gage blocks and other bodies of any reasonable length without the necessity of the wringing operation. Two forms of this instrument are used—one for testing long blocks and another for testing short blocks. Either form can be constructed for testing blocks of any length, but two forms are found to be more practical. 8 p.

RP2918. Correction for instrumental drift in flame photometry, B. W. Mulligan and A. F. Haught

The application of the principles of experimental design to correct for drift in instrumental measurements, specifically in flame photometry, is described. Based on the procedure proposed by Youden, samples and reference standards may be measured in combinations of pairs in a manner such that errors caused by drift can be minimized and the actual amount of drift can be determined. Where the drift is dependent on the magnitude of the quantity measured, grouping by magnitude prior to final measurement is necessary. Application of the procedure to flame photometric determination of alkali elements, under conditions of severe drift, resulted in improving coefficients of variation from an original range of 2.0 to 3.5 to a range of 0.6 to 1.2. 3 p.

RP2919. Mechanism of stress-corrosion cracking in the AZ31B magnesium alloy, H. L. Logan

The mechanism of stress-corrosion cracking of annealed AZ31B magnesium alloy in an aqueous $NaCl$-K_2CrO_4 solution was investigated. Cracking was predominantly an electrochemical process and was shown to be dependent on the rate of strain in the specimen following loading in tension. It is postulated that cracks develop if the protective film on the metal surface is ruptured (over narrow segments of the specimen) at a greater rate than it is repaired in the corroding medium. This would expose film-free metal that is anodic to the filmed metal. 6 p.

RP2920. Evaluation of lens distortion by visual and photographic methods, F. E. Washer, W. P. Tayman, and W. R. Darling

The evaluation of lens distortion by photographic and visual methods is discussed. Measurements made on a single lens using the two methods are reported. The precision of measurement of each method is determined which shows that the observed differences must be attributed to systematic error. Various sources of systematic error are considered. Uncompensated differential plate tipping is identified as the most probable cause of the observed differences. A method of correction is developed. It is concluded that when work is done with extreme care and with due account taken of various insidious sources of error, it is possible to achieve comparable results with either method. 7 p.

TITLE PAGE AND CONTENTS TO VOLUME 61. 6p.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 62, JANUARY-JUNE 1959

RP2921. Heat of mixing of polybutadiene and benzene, R. S. Jessup

Measurements have been made of the heat of mixing of polybutadiene and benzene at 26.9° C by means of a Bunsen-type calorimeter, in which diphenyl ether is the calorimetric medium. The results of these measurements can be represented by the empirical equation

$$\Delta H^M = 12.0 v_1 v_2,$$

where ΔH^M is heat of mixing in joules per cm³, and v_1 and v_2 are volume fractions of solvent and polymer, respectively. The data have been combined with previously reported data on the activity of the solvent in this system to obtain values of $\Delta\overline{S}_1$, the partial molal entropy of dilution. The curve of $\Delta\overline{S}_1/Rv_2^2$ versus v_2 for this system lies above the calculated curve of $\Delta\overline{S}_1^c/Rv_2^2$, where $\Delta\overline{S}_1^c$ is the "configurational entropy" of dilution, and also lies above the corresponding experimental curves for several other polymer-solvent systems. 5 p.

RP2922. Infrared high-resolution grating spectrometer, E. K. Plyler and L. R. Blaine

An infrared grating spectrometer which can be used as a single- or double-pass instrument has been built and set in operation. The collimating mirror has a focal length of 235 centimeters and the instrument has the highest resolution from 1,600 to 3,500 cm^{-1}. In order to have flexibility in scanning the spectra at different speeds, a special drive mechanism has been built which is made of spur gears and worm gears. The speeds range from 2.5 to 200 minutes of time per degree of rotation. Examples of the spectra resolved by the instrument are given. Lines separated by 0.05 cm^{-1} are completely resolved and two lines separated by 0.025 cm^{-1} are partially resolved. 3 p.

RP2923. Determination of titanium, zirconium, niobium, and tantalum in steels: separations by anion-exchange, J. L. Hague and L. A. Machlan

A procedure is described for the determination of titanium, zirconium, niobium, and tantalum in steel. These elements are concentrated by selective precipitation with cupferron from a hydrochloric acid solution of the sample, and then ignited to the oxides. The oxides are fused, and dissolved in a hydrochloric-hydrofluoric acid mixture. Three separate eluates, containing titanium and zirconium, niobium, and tantalum, result from elution with mixtures containing ammonium chloride, hydrochloric acid, and hydrofluoric acid from a column of Dowex-1 anion-exchange resin. Boric acid is added to the eluates to complex the hydrofluoric acid, and the elements are precipitated with cupferron. Titanium is determined by the hydrogen-peroxide method, and zirconium by the phosphate-gravimetric method. Niobium and tantalum are determined by the hydroquinone- and pyrogallol-photometric methods, or by weighing the oxides. 9 p.

RP2924. Preparation of new solution standards of radium, W. B. Mann, L. L. Stockmann, W. J. Youden, A. Schwebel, P. A. Mullen, and S. B. Garfinkel

New radium-solution standards have been prepared in the ranges of 10 micrograms and also 10^{-9} and 10^{-11} gram of radium element. These have been compared with the National Bureau of Standard's 1940 and 1947 series of radium-solution standards and, as a result of these comparisons, it has been found that the 1940 10^{-9} and 10^{-11}-gram solution standards contained some 2 to 3 percent more radium element than certified. It has been shown that this difference probably arose in the dilution of the 1940 standards. 6p.

RP2925. Phase equilibrium relations in the binary system lead oxide-niobium pentoxide, R. S. Roth

The phase equilibrium diagram for the binary system lead oxide-niobium pentoxide has been constructed from observations of fusion characteristics and X-ray diffraction data. The system contains six binary compounds with $PbO:Nb_2O_5$ ratios of 3:1, 5:2, 2:1, 3:2, 1:1, and 1:2. The compound $PbO{\cdot}Nb_2O_5$ was found to melt congruently at 1,343° C and have a stable, reversible phase transformation temperature from the low-temperature rhombohedral form to the high-temperature tetragonal form at 1,150° C. The 5:2, 2:1, and 1:2 compounds melt congruently at 1,220°, 1,233°, and 1,337° C, respectively; the 3:1 and 3:2 compounds melt incongruently at 985° and 1,233° C, respectively. 12 p.

RP2926. Mass spectra of some deuterostyrenes, E. I. Quinn and F. L. Mohler

Mass spectra of alpha, beta, and para deuterostyrene; beta, beta dideuterostyrene; and alpha, beta, beta trideuterostyrene have been measured. The spectra are compared with the intensity distribution computed on the assumption of a random distribution of deuterium in C_8H_8. This gives a fair approximation to the observed spectra. The spectra of doubly charged styrenes are computed on the basis of observed half integer peaks in C_8H_8 and C_8H_7D. The metastable transition peaks of the deuterostyrenes have been recorded. It is suggested that ionized styrene molecules may form an octatetraene ring which dissociates with a random distribution of deuterium atoms but the observed spectra are not completely random and there may be other modes of fragmentation. 4 p.

RP2927. Heat of reaction of diborane with water and the heat of formation of boric oxide, E. J. Prosen, W. H. Johnson, and F. Y. Pergiel

The heat of reaction of gaseous diborane with water to form gaseous hydrogen and a solution of boric acid ($H_3BO_3+1{,}000H_2O$) has been measured by passing gaseous diborane through two successive bubblers in a calorimeter. The heat of the reaction obtained was:

$$\Delta H_{298.15} = -466.34 \pm 2.23 \text{ kj/mole } (-111.46 \pm 0.54 \text{ kcal/mole}).$$

Combination of this value with values previously reported for the heat of decomposition of diborane and the heat of solution of boric oxide yields the following value for the heat of formation of crystalline boric oxide from amorphous boron and gaseous oxygen:

$$\Delta Hf_{298.15} = -1280.89 \pm 3.14 \text{ kj/mole } (-306.14 \pm 0.75 \text{ kcal/mole}).$$ 5 p.

RP2928. Heat of formation of titanium tetrachloride, W. H. Johnson, R. A. Nelson, and E. J. Prosen

The heat of formation of gaseous titanium tetrachloride has been measured by the reaction of metallic titanium with gaseous chlorine in a calorimeter. The value for the heat of formation obtained in this investigation corresponds to the reaction:

$$Ti_{(c)} + 2Cl_{2(g)} = TiCl_{4(g)},$$

$$\Delta Hf°(25° \text{ C}) = -763.2 \pm 2.9 \text{ kj/mole } (-182.4 \pm 0.7 \text{ kcl/mole}).$$

Earlier data are discussed briefly. 4 p.

RP2929. Determination of niobium and tantalum in titanium-base alloys, J. L. Hague and L. A. Machlan

A procedure for the determination of niobium and tantalum in titanium-base alloys is described. The sample is dissolved in a mixture of hydrochloric and hydrofluoric acid, and oxidized with a minimum of nitric acid. The resulting solution is transferred to a column containing a strong quaternary amine anion-exchange resin (Dowex–1). Titanium and other alloying elements, except niobium and tantalum, are removed by elution with an ammonium chloride-hydrochloric-hydrofluoric acid solution. Niobium is removed by elution with an ammonium chloride-hydrofluoric acid solution. Tantalum is collected in a separate eluate of slightly acid ammonium chloride-ammonium fluoride solution. Boric acid is added to complex the fluoride, the earths acids precipitated with cupferron, ignited to the pentoxides, and weighed. 5 p.

RP2930. Properties of zinc borosilicate glasses, E. H. Hamilton, R. M. Waxler, and J. M. Nivert, Jr.

The glass-forming region of the system ZnO-B_2O_3-SiO_2 was surveyed. Glasses were made with compositions within the following limits in mole percent: 50 to 62.5 ZnO, 20 to 43.5 B_2O_3, and 0 to 20 SiO_2. They can be melted and poured below 1,400° C. The glasses have low coefficients of thermal expansion, high values of elastic moduli and Poisson's ratio, and refractive indices from 1.6409 to 1.6798. 4 p.

RP2931. Design and performance of a block-type osmometer, D. McIntyre, G. C. Doderer, and J. H. O'Mara

A block-type osmometer has been designed and constructed utilizing several new features which enhance the precision of the osmotic-pressure measurement and allow simpler manipulative techniques. The details of the construction as well as a discussion of the design and performance of this osmometer are included in the paper. 4 p.

RP2932. Heat of formation of titanium tetrabromide, R. A. Nelson, W. H. Johnson, and E. J. Prosen

The heat of formation of solid titanium tetrabromide has been measured by the reaction of titanium metal with

gaseous bromine in a calorimeter. The following value for the heat of reaction was obtained:

$$Ti(c) + 2Br_2(g) = TiBr_4(c)$$

$\Delta Hf°$ (25° C) = -678.16 ± 4.60 kj/mole (-162.08 ± 1.10 kcal/mole).

Combination of this value with the heat of vaporization of bromine yields the standard heat of formation of $TiBr_4$(c) from Ti(c) and Br_2(liq) as $\Delta Hf°$ (25° C) = -616.72 ± 4.60kj/mole (-147.40 ± 1.10 kcal/mole). 3 p.

RP2933. Adsorption of polyesters on glass, silica, and alumina, R. R. Stromberg, A. R. Quasius, S. D. Toner, and M. S. Parker

The adsorption of several saturated linear polyesters has been studied under a variety of conditions. The study also included di-*n*-butyl sebacate as a model low molecular weight ester and poly(methyl methacrylate). The adsorbents were type E glass powder, silica, and alumina. The glass powder and silica were nonporous materials; the alumina contained a large internal pore structure. The rate of adsorption of the polyesters on glass was very rapid and the adsorpt on isotherm was irreversible. Adsorption from a poor solvent was favored over adsorption from a good solvent. A large number of sites are available on the adsorbent for bond formation and the adsorbed polymer most probably extends into the solution in a coiled configuration. Metallic ions, in addition to silicon, appear to be involved in an electrostatic bond between the polymer and the glass. The Langmuir equation is obeyed at high-equilibrium concentrations, although there is nonconformity at the low concentrations. 7 p.

RP2934. Theory of the effect of drag on the orbital inclination of an earth satellite, J. P. Vinti

The rotation of the earth's atmosphere with the earth gives rise to a change in the inclination of the orbit of an earth satellite. In this paper it is assumed that the drag is in the direction of the air velocity relative to the satellite and that its magnitude diminishes so rapidly with altitude that it is appreciable only near perigee in an elliptic orbit. Without further assumptions about the properties of the drag function, results are then deduced for the secular changes in inclination up to, but not including, the final ballistic stage of motion. 10 p.

RP2935. On a theorem of M. Riesz, M. Pearl

The structure of the set of skew-symmetric, orthogonal matrices of order 4 with elements in the real field is studied. The first and second regular representations of the quaternions are used to represent these matrices and known properties of the quaternions are exploited to obtain characterizations of the skew-symmetric matrices. In the second part of this paper, the underlying structure of the geometry is changed from the Euclidean to the Lorentzian. It is then shown that there are no skew-symmetric, orthogonal (in the Lorentzian sense) matrices of order 4. 6 p.

RP2936. Refinement of the crystal structure of triclinic magnesium pyroborate, S. Block, G. Burley, A. Perloff, and R. D. Mason, Jr.

The triclinic modification of $Mg_2B_2O_5$ was classified as a member of an isostructural series which also includes $Mn_2B_2O_5$, $Fe_2B_2O_5$, and $Co_2B_2O_5$. The crystal structure was refined by the use of successive Fourier projections and a least-squares refinement program on an electronic computer. The structure of $Mg_2B_2O_5$ consists of $B_2O_5^{-4}$ groups and Mg^{+2} ions. Each magnesium atom is surrounded octahedrally by six oxygen atoms, forming an extended sheet of octahedra. The pyroborate groups share corners with octahedra in the sheets and thus link them. Each boron atom is in planar triangular coordination with three oxygen atoms. The pyroborate group has two such triangles with one shared oxygen. The angle between the planes formed by the triangles is 16°. The average boron-to-oxygen distance is 1.38 A. 6 p

RP2937. Heat transfer in laminar flow through a tube, M. Abramowitz, W. F. Cahill, and C. Wade, Jr.

The problem of heat transfer due to laminar flow of a viscous fluid in a channel is studied under the assumption that there is a parabolic distribution of velocity. The effect of axial temperature changes are considered and the solution is based on the simpler situation where axial effects are discussed. The solution, obtained by the method of least squares, is represented in terms of a set of nonorthogonal characteristic functions. These functions and the corresponding characteristic values are determined by numerical integration employing the Runge-Kutta procedure. Finally, asymptotic developments are obtained which are useful in the limiting cases. 5 p.

RP2938. Fluorination of haloaromatic compounds, R. E. Florin, W. J. Pummer, and L. A. Wall

The reactions of BrF_3, ClF_3, and IF_3 with C_6Cl_6, C_6Br_6, C_6Cl_5–CF_3, and other haloaromatic compounds are described. These reactions are not readily controlled, and explosions frequently occurred, particularly when BrF_3 and ClF_3 were used. Dehalogenation of the reaction products led to certain aromatic fluorocarbons, for example, C_6ClF_3 and C_6ClF_4–CF_3. Completely fluorinated aromatic compounds were not easily obtained, and therefore the process is not recommended for the production of these species. 6 p.

RP2939. Synthesis of some disubstituted 3,4,5,6–tetrafluorobenzenes, W. J. Pummer, R. E. Florin, and L. A. Wall

The preparation of 1,2,3,4-tetrafluorobenzene from 2-chloroheptafluorotoluene in a two-step synthesis is described. A new method for the hydrolysis of the trifluoromethyl group was developed using alumina and steam at high temperatures. The products obtained from the hydrolysis of 2-chloroheptafluorotoluene were 2-chloro-3,4,5,6-tetrafluorobenzoyl fluoride and 2,3,4,5-tetrafluorochlorobenzene, the decarboxylated product. The latter compound was converted to 1,2,3,4-tetrafluorobenzene by reduction with hydrogen and palladium at 280° C and atmospheric pressure. Some of the new compounds prepared, in addition to those mentioned previously, include 2-chloro-3,4,5,6-tetrafluorobenzoic acid, 2-chloro-3,4,5,6-tetrafluoroiodobenzene, and 1,2-diiodo-3,4,5,6-tetrafluorobenzene. 5 p.

RP2940. Reactions of aromatic fluorocarbons with hydrogen, R. E. Florin, W. J. Pummer, and L. A. Wall

Various palladium and platinum catalysts were used to effect the following hydrogenation reactions at relatively high conversions and yields:

$$C_6F_4ClH \xrightarrow[280°]{Pd} C_6F_4H_2$$

$$C_6F_4ClC\,F_3 \xrightarrow[280°]{Pd} C_6F_4HCF_3$$

$$C_6F_6 \xrightarrow[300°]{Pt} C_6F_5H, C_6F_4H_2$$

Nickel could be used for some of the reactions, but with much greater difficulty. The products of these reactions can be iodinated and brominated, and hence are a starting

point for the synthesis of many new derivatives of aromatic fluorocarbons. 4 p.

RP2941. Exponential integral $\int_1^\infty e^{-xt}t^{-n}dt$ for large values of n, W. Gautschi

An asymptotic expansion is given which is well suited for numerical computation when n is large and x arbitrary positive. 3 p.

RP2942. Effect of oxygen on the bonding of gold to fused silica, D. G. Moore and H. R. Thornton

Gold pellets were melted on plaques of polished fused silica in vacuum and then heated for 15 minutes at 1,100° C under different oxygen pressures. The force required at room temperature to shear the solidified pellets from the silica surface was found to vary from zero for gold melted in vacuum to 725 pounds per square inch for gold melted under an oxygen pressure of 150 millimeters of mercury. In all cases where bond developed, fracture occurred in the silica rather than at the gold-silica interface. Silica plaques with pellets bonded to them by treatment in oxygen showed no measurable strain when examined with a polarograph, suggesting that the gold had yielded as the specimen cooled.

Tests using Au^{198} as a tracer indicated that gold diffused into the silica lattice at high oxygen pressure but that no diffusion occurred during vacuum heating. Observations made on molten droplets showed no correlation between the contact angles in air and vacuum and the apparent shear strengths. A possible explanation is included to account for this lack of agreement with theory. 9 p.

RP2943. Interferometer for large surfaces, J. B. Saunders and F. L. Gross

An interferometer is described that permits the testing of large areas, such as layout plates. The extension to large areas is obtained by causing a collimated beam of light to reflect from the specimen at a large angle of incidence. The resultant fringe pattern is a contour map of the surface relative to an arbitrarily chosen plane and the contour interval is a function of wavelength and angle of incidence. 3 p.

RP2944. Glass formation in polymers: II. The system rubber-sulfur, G. M. Martin and L. Mandelkern

Volume versus temperature relations encompassing a wide range in temperature and composition have been determined for a series of natural rubber-sulfur vulcanizates and mixtures. The characteristic temperature of glass formation is deduced from these studies. The glass temperature is found to increase continuously from $-69°$ to $+90°$ C in the vulcanizates as the amount of bound sulfur is increased and to be invariant with the composition in the mixtures. A qualitative interpretation of these results is given in terms of the free-volume theory of glass formation. 6 p.

RP2945. Elastic deformations in strips with holes loaded through pins, M. Chi and L. K. Irwin

Bickley's solution for the generalized plane stress in a plate loaded through a pin is extended to give the deformation at any point in a plate loaded through one or two pins which are on the same load line. Analytical expressions are derived that are known to apply to a finite strip with a width $\geq 14a$ and distance between holes $\geq 8a$, where a is the radius of the hole. Numerical examples are developed and presented in the form of graphs for typical cases. 5 p.

RP2946. Absolute light-scattering photometer: I. Design and operation, D. McIntyre and G. C. Doderer

A new light-scattering photometer has been designed and built for determining the absolute scattering from polymer solutions. The instrument is also capable of performing as a research instrument for making measurements at very low and very high angles, and at very low and very high intensities of scattered light. The instrument scans the angular scattering either manually or automatically while measuring continuously the ratio of the scattered light to the incident light. 7 p.

RP2947. Resolution of the dissociation constants of *d,l*-malic acid from 0° to 50° C., M. Eden and R. G. Bates

A method for the precise determination of the dissociation constants for the two overlapping dissociation steps of a weak dibasic acid from the same set of experimental data is described. The procedure, based on an earlier suggestion of Speakman (J. Chem. Soc. **1940**, 855), is applied to the resolution of the thermodynamic dissociation constants of *d,l*-malic acid at intervals of five degrees from 0° to 50° C. The constants were derived from measurements of the electromotive force of cells of the type

Pt; H_2(g), malate buffer solution, KCl(m=0.008), AgCl; Ag.

The 39 buffer solutions were prepared from potassium hydrogen malate and from mixtures of potassium hydrogen malate with perchloric acid or potassium hydroxide, and each contained potassium chloride. The first association constant, K_1, is 3.48×10^{-4} at 25° C. It is given as a function of absolute temperature (T) by

$$-\log K_1 = \frac{1358.85}{T} - 5.1382 + 0.013550T.$$

The second constant, K_2, is 7.99×10^{-6} at 25° C. It is given by

$$-\log K_2 = \frac{1658.53}{T} - 6.2364 + 0.019353T.$$

The thermodynamic quantities $\Delta G°$, $\Delta H°$, $\Delta S°$, and $\Delta C_p°$ related to each dissociation step were computed and compared with the corresponding constants for other acids closely related structurally to malic acid. 10 p.

RP2948. Capacity requirement of a mail sorting device, B. K. Bender and A. J. Goldman

A mathematical model of a sorting device suggested by S. Henig is considered. The relevant parameters are r (the number of destinations for the mail) and k (the number of letters entering the device during each cycle of operation). It is shown that the device will never jam if its capacity is at least $(r-1)(k-1)+k$ letters; this is the lowest possible capacity requirement, and for realistic values of r and k is significantly less than the previously known estimate rk. 3 p.

RP2949. Effect of internal radiant heat transfer on temperature distribution, thermal stress, and deflection in box beams, S. Goodman, S. B. Russell, and C. E. Noble

Thirteen box beams were analyzed to determine the effect of internal radiant heat transfer on temperature distribution, thermal stress, and deflection. A rough experimental check of temperature distribution and beam deflection was made for one case. For maximum beam temperatures above 700° to 900° F, change in emittance of the interior surfaces of the beam had an appreciable effect on the cover (but not the web) temperatures and to an even greater extent, on the beam deflection. At maximum beam temperatures of 1,200° F, an increase in interior surface emittance appreciably relieved the maximum thermal stress. 7 p.

RP2950. Mean absolute value and standard deviation of the phase of a constant vector plus a Rayleigh-distributed vector, J. R. Johler and L. C. Walters

The mean absolute value of the phase and the standard deviation of the phase of a constant vector plus a Rayleigh-distributed vector are determined by an evaluation of the first and second moment integrals of the probability distribution for various values of average relative intensity of the random Rayleigh-distributed component. The results of a quadrature evaluation of the integrals are tabulated over a wide range of values of average relative intensity (k^2=0.010 to 1,000). 4 p.

RP2951. Simple rotating molecular still, G. S. Ross and L. J. Frolen

A simple molecular still has been designed to purify materials which have a low vapor pressure and which are thermally unstable. The apparatus contains no ground glass joints and the distillation is accomplished in a completely closed system. The efficiency of the still was found to be better than that for either the pot-type or the falling film-type molecular stills generally used. 1 p.

RP2952. Scintillation counter method of intercomparing neutron source strengths by means of a manganous sulfate bath, E. R. Mosburg, Jr.

It has proved feasible to use a scintillation counter to measure the relative activity of a large manganous sulfate bath, thereby determining the neutron-emission rates of neutron sources relative to the national standard neutron source of the National Bureau of Standards. A scintillation counter allows the calibration of sources weaker by a factor of seven than those if was previously possible to calibrate by means of a Geiger-Muller counter. The use of Cs^{137} as a reference pulse height to which the scintillation counter system is adjusted by means of a two channel pulse height analyzer makes possible the reliable reproduction of results from day to day. By using the scintillation counter the ratio of the national reference standard neutron source (NBS–II) to the national standard neutron source (NBS–I) has been redetermined and is found to be $0.939_3 \pm 0.001_7$. 3 p.

RP2953. Phase equilibria in the subsystem barium disilicate—dibarium trisilicate, R. S. Roth and E. M. Levin

A revised phase equilibrium diagram for the subsystem $BaO{\cdot}2SiO_2$—$2BaO{\cdot}3SiO_2$ is presented. The previously published diagram showing a complete solid solution series was not verified. Instead, two new compounds were identified by X-ray diffraction powder pattern techniques, and two eutectics were located by the quenching method. The compound $3BaO{\cdot}5SiO_2$ melts incongruently at 1,423° C to form $5BaO{\cdot}8SiO_2$ and liquid. The latter compound melts congruently at 1,446° C. Barium disilicate was found to have a quenchable and slowly reversible phase transformation at about 1,350° C. The X-ray diffraction powder pattern for $2BaO{\cdot}3SiO_2$ was indexed for the first time on the basis of a monoclinic unit cell. 8 p.

RP2954. Separation and determination of phosphate, silicate, and arsenate, W. S. Clabaugh and A. Jackson

A method was developed for quantitatively separating and determining phosphate, silicate, and arsenate when they occur together in solution. All three, at a pH of 1.8, form heteropoly molybdate complexes when heated just to boiling. Only the phosphate complex is extracted into ether from a solution that contains one volume of concentrated hydrochloric acid plus nine volumes of solution. After removing the phosphate, only the silicate complex is extracted into butanol from a solution that contains two volumes of concentrated hydrochloric acid plus nine volumes of solution. The arsenate complex is then extracted into methy isobutyl ketone after readjusting the acidity back to 1+9 by adding silica-free ammonium hydroxide. The various complexes are reduced by adding stannous chloride to the organic solvent and determined spectrophotometrically. The effect of various salts on the complex formation and the extraction is also reported. 5 p.

RP2955. Heat of formation of potassium calcium silicate, E. S. Newman

The heats of solution of $2CaO{\cdot}SiO_2$ (c, β), $CaSO_4$ (C, anhydrite), K_2SO_4 (C, II) and six members of a series of substitutional solid solutions of K_2O in dicalcium silicate were determined in a nitric-hydrofluoric acid mixture by means of an isothermal-jacket calorimeter. From these data and heats of formation taken from the literature, the heat of formation of $K_2O{\cdot}23CaO{\cdot}12SiO_2$ (c) was calculated to be $-6{,}420$ kilocalories per mole at 25° C. 5 p.

RP2956. Heat of formation of boron trichloride, W. H. Johnson, R. G. Miller, and E. J. Prosen

The heat of formation of gaseous boron trichloride has been determined by the direct reaction of gaseous chlorine with amorphous boron in a calorimeter.

$$B(\text{amorph}) + 3/2\ Cl_2(\text{gas}) = BCl_3(\text{gas})$$

$$\Delta Hf°(25° C) = -407.98 \pm 1.34 \text{ kj/mole}$$
$$(-97.51 \pm 0.32 \text{ kcal/mole}).$$

By utilizing the values previously reported for the heats of formation of boric acid, diborane, and pentaborane, the heat of hydrolysis of boron trichloride and the heats of reaction of diborane and pentaborane with chlorine have been obtained. By the use of an estimated value for the heat of sublimation of boron, the average bond energy of the B–Cl bond in boron trichloride is found to be 105.2 kcal at 0° K. The data on the heats of formation of diborane, boric oxide, boric acid, and boron trichloride now form a consistent set of values. 5 p.

RP2957. Thermal degradation of polymers at low rates, S. L. Madorsky

In measuring the rates of thermal degradation of polymers at constant temperatures in the range of 200° to 500° C, one encounters a distortion of the initial parts of the rate curves during the time required to heat the specimen to the pyrolysis temperature. This distortion has been largely overcome by using a new apparatus, based on an electronic balance, in which the degradation of the specimen is carried out at very low rates. The apparatus is equipped with an electronic thermostat that controls the temperature to within ± 0.1° C, and also with an automatic recorder that measures both the temperature and the loss of weight of the specimen. Pyrolysis experiments were carried out in a vacuum in this apparatus on pure specimens of polystyrene, poly(α-methylstyrene), polymethylene, high-molecular-weight polyethylene, and low-molecular-weight polyethylene. The initial rates of degradation, in percent of sample per minute, varied from 0.008 to 0.095. Except for the initial parts of the rate curves, in some cases up to about 30 percent loss of weight, the rate curves at low rates resemble closely those previously obtained at high rates of degradation. 10 p.

RP2958. Pits in metals caused by collision with liquid drops and soft metal spheres, O. G. Engel

An equation is developed to give pit depth as a function of collision velocity for pits formed in soft to medium-hard metal plates as a result of collision with liquid drops. The rear face of the target plate must be a free surface. The plate thickness must not be less than 1.5 to 2.0 times the drop diameter nor greater than 4 to 5 times the drop diameter. It is shown that, under the same conditions on

the target plate, the equation is also applicable to pits formed in soft to medium hard metal plates as a result of collision with spheres of the same metal that flow radially as a result of the collision. Pit-depth-versus-velocity data obtained in other laboratories were used to test the equation. Metals used as targets were copper, 1100–0 aluminum, 2024–0 aluminum, lead, steel, soft iron, and zinc. Mercury was used as the drop liquid against copper, aluminum, lead, and steel. Water was used as the drop liquid against copper, aluminum, and lead. Spheres of copper, aluminum, lead, soft iron, and zinc were used against targets of the same materials, respectively. The equation can be used to calculate the dynamic compressive yield strength of soft to medium-hard metals. 18 p.

RP2959. Earth currents near a monopole antenna with symmetrical top loading, J. R. Wait

Expressions for the fields are developed for a vertical ground-based monopole with a cone or disk located at the top of the antenna to simulate umbrella top loading. The current distribution on the structure is assumed. Using spherical-wave functions, the magnetic-field distribution on the ground plane near the base of the antenna is computed and illustrated by graphs. For the case where the antenna is electrically small, the currents flowing on the cone or disk are shown to contribute only slightly to the total field. 9 p.

RP2960. Infrared absorption spectra of some cyclic acetals of sugars, R. S. Tipson, H. S. Isbell, and J. E. Stewart

The infrared absorption spectra of twenty-eight 1-methoxyethylidene and isopropylidene acetals of sugars have been recorded and analyzed. The formulas of the compounds were grouped according to structure, and the absorption bands for each group were considered in relation to the bands found for the other structurally related compounds. No bands were found for the unequivocal detection of the 1,3-dioxolane ring attached respectively to an aldopentofuranose or a ketopentofuranose, an aldopentopyranose, an aldohexofuranose, an aldohexopyranose or a ketohexopyranose, a uronic acid salt or lactone, a sugar alcohol, or a sugar keto-acid salt. Regardless of the fine structure of the dioxolane compounds, certain strong bands were observed, but the bands are not easily recognized from an inspection of one or two spectra and are not characteristic of these compounds only. 26 p.

RP2961. Earth currents near a top-loaded monopole antenna with special regard to electrically small L- and T-antennas, H. L. Knudsen

An investigation has been made of the ground currents near a top-loaded monopole with nonazimuthal symmetry. Formulas have been developed for the surface current density produced by an inclined, straight wire over a horizontal ground plane for an arbitrary current distribution on the antenna. Working formulas have been developed and numerical calculations of the surface current density on the ground plane have been carried out for the case of a small antenna with a linear current distribution. These results have been used for the calculation of the contribution to the surface current density due to the top loading in the case of an L-antenna and in the case of a T-antenna. In each case both the absolute value of the surface current density arising from the top loading and the relative value of its ϕ-component have been plotted, as it may be expected that this component under certain circumstances may be important in calculating the ground losses in the case of a system of radial ground wires. 14 p.

TITLE PAGE AND CONTENTS TO VOLUME 62. 5 p.

July–August 1959

Description and analysis of the first spectrum of iodine, C. C. Kiess and C. H. Corliss

An extensive survey of the spectra of iodine has led to a list of more than 900 lines emitted by neutral atoms in the region from 23070 A in the infrared to 1195 A in the extreme ultraviolet. Wavelengths between 12304 A and 2061 A were derived from measurements of spectrograms obtained with gratings of high dispersion. Wavelengths of lines outside these limits are the computed values for lines observed on photometric tracings of the infrared, inaccessible to photography, and in the ultraviolet with a vacuum-grating spectrograph. For many of the lines Zeeman patterns were obtained in a magnetic field of about 37,000 oersteds. With these data many of the lines have been classified as combinations between odd levels from the electron configurations $5s^2\ 5p^4\ np$ and $5s^2\ 5p^4\ nf$, and even levels from the configurations $5s^2\ ns$ and $5s^2\ 5p^4\ nd$. Among these levels several sets have been recognized as forming Rydberg sequences that are in close agreement in placing the ground state $5p^5\ ^2P^\circ_{1\frac{1}{2}}$ of I I at 84,340 cm^{-1} below the ground state $5p^4\ ^3P^2$ of I II. This gives 10.45 electron-volts for the ionization potential of the neutral iodine atom. A strong infrared line at 13148.8 A is explained as a magnetic dipole transition between the levels of the ground term $5p^5\ ^2P^\circ$. 18 p.

CH in the solar spectrum, C. E. Moore and H. P. Broida

CH lines in the solar spectrum have been identified by direct comparison of measured laboratory and solar wavelengths and intensities. The comparisons of individual rotational lines are included in a series of tables arranged according to electronic and vibrational transitions. 35 p.

Infrared studies in the 1- to 15-micron region to 30,000 atmospheres, C. E. Weir, E. R. Lippincott, A. Van Valkenburg, and E. N. Bunting

A pressure cell was constructed using a pair of type II diamonds for study of infrared spectra of solids in the 1- to 15-micron region. Using commercial infrared equipment, spectra can be studied routinely to calculated pressures as high as 30,000 atmospheres. Under pressure, bands generally shift to higher frequencies and decrease in intensity. The magnitude of both changes depends on the mode of vibration. Occasionally major changes in spectra occur. In calcite the carbon-oxygen symmetric stretching, mode ν_1, becomes active at elevated pressures while the doubly degenerate ν_3, stretching, and ν_4, bending, frequencies split. From the shift in frequency of ν_1 with pressure the "compressibility", $[(-1/R_0)(dR/dp)]_1$ of the C—O bond length, R, is calculated to be 2.8×10^{-7}/atmosphere. Major spectral changes are not observed in the same pressure ranges in other carbonates having the calcite or aragonite structures. The results for calcite may be explained by a shift of the $CO_3^=$ ion from the trigonal axis under pressure. 8 p.

Phosphinoborine compounds: mass spectra and pyrolysis, L. A. Wall, S. Straus, R. E. Florin, F. L. Mohler, and P. Bradt

The mass spectra of tetramethylphosphinoborine trimer, $[P(CH_3)_2B(CH_3)_2]_3$ (I) and a compound, $P_3(CH_3)_6B_3H_9$, (II) prepared from dimethylphosphinoborine were observed and the compounds were pyrolyzed at 300 to 500° C. Most peaks in the spectrum of (I) came from the P—B. B—C, and P—C cleavages. The mass spectrum of (II) was much more complicated with evidence for methyl group redistribution.

The pyrolysis of both compounds indicates a very complicated mechanism with many unidentifiable compounds. Trends in the formation of volatile products indicate that both compounds are completely decomposed in 4 hr at 450° C. Compound (I) produces trimethylboron, which disappears rapidly above 400° C. Neither (I) nor (II) formed ethane or elemental phosphorus. 4 p.

Experimental and theoretical study of kinetics of bulk crystallization in poly(chlorotrifluoroethylene), J. D. Hoffman, J. J. Weeks, and W. M. Murphey

The rate of isothermal bulk crystallization of poly(chlorotrifluoroethylene), $T_m = 221°$ C, was measured from 170° to 200° C. The intrinsic bulk crystallization, which accurately followed an $n = 2$ law, was shown to be a result of the injection of primary nuclei sporadically in time, with one-dimensional growth of centers derived from these nuclei. The crystallites are exceedingly small. The one-dimensional growth process was isolated by nucleating specimens with seed crystals, and its temperature-dependence determined between 191° and 205° C. The seed crystal isotherms followed an $n = 1$ law. The temperature coefficients of the rate of nucleation and the rate of growth were both strongly negative.

A theory of homogeneous nucleation that takes into account the segmental character of the polymer chains is developed in some detail. A cylindrical nucleus is assumed. In the temperature range near the melting point, region A, where the radius and length of the nucleus are unrestricted, the rate of nucleation is shown to be proportional to $\exp(-\alpha/T^3\Delta T^2)$. The nucleation rate is proportional to $\exp(-\beta/T^2\Delta T)$ in region B, which extends from somewhat below the melting point to considerably lower temperatures; the length of the nucleus has a constant value l_0 in this region, but the radius is unrestricted. (In the above expressions, α and β are constants). Finally, at sufficiently low temperatures, region C is entered. Under certain circumstances, the rate of nucleation in region C will be extremely rapid, and correspond to a "nucleative collapse" of the supercooled liquid state. A calculation of the one-dimensional growth rate shows that it is proportional to $\exp(-\gamma/T^2\Delta T)$ where $\beta = \gamma$.

A careful analysis of the experimental data obtained between 170° and 200° C clearly showed that both the rate of nucleation and the rate of growth were proportional to $\exp(-\beta/T^2\Delta T)$, and not $\exp(-\alpha/T^3\Delta T^2)$. The primary nucleation event was thus of type B in this interval. A detailed analysis of the data is given, and surface free energies and the dimensions of the nuclei quoted. Quenching experiments, where the polymer was crystallized well below 170° C, gave a firm indication of the existence of region C.

An experimental study was made of the extremely slow crystallization process that prevailed when the degree of crystallinity became high. The onset of this stage of the crystallization was interpreted as being the result of a massive degree of impingement. This interpretation is justified by the calculations of Lauritzen, who has given a theory of impingements that predicts a pseudoequilibrium degree of crystallinity.

As indicated above, the growth process originating at homogeneous nuclei is not of a three-dimensional or spherulitic character in the region of study. Such stray spherulites as do appear in this region are shown to originate at heterogeneities. The possibility that the intrinsic growth process may become three-dimensional at crystallization temperatures sufficiently near T_m is discussed. 32 p.

September–October 1959

Reflection of fast neutrons from water, M. J. Berger and J. W. Cooper

The backscattering of fast (0.3, 1, 3, 6, 9, and 14 Mev) neutrons from a semi-infinite water medium has been calculated by the Monte Carlo method. The information obtained includes the joint angular and spectral distribution of the reflected neutrons, the dependence of the number albedo and energy albedo on the source energy and obliquity, and the contributions to the albedo of successive orders of scattering. The spectra were calculated down to epithermal energies (~0.5 ev). The results for each case are based on the analysis of 3,000 neutron histories, generated with the use of an IBM–704 computer. In the random sampling, elastic scattering from hydrogen and oxygen, inelastic scattering from oxygen, and absorption due to n-α and n-p processes were taken into account. The cross sections for some of these interactions are not well known. Parallel calculations with different assumptions about the cross sections were made in order to estimate how sensitively the albedo depends on the cross sections. The paper includes a self-contained description of the Monte Carlo method, its application to the calculation of radiation diffusion and in particular to the neutron albedo problem. Emphasis is placed on the technique of correlated sampling which makes possible an accurate estimate of albedo differences resulting from different assumptions about the cross sections. The random sampling computations were supplemented by analytical calculations of the single-scattering albedo. This was useful for an understanding of the Monte Carlo results because a considerable fraction of the reflected neutrons return after only one collision. 44 p.

Some vibrational-rotational bands of deuterated methanes, H. C. Allen, Jr., and E. K. Plyler

A parallel band at 2,200 cm^{-1} and a perpendicular band at 2,780 cm^{-1} of CH_3D have been observed under high resolution and analysed. The analysis of the perpendicular band revealed the presence of l-type doubling in the doubly degenerate excited state. From the analysis of the parallel band it is found that $B_0 = 3.880$ cm^{-1}. A hybrid band of CD_3H has been observed near 2,600 cm^{-1}. Both active components, A and E are observed and analysed. The ground state B_0 value found from this analysis is in good agreement with previous determinations. 8 p.

Precise coulometric titration of acids and bases, J. K. Taylor and S. W. Smith

Apparatus and techniques are described for the titration of acids and bases by constant-current coulometry. The precision and accuracy of the method are indicated by titrations of benzoic acid, potassium acid phthalate, adipic acid, hydrochloric acid, and sodium carbonate. Standard deviations of ±0.003 percent have been obtained which indicate that the reliability of the method is equal to or exceeds that of classical analytical procedures. 7 p.

Heat of formation of titanium tetraiodide, W. H. Johnson, A. A. Gilliland, and E. J. Prosen

The heat of formation of titanium tetraiodide was determined relative to that of titanium tetrabromide by comparison of their heats of hydrolysis in dilute sulfuric acid. The difference in the heats of formation may be expressed by the equation:

$$TiI_4(c) + 2Br_2(liq) = TiBr_4(c) + 2I_2(c),$$

$$\Delta H(25°\ C) = -230.91 \pm 0.75\ kj/mole$$

$$(-55.19 \pm 0.18\ kcal/mole).$$

By taking the heat of formation of $TiBr_4(c)$ as -616.72 ± 4.60 kj/mole, the heat of formation of $TiI_4(c)$ is calculated to be -385.81 ± 4.64 kj/mole (-91.21 ± 1.11 kcal/mole). The heats of hydrolysis of $TiBr_4$ and $TiCl_4$ were similarly measured; the value obtained for the difference (186.77 ± 1.34 kj/mole) is in good agreement with the difference between the directly determined heats of formation (187.11 ± 5.35 kj/mole). 6 p.

Reactions of pentafluorohalobenzenes, W. J. Plummer and L. A. Wall

Both pentafluorobromobenzene and pentafluoroiodobenzene are reactive intermediates and can be used to introduce the perfluorophenyl (C_6F_5—) group into a variety of new compounds. The chief methods used are the Grignard coupling or addition reaction as well as the Ullmann condensation reaction. Some of the new compounds prepared were pentafluorobenzonitrile, perfluorodiphenyl, pentafluorophenyl-α-ethanol, and pentafluorostyrene. 3 p.

Tritium-labeled compounds I. Radioassay of tritium-labeled compounds in "infinitely thick" films with a windowless, gas-flow, proportional counter, H. S. Isbell, H. L. Frush, and R. A. Peterson

A simple, sensitive, and reliable technique has been devised for the radioassay of nonvolatile, water-soluble tritium compounds. The substance to be analyzed is dissolved in an aqueous solution of a thickening agent, preferably sodium *O*-(carboxymethyl)cellulose or sodium alginate. The solution is placed in a shallow planchet, and after evaporation of the water, the resulting film, which is "infinitely thick" to tritium *beta* particles, is counted with a $2\pi_r$ windowless, gas-flow, proportional counter. By means of an empirical factor, determined with a substance of known radioactivity, the counts are converted to microcuries. In a film having a thickness of 0.7 mg/cm^2, the counting efficiency is about 4 percent; the standard deviation from the mean, obtained in a series of routine measurements, was less than 2 percent. An assay can readily be made with tritium-containing material having 0.01 microcurie of radioactivity. The method, which is applicable to nonvolatile, water-soluble solids, solutions, or liquids, is suitable for routine analyses. 5 p.

Tritium-labeled compounds II. General-purpose apparatus, and procedures for the preparation, analysis, and use of tritium oxide and tritium-labeled lithium borohydride, H. S. Isbell and J. D. Moyer

A general-purpose manifold is described, which is useful for numerous procedures involving tritium gas and tritium-labeled materials.

Methods are given in detail for (a) converting tritium gas to tritium oxide, (b) preparing tritium-labeled lithium borohydride, and (c) conducting a variety of reactions in a closed system. Auxiliary equipment is shown, including water traps, reaction flasks, and apparatus for preparing solutions and making filtrations in closed systems. Methods are presented for assaying tritium-labeled water by (a) dissolving it in a phosphoric anhydride-sulfuric acid solution and counting in a windowless, gas-flow, proportional counter, or (b) converting it to hydrogen-*t* and assaying it in an ionization chamber. The use of tritium-labeled lithium borohydride is illustrated by the preparation of D-galactitol-1-*t* from D-galactose. Subsequent papers will describe the use of this apparatus in the synthesis of tritium-labeled carbohydrates. The detailed description of techniques and apparatus should be helpful to others who are interested in using tritium. 7 p.

Preparation of trichloride and tetrachloride of molybdenum, D. E. Couch and A. Brenner

Molybdenum trichloride was successfully prepared in quantity by the reduction of molybdenum pentachloride with hydrogen. The most satisfactory yields were obtained with a 4 to 5 mole excess of hydrogen at pressures of 100 psi or higher and at a temperature of 125° C.

Molybdenum tetrachloride was prepared by direct reaction of molybdenum trichloride with molybdenum pentachloride in a sealed tube or steel bomb maintained at 250° C. X-ray patterns of the various chlorides were obtained. 4 p.

Infrared spectra of asphalts, B. D. Beitchman

A procedure for preparing thin films of airblown asphalts and a spectroscopic study of such films throughout the infrared region of 2.5 to 15 microns are described. The relationship of transmittance of several absorption bands with the durability of the asphalt is discussed. Exposure to ultraviolet radiation produced changes in transmittance at four wavelengths which, in a series of asphalts studied, showed statistically significant correlations with durability. 5 p.

November–December 1959

Multiple ionization of rare gases by electron impact, M. Krauss, R. M. Reese, and V. H. Dibeler

Electron impact studies of multiple ionization processes in helium, neon, argon, and xenon appear to support theoretical conclusions that the threshold probability for *n*-fold ionization is proportional to the nth power of the electron energy in excess of the threshold energy. The probability law applies, for the cases studied, over a considerable energy range that, for all but He^{2+}, includes the possible onset of more than one mode of ionization. The presence of a Boltzmann spread in the energy of the electron beam or specific focusing effects due to ion source geometry are found to affect only the foot of the probability curve. By the use of certain assumptions, an estimate is also made of the departure from a ^3P ionization probability curve resulting from onset of ionization to the ^1D and ^1S states. 4 p.

Light scattering by commercial sugar solutions, C. J. Rieger and F. G. Carpenter

Using a direct measure of scattered light, it was found that commercial sugar solutions scatter light predominantly in a forward direction. The scattering at angles less than 30° was as much as one hundred times that at right angles to the incident beam.

It was found that the light scattering by commercial sugar solutions is inversely dependent on wavelength to a power of between 2 and 3, and that severe multiple scattering occurs when the turbidity of the solution is larger than 2×10^{-1}cm^{-1} at 436 mμ. The scattering of commercial sugar solutions is compared with that of highly purified sucrose.

A method is discussed that will enable a good approximation of the turbidity of commercial sugar solutions to be made from a single forward scattering measurement at an angle of about 20° with respect to the incident light beam. A correction for scattered light in transmission measurements of these solutions is also introduced. 7 p.

Analysis of the first spectrum of ruthenium (Ru I), K. G. Kessler

The analysis of the first spectrum of ruthenium has been extended with the aid of digital computers. A total of 105 even and 206 odd levels are listed with observed Land° g-factors for 54 even and 148 odd levels. A complete list of approximately 3,400 classified lines in the range 2013 to 11484 A is presented. The ionization limit calculated from a two member series is 59410 cm^{-1} or 7.364 v. 39 p.

Supplementary Zeeman data for the first spectrum of ruthenium (Ru I), J. R. McNally, Jr. and K. G. Kessler

Zeeman data are listed for 207 lines of Ru I between 2400 and 5400 A, all of which have been classified. The spectrograms were made at the Massachusetts Institute of Technology and were analyzed there and at the National Bureau of Standards. 2 p.

Low even configurations in the first spectrum of ruthenium (Ru I), Part 2, R. E. Trees

A published calculation for the $4d^8$, $4d^7\ 5s$, and $4d^6\ 5s^2$ configurations of Ru I (R. E. Trees, J. Opt. Soc. Am. **49**, 838 (1959)) is repeated in steps. Displacements produced

by configuration interaction are evaluated, and departures of term positions from familiar expectations in the absence of configuration interaction are explained. The weaker perturbations produced by second-order effects of the spin-orbit interaction are then determined. It is shown that the neglect of these effects in published hard computations has obscured the remarkably good agreement between theory and observation that is obtainable in spectra of the second long period. The eigenvectors are based on "third-order eigenfunctions" which describe the levels simply, and show the degree of LS-coupling in a more quantitative manner. 6 p.

Thermal degradation of polymers at high temperatures, S. L. Madorsky and S. Straus

Work on thermal degradation of polymers has previously been carried out at temperatures up to about 500° C. In the present work the range has been extended to 850° C. Polystyrene was pyrolyzed in a vacuum and also in helium at atmospheric pressure at 362° and at 850° C. Analysis of the volatile products indicates that higher temperatures and higher pressures cause a greater fragmentation of the volatile products. Samples of poly (vinylidene fluoride), polyacrylonitrile, and polytrivinylbenzene, were pyrolyzed in a vacuum at temperatures from 350° to 800° C. The more volatile products were analyzed qualitatively and quantitatively in a mass spectrometer. The less volatile products were tested for their average molecular weight by a microcryoscopic method.

Rates of thermal degradation were also determined for the last three polymers. The activation energies in the temperature range 218° to 440° C. were found to be 48, 31, and 73 kcal/mole, respectively, for poly(vinylidene fluoride), polyacrylonitrile, and polytrivinylbenzene. 8 p.

Influence of impurities on the pyrolysis of polyamides, S. Straus and L. A. Wall

A study has been made of the effect of drying and purification of polycaprolactam (nylon-6) on its thermal decomposition. The conclusions drawn from previous work, that a hydrolytic mechanism is at least partially operating due to the presence of water and acid polymerization catalysts, are confirmed. Purification of the material decreases the rate of degradation and the production of CO_2, and increases the preexponential factor and the activation energy. The hydrolytic decomposition, which competes with the thermal free-radical degradation process, would be expected to produce carboxylic acids and amines, the former decomposing further to form CO_2. The preexponential factor is increased by sample purification from 10^7 to 10^{10} and the activation energy from 34 to 43 kcal/mole. The decomposition behavior of the purest sample is a nearly perfect example of the random decomposition of linear polymer chains. All other samples of polyamides thus far studied also appear to decompose by random or nearly random mechanisms. 5 p.

A preliminary list of levels and g-values for the first spectrum of thorium (Th I), R. Zalubas

The present state of the analysis of the first spectrum of thorium (Th I) is discussed briefly. Even and odd levels are listed in tables 1 and 2. The low even levels form terms arising from the configurations $6d^2\ 7s^2$ and $6d^3\ 7s$. The Th I standard wavelengths that fit into the known level arrays are presented in table 3. 4 p.

OH in the solar spectrum, C. E. Moore and H. P. Broida

Revised identifications of OH lines in the solar spectrum have been made from the detailed laboratory analyses of the A $^2\Sigma^+$—$X^2\Pi$ bands. In the (0, 0), (1, 1), and (2, 2) bands a total of 175 solar lines are ascribed to OH unblended; 124 have OH as a partial contributor. Laboratory intensities along the branches of the separate bands have been used as a guide in making the solar identifications. 17 p.

Use of chebychev polynomials in thin film computations, K. D. Mielenz

From Herpin's expression for the mth power of a multilayer matrix, very simple closed formulas are derived for the matrices and optical constants of any multilayer with a periodic structure.

According to Epstein's theorem, any symmetrical multilayer is equivalent to a fictitious monolayer. A simple expression for the equivalent index and thickness of this monolayer is deduced for the case of a periodic and symmetrical sequence of equally thick films.

As compared to any other method of numerical computation, the suggested formulation provides a considerable saving of time and work. In a numerical example, this saving amounts to about 80 percent. 4 p.

TITLE PAGE AND CONTENTS TO VOL. 63A. 3 p.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 64A, JANUARY–JUNE 1960

January–February 1960

The "1958 He^4 scale of temperatures." Part I. Introduction, F. G. Brickwedde and Part 2. Tables for the 1958 temperature scale, H. van Dijk, M. Durieux, J. R. Clement, and J. K. Logan

The generally used practical scale of temperatures between 1° and 5.2° K is the He^4 vapor pressure scale based on an accepted vapor pressure equation or table. In Sèvres (near Paris), October 1958, the International Committee on Weights and Measures recommended for international use the "1958 He^4 Scale" based on a vapor pressure table arrived at through international cooperation and agreement. This table resulted from a consideration of all reliable He^4 vapor pressure data obtained using gas thermometers, and paramagnetic susceptibility and carbon resistor thermometers. The theoretical vapor pressure equation from statistical thermodynamics was used with thermodynamic data on liquid He^4 and the vapor equation of state to insure satisfactory agreement of the vapor pressure table with reliable thermodynamic data. 17 p.

Energy levels and spectrum of neutral helium (^{4}He I), W. C. Martin

A table of energy levels based on the most accurate observations now available is given for the neutral ^{4}He atom. The wavelengths contained in a revised list of ^{4}He I lines from 320 A to 21132 A are also based on the best measurements, over half of them having been calculated from the wavenumber separations of appropriate levels. Several previously disturbing features of the ^{4}He term scheme are obviated by the revised level values. In a discussion of the experimental results for this spectrum some comparisons with theory are made. 10 p.

Vibration-rotation structure in absorption bands for the calibration of spectrometers from 2 to 16 microns, E. K. Plyler, A. Danti, L. R. Blaine, and E. D. Tidwell

Suitable bands of common gases have been tabulated and remeasured wherever necessary from 2 to 16 microns to obtain an accuracy of about 0.03 cm^{-1} throughout the region and to provide good calibrating points at frequent intervals. Some 600 rotation-vibration lines are illustrated in 20 spectrograms and wavenumbers are listed in companion tables with considerable intercomparison with worthy data obtained in other laboratories. The absorption bands were remeasured or calibrated by using either a precisely graduated grating circle or standard atomic lines with the fringe system formed by a Fabry-Perot interferometer. Characteristic features of the individual bands are discussed briefly and references to other publications are given. The substances used for calibration include H_2O, CO_2, CO, HCl, HBr, NH_3, C_2H_2, CH_4, N_2O, and polystyrene film. 20 p.

Combustion calorimetry with fluorine: constant pressure flame calorimetry, G. T. Armstrong and R. S. Jessup

Instruments and methods have been developed and are described for the measurement of heats of reaction between fluorine and other gaseous materials. Verification of the amount of reaction of hydrogenous materials is possible. The estimated accuracy of measurements is about 0.3 percent. Lack of certainty of the magnitude of corrections to be applied for hydrogen fluoride nonideality is an important factor. The heat of formation of hydrogen fluoride is found to be -64.4 ± 0.25 kcal/mole on the basis of the reaction of fluorine with ammonia. 11 p.

Pits in metals caused by collision with liquid drops and rigid steel spheres, O. G. Engel

A pit-depth-versus-velocity equation developed earlier was tested further with experimental data obtained using target plates of electrolytic tough pitch copper, 1100–O aluminum, and 2024–O aluminum, the static strength properties of which were measured by testing tensile specimens. The projectiles used to produce the pits were mercury drops, waterdrops, and steel spheres. It was found that the numerical constants in the equation for projectiles that flow during and as a result of the collision are different from those for projectiles that do not flow (hardened steel spheres). Curves calculated using the equation were found to be in acceptable agreement with experimental pit-depth-versus-velocity data for collisions of the indicated projectiles with target plates of the three metals used with the exception of the case of steel-sphere impingement against 2024–O aluminum alloy. In this case work-hardening of the target metal seems to foster a mode of pit formation that was not considered in the development of the pit-depth-versus-velocity equation. 12 p.

Theory of formation of polymer crystals with folded chains in dilute solution, J. I. Lauritzen, Jr., and J. D. Hoffman

A detailed interpretation of the kinetics of homogeneous nucleation and growth of crystals of a linear homopolymer from dilute solution is given. The probability of forming both nuclei with folded chains, and conventional bundle-like nuclei, from dilute solution is analyzed. It is predicted that at sufficiently high dilution, critical nuclei of length l_c^* will be formed from single polymer molecules by sharp folding of the chain backbone. The step height of the nucleus is given approximately by $l_c^* = 4\sigma_e/\Delta f$. Here σ_e is the free energy required to form a unit area of the loop-containing end surfaces, and Δf is the free energy difference per unit volume of crystal between the crystalline and solution states. The quantity Δf is approximately proportional to the degree of supercooling ΔT. The growth of these nuclei is then analyzed. After growth, the resulting crystal is flat and platelike, the loops formed by the chain folds being on the upper and lower surfaces. Kinetic factors determine that the distance between the flat surfaces in the grown crystal will vary over only a narrow range about a value that is in the vicinity of $l^* = 4\sigma_e/\Delta f$. (Neglecting effects due to edge free energies, the theoretical upper and lower limits are $l^* = 4\sigma_e/\Delta f$ and $l^* = 2\sigma_e/\Delta f$, respectively.) In some cases the predicted temperature dependence of the step height of the grown crystal, $l^* = \text{const.}/\Delta T$, may be modified by the existence of a constant term resulting from the presence of an edge free energy ϵ_f. A grown loop-type crystal is predicted to be stable in comparison with a bundlelike crystal of the same shape and volume in a sufficiently dilute solution. The logarithm of the nucleation rate is approximately proportional to $1/(\Delta T)^2$ near the melting point. The exponent n in the free growth rate law is predicted under various assumptions. To the extent that comparison is possible, the predictions given agree with the experimental results obtained by Keller and O'Connor and others on single crystals of unbranched polyethylene grown from dilute solution.

A survey is given of homogeneous nucleation in bulk polymers, where the conventional bundlelike nucleus containing segments from many different molecules is valid, and the essential results compared with those calculated for the dilute solution case.

The theory given for loop nuclei is both general and precise enough at the critical points to suggest that, on crystallization from sufficiently dilute solution, crystals of a definite step height are commonly to be expected for other crystallizable linear polymers than polyethylene, provided loop formation is sterically possible. 30 p.

Studies of beryllium chromite and other beryllia compounds with R_2O_3 oxides, C. E. Weir and A. Van Valkenburg

Reactions between BeO and R_2O_3 oxides at high temperatures were studied. Compound formation was observed between BeO and the following oxides: B_2O_3, Al_2O_3, Ga_2O_3, Y_2O_3, La_2O_3, and Cr_2O_3. No reaction was observed with Sc_2O_3, In_2O_3, and Fe_2O_3. Detailed studies were made of $BeO \cdot Cr_2O_3$ which is isostructural with $BeO \cdot Al_2O_3$. $BeO \cdot Cr_2O_3$ is a semiconductor. Optical and X-ray data are given for all reaction products. 4 p.

Uranium-platinum system, J. J. Park and D. P. Fickle

The phase diagram of the uranium-platinum system was constructed from data obtained by thermal analysis, metallographic examination, and X-ray diffraction. The system is characterized by four intermetallic compounds: UPt, formed peritectoidally at 961° C; UPt_2, formed peritectically at 1,370° C; UPt_3, melting congruently at 1,700° C; and UPt_5, formed peritectically at 1,460° C. One eutectic occurs at 1,005° C and 12 a/o platinum, and a second at 1,345° C and 87.5 a/o platinum. The maximum solubilities are 4.5 a/o uranium in platinum and 5 a/o platinum in gamma-uranium. Platinum lowers the gamma-beta uranium transformation to 705° C and the beta-alpha transformation to 589° C. 11 p.

Nitriding phenomena in titanium and the 6A1–4V titanium alloy, J. R. Cuthill, W. D. Hayes, and R. E. Seebold

Nitriding unalloyed titanium in purified nitrogen at 1,800° F produced a uniformly thick case that consisted of five distinct zones. The same treatment applied to a 6A1–4V titanium alloy resulted in a thinner nitride case that consisted of three zones and elongated nitride grains that penetrated into the core at approximately 45 degrees to the specimen surface. The aluminum appears to be responsible for the formation of the elongated grains. These grains, in turn, appear to be responsible for the nitriding having a more adverse effect on the toughness of the alloy than of the unalloyed titanium, as indicated by preliminary impact test results. The nitride case on the titanium appears to increase in thickness with increase in nitriding time without limit. The nitride case exhibits a hardness equivalent to about 77 Rockwell C at the surface down to almost 50 Rockwell C at the interface. 7 p.

Stability of silver and pyrex in perchloric acid—silver perchlorate solutions and in conductivity water, D. N Craig, C. A. Law, and W. J. Hamer

The stability of mint silver, purified mint silver, and Pyrex fritted crucibles in aqueous solutions of perchloric acid, in aqueous solutions of perchloric acid containing silver perchlorate, and in conductivity water at room temperature was determined. The stability of the silver in various states of subdivision was studied. The corrosion current-density for mint silver in sheet form is 1.1×10^{-8} amp cm^{-2} for 20 percent aqueous solutions of perchloric acid, 1.3×10^{-9} amp cm^{-2} for 20 percent aqueous solutions of perchloric acid containing 0.5 percent silver perchlorate, and within the limits of detection is zero for conductivity water. Pyrex has high stability at 25° C in 20 percent aqueous solutions of perchloric acid and in 20 percent aqueous solutions of perchloric acid containing 0.5 percent silver perchlorate. Finely-divided silver contained in Pyrex crucibles was found to be highly stable

when the crucibles were filled repeatedly with aqueous solutions of perchloric acid containing silver perchlorate, rinsed with conductivity water, and dried at 105° C. These observations are important in the determination of the Faraday by the anodic dissolution of silver in aqueous solutions of perchloric acid which is now underway at the National Bureau of Standards. 7 p.

Note on the preparation of sodium amalgam in the form of pellets, H. S. Isbell, H. L. Frush, and N. B. Holt

A procedure is described for the preparation of sodium amalgam in the form of pellets. 2 p.

March–April 1960

A carbon-14 beta-ray standard, benzoic acid-7-C^{14} in toluene, for liquid scintillation counters, W. F. Marlow and R. W. Medlock

A carbon-14 beta-ray standard for use in liquid scintillation counting has been prepared and standardized. The sample consists of benzoic acid-7-C^{14} dissolved in toluene. Samples of the solution were oxidized quantitatively in a Paar oxygen bomb, and the radioactivity of the carbon dioxide was compared with the radioactivity of carbon dioxide prepared quantitatively from the Bureau's sodium carbonate-C^{14} standard. 4 p.

A comparison of experimental and theoretical relations between Young's modulus and the flexural and longitudinal resonance frequencies of uniform bars, S. Spinner, T. W. Reichard, and W. E. Tefft

The relations from which Young's modulus may be computed from mechanical flexural and longitudinal resonance frequencies have been established by an empirical method using two sets of steel bars. Both sets contained rectangular and cylindrical specimens. For longitudinal vibration of cylindrical specimens, the agreement between the empirical curves and Bancroft's corresponding theoretical relation was within experimental error if Poisson's ratio for both sets is taken to be 0.292. For flexural vibrations, the agreement between the empirical curve and the corresponding theoretical relation developed by Pickett is also within experimental error for about the same value of Poisson's ratio for the rectangular specimens of both sets; but for clylindrical specimens, the empirical values are somewhat lower than those predicted by the theory. 9 p.

Determination of copolymer composition by combustion analysis for carbon and hydrogen, L. A. Wood, I. Madorsky, and R. A. Paulson

A detailed description is given of the method of combustion analysis for carbon and hydrogen to determine the composition of a copolymer from its carbon-hydrogen ratio. The apparatus and procedures have been developed at the National Bureau of Standards over a period of years. The method has been applied chiefly to determine what fraction of a styrene-butadiene copolymer is derived from styrene. Minor ingredients are removed by extraction, with the exception of the bound mercaptan residue for which correction must be made. The amount of bound mercaptan residue is determined from measurements of the sulfur content of the copolymer by the Carius method. Measurements are made of the oxygen content and the ash content, although these do not enter into the calculations. The standard deviation of a measurement of carbon-hydrogen ratio is approximately 0.0010 and is independent of styrene content. This corresponds to a standard deviation of about 0.036-percent bound styrene for polymers of low styrene content and 0.018 percent for polymers of high styrene content. The accuracy of the method is demonstrated by the fact that observations of carbon-hydrogen ratio for four out of five samples of polybutadiene differed by less than one standard deviation from the theoretical value. 6 p.

Some effects of aging on the surface area of portland cement paste, C. M. Hunt, L. A. Tomes, and R. L. Blaine

A hardened cement paste cured at room temperature, from which part of the evaporable water has been removed by vacuum drying, has been studied. The surface area has been shown to decrease with time depending upon the the amount of evaporable water left in the paste. This change is the opposite of that usually observed during hydration and probably represents some collodial growth phenomena analogous to aging observed in other collodial gels. Both water vapor and nitrogen adsorption measurements have been used to show the effects of aging in cement paste.

Wet or dry paste is shown to undergo less change than paste of intermediate evaporable water content, so that if surface area after storage is plotted as a function of evaporable water content, a curve with a minimum is obtained. With increasing storage temperature there is some indication that this minimum might shift towards lower water content.

Aging is shown to occur during the initial drying of a cement paste, so that even the initial surface area of a cement paste depends upon the manner in which the paste has been dried. 7 p.

Conformations of the pyranoid sugars. I. Classification of conformers, H. S. Isbell and R. S. Tipson

An improved system is presented for indicating the principal conformations of pyranoid sugars and derivatives, by attaching two symbols to the systematic name. The *first* symbol shows the kind of pyranoid ring; for example, B=a boat, C=the chair, and S=a skew form. (The three boat and six skew rings are distinguished by subscript numerals referring to exoplanar ring-atoms.) The *second* symbol differentiates between two conformations that have the same type of ring, by describing as A or E the axial or equatorial character of the reference group at a selected ring-atom. If the anomeric group is not quasi, the α anomeric group is used as the reference group. For sugars and derivatives having a quasi anomeric group, and for relatives lacking an anomeric group, the A or E classification is based on the reference group at the lowest numbered, nonquasi, asymmetric ring-atom. 6 p.

Tritium-labeled compounds III. Aldoses-*1-t*, H. S. Isbell, H. L. Frush, N. B. Holt, and J. D. Moyer

In a new method for preparing aldoses labeled with tritium at carbon 1, the aldonic lactone is reduced with lithium borohydride-*t* in pyridine solution. The method is suitable for preparing aldoses-*1-t* having high specific activities. The crude product contains a susbtantial proportion of the corresponding alditol-*1-t*, but the pure aldose-*1-t* is readily separated by fractional recrystallization or paper chromotography. By means of an isotope-dilution technique, yields were determined for the following aldoses-*1-t* and the corresponding alditols-*1-t*: D-arabinose-*1-t*, D-xylose-*1-t*, D-ribose-*1-t*, D-glucose-*1-t*, D-galactose-*1-t*, D-mannose-*1-t*-, L-rhamnose-*1-t*, maltose-*1-t*, and lactose-*1-t*.

These labeled materials were also prepared by reducing the corresponding lactones with sodium amalgam in tritiated water. Although this latter method is not suitable for preparing labeled aldoses of high specific activity, the products are more readily purified than those obtained by reducing the lactones with lithium borohydride-*t*.

D-Glucose-*1-t*, obtained by each of these reduction methods, was oxidized with bromine, and the resulting D-gluconic acid was found to be nonradioactive. Hence, in the samples oxidized, tritium was present only at C1.

An apparatus used for reclaiming tritiated water by freeze-drying is depicted; it incorporates an efficient device for trapping entrained solids or liquids. 4 p.

Determination of aluminum in precipitation hardening stainless steel and high temperature alloys, L. A. Machlan, J. L. Hague, and E. J. Meros.

A procedure is described for the determination of aluminum in high temperature alloys. Aluminum is selectively precipitated with 8-hydroxyquinoline from an ammoniacal solution of the alloy containing citrate and cyanide as complexing agents. The precipitate is ignited under oxalic acid, the oxides fused, and dissolved in acid. A caustic precipitation is made, an aliquot of the filtrate treated with hydrogen peroxide, and the aluminum precipitated with 8-hydroxyquinoline. The aluminum hydroxyquinolate is filtered on a fritted-glass crucible, dried, and weighed. 4 p.

May–June 1960

Phase shift effects in Fabry-Perot interferometry, C. J. Koester

A method is demonstrated for utilizing in Fabry-Perot interferometry the data on reflection phase shift dispersion obtained from fringes of equal chromatic order. Unknown wavelengths can be calculated from the Fabry-Perot patterns obtained with a large etalon spacing, even without prior knowledge of the phase shift of the reflecting surfaces. When the theoretical phase shift as a function of wavelength is known approximately, then the correct orders of interference can be determined for both the Fabry-Perot fringes and fringes of equal chromatic order. From the wavelengths of the latter the phase shift dispersion can be measured to an accuracy of about 10 A. The method is especially useful for reflectors with large dispersion of phase shift, such as multilayers. Results in the visible spectrum are reported for aluminum films and a pair of dielectric 15-layer broadband reflectors. 10 p.

Infrared absorption spectrum of methane from 247° to 3200 cm^{-1}, E. K. Plyler, E. D. Tidwell, and L. R. Blaine

The absorption spectrum of methane has been measured from 2470 to 3200 cm^{-1} with a high-resolution infrared spectrometer. Pressures from 0.01 to 4.5 cm of the gas were used in order to observe both intense and weak lines. A total of 2,460 lines were measured in the entire region. The ν_3 band at 3018 cm^{-1} was measured at very slow scanning rates and the lines of the P and R branches were resolved into several components. The observed spectrum is shown in five figures. 12 p.

Elastic constants of synthetic single crystal corundum at room temperature, J. B. Wachtman, Jr., W. E. Tefft, D. G. Lam, Jr., and R. P. Stinchfield

The six elastic constants (and six elastic compliances) of corundum were determined in the kilocycle per second frequency range by an accurate resonance method. The results were checked in the megacycle per second range with a less accurate, pulse velocity method. The elastic moduli for polycrystalline alumina calculated from the single crystal compliances determined by the resonance method are in good agreement with experimental values obtained on high density polycrystalline alumina. The variation of Young's modulus and of the shear modulus with orientation was calculated from the compliances and the results are shown graphically. The results of the present work do not agree well with previous work on single crystal sapphire. The specification of orientation and the theory used to calculate the elastic constants are given in detail to support the contention that the results of the present work are correct. 15 p.

Radial distribution study of vitreous barium borate, A. Bienenstock, A. S. Posner, and S. Block

X-ray diffraction, radial distribution studies of a 20 percent barium oxide, 80 percent B_2O_3 glass have been performed using both the atomic and electronic distribution functions. From these distributions, the average barium-barium distance has been determined as 6.76 A. This distance is in good agreement with that predicted by Levin and Block on the basis of a structural interpretation of immiscibility data. 5 p.

Separation and determination of small quantities of aluminum in steel, B. B. Bendigo and R. K. Bell

A method is described for determining small amounts of aluminum (0.01 to 0.3 percent) in stainless and carbon steels. A perchloric-sulfuric acid solution of the steel is electrolyzed in a mercury cathode cell to remove most of the iron, and an extraction with chloroform is made to remove elements such as aluminum, residual iron, and titanium as cupferrates from a solution buffered at pH 3.5. These elements are converted from cupferrates to perchlorates; all except aluminum are then extracted as cupferrates with chloroform from 4 N hydrochloric acid. Aluminum in the acid solution is determined photometrically with aluminon (ammonium aurintricarboxylate) at a wave length of approximately 540 millimicrons. An accuracy of ± 0.005 percent aluminum is indicated. 4 p.

Conformations of the pyranoid sugars. II. infrared absorption spectra of some aldopyranosides, R. S. Tipson and H. S. Isbell

The conformations of twenty-four aldopyranosides have been studied by analysis of their infrared absorption spectra. The most stable conformations of twelve of the glycosides had previously been assigned by Reeves from a study of their instability factors; these conformations were assumed to apply to the crystalline state, for which the spectra had been recorded. The compounds were classified into (a) configurationally and (b) structurally related groups, and the spectra were intercompared. The analysis revealed groups of absorption bands which showed a concerted shift on change of anomeric disposition.

With these groups of absorption bands thus identified, intercomparison with nine of the remaining spectra afforded evidence that the anomeric group (1) is axial in methyl D-*glycero*-α-L-*gluco*-heptopyranoside, methyl D-*glycero*-α-L-*manno*-heptopyranoside, and methyl D-*glycero*-α-D-*gulo*-heptopyranoside; (2) is equatorial in methyl 6-deoxy-β-L-mannopyranoside, methyl D-*glycero*-β-D-*gulo*-heptopyranoside, and cyclohexyl D-*glycero*-β-D-*gulo*-heptopyranoside; and (3) either is quasi or occurs as different (or mixed) axial and equatorial forms in methyl α-D-lyxopranoside, methyl β-D-lyxopranoside, and (possibly) α-D-methylgulopyranoside.

Three of the glycosides were available as their crystalline complexes with calcium chloride. The spectra of these complexes were also examined, and the effect of co-crystallization with calcium chloride is pointed out. 25 p.

3.3. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICS AND MATHEMATICAL PHYSICS, VOLUME 63B, JULY–DECEMBER 1959

July–September 1959

Relations between summation methods and integral transformations, W. Greub

Relations between the Lototsky method of summation and those of Borel, Euler, and Knopp are obtained by associating an integral transformation with the series transformation. 13 p.

On a modification of Watson's lemma, F. Oberhettinger

The method of steepest descents is extended to the case when a saddle point and a pole of arbitrary order are involved. An application to a problem in diffraction theory is demonstrated. 3 p.

Principal submatrices of a full-rowed non-negative matrix, K. Goldberg

It is shown that one of the principal submatrices of an incidence matrix without zero rows is a permutation

matrix. From this an inspection method is described for determining whether a non-negative matrix is nilpotent. Application is made to graph theory. 2 p.

Zeros of certain polynomials, A. J. Goldman

Let P be a real parameter. It is proved that all roots of $z^{n+1}-z^n+P=0$ lie in the open unit disk, if and only if $0<P<2 \sin \pi/(4n+2)$. 2 p.

Tables of transport integrals: a supplement, W. M. Rogers, W. J. Hall, and R. L. Powell

Tables of values of the transport integrals, defined by

$$J_n(x) \equiv \int_0^x \frac{e^z z^n dz}{(e^z-1)^2},$$

were previously published in NBS Circular 595 for values of n from 2 through 17. In this paper, values are given for the integrals where n is 18 and 20 and where x ranges from 0.2 to 50.0 in steps of 0.2 8 p.

Lens design: a new approach, O. N. Stavroudis

This paper describes a new method of defining the total aberrations of an optical system and its application to lens design. A system of partial differential equations defining optical image formation is written in the form of 4 by 4 matrices and is applied to the derivation of lens aberrations. It is shown that the form of the matrices facilitates the computation of these aberrations and that equations of condition on the lens parameters can be derived. The use of this method is illustrated through its application to a simple, well-known problem. 12 p.

Analytical integration of the differential equation for water storage, V. M. Yevdjevich

The integration of the storage differential equation at present is usually done mostly by graphical or numerical procedures. An approach to the analytical integration of that equation is the subject of this paper. A new method of fitting the given background curves by mathematically tractable expressions is introduced. The storage-outflow discharge relation is expressed in the form of a power function. A general differential equation for water storage $y'+cPy^3-cy^k=0$ is derived, with c and k constants for the given reservoir, outflow shape and type of flow, and P being the inflow hydrograph. The analytical solutions of this equation for $P=0$, $P=$constant, and certain $P=f(t)$ are given for the integrable cases (tables 1 to 3, eqs (12) to (29)). The application of the results obtained is discussed at the end of the paper. 10 p.

Compressible turbulent boundary layers with heat transfer and pressure gradient in flow direction, A. Walz

The best-known theoretical works on boundary-layer problems, especially in the case of compressible flow without or with heat transfer, are related to the laminar boundary layer, although the turbulent boundary layer is, in practice, often more interesting. The laminar boundary layer is more easily accessible to theoretical treatment because clearly defined relations exist between the viscosity μ and the shear stresses π. In the turbulent case, empirical relations must be introduced. Therefore, attempts to get exact solutions are not worthwhile, while efforts to obtain approximate solutions, based for instance on the von Karman-Pohlhausen principle (Z. Angew. Math. u. Mech. 1, 233, and 252, 1921) of utilizing integral conditions, appear to be appropriate to this problem. In the last few years the accuracy of such approximate solutions for the incompressible case was noticeably improved by the application of a new energy integral condition in connection with a new empirical law for the dissipation in turbulent boundary layers, stated by J. Rotta (Ingr-Arch. 20, 195, 1952) and E. Truckenbrodt (Ingr-Arch. 20, 212, 1952). The empirical laws for dissipation and for turbulent wall friction, which are needed in the present approximate theory, are formulated on the basis of available measurements for incompressible flow. Generalization to the compressible flow with heat transfer is made from physical considerations. Calculated results agree satisfactorily with available experimental data. Some possibilities for improving as well as for simplifying the approximation theory are outlined. 18 p.

October–December 1959

Applications of a theorem on partitioned matrices, E. V. Haynsworth

A reduction formula for partitioned matrices is applied to block-stochastic matrices and other types of partitioned matrices in order to reduce the computation in finding the eigenvalues. Such matrices occur frequently in physics and chemistry, and the reduction formulas given here have been applied successfully in practical problems. In addition, some results of A. Brauer on stochastic matrices and of J. Williamson in partitioned matrices are generalized. 6 p.

Capacity requirement of a mail sorting device: II, A. J. Goldman

The combinatorial analysis of a mathematical model of a sorting device suggested by S. Henig is completed. The relevant parameters are r, the number of destinations for the mail, and k, the number of letters entering the device during each cycle of operation. The capacity of the device, if it is never to jam, should be between rk and $rk-(r-1)$ inclusive; arguments indicating that the latter value is preferable are given. 4 p.

Analytic comparison of suggested configurations for automatic mail sorting equipment, B. K. Bender and A. J. Goldman

Analytic methods are developed to aid in determining the equipment configuration which achieves sorting of outgoing mail at a given (required) rate at least cost. The techniques are applied to a specific numerical problem; several of the suggested configurations are quickly eliminated, and a "hybrid" of two of the proposed configurations is found which comes within four percent of optimum (if a certain pair of parameters is chosen correctly). 22 p.

New method of solution for unretarded satellite orbits, J. P. Vinti.

An axially symmetric solution of Laplace's equation in oblate spheroidal coordinates is found, which may be used as the gravitational potential about an oblate planet. This potential, which makes the Hamilton-Jacobi equation for a satellite orbit separable, has an expansion in zonal harmonics in which the amplitudes of the zeroth and second harmonics can be adjusted to agree exactly with the values for any axially symmetric planet and a fourth harmonic which then agrees approximately with the latest value for that of the earth. The net result is therefore a reduction of the problem of satellite motion to quadratures, with use of a potential field that is much closer to the empirically accepted one for the earth than any heretofore used as the starting point of a calculation. It may thus be possible to do the gravitational theory of a satellite orbit very accurately without use of perturbation theory. The method can take into account a first harmonic in the potential, in case observations are reduced to a center which does not coincide with the center of mass of the planet. 12 p.

Effect of sudden water release on the reservoir free outflow hydrograph, V. M. Yevdjevich

The free outflow hydrograph is studied in the case of a sudden water release from a reservoir. The outflow hydrograph is called free when it is not affected by the

tailwater levels. Both the effect of the steep negative wave, created by sudden water release, and the effect of the flow resistance are analyzed through the use of a fictitious inflow hydrograph. The water accelerated by the steep negative wave movement, whether or not the flow resistance is taken into account, gives this fictitious hydrograph. The procedures are given for the computation of the wave celerities and the new water velocities along the reservoir, for the computation of wavefront heights and the maximum outflow discharges, and for the determination of the fictitious and total inflow hydrograph. The examples are given for the pyramidal reservoirs of rectangular and parabolic cross sections. A general procedure for the determination of the reservoir free outflow hydrograph in an approximate form is derived. 13 p.

Uniform asymptotic expansions for Weber parabolic cylinder functions of large orders, F. W. J. Olver

Expansions of solutions of the differential equation

$$\frac{d^2w}{dt^2}=\mu^4(t^2-1)w,$$

are sought for large values of $|\mu|$, which are uniformly valid with respect to arg μ and unrestricted values of the complex variable t. Two types of expansion are found. Those of the first type are in terms of elementary functions and are valid outside the neighborhoods of the points $t=\pm 1$, the turning points of the differential equation. The second are in terms of Airy functions and hold in unbounded regions containing one of the turning points.

The special forms of the expansions when the variables are real are considered in detail, and asymptotic expansions for the zeros of solutions of the differential equation are found by reversion. Numerical examples are included. 39 p.

TITLE PAGE AND CONTENTS TO VOL. 63B. 3 p.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICS AND MATHEMATICAL PHYSICS, VOLUME 64B-JANUARY-JUNE 1960

January–March 1960

Theory of diffraction in microwave interferometry, D. M. Kerns and E. S. Dayhoff

Microwave Michelson and Fabry-Perot interferometers are respectively considered as instances of: (1) A "reflection system", consisting of a radiating-receiving system and a reflecting object (e.g., a finite mirror); and (2) a "transmission system", consisting of a radiating system and a receiving system with an object (e.g., a Fabry-Perot etalon) interposed. The basic theoretical objective is the calculation of the amplitude and phase of the (time-harmonic) received signal in the systems considered. The electromagnetic field in space transmission paths is represented in terms of continuous angular spectra of vectorial plane waves, and the elements of the systems are described by means of suitable tensor scattering matrices (having both discrete and continuous indices). Needed scattering matrices are considered known; relationships to experimentally determinable data are outlined. The general case of either the reflection or transmission system is soluble formally in terms of a series of integrals stemming from the Liouville-Neumann series solution of certain integral equations. Formulas are obtained for models of the Michelson and Fabry-Perot instruments with arbitrary radiating and receiving characteristics. The theory and various features of the instruments considered, including Fresnel-region (or quasi-optical) behavior, are illustrated by means of examples obtained by choosing relatively simple and rather hypothetical analytical expressions for the radiating and receiving characteristics. 13 p.

Some solutions for electromagnetic problems involving spheroidal, spherical, and cylindrical bodies, J. R. Wait

Solutions are presented for the low-frequency electromagnetic response to an oscillating magnetic dipole by conducting bodies of simple shape. The quasi-stationary approximation is employed throughout, which is valid when the relevant dimensions of the problem are all small compared to the free-space wavelength. This amounts to matching solutions of the wave equation within the bodies to solutions of Laplace's equation outside. The results have application to geophysical prospecting. 18 p.

Kantorovich's inequality, M. Newman

An elementary proof with a generalization of an inequality of Kantorovich is given. 2 p.

A symmetric continuous poker model, A. J. Goldman and J. J. Stone

Beginning with von Neumann, mathematicians concerned with the rational analysis of conflict situations have realized that investigation of accurate or simplified versions of common card games leads to techniques and insights applicable to situations of military or economic interest. In the present paper, a symmetric poker model one stage more complicated than the original von Neumann game is solved. There are two bet levels, a, b, and an ante of 1 unit ($a>b>1$); no raises are permitted. The game has a unique optimal strategy, which forbids bluffing on a low hand. The limiting case $b=1$ is shown to yield the von Neumann model. 6 p.

Moebius function on the lattice of dense subgraphs, R. E. Nettleton and M. S. Green

The Moebius function f_k on the lattice of k-dense subgraphs of a connected graph, defined in a previous paper, is calculated for graphs G containing isthmuses and articulators. f_1 evaluated for the null graph ϕ is shown to vanish if G contains an isthmus, while for any integer q there exist graphs containing articulators for which $f_1(\phi)=q$. The "lattice of path sets" joining a pair of points and the lattice of graphs "associated with G and a subgraph G'" are defined and the Moebius functions on these lattices are shown in certain cases to be related to f_1. 7 p.

The minimum of a certain linear form, K. Goldberg

The positive minimum of the integral linear form $L(x_1, \ldots, x_n)=a_1x_1+\ldots+a_nx_n$ is found subject to the conditions $a_i>0$ and $L(x_1, \ldots, x_n)\geq 2a_ix_i$ for $i=1,2, \ldots, n$. 2 p.

Space of k-commutative matrices, M. Marcus and N. A. Khan

Let $[A, X]=AX-XA$ and $[A, X]_k=[A, [A, X]_{k-1}]$. Those matrices X which "k-commute" with a fixed matrix A are investigated. In particular, the dimension of the null space of the linear transformation $T(X)=[A, X]_k$ when A is nonderogatory is determined. 4 p.

Selected bibliography of statistical literature, 1930 to 1957: I. Correlation and regression theory, L. S. Deming

This is the first in a series of bibliographies dealing with various specific subjects in the field of statistics. References and titles of important contributions in correlation and regression theory have been taken from technical journals published throughout the world since 1930. 14 p.

Selected bibliography of statistical literature, 1930 to 1957: II. Time series, L. S. Deming

This is the second in a series of bibliographies dealing with various specific subjects in the field of statistics. References and titles of important contributions to the study of time series have been taken from a wide variety of technical journals published in the many languages and countries which have been actively engaged in statistical analysis. 8 p.

Non-self-adjoint boundary value problems in ordinary differential equations, W. Greub and W. C. Rheinboldt

It is shown that the theory of non-self-adjoint linear ordinary differential equations can be simplified and unified if, instead of specifying linear boundary conditions in the conventional way, one merely specifies the linear subspace determined by the boundary conditions. If this is done, the corresponding linear space of the adjoint problem is the orthogonal complement of the original space with respect to the scalar product defined by the right-hand side of Green's boundary formula. 8 p.

Criteria for the existence and equioscillation of best Tchebycheff approximations, J. R. Rice

Let $F(a,x)=\Sigma a_i\varphi_i(x)$ where $\varphi_i(x)$ are continuous in [0,1] and the a_i are real parameters. The following theorem answers the principal questions of a general nature in the theory of Tchebycheff approximations: THEOREM. Let $\{\varphi_i(x)\}$ form a Tchebycheff set and let $f(x)$ be an arbitrary function continuous on [0,1]. Then (A) $f(x)$ possesses a best approximation, (B) a necessary and sufficient condition that $F(a^*,x)$ be a best approximation to $f(x)$ is that $\max|F(a^*,x)-f(x)|$ alternates at least n times in [0,1], (C) the best approximation to $f(x)$ is unique. A. Haar [Math. Ann. 78, 43–56 (1928)] posed and answered the following question: What conditions on F are necessary and sufficient for theorem C to be valid? The condition he found is that $\{\varphi_i(x)\}$ must form a Tchebycheff set. This paper poses and answers the following three questions: (1) What conditions on F are necessary and sufficient for theorem A to be valid? (2) What conditions on F are necessary and sufficient for theorem B to be valid? (3) What conditions on F are necessary and sufficient for both theorems A and B to be valid?

This paper does not tacitly assume that the a_i may assume all values. 3 p.

Note on the solution of Riccati's differential equation, H. H. Howe

Three recurrence formulas are developed, giving the solution of a particular case of Riccati's equation in power series valid in the neighborhoods of 0, ∞, and an arbitrary point, respectively. The first two were programed for computation on the SEAC. 4 p.

On a generalization of the index notation for absolute tensors of arbitrary order, E. H. Brown

A generalized vector index notation is introduced which facilitates study of properties of tensors regardless of order and variance of components. This generality is obtained by replacing the set of m indices, each of which vary in a single domain of n integers, by one *vector* index which varies over the integral lattice points of an m-dimensional domain. The notation also suggests an elegant treatment of order transformations of tensors. 5 p.

Upper and lower bounds for the center of flexure, L. E. Payne

There is disagreement in the literature as to how the center of flexure of an isotropic elastic beam should be defined. In either of the two most widely accepted definitions, upper and lower bounds for the coordinates of the center of flexure are obtained. 7 p.

Half-round inductive obstacles in rectangular waveguide, D. M. Kerns

Formulas are derived for the accurate calculation of the lowest-mode, lumped-element representation of perfectly conducting half-round inductive obstacles in rectangular waveguide. These obstacles consist of either one or two opposed semicircular cylindrical indentations extending across the narrow sides of the waveguide. They seem especially suitable for use as precise calculable standards of reflection or impedance in waveguide. Schwinger's integral equation approach is used to obtain stationary expressions for the desired parameters as functionals of the surface currents on the obstacles. Upper bounds are obtained for one of the two parameters. Explicit formulas are derived for the values of the parameters under the assumption of n-term Fourier sine-series expansions for the obstacle currents. Rapid convergence is indicated by numerical evaluations for $n=1$, 2, and 3. In the process of obtaining expressions suitable for numerical calculation, an expansion (believed to be new) of the Green's function of the problem is obtained and the sums of certain infinite series of Bessel's functions occurring in this expansion are expressed in terms of definie integrals. A brief numerical table of these sums, sufficient for the evaluation of the $n=1$ approximation, is included. 18 p.

3.4. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 63C, JULY–DECEMBER 1959

Creep of cold-drawn nickel, W. D. Jenkins and C. R. Johnson

Creep tests were made in tension under constant loads at temperatures of 300°, 700°, 900°, and 1,200° F on specimens of nickel initially cold-drawn to 40-percent reduction in area. None of the equations for defining the strain-time relationship proposed by other investigators was found to be suitable to express or predict the creep-test results of this investigation with high accuracy because these equations inadequately describe the changes in structure accompanying the creep processes. However, conformance to the parabolic strain-time law was obtained over limited ranges of stresses and strains. The effects of cold-drawing on the creep properties are discussed. Certain etching techniques were employed that gave evidence of the presence and movement of dislocations in the structure. 18 p.

Friction and endurance of prelubricated and unlubricated ball bearings at high speeds and extreme temperatures, H. S. White

Endurance tests were made with 20-millimeter bore prelubricated ball bearings, at 10,000 revolutions per minute, using polyester felt rings saturated with di(2-ethylhexy) sebacate containing appropriate additives, at ambient temperatures ranging from 80° to 400° F. Tests were made with greases for comparative purposes. Results indicate that endurance with these oil-soaked pads is comparable with the high-temperature performance of MIL–G–3278 grease at 250° F and MIL–L–3545 grease at 300° F. Some endurance tests were made with special bearings (20-millimeter bore) made of high-speed tool steel, prelubricated at 450° F ambient temperature, and unlubricated at 650° F ambient temperature (5,000 revolutions per minute at 650° F). Experiments were made with greased bearings and with felt-pad oiled bearings in gyros and small high-speed direct-current motors at high temperatures. With oiled bearings and with unlubricated bearings, wearing or breaking of separators (ball cages) was the most common cause of failure. Compared to low-temperature greases MIL–G–3278 and MIL–G–7421 with oiled bearings starting friction was low and running friction was about one-tenth that of greased bearings at −75° F ambient temperature. 11 p.

Effect of light and water on the degradation of asphalt, L. R. Kleinschmidt and H. R. Snoke

Coatings prepared from two blown petroleum asphalts in a thickness range of 0.002 to 0.04 inches were exposed to accelerated test conditions and outdoors. When exposed to light only, a surface film, insoluble in common asphalt solvents, was formed. The formation of this surface film was accompanied by a gain in weight of the coatings, apparently due to an oxygen pickup. This sur-

face film retarded further degradation of the maltenes during the exposures made to light only. When the coatings were immersed in water after exposure, or sprayed with water during exposure, or exposed outdoors, they lost weight. These decreases in weight were found to be in part due to the extraction of water-soluble, light-degraded material. Their magnitudes were dependent upon the asphalt exposed, the thickness of the exposed coatings, and the exposure conditions. The relationship between the losses in weight and water-soluble material, when considered in conjunction with the oxygen content of the asphalts and the water-soluble materials, indicated that volatile degradation products were also formed.

When the surface skin formed by the action of light was partially removed by washing with water, percentage decreases were noted in the water-white oils, dark oils, and asphaltic resins. Since these decreases were unequal in magnitude and since the losses in weight were dependent on the thickness of the coating, it was concluded that light-degradable components of the asphalt had migrated to the surface to replace degraded material that had been washed away. 6 p.

Current and potential relations for the cathodic protection of steel in a high resistivity environment, W. J. Schwerdtfeger

In order to evaluate potential and current criteria for the cathodic protection of bare low-carbon steel in a high-resistivity environment, specimens were exposed in the laboratory for a period of two months to a soil having a resistivity of about 20,000 ohm-centimeter.

Previous work in low-resistivity environments by the author and by other investigators has shown that corrosion can be reduced to a negligible degree by polarizing a steel structure to -0.85 volt (protective potential) with reference to a copper-copper sulfate electrode. In such studies by the author, cathodic polarization curves have also been shown to be useful in indicating the current density required for cathodic protection.

In the present study the above criteria were again evaluated. In addition to protecting the steel at the protective potential (free of IR drop), the effect on protection of including IR drop caused by the protective current was also noted. Also, cathodic polarization curves were obtained on a recorder in conjunction with a bridge circuit to eliminate the IR drop.

The results show that the best degree of protection was achieved on the specimen controlled at -0.77 volt (without IR) with reference to a saturated calomel half-cell. This is approximately equivalent to the protective potential -0.85 volt with reference to the copper-copper sulfate electrode. Applied current indicated by the break (change-in-slope) in the cathodic polarization curve agreed reasonably well with the actual current necessary to maintain polarization at -0.77 volt (free of IR).

The current required for protection was about three times the magnitude of the corrosion current; therefore, the corrosion reaction was either under anodic control (unlike previous studies) or an equivalent type of control which was caused by high resistance at anodic areas. 9 p.

A tilting air-lubricated piston gage for pressures below one-half inch of mercury, U. O. Hutton

A description is given of a tilting dead-weight piston gage constructed at the National Bureau of Standards for ranges of differential pressure up to about 0.5 inch of mercury. A resolution of better than 1 part in a hundred thousand of full scale has been obtained by use of the toolmaker's sine bar method of angle measurement. The scale is a linear function of the sine. The instrument can be calibrated from basic measurements of length and weight, is rugged, and may be constructed in almost any laboratory mechanical shop. Sources of possible errors in reading are discussed in detail. Comparative tests with certain other gages or manometers are cited wherein linearity was found to be within 1 part in 10,000 and agreement within 2.5 parts in 10,000. The uses of the gage are briefly discussed. 11 p.

Compact multi-anvil wedge-type high pressure apparatus, E. C. Lloyd, U. O. Hutton, and D. P. Johnson

Apparatus for generating high pressures by application of force by an anvil against each face of a solid polyhedron is described. The equipment constructed utilizes a tetrahedron of pyrophyllite and four tungsten carbide anvils as described earlier by H. T. Hall. External force is applied to only one of the anvils, and wedge reaction forces set on the other anvils, permitting the equipment to be used in a conventional hydraulic press. Examples of results of use of the equipment are given. Success of the design has been shown by the repeated generation of pressures in excess of 100,000 atmospheres indicating that large existing presses might be used to generate pressures of this order in volumes of several cubic inches. For higher pressures a two-stage multi-anvil apparatus is proposed in which the second-stage anvils are embedded in a large pyrophyllite tetrahedron to obtain necessary supporting forces. 6 p.

A coulometric-titration coulometer, S. W. Smith and J. K. Taylor

A highly precise coulometer is described which permits time integration of currents totaling 100 coulombs or more with a precision of about 1 part in 100,000. The current to be integrated oxidizes hydroquinone in an electrolysis cell, producing quinone and acid. The quinone is then reduced by constant-current coulometric titration, the end point being indicated by hydrogen-ion concentration measurements. 4 p.

Electron beam magnetometer, L. Marton, L. B. Leder, J. W. Coleman, and D. C. Schubert

A theoretical investigation of the electron optics of an electron beam deflection method for detecting small magnetic fields is presented. It is shown that remarkably high sensitivity can be reached. A laboratory model of such a magnetometer was constructed, and it was demonstrated that the theoretical estimate of sensitivity, 3×10^{-5} ampere per oersted, could be attained in practice. A discussion of the possible improvements which could extend the sensitivity of the device is also given. 7 p.

A refined X-band microwave microcalorimeter, G. F. Engen

The microcalorimetric method for evaluation of the efficiency and substitution error of a bolometer mount proposed by Macpherson and Kerns has been the object of further study and refinement at the Boulder Laboratories of the National Bureau of Standards, and an improved instrument based on this technique has been recently placed in operation.

The new microcalorimeter design features are: (1) Greatly improved ambient temperature control, permitting higher sensitivity and resolution; (2) improved d-c instrumentation; (3) improved mechanical construction giving better repeatability; (4) relocation of the thermopile so that it no longer is attached directly to the bolometer mount, thus providing flexibility in the choice of termination; and (5) a more comprehensive treatment of the calorimetric substitution or equivalence error. These features permit the determination of the effective efficiency of a bolometer mount to an accuracy of better than 0.2 percent. 6 p.

October–December 1959

Conical coaxial capacitors and their advantages, M. C. Selby

Adjustable capacitors having electrodes in the form of coaxial cones or frustums have been used on rare occasions in the past, but their potential superiority to other types of capacitors for some important applications has been overlooked. The advantage of this geometry over cylindrical or disk forms is that the practical capacitance range is several times larger. An example cites the capacitance ranges for the same mechanical and percentage

accuracy of a disk, cylindrical and conical type to be 10, 40, and 168 to 1, respectively. An approximate equation was derived for this conical capacitor and close agreement is shown between computed and measured values of capacitance versus electrode displacement. Multiple cone and specially shaped electrodes are suggested to obtain large values of capacitance with an appreciable saving of space and further increased range of capacitance. 3 p.

A photoelectric followup and recording system, and its application to remote observations of the beam in high-precision balances, H. A. Bowman and L. B. Macurdy

A device is described which permits a significant increase in the frequency of the oscillations of the beam of a balance, thereby shortening the interval during which upsetting ambient conditions can act. The device is a servo-driven photoelectric followup system responding to the position-modulated light signal reflected from a mirror attached to the balance 12 ft away from the photocell. Reproducibility in observing the position of the light beam is 0.001 in. or less. 6 p.

A stroboscopic vibration analyzer, S. Edelman, R. Brooks, S. Saito, E. Jones, and E. R. Smith

An instrument for studying the amplitude and phase relations which exist in complex periodic processes is described in this paper. The process treated here is vibration of complicated bodies. The motion at each point of interest is detected by a vibration pickup. The signal from each pickup is heterodyned with a common signal that differs from the vibration frequency by a small amount to produce a set of signals at the difference frequency. The desired relations are exhibited at the difference frequency which is low enough to give a slow motion effect. The output circuitry allows scope for ingenuity to choose a presentation suited to a particular problem. 7 p.

Evaluation of lens distortion by the inverse nodal slide, F. E. Washer and W. R. Darling

The evaluation of lens distortion by means of the inverse nodal slide method is discussed. The sources of error inherent in the method are investigated. Emphasis is given to the effect of asymmetric use of apertures. Measurements are reported on the same lens for which distortion values were measured by the direct nodal slide and photographic methods. A comparison of results obtained by the three different methods is given. It is concluded that accurate values of the distortion of a lens can be obtained by the inverse nodal slide method and that the precision of measurement is comparable to that of the two other methods mentioned when proper attention to sources of error is given. 8 p.

Evaluation of lens distortion by the modified goniometric method, F. E. Washer and W. R. Darling

This is the third of a series of papers dealing with factors affecting the accuracy of measurement of lens distortion by various visual and photographic processes. This paper presents the results of a study of the visual modified goniometric method which employs a viewing theodolite and accurate linear scale. Sources of error are investigated and discussed. Measurements are reported on the same lens that was used in the analysis of two visual and one photographic distortion measuring processes. A comparison of results by the four different methods is given. It is concluded that accurate values of lens distortion can be obtained by the modified goniometric method provided care is taken to use centered apertures and to preserve known angular relationships between telescope pointings and successive locations. 8 p.

Proposed criteria for defining load failure of beams, floors, and roof constructions during fire tests, J. V. Ryan and A. F. Robertson

A brief account is presented of procedures used in development of criteria for defining the point at which fire test specimens fail to sustain load during test. It is proposed that both a deflection of $L^2/800d$ and an hourly rate of deflection of $L^2/150d$ be taken as an indication of load failure. In these formulas, L is the span between supports of the member or element found to be critical under fire exposure, and d is the distance between upper and lower extreme fibers of the particular structural component or assembly. 4 p.

Conductive flooring for hospital operating rooms, T. H. Boone, F. L. Hermach, E. H. MacArthur, and R. C. McAuliff

Characteristics and performance of available types of conductive flooring materials were investigated in the laboratory. The study showed that the electrodes and instruments used to measure the floor greatly affected the measured resistance, but that the method specified by the National Fire Protection Association for measuring the electrical resistance reasonably simulated the conditions under which a floor functions in reducing electrostatic hazards. The physical, chemical, and serviceability characteristics of conductive floorings investigated showed results comparable with those of nonconductive flooring of the same type. Consequently, with some limitations, an architect may base his choice of a conductive flooring material on his knowledge of the behavior of similar nonconductive materials. 16 p.

Measurement of the aging of rubber vulcanizates, J. Mandel, F. L. Roth, M. N. Steel, and R. D. Stiehler

A study of aging data in the literature and of measurements made at the National Bureau of Standards indicates that ultimate elongation is the best of the tensile properties for characterizing the deterioration of rubber vulcanizates during storage at various temperatures. Ultimate elongation (strain at failure) decreases during aging for all types of rubber vulcanizates; whereas tensile strength and modulus may increase, decrease, or remain essentially unchanged.

This study includes measurements of ultimate elongation of a nitrile rubber vulcanizate after various periods of storage at temperatures of 23°, 34°, 45°, 57°, 70°, 85°, and 100° C. It also includes a study of the published data on ultimate elongation obtained in an interlaboratory test conducted by Subcommittee 15 of ASTM Committee D–11, involving vulcanizates of five different rubbers stored at 25°, 70°, 100°, and 121° C.

The change in ultimate elongation over prolonged periods of storage cannot be expressed by a simple mathematical equation. However, during most of the useful storage life of a rubber vulcanizate, the elongation decreases approximately linearly with the square root of time. The data indicate that for some vulcanizates an estimate of storage life at room temperature can be made from measurements of ultimate elongation at two or more elevated temperatures. 5 p.

TITLE PAGE AND CONTENTS TO VOL. 63C. 3 p.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 64C, JANUARY-JUNE 1960

January–March 1960

Power loss and operating temperature of tires, R. D. Stiehler, M. N. Steel, G. G. Richey, J. Mandel, and R. H. Hobbs

The power loss of pneumatic tires was measured under steady-state conditions by means of two dynamometers, one of which measured the total power input and the other power output. A steel wheel was used to measure the power loss in the equipment and in windage. The power required to flex the tire (input power minus output power minus equipment and windage losses), was not affected by the tractive effort (output power). The coefficient of rolling resistance, a dimensionless quantity, was calculated by means of the equation: $R=(P/SL)$, where P is power loss of tire, S is speed, and L is load. This coefficient increased at an increasing rate with the slip angle (angle

between plane of tire and direction of travel) and was approximately doubled at an angle of 2 degrees.

The change in R with speed varied and appeared to depend on construction of the tire. Both nylon and steel wire truck tires exhibited a decrease in R with speed, rayon truck tires showed either no change or a linear increase in R with speed, and for passenger car tires R increased at an increasing rate with speed, particularly for a rayon tire. R increased with load for all but the steel wire tire. The change in R with inflation pressure was studied only for rayon truck tires. R increased linearly with the reciprocal of the pressure but the rate was dependent on the speed and load conditions.

The type of rubber had a pronounced effect on R and combinations of natural and styrenebutadiene rubber caused R to be larger than expected from the values of R for tires made from a single rubber. Varying the type of carbon black in the treads of truck tires had no effect on R, but SAF black in passenger car tires caused R to be larger than that when HAF black was used. Because of constructional differences, no conclusions on effect of cord could be drawn. However, R for a steel wire truck tire was the lowest observed, and the values for rayon tires were lower than those for nylon tires exceept at high speeds.

The temperature rise of the air in the inner tube was found to be related to the power loss by the relation: $\Delta T/P = G + H/(SL)^{0.8}$ where G and H are parameters dependent on the thermal resistance of the rubber compounds and of the interface between tire and air or roadway, respectively. The ratio $\Delta T/P$ remained essentially unchanged by changes in inflation pressure and did not appear to be affected by the type of cord. 11 p.

Effects of antioxidants on asphalt durability, B. D. Beitchman

The mechanism by which asphalt degrades during weathering can be studied profitably by observing the action of materials which inhibit this degradation.

A number of antioxidants which are believed to function either by their ability to inhibit chain reactions or to decompose peroxides were studied for their effectiveness in retarding weight loss and promoting durability of roofing asphalts. Inhibitors of chain reactions in some cases inhibited weight loss without extending durability. Compounds which decompose peroxides were observed to be capable of extending the durability of an asphalt and also of retarding weight loss. Phenothiazine, which is believed to function primarily as a peroxide decomposer, proved to be the most outstanding of the inhibitors tested.

A study made in one asphalt of the dependence of phenothiazine activity on concentration indicated that a concentration of 2 percent was optimum. In several other asphalts, 2 percent phenothiazine retarded weight loss to varying extents without significantly altering the durability of the asphalt.

Synergistic activity was shown by the use of an inhibiting mixture containing phenothiazine and *N*-phenyl-2-naphthylamine.

The results of this study support the hypothesis of a free radical process being involved to a considerable degree in asphaltic degradation during weathering. 5 p.

Temperature stratification in a nonventing liquid helium Dewar, L. E. Scott, R. F. Robbins, D. B. Mann, and B. W. Birmingham

The presence of a large temperature gradient in Dewars used for transporting helium is undesirable because it may be accompanied by unnecessarily high internal pressures when the contents are sealed. In a study of the problems, such gradients were observed in experiments conducted with a 39.7-liter stainless steel Dewar. A method is shown for calculating the pressure rise in the absence of temperature gradients and the results are compared with the observed pressure rise. In some cases curves representing calculated and observed pressure rise intersect. A possible explanation of this situation is given. The destratifying effect of a concentrated heat input and of copper rods is shown. 5 p.

Expansion engines for hydrogen liquefiers, E. H. Brown

Criteria are developed for the practicability of expansion engines and expansion turbines in large hydrogen liquefiers. Some additional data on pertinent properties such as the sonic velocity of normal hydrogen are included. The analysis suggests that use of expansion turbines in hydrogen liquefiers having a production capacity of less than 5,000 liters per hour ordinarily would not be justified. For greater capacities, however, use of modern materials and design should make expansion turbine performance even more favorable than in liquefiers for denser fluids. 12 p.

A statistical chain-ratio method for estimating relative volumes of mail to given destinations, N. C. Severo and A. E. Newman

A sampling method, called the chain ratio method, is applied in estimating the distribution of mail by destination. Variances and coefficients of variation for the estimators are given. The details and results of three applications of this sampling method to outgoing first-class letter mail are given. These studies were conducted by the National Bureau of Standards in San Francisco, Los Angeles, and Baltimore. 11 p.

Standard free-air chamber for the measurement of low energy X-rays (20 to 100 kilovolts-constant-potential), V. H. Ritz

A description of the new National Bureau of Standards "low" energy free-air chamber is given. The standard chamber is designed to measure the exposure dose in roentgens for X-ray beams generated at potentials from 20 to 100 kilovolts-constant-potential (kvcp) with filtrations ranging from 2 millimeters of beryllium to 2 millimeters of beryllium plus 4 millimeters of aluminum. The chamber has been compared with the National Bureau of Standards "medium" energy standard at 60, 75, and 100 kvcp with filtrations of 3, 3, and 4 millimeters of aluminum, respectively. The two standard chambers agreed to within 0.3 percent. 5 p.

Transmittance of materials in the far infrared, E. K. Plyler and L. R. Blaine

The transmittance of several crystalline materials with thicknesses of about 5 mm has been measured from 17 to 55 μ. The crystals are sodium chloride, potassium chloride, potassium bromide, thallium bromide-iodide, cesium bromide, and cesium iodide. Also the transmittance of a polyethylene film containing carbon black has been measured to 100 μ and an example of its use as a transmission filter for the far infrared is given. 2 p.

Equipment and method for photoelectric determination of image contrast suitable for using square wave targets, F. W. Rosberry

Conventional measurements of the resolving power of lenses employ measuring photographs of test charts containing an array of accurately spaced parallel lines. This method has limited precision because of the variability of photographic emulsions and is time-consuming in operation. This paper extends previous work by others in obviating these differences by using a direct photoelectric scanning of a line-pattern image formed by the lens under test. Square wave high contrast resolving power targets with two different line pattern arrangements were used as test objects. The image was moved across a stationary slit and photomultiplier tube. The output was recorded as relative transmission. 8 p.

Formation of silver sulfide in the photographic image during fixation, C. I. Pope

A photographic silver image is made permanent (fixed) after development by bathing it in a solution containing thiosulfate which forms a soluble thiosulfate complex with

the residual silver halide. Some of the silver in the image is sulfided by the thiosulfate during fixation. The purpose of this study was to determine the amount of sulfiding of the silver in the image during fixation of film and paper. The amount of the silver reacting depends on the type of the light-sensitive layer. Also, during bleaching, the residual thiosulfate in the film or paper reacts with silver in a potassium dichromate-sulfuric acid bleach bath to form silver sulfide. For one paper, it was shown that the amount of silver sulfide which was formed in the bleach bath increased with the increase of the concentration of the residual thiosulfate in the paper. A procedure was developed for the reduction of silver sulfide in an emulsion layer to silver so that the silver sulfide may be determined in terms of the optical density of the silver deposit. The use of hypo eliminators was investigated and a test procedure was found for testing the effectiveness of hypo eliminators. A small amount of potassium iodide added to the fixing bath was found effective in preventing most of the sulfiding of the silver image during fixation. 9 p.

Capacitor calibration by step-up methods, T. L. Zapf

Step-calibration methods are used in many physical laboratories for the extension of measurements to quantities far removed from the magnitude of greatest accuracy at which absolute determinations are made. The excellent precision of repetitive substitution procedures is exploited by step-up or step-down methods to extend measurements to higher or lower magnitudes without serious degradation of accuracy. The application of step-up techniques to the calibration of variable air capacitors is described in this paper as a practical example of the method. 5 p.

April–June 1960

Measurement of cobalt-60 and cesium-137 gamma rays with a free-air chamber, H. O. Wyckoff

Design data for free-air chambers measuring cobalt-60 and cesium-137 gamma rays in roentgens are presented. It has been shown that the Jaffé-Zanstra method of obtaining the saturation current is adequate for air pressures of about 4 to 12 atmospheres. Also, radiation measurements of the gamma rays from cobalt-60 and cesium-137 made by a cavity chamber and a free-air chamber agree to within the experimental errors. 11 p.

Apparatus for the measurement of the normal spectral emissivity in the infrared, A. G. Maki, R. Stair, and R. G. Johnston

Apparatus and methods are described for measuring in the infrared the normal spectral emissivity of metals and coatings or oxides which tightly adhere to metals. Examples of the use of this apparatus are given in measurements of the emissivity of platinum and of oxidized Inconel within the spectral region of 1.5 to 15 microns. Measured values were reproduced to better than 5 percent. 4 p.

Electrostatic deflection plates for cathode-ray tubes.

I. Design of single-bend deflection plates with parallel entrance sections.

II. Deflection defocusing distortion of single-bend deflection plates with parallel entrance sections, L. Frenkel

In section I, a plate design system is offered which allows rapid and accurate determination of mechanical plate parameters to achieve given electrical plate characteristics. The design is suitable for single-bend plates with parallel entrance sections. The design curves were calculated under the conventional assumptions of small deflection theory, but corrections for the entrance and exit fields are included. The method of calculating the curves and corrections is indicated in an appendix.

Section II deals with deflection defocusing of such plates, a convenient formula for calculating the defocusing distortions of single-bend deflection plates is derived and compared with experiment. This type of distortion is proportional to the square of the deflection angle and is shown to be sensitive to plate design. In general, long deflection plates give lower distortions while the most "economical" plates yield larger distortions. Post deflection is shown to lead to increased distortions. 11 p.

The functional synthesis of linear plots, J. P. Vinti and R. F. Dressler

In practical engineering or experimental work one often encounters a function F of many variables, $F(x's, y's, z's)$, represented only by the families of curves obtained by plotting F against each of the x's on Cartesian graph paper, against each of the y's on semilog paper, and against each of the z's on double-log paper. It frequently happens that these curves are all approximately straight lines over a limited range of interest. On the assumption that they are all true straight lines, the present note shows how to synthesize all the graphical representations, for any number of parameters, into the most general formula possible, expressing F as the product of a multilinear function of the x's and the exponential of a constant-free multilinear function of the y's and of the log z's, the coefficients in both multilinear functions being independent of the x's, y's, and z's. 5 p.

Radiation field from a rectangular source, J. H. Hubbell, R. L. Bach, and J. C. Lamkin

Many radiation shielding problems involve calculations of the response of an isotropic detector to radiation of arbitrary angular distribution from uniform rectangular sources. In calculations of this type the family of integrals $\int s(\cos\theta dS/r^2) P_l(\cos\theta)$ and the integral $\int s(dS/r^2) \exp(-\mu t/\cos\theta)$ are frequently encountered, where θ is obliquity with respect to an axis perpendicular to the plane containing the rectangular radiant surface, S, r is the distance from an element of source area, dS, to the detector, μ is the attenuation coefficient, and t is the barrier thickness. Solutions of the first type of integral facilitate use of Legendre expansion representations of radiation directional distributions, and may also have application in other radiant surface studies, such as illumination and heat exchange engineering. The second integral relates to exponentially attenuated radiation from a plane isotropic rectangular source separated from the detector by a layer of material of thickness t. Formulas, expansions, and numerical results are presented. 18 p.

Microwave attenuation measurements with accuracies from 0.0001 to 0.06 decibel over a range of 0.01 to 50 decibels, G. F. Engen and R. W. Beatty

The application of certain power stabilization and measurement techniques to the problem of attenuation measurement has yielded a measurement system with a stability and resolution of the order of 0.0001 decibel. A practical application for this technique was recently provided in the calibration of a rotary vane type of variable microwave attenuator.

In order to take complete advantage of this increased stability it was necessary to apply refined techniques to the evaluation and reduction of mismatch error.

This proved to be by far the most exacting practical application of the cited techniques encountered to date, but the results of this calibration showed excellent agreement with the mathematically predicted values used in marking the attenuator dial. 7 p.

Effect of oleophobic films on metal fatigue, H. E. Frankel, J. A. Bennett, and W. L. Holshouser

The fatigue strengths of a low-alloy steel, a magnesium alloy, and a copper-beryllium alloy were increased by coating the specimens with certain polar organic compounds. Also the dispersion of the results was much less for coated specimens of these materials than for clean ones. Similar tests showed no effect with titanium or

6061 aluminum alloy, and only a slight improvement for 17–7 PH stainless steel.

The full beneficial effect of the coatings was found only with compounds having a carbon chain of at least twelve, and this effect was not significantly reduced when the coated specimens were tested in water. Organic solvents (benzene and xylene) had a deleterious effect on the fatigue life of materials that were improved by oleophobic coatings.

It is suggested that the effect of the coatings is principally due to their ability to present a barrier to water and oxygen molecules. 4 p.

Ratio-recording spectroradiometer, H. K. Hammond III, W. L. Holford, and M. L. Kuder

A ratio-recording spectroradiometer has been constructed primarily for determining the relative spectral irradiance from fluorescent lamps in the visible spectrum. Radiant flux from a test source and a comparison source is transmitted or reflected by separate diffusers. The irradiance from each diffuser is sampled alternately of the order of 100 times a second by a double prism monochromator with cam-linearized wavelength drive from 360 to 760 mμ. A 14-stage multiplier phototube with S–20 response is used with an electronic gate and integrator circuits to compare the spectral irradiances from the two sources. When the phototube outputs are unequal, a servo unit adjusts apertures in each beam to equalize them. The measured parameter is the amount of adjustment required for equalization at each wavelength. The apertures are adjusted by a cam coupled to a pen which records the ratio on a three-cycle logarithmic strip chart. The instrument requires about 8 minutes to record the spectrum at 10mμ per inch. An expanded scale of 1 mμ per inch is used for evaluating the energy in the spectral lines. The speed of wavelength scan may be made inversely proportional to the unbalance signal, if desired, to provide ample time to record spectral lines accurately. Symmetry of beam treatment is demonstrated by interchanging test and comparison sources and recording the inverse ratio. 7 p.

An intermittent-action camera with absolute time calibration, G. Hefley, R. H. Doherty, and E. L. Berger

A detailed description is presented of a film-recording system in which a randomly occurring event and its absolute time are recorded simultaneously. The system consists of a 16-millimeter framing camera capable of intermittent operation at a maximum rate of 140 frames per second (fps) and a clock capable of reading out time with an absolute accuracy of plus or minus 1 millisecond (msec). 7 p.

3.5 PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION D. RADIO PROPAGATION VOLUME 63D, JULY–DECEMBER 1959

July–August 1959

Preliminary results of the National Bureau of Standards radio and ionospheric observations during the international geophysical year, D. M. Gates

A review is given of the activities of the National Bureau of Standards during the International Geophysical Year. The equipment used on each project is described and preliminary results of the observations are given. The following areas of research are discussed: (1) World Warning Agency, (2) Ionospheric Vertical Sounding Stations, (3) VHF Propagation, (4) VHF Equatorial Forward Scatter, (5) Radio Noise Network, (6) Radio Satellite Observations, (7) Airglow Observations, and (8) World Data Center for Airglow and Ionosphere. 14 p.

Origin of [OI] 5577 in the airglow and the aurora, F. E. Roach, J. W. McCaulley, and E. Marovich

The distribution of 5577 zenith intensities at stations in the subauroral zone is found to be unimodal with no discontinuity at the visual threshold. This is interpreted as evidence that 5577 airglow and 5577 aurora may have a common origin. 4 p.

Comparison of absolute intensities of [OI] 5577 in the auroral and subauroral zones, F. E. Roach, J. W. McCaulley, and C. M. Purdy

The distribution of 5577 zenith intensities is compared for Fritz Peak, Colo., in the subauroral zone and Thule, Greenland, near the geomagnetic pole. The absolute intensity is bright enough to permit visual detection at the Colorado station during 2 percent of the time and at the Greenland station, 27 percent of the time. The distribution curves have a general similarity, suggesting a phenomenological similarity in the excitation mechanisms at the two stations. 2 p.

Origin of "very-low-frequency emissions," R. M. Gallet and R. A. Helliwell

Selective traveling-wave amplification in the outer ionosphere is postulated to explain very-low-frequency emissions, a class of very low-frequency (1 to 30 kilocycles per second) natural noise. By analogy with the mechanism of traveling wave tubes, low-level ambient noise in the outer ionosphere is amplified in streams of incoming ionized solar particles at frequencies for which the stream and wave velocities are equal. Required velocities are in the range 0.01 to 0.1 c (where c is the velocity of light). Streams with densities of the order of one electron per cubic centimeter would provide sufficient energy. Phenomena which can be explained qualitatively by the theory are the hiss, quasi-constant tones, dawn chorus and related transients, and very long trains of whistler echoes. A quantitative example shows how the theory can reproduce the general form of certain characteristic discrete spectra "hooks" of emissions, and how this leads to definite values of particle velocity and a law for the distribution of electron density in the outer ionosphere. 7 p.

Climatology of ground-based radio ducts, B. R. Bean

An atmospheric duct is defined as occurring when geometrical optics indicate that a radio ray leaving the transmitter and passing upwards through the atmosphere is sufficiently refracted that it is traveling parallel to the earth's surface. Maximum observed incidence of ducts was determined as 13 percent in the tropics, 10 percent in the arctic and 5 percent in the temperate zone by analysis of 3 to 5 years of radiosonde data for a tropical, temperate, and arctic location. Annual maximums are observed in the winter for the arctic and summer for the tropics. The arctic ducts arise from ground-based temperature inversions with the ground temperature less than −25° C while the tropical ducts are observed to occur with slight temperature and humidity lapse when the surface temperature is 30° C and greater. 6 p.

Power requirements and choice of an optimum frequency for a worldwide standard-frequency broadcasting station, A. D. Watt and R. W. Plush

Calculations are presented for the expected transmission characteristics and atmospheric noise levels in the 8- to 100-kc band. When these are combined with carrier-to-noise requirements for a given precision of frequency comparison, it is indicated that a minimum radiated power in the order of 10 to 100 kw for frequencies in the vicinity of 20 kc will be required to provide worldwide coverage. Minimum observation times of 15 to 30 min appear to be required for these transmitter powers in order to obtain a precision of frequency comparison of 1 part in 10^8 for typical transmission paths. Carrier-to-noise requirements and the factors determining this ratio are considered for typical receiving systems. 10 p.

Measurements of phase stability over a low-level tropospheric path, M. C. Thompson, Jr., and H. B. Janes

A knowledge of the statistics of atmosphere-induced variations in the phase of the received signal (i.e., variations in electrical path length) is essential in evaluating the reliability of any system using radio waves for measuring distance and/or velocity. This paper describes an analysis of phase variations measured at 9,400 megacycles per second over a 9.4-mile path near Boulder, Colorado, during a 40-hour period in September 1958. The power spectral density of these variations is shown to be approximately proportional to $f^{-2.8}$ over a wide range of frequencies throughout the period of recording. The long-term phase variations are closely correlated with atmospheric refractivity measurements made at the path terminals. 7 p.

System loss in radio wave propagation, K. A. Norton

A summary is presented of the ways in which the concept of system loss and the closely related concepts of transmission loss, basic transmission loss, propagation loss, and path antenna gain may be used for precise, yet simple, descriptions of some of the characteristics of radio wave propagation which are important in the design of radio systems. Definitions of various terms associated with the concept of system loss are given which introduce a greater flexibility into its use without any loss in precision. It is shown that the use of these added terms and concepts makes feasible the extension of the use of this method of description to any portion of the radio spectrum. A more general formula for the system loss is given which may be used for antennas with an arbitrarily small separation. Using this formula it is shown that the system loss between small electric or magnetic dipoles separated by a distance $d \ll \lambda$ can be made arbitrarily small even though the individual antennas have large circuit losses. Formulas are developed for the percentage of time that a desired signal is free of interference, and these are used to demonstrate methods for the efficient use of the spectrum. In particular, contrary to general belief, it is shown that efficiency is promoted by the use of high power and high antennas and, in the case of a broadcast service, sufficiently *small* separations so that there is appreciable mutual interference. An analysis is made of the variance of the path antenna gain in ionospheric scatter propagation. Methods are given for the calculation of the transmission loss for the ground wave and tropospheric scatter modes of propagation through a turbulent model atmosphere with an exponential gradient. Examples of such calculations are given which cover a wide range of frequencies and antenna heights. Finally, examples are given of the expected range of various tropospheric point-to-point scatter systems such as an FM multichannel teletype system, a television relay or an FM broadcast relay. 21 p.

Mode expansion in the low-frequency range for propagation through a curved stratified atmosphere, H. Bremmer

This expansion is particularly useful when considering ionospheric propagation at low frequencies. The complex problem dealing with two media, viz., a homogeneous earth and a surrounding stratified atmosphere, leads to intractable expressions. However, as the influence of the earth may be accounted for by an approximate boundary condition at the earth's surface, the problem is then reduced to that of the outer medium only. The coefficients of the mode expansion for this simplified problem will be derived while taking into account the earth's curvature; however, the latter proves to be negligible under very general conditions. The expansion to be derived is wanted in particular when studying the influence of a gradual transition in the electron density with height at the lower edge of the ionosphere. 11 p.

Transmission and reflection by a parallel wire grid, M. T. Decker

A comparison is made at X-band frequencies of the theoretical and measured transmission and reflection coefficients for a parallel wire grid. The methods used are applicable to the measurements of these factors for various building materials. 4 p.

Synoptic variation of the radio refractive index, B. R. Bean and L. P. Riggs

The synoptic variation of the atmospheric radio refractive index, evaluated from standard weather observations, is examined during an outbreak of polar continental air. It is found that the reduced-to-sea-level value of the refractive index is a more sensitive synoptic parameter than the station value. The reduced value is quite sensitive to the humidity and density structure of the storm under study while the great station elevation dependence of the station value tends to mask synoptic changes. The reduced value changes systematically with the approach and passage of the polar front. The present system shows a consistent increase of the reduced value in the warm sector of the wave and a marked decrease behind the cold front. 7 p.

Low-frequency propagation paths in arctic areas, A. D. Watt, E. L. Maxwell, and E. H. Whelan

The very low ground conductivities encountered in arctic areas, and the particular ionospheric conditions prevailing at high latitudes, can lead to rather unusual radiation and propagation conditions. In order to determine the magnitude of these effects, field intensities from transmitters located in the Labrador and Greenland areas were measured both on the surface of the earth and during several aircraft flights over this area. The many factors involved in lf propagation are considered and calculated field intensities compared with experimental values. Under conditions where the initial portion of the propagation path is across icecap or permafrost, the attenuation observed is very great, and when the propagation path extends out over sea water, the field intensity recovery taking place after the coastline is crossed is very marked. Estimates of skywave field intensity appear to agree with the observed results provided the radiated field pattern is suitably modified by the antenna cutback factor which accounts for the presence of a finitely conducting curved earth. These vertical patterns based on work by Wait, along with the field intensity flight data, indicate that the siting of low-frequency stations several miles or more inland in arctic regions may cause a great increase in total transmission path loss. 14 p.

Stratification in the lower ionosphere, C. Ellyett and J. M. Watts

A survey of the evidence for stratification in the ionosphere below 100 km is given, covering radio and optical observations, and rocket measurements. The conclusion is reached that one stratum at about 85 km is observed consistently, and that other fine structure exists but has no long time constancy of height or pattern. There is no series of preferred heights below 100 km. The authors consider explanations which may account for the observations, and advocate the testing of radio methods of exploration in conjunction with rocket measurements in order to develop the most practicable means of obtaining accurate electron density versus height profiles on a synoptic basis. 18 p.

Effect of small irregularities on the constitutive relations for the ionosphere, K. G. Budden

Irregularities in the ionosphere which are small compared with one wavelength may modify the constitutive relations, and hence, may affect the refractive indices for electromagnetic waves. The modifications are in some ways similar to those which would be introduced into the Appleton-Hartree formula by a Lorentz force. The theory is given first for the case when the irregularities extend only in one dimension, and it is found that even in a loss-free medium the refractive index now has an imaginary part

which might be associated with loss of energy from the wave by scattering. The theory for three-dimensional irregularities is then discussed but is more difficult, and a method of successive approximations is used. The results indicate that small irregularities may play an important part in the propagation of very-low-frequency radio waves in the ionosphere. In particular, they may explain why "whistlers" are observed only on comparatively rare occasions. 15 p.

Ionospheric investigations using the sweep-frequency pulse technique at oblique incidence, V. Agy and K. Davies

This paper describes the present state of oblique-incidence investigations of the ionosphere, using the sweep-frequency pulse technique, with special reference to the work carried out at the National Bureau of Standards. After a short review of the published literature, oblique-incidence sweeps are presented showing the diurnal and seasonal variations on two east-west paths of lengths 1,150 kilometers and 2,370 kilometers. The discrepancies between observed and calculated maximum usable frequencies are presented for both paths and then various phenomena of interest are shown. Finally, the above phenomena are discussed in the light of existing knowledge and theory and, in particular, it is shown that the discrepancies between observed and calculated maximum usable frequencies are unlikely to be caused by magnetoionic deviation of the ray. 24 p.

Fields in electrically short ground systems: an experimental study, A. N. Smith and T. E. Devaney

An experimental study of magnetic field distribution in a simplified radial ground system on poorly conducting soil under an electrically short, toploaded monopole is described. It is shown that the distribution is that expected from the theory of J. R. Wait in those portions of the radial system satisfying the assumptions of the theory, and that the theory may still be successfully applied for H-field power loss computations even when this is not fully the case. The particular model system studied exhibits a condition suggesting damped standing waves on the radials in the area where the radial spacing exceeds that required by the theory. 6 p.

Diffraction of electromagnetic waves by smooth obstacles for grazing angles, J. R. Wait and A. M. Conda

The diffraction of electromagnetic waves by a convex cylindrical surface is considered. Attention is confined primarily to the region near the light-shadow boundary. The complex-integral representation for the field is utilized to obtain a correction to the Kirchhoff theory. Numerical results are presented which illustrate the influence of surface curvature and polarization on the diffraction pattern. Good agreement with the experimental results of Bachynski and Neugebauer is obtained. The effect of finite conductivity is also considered. 17 p.

Very-low-frequency radiation spectra of lightning discharges, W. L. Taylor and A. G. Jean

Spectral analyses are given of the groundwave portion of 33 sferic waveforms recorded from cloud-to-ground lightning discharges which occurred at distances ranging between about 150 and 600 kilometers from Boulder, Colo. Frequencies of peak energy lie between 5 and 20 kilocycles per second, which agree favorably with other published results. The average value of energy calculated from the groundwave pulses was found to be 26,600 joules, which is lower than values derived from other experiments. Various parameters, such as the peak amplitude and duration of the first half-cycle, are related to the radiated energy of the stroke. 6 p.

Radio-wave scattering by tropospheric irregularities, A. D. Wheelon

The subject of radio-wave scattering by turbulent irregularities in the tropospheric index of refraction is reviewed. Descriptions of the turbulent medium are considered first, together with a status report on physical theories for the spectrum of irregularities. Phase and amplitude scintillations induced on electromagnetic waves propagated along line-of-sight paths are discussed next. The complementary problems of signal statistics and electromagnetic-propagation calculations are summarized and compared with available data. Both the geometrical optics and wave theory approaches are discussed. The theory of propagation beyond the horizon by scattering from the same irregularities is then described. A current review of the predictions for received power, signal fluctuations, and antenna effects is given. The paper is primarily a review of the essential and auxiliary predictions of scatter theory, but also contains a considerable amount of unpublished research by the author. 29 p.

Study at 1,046 megacycles per second of the reflection coefficient of irregular terrain at grazing angles, R. E. McGavin and L. J. Maloney

An experimental determination of the reflection coefficient over rough terrain is reported. The reflected signal received over rough terrain is considered to be made up of two components, one that is a specular component and the other a Rayleigh-distributed component. Where one terminal is low, the Rayleigh component is considered to be small with respect to the specular component but increases in relative magnitude as the height of the lower terminal increases. A terminal height is reached where the specular component is no longer significant, and the reflected energy is essentially Rayleigh-distributed. A terminal height is quickly reached above which the mean value of the reflected energy is relatively constant, of a low value, and independent of the grazing angle. 14 p.

Synoptic study of the vertical distribution of the radio refractive index, B. R. Bean, L. P. Riggs, and J. D. Horn

An analysis of the vertical structure of an intense outbreak of continental polar air is presented in terms of the radio refractive index of the atmosphere. Employed for the first time is a reduced index analogous to potential temperature. The reduced value more clearly shows the refractive index structure than the classical methods used heretofore. This new unit is a measure of both atmospheric density and humidity and shows, on a single cross section, the airmass structure and the dynamic mixing of air around the frontal interface. 6 p.

November–December 1959

Radio-refractive-index climate near the ground, B. R. Bean and J. D. Horn

The radio refractive index of air is a function of atmospheric pressure, temperature, and humidity and is found to vary in a systematic fashion with climate. It was found that the surface value of the refractive index may be estimated four to five times more accurately from charts of reduced-to-sea-level values than from similar sized charts of surface index. Worldwide maps of 5-year means of this reduced value are presented for the months of February and August, for the minimum monthly mean value of the year and for the range of monthly mean values. Year-to-year variation of monthly means is also considered. Applications of these data to the prediction of radio field strengths indicate a possible 30-decibel difference in median level of identically equipped tropospheric communications systems due to climate alone. 13 p.

Path antenna gain in an exponential atmosphere, W. J. Hartman and R. E. Wilkerson

The problem of determining path antenna gain is treated here in greater detail than previously. The method used here takes into account for the first time the exponential decrease of the gradient of refractive index with height, and a scattering cross section inversely proportional to the fifth power of the scattering angle. Results are given for all combinations of beamwidths and path geometry, assuming that symmetrical beams are used on both ends of the path and that atmospheric turbulence is isotropic. The result appears as a function of both of the beamwidths, in addition to other parameters, and thus the loss in gain cannot be determined independently for the transmitting and receiving antennas. The values of the loss in gain are generally lower than the previous estimates for which a comparison is possible. 14 p.

Effect of atmospheric horizontal inhomogeneity upon ray tracing, B. R. Bean and B. A. Cahoon

The tracing of radio rays is normally carried out under the assumption that the refractive index varies only in the vertical direction. Although this assumption appears to be quite reasonable in the average or climatic sense, it is seldom satisfied under actual conditions and is strongly violated by horizontal airmass changes occurring near frontal and land-sea interfaces. This latter case is investigated by tracing rays through two instances of observed marked horizontal variation of the refractive index. The bending for these ray paths was then compared with values obtained under the normal assumption of horizontal homogeneity.

Although at 1 kilometer and above these horizontal changes appear to have little effect, rays emitted at low elevation angles are sensitive to extreme horizontal variations of the atmosphere near the surface, such as those associated with ducting conditions. However, since it appears that such conditions occur less than 15 percent of the time at most locations, the majority of ray-path calculations may be carried out under the normal assumption of horizontal stratification of the refractive index. 6 p.

On the correlation of solar noise fluctuations in harmonically related bands, L. R. O. Storey

A method is proposed for the study of the solar corona, by observing a delayed correlation between rapid fluctuations of enhanced solar radio emission in harmonically related frequency bands. The correlation is expected in those types of emission that are produced by nonlinear plasma oscillations. The delay of the fundamental frequency with respect to the harmonic would be brought about by dispersive group retardation in the corona. The method appears to be most suitable for use with type II bursts, though it might also be applied to other types of nonthermal solar emission. 4 p.

A monochromatic low-latitude aurora, F. E. Roach and E. Marovich

A monochromatic (6300 A) auroral arc occurred over Colorado on September 29/30, 1957. It seems to have been a continuation of a similar arc observed at Haute Provence, France, on the same night. Its intensity decreased during the night from about 7,000 rayleighs to 2,000 rayleighs compared with a normal zenith intensity of 100 to 200 rayleighs. It was relatively fixed (geographically) during the night, south of and apparently independent of a visual aurora that was active to the north from 0100 to 0400 m.s.t. The magnetic dipole lines of force from the arc extend out into space between the two Van Allen radiation belts. It is speculated that the arc may be associated with one of the belts. 5 p.

Pattern synthesis for slotted-cylinder antennas, J. R. Wait and J. Householder

The radiation from a cylinder excited by an array of axial slots is discussed. A procedure for synthesizing a given radiation pattern is developed with particular attention being paid to a Tchebyscheff-type pattern. Specifying the side lobe level and the width of the main beam, the required source distributions are computed for a number of cases. The effect of using a finite number of slot elements to approximate the continuous source distribution is also considered.

Central Radio Propagation Laboratory exponential reference atmosphere, B. R. Bean and G. D. Thayer

The background and development of an exponential model of atmospheric radio refractivity, the "C.R.P.L. Exponential Reference Atmosphere" is outlined. A set of ray tracings for the model is presented in the form of tables of refraction variables for the complete range of observed values of surface refractive index. A detailed analysis of the accuracy of the ray tracing and tabulation methods is made for these tables. The variables are presented as numbers between one and ten multiplied by the appropriate power of ten, thus maintaining a maximum number of significant figures. The tables may be used for the solution of practical refraction problems involving elevation angle errors, range errors, and similar quantities. 3 p.

Excitation mechanisms of the oxygen 5577 emission in the upper atmosphere, E. Tandberg-Hanssen and F. E. Roach

Possible excitation mechanisms for the green 5577 emission are considered in the light of recent data on the dynamics of the upper atmosphere. Photochemical reactions as affected by mass motions as well as excitation directly due to the mass motions are analyzed. It is concluded that either or both mechanisms could probably account for the observed emission. 6 p.

A method for measuring local electron density from an artificial satellite, L. R. O. Storey

A method is proposed for measuring the electron density at known points in the outer ionosphere, by the use of vlf receiving equipment in an artificial satellite, in conjunction with a vlf transmitter on the ground. The transmitter would radiate continuous waves, which would be propagated through the ionosphere in the "whistler" mode. The basis of the method is a measurement of the local wave admittance of the medium, by comparison of the signals received on an electric dipole and on a loop.

A further proposal is made for an integrated vlf satellite experiment, in which several different types of observation would be made simultaneously. 16 p.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION D. RADIO PROPAGATION, VOLUME 64D, JANUARY—JUNE 1960

January–February 1960

Effect of antenna size on gain, bandwidth, and efficiency, R. F. Harrington

A theoretical analysis is made of the effect of antenna size on parameters such as gain, bandwidth, and efficiency. Both near-zone and far-zone directive gains are considered. It is found that the maximum gain obtainable from a broadband antenna is approximately equal to that of the uniformly illuminated aperture. If higher gain is desired, the antenna must necessarily be a narrow-band device. In fact, the input impedance becomes frequency sensitive so rapidly that, for large antennas, no significant increase in gain over that of the uniformly illuminated aperture is

possible. Also, if the antenna is lossy, the efficiency falls rapidly as the gain is increased over that of the uniformly illuminated aperture. 12 p.

Surface-wave resonance effect in a reactive cylindrical structure excited by an axial line source, A. L. Cullen

It is shown that a purely reactive cylinder excited by a neighboring line source can, under suitable conditions, give rise to a radiation pattern closely approximating the function $\cos n\theta$.

In a numerical example, a cylinder of three transverse electro-magnetic (T.E.M.) wavelengths circumference has a surface reactance chosen to emphasize the term $\cos 6\theta$ in the Fourier series of the resultant radiation pattern. It is shown that only 1.1 percent of the total power delivered to the line source is radiated in unwanted modes.

It is also shown that the position of the line source does not affect this result to first order provided that $k(b-a) \ll 1$, where $b-a$ is the distance of the line source from the cylindrical surface. 7 p.

Basic experimental studies of the magnetic field from electromagnetic sources immersed in a semi-infinite conducting medium, M. B. Kraichman

Using electromagnetic sources, consisting of various dipoles and loops immersed in a concentrated sodium chloride solution, measurements were made verifying the magnetic field propagation equations in air, derived previously by several authors. The receiver was farther away from the source than a wavelength in the conducting medium, but much closer than a wavelength in air.

An expression is derived giving the value of the magnetic field in air due to a rectangular loop with a horizontal axis by assuming the loop to consist of two electric dipoles corresponding to the horizontal members. Experimental data verifying this expression are presented.

Also, using submerged electric dipoles, measurements were made of the magnetic field in air which show that the field is determined solely by the current in the horizontal radiating wires of the dipoles. 5 p.

A very-low-frequency antenna for investigating the ionosphere with horizontally polarized radio waves, R. S. Macmillan, W. V. T. Rusch, and R. M. Golden

The advantages of a horizontal half-wave resonant antenna for very-low-frequency propagation experiments lie in its relatively simple and inexpensive construction and in its radiation pattern which is maximum in the vertical direction. The radiation fields of this type of antenna located at the surface of a conducting earth consist of: 1, A horizontally polarized space-wave field radiated in the perpendicular bisector plane of the antenna; and 2, a vertically polarized groundwave field radiated along the axis of the antenna. This vertically polarized field is zero at right angles to the antenna. These fields have been experimentally verified.

The use of a 50-kilocycle horizontal half-wave antenna for vertical-incidence ionospheric sounding experiments is described. The radiation pattern of this antenna is well suited for ionospheric soundings since a receiver located in the groundwave null receives only the reflected skywave signal.

Ground-resistivity measurements made at a number of locations in Central and Southern California were correlated with the geology of the terrain. This correlation showed that the ground resistivity is highest (a condition necessary for optimum antenna efficiency) in areas where the underlying rock formations are relatively unfractured. The amount of annual rainfall and other climatic conditions have little or no effect on the resistivity.

Finally, a unique antenna system is presented which employs resonant loading circuits to convert a section of an existing power line into a horizontal half-wave very-low-frequency transmitting antenna. 9 p.

Effects of high-altitude nuclear explosions on radio noise, C. A. Samson

High-altitude nuclear explosions over Johnston Island in August 1958 appear to have had a rather pronounced effect on the radio noise recorded at Kekaha, Hawaii. Graphs are presented showing the hour-to-hour variation of the noise during August at eight frequencies from 13 kc to 20 Mc. All frequencies seem to have been affected, and the drop in received noise power amounted to as much as 32 db in the hour following the first explosion. The period of time over which abnormal noise conditions were observed suggests that high-altitude nuclear explosions may have a rather persistent effect on radio communications at certain frequencies. 4 p.

Measured frequency spectra of very-low-frequency atmospherics, T. Obayashi

New spectroscopes recording continuously the amplitude-frequency spectra of vlf atmospherics have been developed. Two receivers cover the frequency ranges 1 to 10 kc and 5 to 70 kc sweeping the respective bands repeatedly, and their outputs are displayed on intensity modulated cathode-ray tubes which are photographed on slowly moving film.

Observations have been carried out since June 1958, and it appears that the results provide an excellent experimental basis for comparisons with the mode theory of vlf ionospheric propagation. It is found that the frequency spectrum of distant atmospherics indicates a pronounced absorption near 3 to 5 kc, a broad intensity maximum around 10 to 20 kc, and a general decrease towards higher frequencies with undulating peaks. The selective absorption bands appearing in the spectrum are variable according to the time of day and seasons. These changes may be interpreted loosely as an ionospheric effect which is associated with the cutoff frequency of the waveguide bounded by the earth and the ionosphere. The solar flare effect on vlf atmospherics propagation is also revealed, which indicates a sudden shift of the spectrum to higher frequencies owing to the increase of ionization and the lowering of a reflecting height of the ionosphere. 8 p.

Determination of the amplitude-probability distribution of atmospheric radio noise from statistical moments, W. Q. Crichlow, C. J. Roubique, A. D. Spaulding, and W. M. Beery

During the International Geophysical Year, the National Bureau of Standards established a network of atmospheric noise recording stations throughout the world. The ARN–2 noise recorder at these stations measures three statistical moments of the noise: average power, average voltage, and average logarithm of the voltage. An empirically-derived graphical method of obtaining an amplitude-probability distribution from these three moments, and its development, is presented. Possible errors, and their magnitudes, are discussed. 8 p.

Measurements of coastal deviation of high-frequency radio waves, C. W. McLeish

The angular deviation of the phase front of a wave propagated across a fresh water shoreline has been measured over the frequency range from 3 to 20 Mc. The deviation is found to be roughly half that which theoretically would be obtained if the same sites were adjacent to infinitely conducting surfaces. 3 p.

An exact earth-flattening procedure in propagation around a sphere, B. Y.–C. Koo, and M. Katzin

By a refinement of the procedure used in the usual earth-flattening approximation, the problem of propagation around a spherical earth is reduced to an exact

equation of the same form. Thereby the earth-flattening procedure becomes applicable to arbitrarily large heights and distances. It is also found that existing solutions of the approximate equations can be re-evaluated to yield the exact solutions for slightly different refractive index distributions. 4 p.

Limit of spatial resolution of refractometer cavities, W. J. Hartman

Filter factors that determine an upper limit for the wave numbers for which refractometer measurements can be used to calculate the spectrum of refractivity are derived in this paper based on the assumption that refractometers measure a weighted average of the refractive index in a volume of air surrounding the center of the refractometer cavity. Two models are used assuming the weighting function has spherical symmetry around the center and one model is used assuming the function has cylindrical symmetry. All models result in a simple mathematical form which should be easy to use in further theoretical developments. 8 p.

Conference on arctic communication, R. C. Kirby and C. G. Little

News and commentary on arctic communication conference. 8 p.

Tropospheric scatter propagation and atmospheric circulations, W. F. Moler and D. B. Holden

Transhorizon vhf and uhf fields exhibit deep fades or large signal enhancements of several hours' duration, as the propagation mechanism alternates between partial reflection and scattering caused by turbulent dielectric fluctuations in the atmosphere. Such alternations occur when strong refractive layers develop below 3,000 ft. Surface wind streamline analyses show that mesoscale centers of convergence or divergence cause local redistribution of refractve layering, tending to produce the change from one mechanism to the other.

Current scattering theory and the empirical findings of others are examined to determine the gross meteorological factors that influence changes in scattered fields. The two variables in the turbulent scattering coefficients, the scattering angle and the intensity of dielectric fluctuations at high wave numbers, are found to be dependent upon the refractive layering and the thermal stability of the airmass. It has been shown elsewhere that refractivity and stability are principally functions of the vertical velocity in the atmosphere. It is shown here that the direction and relative magnitude of the vertical velocity can be inferred from the upper-tropospheric wind velocity divergence. Received scattered signals are found to be well correlated with computed velocity divergence.

It is suggested that the variations of scattered signal level or range can be predicted in a routine manner by regular meteorological personnel using ordinarily available meteorological data. 13 p.

Layered earth propagation in the vicinity of Point Barrow, Alaska, G. M. Stanley

The relative field strength of a vertically polarized low-frequency radio signal was measured as a function of distance over several radial paths in the vicinity of Point Barrow, Alaska. The attenuation of the recorded signal was very much less than predicted by the theory of propagation of a ground wave signal over a plane, homogeneous, infinitely conducting earth. The analysis of these data in terms of a plane, layered, finitely conducting earth appears to resolve the anomaly. 3 p.

Optimum frequencies for outer space communication, G. W. Haydon

Frequency dependence of radio propagation and other technical factors which influence outer space communications are examined to provide a basis for the selection of frequencies for communication between earth and a space vehicle or for communication between space vehicles. 5 p.

The joint use of the ordinary and extraordinary virtual height curves in determining ionospheric layer profiles, L. R. O. Storey

An extension of Budden's matrix method for determining ionospheric layer profiles is described. When analyzing vertical incidence ionograms by the matrix method, it is usual to interpret the virtual height curve for the ordinary mode only. Errors then arise from the presence in the lower ionosphere of low-density ionization for which the plasma frequency is less than the lowest frequency observed. In the proposed extension of the method, such errors are reduced by making use of the extraordinary virtual height curve as well as of the ordinary. 14 p.

Measured statistical characteristics and narrow-band teletype message errors on a single-sideband 600-mile-long ultrahigh-frequency tropospheric radio link, E. F. Florman and R. W. Plush

Measurements of a 417 megacycles per second unmodulated radio carrier over a 600-mile tropospheric path indicated that the variations of the received carrier envelope amplitude with time over 30-minute periods roughly approximated a Rayleigh distribution in the majority of the tests. Cumulative time distributions of the carrier fade durations were obtained over a range of carrier envelope power levels and were found to resemble corresponding distributions for narrow band thermal noise. The fade rate of the carrier envelope, at the median power level, was less than 0.2 cycle per second; this comparatively low fade rate is thought to be due mainly to the narrow (1°) antenna beam widths that were used and the consequent low order of multipath propagation of the radio waves. The half hour median power levels of the received carrier varied over a range of approximately ± 8 decibels. The effective low-pass bandwidth of the carrier envelope spectrum was found to vary from 0.06 to 0.17 cycle per second. The measured median transmission loss was approximately 183 decibels which is within 3.5 decibels of the calculated value for the summer afternoon hours covered by the tests.

With antennas spaced (normal to the path) at each end by 150 wavelengths it was found that parallel-path, divergent-path, or convergent-path types of transmission gave cross-correlation coefficients of the carrier envelopes which ranged from 0.08 to 0.20. For the same antenna spacing but using crossed-path type of transmission, the cross-correlation coefficient was 0.57. Diversity measurements of single-path crossed polarization type of transmission indicated that the cross-correlation coefficient of the carrier envelopes was very close to unity.

Nondiversity narrow-band FSK error measurements indicated that an 18-decibel signal-to-noise power ratio over an effective bandwidth of 290 cycles per second (at the limiter-discriminator input) for a fading signal resulted in 0.8 percent binary errors and 4.0 percent teletype character errors. Extrapolation of these results indicates that a signal-to-noise ratio of 27 decibels is required to reduce the teletype character error rate to 0.1 percent in the same effective bandwidth. 9 p.

Impedance of a corner-reflector antenna as a function of the diameter and length of the driven element, A. C. Wilson

Impedance measurements have been made for a monopole in a corner reflector over an image plane as a function of the monopole length, diameter, and position within the corner-reflector structure. The results are presented as a family of curves which should be useful in the design of the driven element for a corner-reflector antenna of the size described in this paper and for other corner-reflector antennas with similar parameters. 3 p.

The electric field at the ground plane near a top-loaded monopole antenna with special regard to electrically small L- and T-antennas, H. L. Knudsen and T. Larsen

The present article deals with the calculation of the electric field strength at the ground plane near electrically small top-loaded antennas having a known current distribution, with special reference to L- and T-antennas. The formulas and numerical values obtained here for this component may be used in calculating the contribution to the ground losses around an antenna of the above-mentioned type due to the vertical component of the earth current.

An exact expression involving an integral has been obtained for the electric field strength at the ground plane due to the current in a linear antenna having an arbitrary inclination. If the length and the height of the antenna is small compared to the wavelength, and if the current distribution on the antenna can be expressed by a finite number of terms of a power series, it is theoretically possible to obtain a closed expression for the field at the ground plane. However, only in special cases does this expression become sufficiently simple to be of practical value for numerical calculations.

Working formulas have been obtained and numerical calculations carried out for the near zone field of an electrically small vertical or horizontal antenna with a linear current distribution. Based on these results, a calculation has been made of the electric field strength at the ground plane near electrically small L- and T-antennas. Also the relative contribution to this component due to the top loading has been calculated. 13 p.

Terrestrial propagation of very-low-frequency radio waves. A Theoretical Investigation, J. R. Wait

A self-contained treatment of the waveguide mode theory of the propagation of very-low-frequency radio waves is presented. The model of a flat earth with a sharply bounded and homogeneous ionosphere is treated for both vertical and horizontal dipole excitation. The properties of the modes are discussed in considerable detail.

The influence of earth curvature is also considered by reformulating the problem using spherical wave functions of complex order. The modes in such a curved guide are investigated and despite the initial complexity of the general solution, many interesting and limiting cases may be treated in simple fashion to yield useful and convenient formulas for calculation.

Other factors considered are the influence of the earth's magnetic field, antipodal effects, resonator type oscillations, and the influence of stratification at the lower edge of the ionosphere. 52 p.

Aurora of October 22/23, 1958, at Rapid City, South Dakota, F. E. Roach and E. Marovich

During the night of October 22/23, 1958, auroral activity at Rapid City, South Dakota, included (a) a visible aurora in the northern part of the sky and; (b) a "monochromatic" (6300 A) arc through the zenith with an azimuth 12° from east-west (geomagnetic). The intensity changes of the arc were independent of the changes in the visible aurora. It moved slowly southward during the night corresponding to a linear speed of about 8 meters per second if its height is 300 kilometers. It is suggested that it is a member of a family of monochromatic arcs which have until recently escaped detection because their red color makes them invisible even though intrinsically intense. 5 p.

May–June 1960

A theory of radar scattering by the moon, T. B. A. Senior and K. M. Siegel

A theory is described in which the moon is regarded as a "quasi-smooth" scatterer at radar frequencies. A scattered pulse is then composed of a number of individual returns each of which is provided by a single scattering area. In this manner it is possible to account for all the major features of the pulse, and the evidence in favor of the theory is presented. From a study of the measured power received at different frequencies, it is shown that the scattering area nearest to the earth is the source of a specular return, and it is then possible to obtain information about the material of which the area is composed. The electromagnetic constants are derived and their significance discussed. 13 p.

A theory of wavelength dependence in ultrahigh frequency transhorizon propagation based on meteorological considerations, R. Bolgiano, Jr.

Recent radio data indicate that the wavelength dependence of ultrahigh frequency transhorizon propagation varies widely in time. This is in contradiction with theoretical explanations previously set forth. Each attempt to account for the underlying effects of ever-present atmospheric motions has, in the past, pointed toward a unique form of the dependence. Extensive discussions have resulted as to the validity and relative merits of the various forms, but at no time has a variable wavelength dependence been proposed.

Since scatter propagation theory has predicted so satisfactorily the broad aspects of the radio signals, it is retained as the basis for further analysis. A new model is developed for the structure of refractive index fluctuations induced by turbulence. Grounded on a theory of homogeneous turbulence in a stably stratified atmosphere, which has been developed concurrently by the author, this new model provides an explanation for the observed distribution of wavelength dependence. It suggests that at times when the *dynamic stability* of the air within the scattering volume is neutral the received power should be nearly independent of radio wavelength. On the other hand, when the atmosphere is dynamically stable the signal strength should be proportional to the square, or higher power, of the wavelength.

These predictions have been tested by comparing the results of a *scaled-frequency* experiment with simultaneous meteorological data gathered along the path. Richardson's number for the 1- to 3-kilometer layer, within which the principal scattering volume lies, has been employed as an index of dynamic stability, though it falls short of ideal in some respects. The 0.8 value of correlation found between Richardson's number and the wavelength dependence is highly suggestive that a relation of the nature predicted does, in fact, exist. 7 p.

A preliminary study of radiometeorological effects on beyond-horizon propagation, F. Ikegami

A study was made of American and Japanese radiometeorological data in order to suggest the dominant factors in propagation beyond the horizon. The diurnal variability of radio field strengths seems to be sensitive to the crossover height of rays tangent to the radio horizon and disappears for crossover heights greater than about 500 meters. High hourly median field strengths were observed in Japan corresponding to the existence of a marked refractive index discontinuity layer in a common volume of two antenna beams. The results of these experiments suggest that laminar structures of the atmosphere play an important role in beyond-horizon radio propagation. 8 p.

The trade-wind inversion as a transoceanic duct, M. Katzin, H. Pezzner, B. Y.-C. Koo, J. V. Larson, and J. C. Katzin

Radiosonde data for stations in the South Atlantic trade-wind belt are analyzed to determine the potentialities of the trade-wind inversion as an elevated duct for transoceanic radio transmission. These were supplemented by refractometer soundings made by an aircraft during the latter part of 1958. These records indicate that a duct is present in the majority of the cases. Since it is known that the radiosonde underestimates ducting because of its slow response, it is concluded that a duct is present practically all the time. On the basis of the data analyzed, an experiment with two aircraft is suggested to test the propagation potentialities of this mechanism. A fre-

quency of around 200 megacycles per second appears to be a good choice for an initial experiment. 7 p.

An analysis of propagation measurements made at 418 megacycles per second well beyond the radio horizon (a digest), H. B. Janes, J. C. Stroud, and M. T. Decker

During an 18-month period in 1952 and 1953, transmission loss measurements at 418 megacycles were made over a 134-mile path between Cedar Rapids, Iowa, and Quincy, Illinois. Continuous recordings made simultaneously at several receiving antenna heights from 30 to 665 feet yielded information on diurnal and seasonal variations in both the hourly median basic transmission loss and in height gain. These data are compared to predictions made using the method developed by Rice, Longley, and Norton and are found to be in good agreement, particularly at the lower antenna heights. An analysis of the correlation of short-term signal level variations observed at horizontally and vertically spaced antennas is described. 3 p.

On the calculation of the departures of radio wave bending from normal, B. R. Bean and E. J. Dutton

The calculation of nonnormal tropospheric bending of radio waves is treated in terms of a reduced-to-sea-level value of the refractive index. This method emphasizes departures of bending from the average bending for the United States and consists of visualizing ray bending as consisting of two parts; an "average" component and a "departure-from-average" component. The "average" component comprises most of the bending and is obtained accurately from refraction tabulations while the component due to departures is easily obtained by graphical means. 5 p.

On the mode theory of very-low-frequency propagation in the presence of a transverse magnetic field, D. D. Crombie

The effect of a purely transverse horizontal magnetic field on the propagation of very-low-frequency (vlf) waves is considered. It is shown that the magnetic field introduces nonreciprocity, and that for propagation along the magnetic equator, the rate of attenuation is less for west-to-east propagation than for east-to-west propagation. 3 p.

On the theory of reflection of low- and very-low-radio-frequency waves from the ionosphere, J. R. Johler and L. C. Walters

The regiorous application of the magneto-ionic theory to the calculation of reflection coefficients for a sharply bounded ionosphere model is carried out. The paper is illustrated with computations applicable to the *D*-region or the *E*-region of the ionosphere. The quasi-longitudinal approximation is derived from this theory and the range of validity of this approximation is illustrated. The restrictions imposed by the use of a sharply bounded model ionosphere are discussed. 18 p.

Focusing, defocusing, and refraction in a circularly stratified atmosphere, K. Toman

Focusing, defocusing, astronomical refraction and path length of rays as a function of the departure angle Δ of the ray at the source is described for cases with the source outside, inside, or on the boundary of a circular stratification. Relative to zero elevation angle symmetrical and centrosymmetrical distributions are found. 2 p.

Response of a loaded electric dipole in an imperfectly conducting cylinder of finite length, C. W. Harrison, Jr., and R. W. P. King

Analytical relationships are developed which permit calculation of the power in the load impedance of an electric probe, symmetrically located within an imperfectly conducting cylinder of small radius compared to the wavelength, in terms of the electric field incident upon the cylinder. 5 p.

Impedance characteristics of a uniform current loop having a spherical core, S. Adachi

The radiation impedance is derived by the electromotive force method in a convenient form as the sum of the self-radiation impedance of a loop in the free space and an additional term due to the reaction between the loop and the sphere which is proportional to the well-known expansion coefficient of a magnetic-type scattered wave from a sphere in an incident plane wave. The first antiresonance frequency has been given in the form of a universal curve for a very small uniform current loop with core of an arbitrary composition of μ_s and ϵ_s, subject to the condition that the refraction coefficient $N=\sqrt{\mu_s \epsilon_s}$ is extremely large. Some numerical calculations show that high $-\mu$ core is desirable for a comparatively lower frequency region, and high $-\epsilon$ core is rather desirable in an antiresonance region. 5 p.

3.6. CIRCULARS

Circulars are compilations of information on various subjects related to the Bureau's scientific and technical activities. They not only include the results of Bureau studies but give data of general interest from other sources. The Circular series was discontinued in June 1959. After this date material that would formerly have been published in the Circular series has been largely directed to the Journal of Research and the new Monograph series (page 59). See "Price List of Available Publications," page 161.

C440 Supplement. Viscosities of sucrose solutions at various temperatures: Tables of recalculated values, J. F. Swindells, C. F. Snyder, R. C. Hardy, and P. E. Golden

The tables of viscosities of sucrose solutions appearing in NBS Circular 440 were calculated, assuming the value of the viscosity of water at 20° C to be 1.0050 centipoises. Subsequently, a redetermination of the absolute viscosity of water at 20° C established the value 1.0020 centipoises. In addition, more precise values have been obtained for the calibration constants of the viscometers used in the original measurements of sucrose solutions upon which the tables were largely based. Incorporating these more precise values, the above tables have been recalculated. July 31, 1958. 7 p.

C467, Vol. III. Atomic energy levels, C. E. Moore

The compilation of Atomic Energy Levels as derived from the analyses of optical spectra, exclusive of hyperfine structure, has continued. Volume I of Circular 467, issued in 1949, contained data for 206 spectra of the first 23 elements in the periodic table, hydrogen through vanadium. The energy levels are listed by terms starting with the ground state zero. A uniform style of notation is used, and for complex spectra arrays of observed terms are included for comparison with similarly arranged arrays of predicted terms, which are given in the Introduction for each isoelectronic sequence. For each spectrum a brief discussion of the analysis is given, together with a detailed bibliography. Limits and ionization potentials are given when known. Similarly, the configurations of the individual terms are included together with g-values derived from the observed Zeeman patterns.

Volume II issued in 1952, is similarly arranged. It includes data for 152 spectra of the 18 elements chromium through niobium.

Volume III was issued in 1958, continuing the program to heavier elements. This volume contains similar data for 124 spectra of 32 elements, molybdenum through lanthanium and hafnium through actinum.

This completes the periodic table for the two groups of elements known as rare earth. The atomic spectra of these elements will be covered in Volume IV of Circular 467, which is now being started.

These volumes contain much unpublished material and are useful to workers in many fields of science. This program has stimulated work on spectrum analysis not only in the laboratory but also among theoretical workers. Circular 467, Volume I, June 15, 1949. 309 p. Circular 467, Volume II, August 15, 1952. 227 p. Circular 467, Volume III, May 1, 1958. 245 p.

C539, Vol. 7. Standard X-ray diffraction powder patterns. Data for 53 substances, H. E. Swanson, N. T. Gilfrich, and M. I. Cook

Fifty-three standard X-ray diffraction powder patterns are presented. Forty-six are to replace sixty-two patterns already represented in the X-ray Powder Data File, and seven are for substances not previously represented. The X-ray Powder Data File is a compilation of diffraction patterns from all sources and is used for the identification of unknown crystalline materials by matching spacing and intensity measurements. In this Circular, comparison is made of all powder diffraction data available for each of the substances reported. The patterns were made with a Geiger counter X-ray diffractometer, using samples of high purity. The *d*-values were assigned Miller indices determined by comparison with calculated interplaner spacings and from space group considerations. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible.

Included are X-ray data for the following fifty-three substances: $AlCl_3{\cdot}6H_2O$, NH_4NO_3, $(NH_4)_2C_2O_4{\cdot}H_2O$, NH_4ClO_4, $BaMoO_4$, BaS, $BaWO_4$, $CdCO_3$, CdSe, $CaCrO_4$, $Ca(NO_3)_2$, CaS, Cs_2SO_4, $AuSb_2$, AuSn, LaF_3, LaOCl, $PbMoO_4$, $PbWO_4$, $LiIO_3$, $LiNO_3$, $MgCO_3$, $MgSO_4{\cdot}7H_2O$, MgS, $MnCO_3$, Hg_2Br_2, HgSe, $NiSO_4{\cdot}6H_2O$, $KBrO_3$, KCNO, K_2TiF_6, KIO_4, $KMnO_4$, RbBr, $AgClO_3$, Ag_2MoO_4, Ag_2SO_4, $NaIO_4$, $NaClO_4$, $SrMoO_4$, SrS, $SrWO_4$, NH_4SO_3, TeO_2, TlBr, Tl_4PO_4, $TlPO_4$, SnTe, $CO(NH_2)_2$, Zn_2SiO_4, $ZnSO_4$, and $Zr(SO_4)_2{\cdot}4H_2O$. September 27, 1957. 70 p.

C539, Vol. 8. Standard X-ray diffraction powder patterns. Data for 61 substances, H. E. Swanson, N. T. Gilfrich, M. I. Cook, R. Stinchfield, and P. C. Parks

Sixty-one standard X-ray diffraction powder patterns are presented. Thirty-three are to replace thirty-nine patterns already represented in the X-ray Powder Data File, and twenty-eight are for substances not previously represented. The X-ray Powder Data File is a compilation of diffraction patterns from all sources and is used for the identification of unknown crystalline materials by matching spacing and intensity measurements. In this Circular, comparison is made of all powder diffraction data available for each of the substances reported. The patterns were made with a Geiger counter X-ray diffractometer, using samples of high purity. The *d*-values were assigned Miller indices determined by comparison with calculated interplanar spacings and from space group considerations. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible.

Included are X-ray data for the following sixty-one substances: $Al_2O_3{\cdot}6CaO{\cdot}3SO_3{\cdot}31H_2O$, $(NH_4)_3SeBr_6$, $(NH_4)_2TeBr_6$, $(NH_4)_2IrCl_6$, $(NH_4)_2PdCl_6$, $(NH_4)_2TeCl_6$, NH_4VO_3, $(NH_4)_3PO_4(MoO_3)_{12}{\cdot}4H_2O$, Be_2SiO_4, BiOBr, $CaBr_2{\cdot}6H_2O$, $Ca(HCO_2)_2$, CaF_2, $CsBrO_3$, Cs_2PtBr_6, Cs_2SeBr_6, $CsClO_3$, $CsCr(SO_4)_2{\cdot}12H_2O$, CsBF$_4$, $CsGa(SO_4)_2{\cdot}12H_2O$, Er_2O_3, $GaPO_4$ (α-quartz type), GeO_2 (tetragonal), $InPO_4$, $Pb(HCO_2)_2$, Pb_3O_4 (minimum), $Pb_5(PO_4)_3OH$ (lead hydroxyapatite), $LiClO_4{\cdot}3H_2O$, NdF_3, NdOCl, $NiSiF_6{\cdot}6H_2O$, $NbSi_2$, K_2PtBr_6, K_2SeBr_6, $KReO_4$, $K_3PO_4(MoO_3)_{12}{\cdot}4H_2O$, KCNS, $RbBrO_3$, Rb_2TeBr_6, $RbClO_3$, Rb_2TeCl_6, Rb_2SO_4, $ScPO_4$, AgI (iodyrite), $AgReO_4$, $Na_2CO_3{\cdot}H_2O$ (thermonatrite), $Sr(HCO_2)_2$, $Sr(CHO_2)_2{\cdot}2H_2O$, $SrI_2{\cdot}6H_2O$, $TaSi_2$, $TlBrO_3$, $TlClO_3$, $TlIO_3$, TlCNS, Ti_5Si_3, WS_2, V_2O_5, YPO_4 (xenotime), $ZnCO_3$ (smithsonite), $ZnSiF_6{\cdot}6H_2O$, and $ZnSO_4{\cdot}7H_2O$ (goslarite). April 1, 1959. 76 p.

C539, Vol. 9. Standard X-ray diffraction powder patterns. Data for 43 substances, H. E. Swanson, M. I. Cook, T. Isaacs, and E. H. Evans

Forty-three standard X-ray diffraction powder patterns are presented. Thirty-one are to replace forty-one patterns already given in the X-ray Powder Data File, and twelve are for substances not previously included. The X-ray Powder Data File is a compilation of diffraction patterns from all sources and is used for the identification of unknown crystalline materials by matching spacing and intensity measurements. In this Circular, comparison is made of all powder diffraction data available for each of the substances reported. The patterns were made with a Geiger counter X-ray diffractometer, using samples of high purity. The *d*-values were assigned Miller indices determined by comparison with calculated interplaner spacings and from space group considerations. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible.

Included are X-ray data for the following forty-three substances: α-Al_2O_3 (corundum), NH_4N_3, $(NH_4)HCO_3$ (teschemacherite), $(NH_4)_2PtBr_6$, NH_4ReO_4, $(NH_4)_2SO_4$ (mascagnite), $BeAl_2O_4$ (chrysoberyl), $Be_3Al_2(SiO_3)_6$ (beryl), BiOI, $CdBr_2$, $CdCl_2$, $12CaO{\cdot}7Al_2O_3$, $Ca_3Fe_2Si_3O_{12}$ (andradite), Cs_2TeBr_6, $CsNO_3$, β-$CrPO_4$, $CoAl_2O_4$, CoO, Co_3O_4, Dy_2O_3, $ErPO_4$, Ho_2O_3, $MgCr_2O_4$ (picrochromite), $MnAl_2O_4$ (galaxite), $MnFe_2O_4$ (jacobsite), Mn_2O_3 (partridgeite), HgO (montroydite), $Nd[(C_2H_5)SO_4]_3{\cdot}9H_2O$, $NiAl_2O_4$, Ni_2GeO_4, KBH_4, $K_3Co(NO_2)_6$, K_2ZrF_7, PrOCl, γ-AgI, $AgIO_4$, $NaBH_4$, $SrZrO_3$, S, TeO_2 (tellurite), Tm_2O_3, $TiO_{1.515}$, and ZnI_2. February 25, 1960. 64 p.

C552, 3d ed. Standard materials. Issued by the National Bureau of Standards

A descriptive listing of the various Standard Materials issued by the National Bureau of Standards is given. A schedule of fees and weights, as well as directions for ordering, is included. Summarized tables of analyses are presented, to indicate the type of standards of composition presently available. Announcements of new standards will be made in scientific and trade journals, and the current status of the various standards will be indicated by an *insert sheet* issued with this Circular. April 8, 1959. 27 p. (Supersedes C552, 2d ed., April 15, 1957).

C563, 1st Supplement. Periodicals and serials received in the Library of the National Bureau of Standards, August 1958, N. J. Hopper and H. W. Reinhart

This supplement lists new periodical titles added to the collection of the National Bureau of Standards Library from April 1955 to August 1958. It also includes changes in title, titles that have ceased publication, and titles that are no longer received.

A list of Russian periodicals currently received, and also of translations of Russian periodicals, is included at the end of this publication.

The footnote references are the same as those used in the original list. December 30, 1958. 10 p.

C577 Supplement. Energy loss and range of electrons and positrons, A. T. Nelms

Tabulations of the mean energy loss due to ionization and excitation which include the density effect and the range derived from this quantity are given for electrons and positrons in several materials. July 30, 1958. 31 p.

C583 Supplement. X-ray attenuation coefficients from 10 kev to 100 Mev, R. T. McGinnies

A revision is given of the X-ray attenuation coefficients presented in National Bureau of Standards Circular 583. Table 4 of that publication is eliminated, and a new table is given for each material for photon energies less than 100 kev. The uncertainties in the estimates of attenuation coefficients at low energies are from 3 to 5 percent, which is the same as was previously given at higher energies. The cross sections for scattering are unchanged. Two values are listed for the photoelectric cross section, one calculated from the Sauter-Stobbe formulas and the other derived from new experimental evidence. The procedures for smoothing experimental data are described and are generally the same as were used in Circular 583. In addition to the systematic coverage of the region from 10 kev to 100 Mev, some data are included for a number of elements based on experimental measurements below 10 kev and above 100 Mev. A comparison is made between calculated and experimental total attenuation coefficients at energies above 10 Mev. October 30, 1959. 10 p.

C584. Simulator for use in development of jet engine controls, E. S. Sherrard

A method of simulation and cost estimates of simulator components are given for a simulator to be used in the development of turbojet engine control systems for aircraft. The simulator employs typical d-c analog computer components. It is capable of representing a twin-spool, variable-nozzle, afterburning turbojet engine, as well as the engine's controller. The simulator is of moderate accuracy, flexibility, and cost. It is intended to be used in the determination of the stability and performance of the engine control system. September 16, 1957. 17 p.

C585. The measurement of thickness, G. Keinath

The numerous methods for the measurement of thickness in laboratory or shop are treated in seven groups according to physical operating principles: Mechanical—weight/dimension relationships, acoustics, vibration, displacement with various conversions; chemical—stripping, spectrochemical analysis; electrical—dielectric breakdown, resistance, electrochemical, capacitance, thermoelectricity; magnetic—attractive force, reluctance, saturation, inductance, eddy currents; optical—microscopy (also electron microscopy), interferometry, diffraction, shadow; X-ray—absorption, diffraction backscatter, spectrometry; radioactive radiation—absorption, backscatter, tracers. Ranges, accuracies, advantages, and limitations are discussed. A bibliography of references, a limited list of suppliers, and a detailed index of the gages, methods, applications, and trade names covered are appended. January 20, 1958. 79 p.

C586. Electric hygrometers, A. Wexler

This Circular is a review of the art of measuring the moisture content of air by the methods of electric hygrometry. The basis of these methods is the change in electrical resistance of a hygroscopic material with change in humidity. September 3, 1957. 21 p.

C587. Electroforming of waveguide components for the millimeter-wavelength range, A. A. Feldmann

The technique of electroforming has become very important in the production of precision waveguide components. In the millimeter-wavelength range it represents almost the sole method of construction for precision components. Given machine-shop facilities, normal laboratory facilities, and a few auxiliary items, electroforming of the best quality can be done without much difficulty. This is of particular importance to research workers in university or Government laboratories. Simple techniques are outlined that permit the production of high-quality millimeter components with a minimum of equipment, time, or specialized knowledge of electrodeposition. November 15, 1957. 13 p.

C588. Determination and correlation of flow capacities of pneumatic components, D. H. Tsai and M. M. Slawsky

Some of the problems of measurement and correlation of flow capacities of pneumatic components are discussed. A dimensionless "area factor," defined as the ratio of the "effective area" of the component to some reference area (equation 7), is introduced. The physical significance of the area factor and its experimental determination are discussed in some detail. Sample data are also included to show that this area factor provides a valid and convenient basis for comparing the flow capacities of components, regardless of their size and design, and over a wide range of test conditions. October 15, 1957. 7 p.

C589. Tables of dielectric dispersion data for pure liquids and dilute solutions, F. Buckley and A. A. Maryott

Primary dielectric dispersion data and characterisvic dispersion parameters are tabulated for almost 200 substances in the liquid state and for dilute aqueous and nonaqueous solutions with more than 150 solutes. There are 6 tables and 1 section of graphs. There are 4 tables for pure liquids, 2 containing summaries of the derived dispersion parameters and 2 containing the primary data. The section on graphs supplements the tables for pure liquids and contains reproductions of pertinent data that are available only in the form of graphs. November 1, 1958. 95 p.

C590. Methods of testing thermocouples and thermocouple materials, Wm. F. Roeser and S. T. Lonberger

Various methods used for testing thermocouples and thermocouple materials and the precautions that must be observed in order to attain various degrees of accuracy are described. In particular, the methods that have been developed and used at the National Bureau of Standards are outlined in detail, and some guidance is given to the reader in the selection of the method best adapted to a given set of conditions.

Consideration is given primarily to the calibration of platinum versus platinum-rhodium, copper-constantan, Chromel-Alumel, and iron-constantan thermocouples. February 6, 1958. 21 p. (Supersedes RP768).

C591, Sect. 1. System design of digital computers at the National Bureau of Standards: methods for high-speed additions and multiplication

1. A logic for high-speed addition, A. Weinberger and J. L. Smith

A method is described whereby increased speed of operation in a binary digital adder is obtained by organizing the electronic elements for the carry-generating network into a more efficient system. This network is so organized that certain special auxiliary functions of the digits in the two numbers to be added are formed during the early phases of the addition cycle. These auxiliary functions are used during subsequent phases of the cycle to generate the carry digits in large groups simultaneously instead of generating each carry individually and sequentially as is the case in conventional adder designs.

When associated with a suitably fast storage device, this type of adder permits the design of arithmetic processing units that operate up to 150 times faster than earlier National Bureau of Standards computers, using the same basic types of electronic elements.

2. Shortcut multiplication for binary digital computers J. L. Smith and A. Weinberger

A method for increasing the basic multiplication speed of a computer is described in which certain time-consuming

but non-essential steps are omitted. Such steps are ordinarily included when the elementary definition of binary multiplication as a simple sequence of repeated addition and single-position shift operations is applied in a straightforward fashion. It is shown that most of these elementary steps can be omitted for any continuous string of similar digits that occurs in the multiplier number. Fullest advantage of this can be taken if provision is made to perform various multiposition shifts as rapidly as possible. Implementing the method requires the continual sensing of several of the multiplier digits in advance in order to discover which of the elementary steps are non-essential and can be omitted. Speed factors of up to 3 over conventional methods can generally be obtained. February 14, 1958. 22 p.

C592. Nickel and its alloys, J. G. Thompson

A review is presented of available information about the occurrence, recovery and refining, properties, and uses of high-purity and commercial forms of nickel, and about the properties and industrial applications of its important alloys. The Circular is a revision of National Bureau of Standards C485 issued in 1950. February 5, 1958. 87 p. (Supersedes C485).

C593. The federal basis for weights and measures. A historical review of Federal legislative effort, statutes, and administrative action in the field of weights and measures in the United States, R. W. Smith

A review is presented, for the period 1776–1956, very largely in chronological form, of congressional efforts and accomplishments in the general weights and measures area, with particular emphasis on units and standards.

Certain important and closely related administrative actions initiated by Hassler and Mendenhall in the nineteenth century are cited. Current Federal statutes having weights and measures significance are discussed briefly. In its entirety the Circular presents a connected and reasonably comprehensive story of the Federal contribution to the legislative basis for weights and measures administration in the United States. June 5, 1958. 23 p.

C594. Preparation, maintenance, and application of standards of radioactivity, W. B. Mann and H. H. Seliger

The methods available for the preparation and maintenance of primary and secondary standards of radioactivity are reviewed, and the applications of such standards to problems in physics are discussed. June 11, 1958. 47 p.

C595. Tables of transport integrals $J_n(x) \equiv \int_0^x \frac{e^z z^n dz}{(e^z-1)^2}$,

W. M. Rogers and R. L. Powell

The transport integrals, $J_n(x)$, defined by

$$J_n(x) \equiv \int_0^x \frac{e^z z^n dz}{(e^z-1)^2},$$

are utilized often in the development of theories describing the thermal conductivity, electrical conductivity, thermal electromotive force, specific heat, and other similar transport properties of solids. The tables include values to six significant figures of the integral for the index integer n ranging from 2 through 17, and for the limit of integration x ranging from 0.1, by 0.1 intervals, to the limiting upper value, that ranges from 25 for n=2 to 40 for n=17. The three series utilized to represent the integral in different ranges are derived. The limiting values in the upper range and the asymptotic series expansions in the lower range are also given. Auxiliary tables include the values of the Riemann Zeta numbers and Bernoulli numbers utilized in the calculations. July 3, 1958. 46 p.

C596. Single-phase transfer of liquefied gases, R. B. Jacobs

The problems encountered in the single-phase transfer of liquefied gases are discussed in detail. A general system of equations and the empirical information required for the design of long-distance transfer systems are presented.

A closed-form solution of the mathematical equations for incompressible flows is obtained and discussed. Information required for numerical computations involving helium, hydrogen, nitrogen, and oxygen is presented in graphical form. The numerical solution for three general problems involving hydrogen and oxygen are obtained. December 1, 1958. 42 p.

C597. Energy spectrum resulting from electron slowing down, R. T. McGinnies

The process of electron slowing down is described qualitatively and the resulting energy spectrum defined in terms of differential track length. A method developed by Spencer and Fano for the calculation of the electron spectra has been applied extensively by means of an automatic computer. The accumulation of secondary knock-on electrons is included in the calculations and bremsstrahlung losses are neglected. Tabulations of differential track length are given for aluminum, copper, tin, lead, air, water, bone, muscle, and polyethylene (C_2H_4), with up to 17 source energies each. Source energies range from 10.46 million electron volts to 6.438 kilo electron volts. A tabulation of the probability for the production of knock-on secondary electrons is also given. These data are an abstract of a much larger tabulation, printed by the computing machine, which is available on loan from the library of the National Bureau of Standards. February 20, 1959. 16 p.

C598. Techniques for accurate measurement of antenna gain, H. V. Cottony

Comparison of published results of experimental antenna measurements, particularly gains, reveals apparent discrepancies of the order of one or more decibels. Experimental work at the National Bureau of Standards on scaled model antennas for long-range VHF communication via ionospheric scatter revealed some sources of difficulties and led to the adoption of special precautions resulting in significantly more consistent and, it is believed, more accurate results. The procedures are based on the comparison method but include, in addition to the standard antenna, the use of a third antenna here designated as the reference antenna. To obtain more accurate measurements it was found essential to correct for the standing wave pattern in the field set up, presumably, by reflections from the irregularities in the terrain. Special features of instrumentation, including methods for minimizing and measuring matching losses, are described. The accuracy of the techniques has been verified by measuring the gain of an antenna, the value of which could be accurately calculated. December 1958. 10 p.

C599. On the theory of fading properties of a fluctuating signal imposed on a constant signal, H. Bremmer

This paper deals with a theoretical investigation of the fading properties of a signal composed of a fluctuating contribution, and another steady contribution with fixed amplitude and phase. It is assumed that the central limit theorem may be applied to two proper quantities describing the fading signal as a quasi-monochromatic function of the time. The results are applicable to any autocorrelation function for the fluctuating contribution.

The first part of the paper (sections 1 to 16) is mainly restricted to the idealized case in which any two components of the fluctuating part of the complete signal that are in quadrature with respect to their phase do have identical statistical properties; the fluctuating part is then termed a "random" signal. This idealized case is shown to constitute but an approximation if applied to the fluctuating field due to first order scattering in a turbulent

atmosphere. Therefore, in the second part of the paper (sections 17 to 26) the theory has been extended to fluctuating contributions (then termed "quasi-random" contributions) not satisfying the above condition of isotropy. All results then depend on two complex correlation functions $a(\tau)$ and $b(\tau)$ instead of on the single function $a(\tau)$ governing the simplified theory. In contrast to $a(\tau)$, the function $b(\tau)$ does not exclusively depend on the energy spectrum of the fluctuating contribution.

The fading properties investigated for the composed signal are the distribution functions of both the amplitude and phase, as well as the average number of crossings of each of them (per unit time interval) through any given level. The complicated general formulas reduce to simple expressions in the two extreme cases of (a) absence of the steady signal (e.g., tropospheric scatter propagation to distances far beyond the transmitter's horizon), and (b) predominance of the steady signal (e.g., line of sight propagation to distances well within the horizon). The first limiting case leads, when neglecting the influence of $b(\tau)$ (then being very small), to the well-known Rayleigh distribution for the amplitude, to a homogeneous distribution for the phase, and to a fading rapidity (defined as the average number of crossings per unit time interval through the level most frequently passed) which is for the amplitude faster than for the phase by a factor of 3.04. The second limiting case amounts to normal distributions for both amplitude and phase, and to fading rapidities of these quantities which are only identical insofar as the different behaviour of the in-phase and in-quadrature component (with respect to the steady signal) does have no numerical importance. On the other hand, measurements of the difference in the amplitude-fading rapidity and the phase-fading rapidity will reveal the effect of the asymmetry with respect to the two mentioned components of the scattered signal. May 25, 1959. 32 p.

C600. Calibration of liquid-in-glass thermometers, J. F. Swindells

This Circular contains information of general interest to both manufacturers and users of liquid-in-glass thermometers, as well as those who wish to calibrate thermometers or submit them to the National Bureau of Standards for calibration. Important elements of thermometer design are discussed, and eligibility requirements for certificates or reports of tests are given. Factors affecting the use of common types of liquid-in-glass thermometers are included together with tables of tolerances and reasonably attainable accuracies. The calculation of corrections for the temperature of the emergent stem is given in detail for various types of thermometers and conditions of use. The Circular also describes the techniques and equipment used in the calibration procedures and provides instructions for applicants requesting thermometer calibration services. January 8, 1959. 21 p. (Supersedes C8).

C601. Recorder survey: recording surfaces and marking methods, G. Keinath

This Circular surveys the characteristics and comparative advantages of continuous traces, dotted traces, and printed characters, as produced by inking, incision, impression, indentation, deposition, heat, light, electric discharge, electron beam, magnetism, chemical action, or fluid streamlines. Descriptive and reference material is included on three physical components of the recording system—the reservoir of material or energy, the marking point or matrix positioned by the measuring element, and the chart surface which preserves the record. September 1, 1959. 41 p.

C602. Testing of glass volumetric apparatus, J. C. Hughes

This Circular contains specifications and tolerances for glass volumetric apparatus of precision grade. Detailed information is given as to dimensions, graduations, inscriptions, and tolerances for burets, pipets, flasks, cylindrical graduates, and certain kinds of special apparatus.

A description of test methods used and the reports furnished and directions for submitting apparatus are included. April 1, 1959. 14 p. (Supersedes C434).

C603. Stark broadening functions for the hydrogen lines, A. B. Underhill and J. H. Waddell

Numerical values of the intensities of the Stark components of the hydrogen lines and the Stark broadening functions, $S(\alpha)$, are presented for all series members up to and including $n=18$. The $S(\alpha)$ functions are tabulated for lines of the Balmer, Lyman, Paschen, and Brackett series of hydrogen. The data can be used to compute self-consistent profiles of the hydrogen lines in stellar spectra. May 1, 1959. 94 p.

3.7. MONOGRAPHS

Monographs are usually contributions to the technical literature which are too lengthy for publication in the Journal of Research. They often provide extensive compilations of information on subjects related to the Bureau's technical program. Until July 1959 most of this type of material was published in the Circular series (page 55). See "Price List of Available Publications," page 161.

Mono. 1. Energy dissipation by fast electrons, L. V. Spencer

Tabulations are given of the energy dissipated by fast electrons at different distances from monoenergetic electron sources, for plane perpendicular and point isotropic sources. A summary of the theoretical methods and data utilized, and a table of spatial moments are also included. September 10, 1959. 70 p.

Mono. 2. Temperature-induced stresses in solids of elementary shape, L. H. Adams and R. M. Waxler

In general, a solid subjected to non-uniform temperature change develops internal stresses. These are determined by, (1) the temperature distribution within the solid, and (2) certain physical constants of the material. Although the necessary fundamental relations are known, the computation of stresses in even simple solids has heretofore been a tedious operation. For two varieties of heating, the equations determining stress have now been put in convenient form for practical use, and tables of certain temperature functions are offered as a means of quickly determining stresses in a slab, in a cylinder, or in a sphere subjected to either of two modes of heating. The temperature-distribution tables independently will provide a useful means for the ready estimation of temperature gradients. June 21, 1960. 27 p.

Mono. 3, Vol. I. Table of wavenumbers, 2000 A to 7000 A, and Vol. II. Table of wavenumbers, 7000 A to 1000 μ, C. D. Coleman, W. R. Bozman, and W. F. Meggers

A two-volume table for converting wavelengths in standard air to wavenumbers in vacuum was computed by using the equation $\sigma_{vac}=1/\lambda(n_{air})$, where n was computed from Edlén's 1953 equation for the refractive index of air. Wavenumbers are given to the nearest 0.001 K(cm^{-1}) for wavelengths from 2000 to 7000 A in Volume I, and 7000 A to 1000 μ in Volume II. Proportional tables are given for linear interpolation between entries of λ. Also included are the vacuum increase in wavelength, $\lambda(n-1)$; and the refractivity of standard air in the form $(n-1)$ 1000. Mono. 3, Vol. I, May 2, 1960. 500 p. Mono. 3, Vol. II, May 16, 1960. 534 p.

Mono. 4. CRPL exponential reference atmosphere, B. R. Bean and G. D. Thayer

The background and development of an exponential model of atmospheric radio refractivity, the CRPL Exponential Reference Atmosphere, is outlined. A set of ray tracings for the model is presented in the form of tables of refraction variables for the complete range of observed values of surface refractive index. A detailed analysis of the accuracy of the ray tracing and tabulation methods is made for these tables. The variables are presented as numbers between 1 and 10 multiplied by the appropriate power of 10, thus maintaining a maximum number of significant figures. The tables may be used for the solution of practical refraction problems involving elevation angle errors, range errors, and similar quantities. October 29, 1959. 67 p.

Mono. 5. Preservation of documents by lamination, W. K. Wilson and B. W. Forshee

The chemical stability and physical properties of cellulose acetate film used to preserve and restore old or damaged documents by lamination were investigated. Pretreatment of documents with alkaline media before lamination is desirable if the paper contains an appreciable amount of acid. The lamination process does not degrade cellulose acetate film to a measurable extent. Acid-free papers are not degraded during lamination, but papers containing acid are degraded in proportion to the amount of acid present. Tissue added to the laminate increases the tensile strength and internal tear resistance, but decreases edge-tear resistance as compared to that of film alone extending beyond the paper.

The loss of plasticizer with time from a cellulose acetate laminating film does not impair the properties of the laminate. Composition and performance specifications for a cellulose acetate laminating film suitable for archival use are presented. The properties of polyethylene and polyethylene terephthalate films of interest in connection with their possible use for the protection of documents are discussed. October 30, 1959. 20 p.

Mono. 6. Properties of high-temperature ceramics and cermets. Elasticity and density at room temperature, S. M. Lang

In order to provide some of the basic data necessary for the effective utilization of ceramics and cermets in various high-temperature applications, a specimen "bank" of such materials, mainly commercially fabricated, was established for the measurement of physical properties and constants. This Monograph describes: (1) The materials and some of their fabrication data; (2) bulk densities; (3) theoretical densities; and (4) the dynamic room-temperature elastic constants. Data are given for 46 sets of specimens, representing 20 different materials; these include oxides, carbides, borides, cermets, and an intermetallic compound. A statistical evaluation was used for analyzing the data.

Results of the room-temperature measurements show that: (1) Significant variations are common both in the specimens of one group and from group to group of specimens prepared of the same material; (2) the largest variations occur for specimens formed by hot-pressing, although average values are higher for hot-pressed specimens; and (3) measurements of the dynamic elastic constants by the sonic method are more sensitive as indicators of homogeneity and group uniformity than bulk-density measurements. March 1, 1960. 45 p.

Mono. 7. Precise measurement of heat of combustion with a bomb calorimeter, R. S. Jessup

This Monograph gives detailed descriptions of apparatus and methods which are used at the National Bureau of Standards for precise determinations of heats of combustion of liquid hydrocarbon fuels. Numerical examples are given of methods of calculating results of measurements from observed data. The technique of making and filling glass bulbs to contain samples of volatile liquid fuels is described.

The accuracy of the methods described is about 0.1 percent. This is intermediate between the accuracy of 0.01 or 0.02 percent attained in certain measurements on pure compounds, and the accuracy of several tenths of one percent obtainable with published standard procedures for measurements on fuels. February 26, 1960. 23 p.

Mono. 8. Mercury barometers and manometers, W. G. Brombacher, D. P. Johnson, and J. L. Cross

The various designs of mercury barometers and manometers are briefly described, with a more extended discussion of the various design elements which may affect the achievable accuracy. Sources of error in measuring pressures are described in considerable detail, particularly for portable instruments, including scale, temperature, gravity, capillarity, vacuum errors and return gas column. Methods of minimizing those errors and of making the corrections, including extensive tables, are presented. Standard conditions are defined and the pertinent properties of mercury given. The paper contains 65 literature references. May 20, 1960. 59 p.

Mono. 9. A method for the dynamic determination of the elastic, dielectric, and piezoelectric constants of quartz, S. A. Basri

Several dynamic determinations have been made of the constants of quartz. Most of these determinations do not take into account the piezoelectric effect; those that do, suffer from certain deficiencies which are discussed in this paper.

Taking into account the piezoelectric effect, expressions for the frequency of longitudinal vibration of rectangular bars and thickness shear vibration of infinite plates are derived and applied to the determination of the constants of quartz. On the basis of present theoretical knowledge, it is suggested that the best procedure is to measure the frequency of vibration of 2 particular cuts for rectangular bars, and 7 cuts for plates, and to measure the capacitance at zero frequency of a rectangular bar. These 10 measurements provide the data for determining the 6 elastic, 2 dielectric, and 2 piezoelectric constants of quartz uniquely.

For accurate measurements, it will first be necessary to determine the linear coefficients of expansion of quartz to higher accuracy than is available at present. June 1, 1960. 22 p.

Mono. 10. The "1958 He^4 scale of temperatures". Part 1. Introduction, F. G. Brickwedde and Part 2. Tables for the 1958 temperature scale, H. van Dijk, M. Durieux, J. R. Clement, and J. K. Logan

The generally used practical scale of temperatures between 1° and 5.2° K is the He^4 vapor pressure scale based on an accepted vapor pressure equation or table. In Sèvres (near Paris), October 1958, the International Committee on Weights and Measures recommended for international use the "1958 He^4 Scale" based on a vapor pressure table arrived at through international cooperation and agreement. This table resulted from a consideration of all reliable He^4 vapor pressure data obtained using gas themometers, and paramagnetic susceptibility and carbon resistor thermometers The theoretical vapor pressure equation from statistical thermodynamics was used with thermodynamic data on liquid He^4 and the vapor equation of state to insure satisfactory agreement of the vapor pressure table with reliable thermodynamic data. (Reprinted from the Journal of Research of the NBS—A, Physics and Chemistry, Vol. 64A, No. 1, January–February 1960). June 17, 1960. 17 p.

Mono. 11. Conductive flooring for hospital operating rooms, T. H. Boone, F. L. Hermach, E. H. MacArthur, and R. C. McAuliff

Characteristics and performance of available types of conductive flooring materials were investigated in the

laboratory. The study showed that the electrodes and instruments used to measure the floor greatly affected the measured resistance, but that the method specified by the National Fire Protection Association for measuring the electrical resistance reasonably simulated the conditions under which a floor functions in reducing electrostatic hazards. The physical, chemical and serviceability characteristics of conductive floorings investigated showed results comparable with those of nonconductive flooring of the same type. Consequently, with some limitations, an architect may base his choice of a conductive flooring material on his knowledge of the behavior of similar nonconductive materials. (Reprinted from the Journal of Research of the NBS—C, Engineering and Instrumentation, Vol. 63C, No. 2, October–December 1959). March 21, 1960. 16 p.

Mono. 12. Stabilization of free radicals at low temperatures

This volume is the final report of the National Bureau of Standards Free Radicals Research Program. The three-year program which ran from September 1956 to October 1959 was devoted to the study of the properties of reactive molecular fragments trapped in inert matrices at low temperatures. The first paper describes the organization and operations of the Free Radicals Research Program. The next seven papers summarize the technical accomplishments of the NBS Program, as viewed against the status of the entire field of radical trapping. The ninth paper is a summary of the Fourth International Symposium on Free Radical Stabilization which was held in Washington, D.C., August 31 through September 2, 1959. The final paper is a complete cross-referenced bibliography of papers published as a result of the research completed during the three-year period of the Program. August 1, 1960. 110 p.

Mono. 13. Mechanical properties of structural materials at low temperatures, a compilation from the literature, R. M. McClintock and H. P. Gibbons

The tensile strength, yield strength, tensile elongation, and impact energy of about two hundred materials, metallic and nonmetallic, are given graphically as functions of temperature between 4° and 300° Kelvin. June 1, 1960. 180 p.

Mono. 14. Bibliography on molecular and crystal structure models, D. K. Smith

A bibliography on molecular and crystal structure models is presented. The references are classified into those discussing models in general, static models, dynamic models, or construction devices. The static models are further classified in molecular (Fisher-Hirschfelder-Taylor type), closed packing, open molecular, open crystal structure, open with parallel rods, polyhedral, and miscellaneous models. A short annotation is given which describes the model types and indicates the more significant articles pertaining to them. May 20, 1960. 7 p.

Mono. 15. Calibration of line standards of length and measuring tapes at the National Bureau of Standards, L. V. Judson

The methods used at the National Bureau of Standards in calibrating line standards of length and measuring tapes submitted for standardization are outlined. The equipment used is described briefly. There is a discussion of some considerations that should be given as to whether or not a standard should be submitted to the Bureau. Instructions are given for submitting items to the Bureau for calibration. The appendix contains useful information on the use of steel tapes. May 20, 1960. 11 p. (Supersedes C572).

Mono. 16. Vibration-rotation structure in absorption bands for the calibration of spectrometers from 2 to 16 microns, E. K. Plyler, A. Danti, L. R. Blaine, and E. D. Tidwell

Suitable bands of common gases have been tabulated and remeasured wherever necessary from 2 to 16 microns to obtain an accuracy of about 0.03 cm^{-1} throughout the region and to provide good calibrating points at frequent intervals. Some 600 rotation-vibration lines are illustrated in 20 spectrograms and wavenumbers are listed in companion tables with considerable intercomparison with worthy data obtained in other laboratories. The absorption bands were remeasured or calibrated by using either a precisely graduated grating circle or standard atomic lines with the fringe system formed by a Fabry-Perot interferometer. Characteristic features of the individual bands are discussed briefly and references to other publications are given. The substances used for calibration include H_2O, CO_2, CO, HCl, HBr, NH_3, C_2H_2, CH_4, N_2O, and polystyrene film. (Reprinted from the Journal of Research of the NBS—A, Physics and Chemistry, Vol. 64A, No. 1, January–February 1960.) June 21, 1960. 20 p.

Mono. 17. New description of thorium spectra, R. Zalubas

Wavelengths and estimated intensities in electrodeless lamp and spark sources are presented for 15121 lines of Th I, Th II, Th III, and Th IV in the spectral range from 2000 to 11550 A. Previously published interferometric values are in this table rounded off to three decimal places and followed by the letter i. June 21, 1960. 103 p.

3.8. HANDBOOKS

These are recommended codes of engineering and industrial practice, including safety codes, developed in cooperation with the national organizations and others concerned. In many cases the recommended requirements are given official status through their incorporation in local ordinances by State and municipal regulatory bodies. See "Price List of Available Publications," page 161.

H28 (1957)—Part II. Screw-thread standards for Federal services, 1957. Amends in part H28 (1944) (and in part its 1950 Supplement).

Part II includes standards for pipe threads, Dryseal pipe threads, hose coupling and fire hose coupling threads, gas cylinder valve outlet, inlet, and safety device threads, and hose connections for welding and cutting equipment. Parts I and II supersede all of Handbook H28 (1944) and the 1950 Supplement thereto excepting sections IX and X and appendix 5. November 16, 1959. 119 p.

H63. Protection against neutron radiation up to 30 million electron volts

Information for protection of personnel working near reactors, accelerators and radioactive neutron sources is included in this report. The physical problems of measuring neutron radiation and absorbed neutron dose are discussed as well as the current status of information on the biological effects of neutrons. Rules are recommended for safe operation of neutron sources and for protection of personnel. The recommendations of this Handbook take into consideration the January 8, 1957, statement of the National Committee on Radiation Protection and Measurement lowering the maximum permissible levels for radiation workers. November 22, 1957. 88 p.

H64. Design of free-air ionization chambers, H. O. Wyckoff and F. H. Attix

The material in this Handbook is a collection of the data required for designing free-air ionization chambers. These chambers are principally used for the calibration of the smaller clinical and field instruments. Until recently, they were used in a few of the large national standards laboratories; with the increase in radiation therapy, more of the national laboratories and many industries have become interested in providing such calibration facilities.

The handbook contains information for the design of primary standards to measure radiation in roentgens from the majority of the sources now used in medical radiology. For a given design, it also includes data on the magnitude of the corrections required to obtain a determination of the number of roentgens in 50 to 500 kv X-ray beams from the ionization measurements. Sample computations and an estimate of the possible errors in such determinations are included. Some of this data is based on information obtained during intercomparisons of the free-air chambers of the national standards laboratories of various countries. December 13, 1957. 16 p.

H65. Safe handling of bodies containing radioactive isotopes (A guide for surgeons, pathologists, and funeral directors)

This is one of a series of reports prepared by the National Committee on Radiation Protection and Measurements. The present Handbook is a revision of Handbook 56, Safe Handling of Cadavers Containing Radioactive Isotopes. This revision was prepared in order to include information on additional isotopes used in therapy and encountered in the handling of bodies, and to conform with the lowered maximum permissible radiation levels recently recommended both nationally and internationally. July 10, 1958. 20 p. (Supersedes H56).

H66. Safe design and use of industrial beta-ray sources

This Handbook was prepared to serve as a guide toward the safe design, manufacture, installation, use, maintenance, and disposal of beta-ray sealed sources for industrial applications. In addition, it may be of some help to the reader in complying with the radiation protection regulations issued by the U.S. Atomic Energy Commission and other Federal and State agencies. However, as these governmental regulations may be changed from time to time, they may differ in detail from the recommendations that are given. The Handbook was prepared by Subcommittee 8 on Sealed Beta-Ray Sources of the ASA–Z54 Sectional Committee on Protection for the Industrial Use of Radiation. May 28, 1958. 28 p.

H67. Checking prepackaged commodities. A manual for weights and measures officials, M. W. Jensen

A manual for State and local weights and measures officials, describing a method for controlling various types of prepackaged commodities. March 20, 1959. 27 p.

H68. Tabulation of data on receiving tubes, C. P. Marsden, W. J. Keery, and J. K. Moffitt

A tabulation of Receiving-Type Electron Tubes with some characteristics of each type has been prepared in the form of two major listings, a Numerical Listing in which the tubes are arranged by type number, and a Characteristic Listing in which the tubes are arranged by tube type and further ordered on the basis of one or two important parameters. The tabulation is accompanied by a listing of similar tube types and basing diagrams for the listed tubes. November 1, 1959. 110 p.

H69. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure

This Handbook represents a complete revision of Handbook 52, originally published in 1953. It was prepared jointly by the NCRP and the ICRP. All of the material in the earlier handbook was reviewed and revised in light of the basic changes in our permissible dose concepts introduced in January 1957 and April 1958. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water are given for approximately 300 radionuclides as compared with about 100 in the original report. As a result of the review, some of the values have been revised up or down and some have remained the same as in the earlier report. The more detailed discussion of some of the derivations and the bibliography have been published in the ICRP Committee 3 report on X-rays Up to 3 Mev and Alpha and Gamma Rays From Sealed Sources, 1958 revision. (Pergamon Press, New York, N.Y., April 1960). June 5, 1959. 95 p. (Supersedes H52).

H71. Specifications for dry cells and batteries

This seventh edition of American Standard Specification for Dry Cells and Batteries, American Standard C18, includes new tests, up-to-date data, and covers new types of dry cells. An alarm test with results on batteries suitable for alarm circuits is a new feature of this seventh edition of the specification. Performance data on flashlight batteries, radio batteries, hearing-aid batteries, etc., have been brought up to date. Batteries for use with transistors are included in this specification for the first time. December 29, 1959. 20 p. (Supersedes C559).

3.9. MISCELLANEOUS PUBLICATIONS

As the name implies, this series includes material which, because of its character or because of its size, does not fit into any of the other regular publication series. Some of these are charts, administrative pamphlets, Annual Reports, Weights and Measures Conference Reports, and other subjects appropriate to the Miscellaneous series. See "Price List of Available Publications", page 161.

M221. Hydraulic research in the United States, 1957, H. K. Middleton

Research and development projects being conducted in 1957 in hydraulic and hydrologic laboratories of universities and Federal agencies throughout the United States and Canada are briefly described. A list of the contributing laboratories is given. The status of continuing projects covered by previous issues of the publication is reported upon, as well as on new projects in progress, the results of completed work are given. References to publications relating to the projects and an extensive subject index are included. July 24, 1957. 220 p.

M222. Report of the 42d National Conference on Weights and Measures, 1957

A report of the proceedings of the forty-second National Conference on Weights and Measures, held in Washington, D.C., June 3, 4, 5, 6, and 7, 1957, and attended by state, county, and city weights and measures officials. 133 p.

M223. Annual report 1957 National Bureau of Standards

This is a summarized illustrated report of the research and development activities of the Bureau in the fields of physics, chemistry, engineering, and mathematics, during the fiscal year ending June 30, 1957. Brief accounts are included relating to projects completed by or in progress in the Bureau's scientific and technical divisions, including electricity and electronics, optics and metrology, heat, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, data processing systems, cryogenic engineering, radio propagation, radio standards, and basic instrumentation.

A statement of the Bureau's testing, calibration, and Standard Samples activities by Divisions is also included, as well as a review of its technical services and cooperation, both national and international. 143 p.

M224. Hydraulic research in the United States, 1958, H. K. Middleton

Research and development projects being conducted in 1958 in hydraulic and hydrologic laboratories of universities and Federal agencies throughout the United States and Canada are briefly described. A list of the contributing laboratories is given. The status of continuing projects covered by previous issues of the publication is reported upon, as well as on new projects in progress, the results of completed work are given. References to publications relating to the projects and an extensive subject index are included. August 15, 1958. 167 p.

M225. Report of the 43d National Conference on Weights and Measures, 1958

A report of the proceedings of the forty-third National Conference on Weights and Measures, held in Washington, D.C., June 9, 10, 11, 12, and 13, 1958, and attended by state, county, and city weights and measures officials. 146 p.

M226. Research highlights of the National Bureau of Standards, Annual report 1958

This is a summarized illustrated report of the research and development activities of the Bureau in the fields of physics, chemistry, engineering, and mathematics, during the fiscal year ending June 30, 1958. Brief accounts are included relating to projects completed by or in progress in the Bureau's scientific and technical divisions, including electricity and electronics, optics and metrology, heat, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral projects, building technology, applied mathematics, data processing systems, cryogenic engineering, radio propagation, radio standards, and basic instrumentation.

A statement of the Bureau's testing, calibration, and Standard Samples activities by Divisions is also included, as well as a review of its technical services and cooperation, both national and international. 138 p.

M227. Hydraulic research in the United States, 1959, H. K. Middleton

Research and development projects being conducted in 1959 in hydraulic and hydrologic laboratories of universities and Federal agencies throughout the United States and Canada are briefly described. A list of the contributing laboratories is given. The status of continuing projects covered by previous issues of the publication is reported upon, as well as on new projects in progress, the results of completed work is given. References to publications relating to the projects and an extensive subject index are included. October 1, 1959. 188 p.

M228. Report of the 44th National Conference on Weights and Measures, 1959

A report of the proceedings of the forty-fourth National Conference on Weights and Measures, held in Washington, D.C., June 8, 9, 10, 11, and 12, 1959, and attended by state, county, and city weights and measures officials. 144 p.

M229. Research highlights of the National Bureau of Standards, Annual report 1959

This is a summarized illustrated report of the research and development activities of the Bureau in the fields of physics, chemistry, engineering, and mathematics, during the fiscal year ending June 30, 1959. Brief accounts are included relating to projects completed by or in progress in the Bureau's scientific and technical divisions, including electricity and electronics, optics and metrology, heat, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, data processing systems, cryogenic engineering, radio propagation, radio standards, and basic instrumentation.

A statement of the Bureau's testing, calibration, and Standard Samples activities by Division is also included, as well as a review of its technical services and cooperation, both national and international. 169 p.

3.10. BUILDING MATERIALS AND STRUCTURES REPORTS

This series reports the results of research in building technology work at the National Bureau of Standards. The objective is to provide government, the interested professions, and the building industry with technical data useful in the preparation of building codes, standards, and engineering design criteria. Subjects of primary interest are the properties of building materials, structures, equipment, and facilities. Effective July 1959, this series was discontinued. Papers on building technology are now published in the Journal of Research (usually Section C. Engineering and Instrumentation), or the Monograph series (page 59). See "Price List of Available Publications", page 161.

BMS140, 3d ed. Building construction and maintenance, E. R. Meggers

Selected references on building materials, equipment, good construction practices for new construction, and the modernization and maintenance of buildings. January 15, 1959. 30 p.

BMS144, 2d Supplement. Sound insulation of wall, floor, and door constructions, R. V. Waterhouse, R. D. Berendt, and R. K. Cook

Sound insulation data are presented for building structures measured at the National Bureau of Standards in the period July 1955 to December 1956. These figures constitute the second supplement to the data published in Building Materials and Structures Report 144. The accuracy of the figures is discussed. Details are also given of a new average figure, called the *Energy Average*, for the over-all sound insulation of a panel, and why it is preferable to the *Decibel Average*, which it is designed to supersede. December 1, 1958. 13 p.

BMS151. Thermal resistance of airspaces and fibrous insulations bounded by reflective surfaces, H. E. Robinson, L. A. Cosgrove, and F. J. Powell

Observed insulating values are presented for 28 test panels, of which 23 were insulated with reflective membranes used alone or in combination with fibrous insulations. The panels were tested at five different orientations corresponding to use as walls, ceilings, or floors. The observed insulating values of panels are compared with calculated values based on a method and data developed in previous work at the National Bureau of Standards, and summarized in an appendix to this report. Observed values for panels agreed within 10 percent, in most cases, with calculated values. Departures of observed from calculated values are attributed to such factors as nonuniformity of airspace thickness, moisture condensation on reflective surfaces, air circulation between tandem airspaces, and effects due to local high conductance at edges of insulations or radiation from framing members. November 14, 1957. 22 p.

BMS152. Wind pressures in various areas of the United States, G. N. Brekke

A procedure is described for developing a wind-pressure map that shows minimum resultant wind pressures (30 feet above ground) for design purposes throughout the continental United States. This map was used in the 1955 revision of the American Standards Association's standard A58.1, *American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*. It is based on records of annual fastest-single-mile wind speeds at 155 U. S. Weather Bureau stations. In computing resultant wind pressures from these data, allowance was made for gusts and for building shape. Values for 15 of the stations were also adjusted for altitude or for unusual local wind conditions. A table of design wind pressures at various heights from less than 30 to more than 1,200 feet above ground is derived for use with the map. The principal sources of strong winds affecting building constructions are briefly reviewed. April 24, 1959. 8 p.

3.11 APPLIED MATHEMATICS SERIES

The Applied Mathematics Series contains mathematical tables, manuals and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computers and others engaged in scientific and technical work. Some of the volumes are reissues, to meet a continuing demand, of the Mathematical Tables prepared by the Project for the Computation of Mathematical Tables conducted by the Federal Works Agency, Work Projects Administration for the City of New York, under the scientific sponsorship of and made available through the National Bureau of Standards. The Mathematical Tables series (MT) as originally issued is out of print; the list, by title, is given in NBS Circular 460.

When the Applied Mathematics Division was established at the National Bureau of Standards in July 1947, the Mathematical Tables Project became identified with the unit of this Division known as the Computation Laboratory. See "Price List of Available Publications", page 161.

AMS49. Further contributions to the solution of simultaneous linear equations and the determination of eigenvalues

Three related but independently presented papers describe some recently developed techniques for the solution of certain problems of numerical analysis: Kernel polynomials in linear algebra and their numerical applications, by E. L. Stiefel; The quotient-difference algorithm, by P. Henrici; Solution of eigenvalue problems with LR-transformation, by H. Rutishauser. The techniques developed are useful in solving simultaneous linear equations, in finding the eigenvalues of a matrix, in the construction of orthogonal polynomials, in the factorization of polynomials, in expanding into continued fractional functions defined by power series of Laplace integrals, and in many other problems. January 15, 1958. 81 p.

AMS50. Tables of the bivariate normal distribution function and related functions

This volume is a compilation and extension of various tables of Karl Pearson, Evelyn Fix, Jerzy Neyman and H. H. Germond relating to the bivariate normal frequency function $g(x,\,y,\,z)=(1/2\pi\sqrt{1-r^2})\ \exp[-\frac{1}{2}(x^2+y^2-2rxy)/(1-r^2)]$. Table I gives values of $L(h,k,r)=\int_h^\infty dx\int_k^\infty g(x,y,r)\,dy$ for $h,k=0(.1)4,\ r=0(.05)0.95(.01)1,\ 6D$. Table II gives values of $L(h,k,-r)$ for $h,k=0(.1)u_n$ where $u_n\leq 4$ and $L<\frac{1}{2}.10^{-7},\ r=0(.05)\ .95(.01)1,\ 7D$. The major portion of tables I and II have been compiled from Karl Pearson's "Tables for Statisticians and Biometricians," Part II. Table III tabulates $V(h,\lambda h)=\int_0^h dx\int_0^x z(x)\,z(y)\,dy$ where $z(t)=(1/2\pi)\ \exp(-\frac{1}{2}t^2)$ for $\lambda=0.1(.1)1,\ h=0(.01)4(.02)4.6(.1)5.6,\infty,\ 7D$. Table IV gives $V(\lambda h,h)$ for $\lambda=0.1(.1)1,\ h=0(.01)4(.02)\ 5.6,\infty,\ 7D$. Finally table V gives values of $(1/2\pi)\sin^{-1}r$ for $r=0(.01)1,\ 8D$. The Introduction is composed of two main parts, one dealing with the statistical applications of these tables, the other relating to interpolation and the computation of the tables. June 15, 1959. 258 p.

AMS51. Tables of the exponential integral for complex arguments

The function, $E_1(z)=\int_z^\infty (e^{-u}/u)\,du,\ z=x+iy$, is tabulated to six decimal places, for $0\leq x\leq 4,\ 0\leq y\leq 10$, with intervals between the arguments so chosen that quadratic interpolation will yield the fullest attainable accuracy over most of the region. Also tabulated is $E_1(z)$ to ten decimal places over the region $0\leq -x,\ y\leq 3.1$ at intervals of 0.1. To facilitate interpolation the function $E_1(z)+\log_e z$ is tabulated for $0\leq x,\ y\leq 1$ to six decimal places and for $0\leq -x,\ y\leq 1$ to ten decimal places. For the region $4\leq x\leq 10,\ 0\leq y\leq 10$ the auxiliary function $e^z E_1(z)$ is tabulated to six decimal places since interpolation for the same number of significant figures is easier for this function than for $E_1(z)$. Finally, a short table of $e^z E_1(z)$ over the region $0\leq +x,\ y\leq 20$ is given to six decimal places over varying intervals. May 15, 1958. 634 p.

AMS52. Integrals of airy functions

Part I gives tables of integrals of the Airy function

$$f(x)=\int_0^x Ai(-t)\,dt; \qquad F(x)=\int_0^x f(t)\,dt$$

where

$$Ai(x)=\frac{1}{\pi}\int_0^x \cos\left(\frac{t^3}{3}+xt\right)dt$$

with second central differences for $x=-2(.01)5$ to 8 decimal places and 7 decimal places, respectively. Part 2 gives tables of the modified Airy integral

$$A_0(x)=\int_0^\infty e^{-xt-(t^3/3)}dt$$

and its derivative $A'_0(x)$ with second central differences for $x=0(.01)1(.02)5(.0_2)11,\ 1/x=.01(.01).1$, to 8 decimal places. In addition, a skeleton table is given of $G(x)=\int_0^x A_0(t)\,dt$ for $x=.5,\ 1(1)11$, to 8 decimal places. May 15, 1958. 28 p.

AMS53. Table of natural logarithms for arguments between five and ten to sixteen decimal places

The table gives 16-place values of the natural (to the bases) logarithms of the decimal numbers from 5 to 10 at intervals of 0.0001. This volume is a companion volume to AMS31. The table was originally issued in the MT series as volume IV in a four-volume table of natural logarithms MT12. March 28, 1958. 506 p. (Supersedes MT12).

AMS54. Fractional factorial experiment designs for factors at three levels, W. S. Connor and M. Zelen

This publication contains a collection of fractional factorial designs of the series $(1/3^p)x3^n$ for $p=1,\ 2,\ 3,\ 4,\ 5$, and for n ranging from 4 to 10 factors. The experiment

plans are constructed so that the treatment combinations are grouped into blocks, thus allowing the experimenter to take advantage of any homogenous grouping of the experimental material. May 1, 1959. 37 p.

AMS56. Tables of osculatory interpolation coefficients, H. E. Salzer

The tables give the coefficients $A_i(p)$ and $B_i(p)$ where

$$f(x_0+ph)=\sum_{i=\frac{n-1}{2}}^{\left[\frac{n}{2}\right]}\{A_i(p)f_i+B_i(p)hf_i'\}$$

for $n=2(1)5$ and $p=-\left[\frac{n-1}{2}\right](1.0)\left[\frac{n}{2}\right]$, exact values or nine decimal places. These coefficients facilitate interpolation when both a function and its first derivative are tabulated. May 8, 1959. 25 p.

AMS57. Basic theorems in matrix theory, M. Marcus

This publication is a survey of the basic identities and inequalities of matrix theory, and is intended as a handy reference for research workers and students. Included are results dealing with elementary properties, canonical forms, invariance, congruence, commutativity, orthogonalization, eigenvalues, determinants, sub-matrices, rank, determinant and rank inequalities, numerical methods for inversion and eigenvalues, and condition numbers. No attempt has been made to provide proofs for the theorems listed; and all statements are made directly in terms of matrices rather than linear transformations. References are given after each result, unless the result is found in most textbooks on matrices. January 22, 1960. 27 p.

TECHNICAL NOTE SERIES

This series was initiated in 1959 to supplement the Bureau's regular publications program. Technical Notes provide a means for making available scientific data that are of transient or limited interest. They are available for sale by the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (Order by PB number only). See "Price List of Available Publications", page 161.

TN1 (PB151360). A double-pulse total-absorption fast neutron spectrometer, L. J. Nicastro and R. S. Caswell

A fast neutron spectrometer utilizing the double-pulse total-absorption technique has been developed for use in the energy range 1–20 Mev. The total absorption spectrometer uses a hydrogenous scintillator, in which a fast neutron may lose all its energy, together with a detector for slow neutrons. Scintillation detection of the disintegration caused by absorption of a slow neutron in an element of high reaction cross section serves to identify those neutrons which lost essentially all their energy in the hydrogenous scintillator.

Various organic liquid scintillators loaded with natural methyl borate, and a plastic scintillator with a boron-10 or lithium-6 slow neutron scintillation detector nearby were all tested with monoenergetic neutrons obtained from the D(d,n) He^3 and T(d,n) He^4 reactions. The best experimental results were obtained with a plastic scintillator and a Li^6I(Eu) crystal. Representative data for this spectrometer are presented. For comparison purposes, the results of Monte Carlo calculations, made by Leiss for a phenylcylohexane liquid scintillator loaded with methyl borate (B^{10} enriched), are also included. April 24, 1959. 25 p.

TN2 (PB151361). World maps of F2 critical frequencies and maximum usable frequency factors, D. H. Zacharisen

This publication reports six months of contour maps and charts for use in predicting F2-layer maximum usable frequencies. Prediction maps for each even hour of Greenwich Mean Time and charts in which time is continuous along the abscissa are given for the months of January, March, June, July, September and December.

The four parameters used for predicting MUFs are foF2 and the 4000 km MUF factor for a twelve-month running average Zurich sunspot number of 50, and the rates of change of foF2 and 4000 km MUF factor with sunspot number. The first three parameters use a map presentation with GMT constant over the surface of the map. The fourth parameter uses a chart presentation in which the ordinate is geomagnetic latitude and the abscissa is local time. April 1959. 244 p.

TN3 (PB151362). Detwinning quartz crystals, F. P. Phelps

Attempts were made to detwin quartz by cooling through the inversion temperature while a d.c. potential was applied and later with RF potential across the plate. BT, AT and X cut plates were used. Air was largely removed to improve the insulation but this was not wholly satisfactory because of the difficulty of adequately degassing the sample. Some samples yielded untwinned plates, others did not. It appeared that different samples of quartz behaved differently in respect to ease of changing the twin pattern. The method used did not appear commercially useful because of the erratic behavior of different pieces of quartz. April 1959. 5 p.

TN4 (PB151363). The vapor pressures of some hydrocarbons in the liquid and solid state at low temperatures, W. T. Ziegler

This paper presents a brief review of the literature pertaining to the vapor pressure of 11 hydrocarbons at low temperatures. These hydrocarbons are methane, ethane, propane, *n*-butane, isobutane (2-methyl propane), *n*-pentane, ethylene, propylene, 1-butene, acetylene and cyclopropane. All of these except cyclopropane are encountered in the purification of hydrogen from refinery sources. Vapor pressure data are given for most of these hydrocarbons over the pressure range 0.001 to 1,500 mm Hg. These data have been used to estimate the triple-point pressures of the hydrocarbons where these pressures were not found in the literature. Some data for the vapor pressures of solid methane, ethane, *n*-butane, ethylene, acetylene and cyclopropane are included. May 1959. 17 p.

TN5 (PB151364). Tables of median hourly values of the solar zenith angle (x) for 35 locations, R. E. McDuffie

This report consists of tables of hourly values of cosine x from sunrise to sunset for the 15th day of each month appropriate to 35 vertical incidence ionospheric stations associated with the National Bureau of Standards. February 1959. 38 p.

TN6 (PB151365). An analysis of propagation measurements made at 418 Mc well beyond the radio horizon, H. B. Janes, J. C. Stroud, and M. T. Decker

This report presents the result of an analysis of transmission loss measurements made at 418 Mc over the 134-mile path from Cedar Rapids, Iowa to Quincy, Ill., during 1952 and 1953. The data consisted chiefly of continuous simultaneous recordings of signal level at several receiving antenna heights, ranging from 30 to 665 feet above ground. These data are reduced to tabulations of hourly median values of basic transmission loss and fading

range. These values, as well as the hourly difference in transmission loss observed at two heights (height-gain) are also shown plotted in scatter diagrams versus time of day for each of the 13 two-week recording periods. The medians for each recording period of all hourly values of median basic transmission loss, fading range and height-gain are plotted versus time of year to show any seasonal variation in these statistics. A formula developed at NBS for predicting the median basic transmission loss in tropospheric scatter propagation is shown to be in good agreement with the data. The results of a study of the correlation of short-term signal variations observed at horizontally and vertically spaced antennas are given. May 1959. 84 p.

TN7 (PB151366). Low- and very low-radiofrequency tables of ground wave parameters for the spherical earth theory: the roots of Riccati's differential equation, J. R. Johler, L. C. Walters, C. M. Lilley

The roots of Riccati's differential equation are tabulated in detail throughout the low- and very low-radiofrequency part of the spectrum. The zeroes and certain other parameters used in the calculation of the amplitude and phase of the ground wave by the rigorous series of residues are also tabulated. February 1, 1959. 86 p. (Supplementary numerical data for C573).

TN8 (PB151367). Thermodynamic properties of helium at low temperatures and high pressures, D. B. Mann and R. B. Stewart

The most comprehensive investigations of the thermodynamic properties of normal helium I and II were published over a period of the last 30 years by W. H. Keesom. A culmination of most of this work was published by Keesom in 1942. Since that time, numerous investigators have found several discrepancies in this original work in the temperature range below 20° K. Recent interest in the compressed liquid region, an area not covered extensively by Keesom's work has resulted in new experimental data. These investigations and corrections to Keesom's work have been published, not as additions to the original Keesom work, but as separate and sometimes isolated articles of very narrow interest and not in readily usable form. Also the new data have little value until their relation to existing data is established.

Methods of property diagram construction are also explained, and the results are presented in the form of temperature-entropy and enthalpy-entropy diagrams. Pressures to 100 atmospheres, temperatures from 0° K to 20° K and specific volumes from 5 liters/kgm. to 800 liters/kgm. are presented. May 1959. 39 p.

TN9 (PB151368). Frequency dependence of VHF ionospheric scattering, J. C. Blair

Results of frequency dependence measurements in VHF scatter propagation are given. Data included were taken from continuous recordings of transmissions over the 1300 Km path from Long Branch, Illinois to Boulder, Colorado. Frequencies of 30, 40, 50, 74 and 108 Mc/s were recorded simultaneously. Data were included for the period September 1957 to June 30, 1958.

One principal result is that over the full range of frequencies observed, received power closely follows the exponential relationship $P_r \alpha \frac{1}{f^n}$. The value of n varied diurnally from 5 to 8, expressed for constant-aperture receiving antenna.

Among other results reported are the relationship of short-term signal amplitude distributions to relative influence of meteoric activity as well as the fading rates observed, and the effect on the signal of SID's.

The results presented herein are presented prior to completion of actual calibrating measurements on the antenna systems and are subject to some review after such measurements are made. April 1959. 52 p.

TN10 (PB151369). Calculated behavior of a fast neutron spectrometer based on the total absorption principle, J. E. Leiss

Performance calculations for a total absorption fast neutron spectrometer are presented. The spectrometer detecting element is a boron-10-loaded liquid scintillator. By making the scintillator a thin disk, only those neutrons whose first collision is a large-energy-loss hydrogen collision have appreciable chance of remaining in the spectrometer long enough to be captured. The expected energy resolution and efficiency of this type of spectrometer are determined, and are comparable to other types of fast neutron spectrometers. April 14, 1959. 36 p.

TN11 (PB151370). Penetration of gamma rays from isotropic sources through aluminum and concrete, M. J. Berger and L. V. Spencer

Semi-analytical expressions, with numerically specified parameters, are given which represent the gamma ray dose distribution in infinite aluminum or concrete media, for sources that are monoenergetic (with energies between 10.22 Mev and 0.0341 Mev), isotropic, and have the form of an infinite plane, point, disk or spherical surface. May 11, 1959. 13 p.

TN12 (PB151371). Transmission loss in radio propagation: II, K. A. Norton

In an earlier report with this title the concept of transmission loss was defined and its advantages explained. In this report a survey will be made of the transmission losses expected for a wide range of conditions, i.e., for distances from 10 to 10,000 statute miles; for radio frequencies from 10 kc to 100,000 Mc; for vertical or horizontal polarization; for ground waves, ionospheric waves, and tropospheric waves; over sea water or over land which may be either rough or smooth; and for various geographical and climatological regions. June 1959. 151 p.

TN13 (PB151372). Technical considerations leading to an optimum allocation of radio frequencies in the band 25 to 60 MC, K. A. Norton

The object of this study is to outline very briefly the technical considerations leading to an optimum allocation of radio frequencies in the band 25 to 60 Mc. This report will indicate what technical information is now available and where it may be obtained, as well as what additional information should be obtained in the future. June 1959. 96 p.

TN14 (PB151373). Analysis of ionospheric vertical soundings for electron density profile data. I. Facilities for convenient manual reduction of ionograms, J. W. Wright and R. B. Norton

Facilities for manual reduction of ionospheric vertical soundings to true heights are prepared using the "10 point" ratios of Ventrice and Schmerling. A study of the effects of the earth's magnetic field on true height calculations permits selection of five sets of these ratios assuring equal accuracy of application for any part of the world. The facilities available are in the form of transparent overlays and matching special graph paper. July 1959. 13 p.

TN15 (PB151374). Prediction of the cumulative distribution with time of ground wave and tropospheric wave transmission loss. Part I—The prediction formula, P. L. Rice, A. G. Longley, and K. A. Norton

This report describes a method for predicting the cumulative distribution with time of transmission loss at fre-

quencies above 10 megacycles per second over paths of arbitrary length. The method makes use of available information about terrain profiles and surface meteorological data, and is based on the CRPL radio standard atmospheres, in which the radio refractive index decreases linearly with height for the first kilometer above ground, and then decreases exponentially with height. Discussion of the theoretical basis for this formula and a demonstration of its accuracy by comparison with experimental data are reserved for later parts of this report. July 1959. 81 p.

TN16 (PB151375). Some applications of statistical sampling methods to outgoing letter mail characteristics, N. C. Severo, A. E. Newman, S. M. Young, and M. Zelen

This paper presents applications of statistical sampling procedures especially devised to procure information about the characteristics of outgoing letter mail. The results of four separate studies carried out in the Washington, D.C., San Francisco, and Los Angeles post offices are herein summarized. The techniques used in the various studies were developed so that the required information would be of predetermined reliability and could be gathered without the use of a large staff and without interrupting the flow of mail. The four studies presented concern: (1) letter size and color characteristics, (2) ratio of hand canceled mail to machine canceled mail, (3) top and bottom clearance space of an addressed envelope, (4) proportions of long and short letters. July 1959. 129 p.

TN17. (PB151376). Canceled.

TN18 (PB151377). Radio noise data for the International Geophysical Year July 1, 1957–December 31, 1958, W. Q. Crichlow, C. A. Samson, R. T. Disney, and M. A. Jenkins

Radio noise data were obtained during the IGY from fifteen stations in a world-wide network equipped with the ARN–2 noise recorder developed by the National Bureau of Standards. Tables are presented which give the median values of recorded noise for each month at all hours of the day, and also the seasonal average of the noise by four-hour time blocks. July 27, 1959. 235 p.

TN18–2 (PB151377–2). Quarterly radio noise data—March, April, May 1959, W. Q. Crichlow, C. A. Samson, R. T. Disney, and M. A. Jenkins

Radio noise power, voltage, and logarithm of the voltage are being recorded at a network of field stations throughout the world. The data recorded at these locations during the season March, April, May 1959 are presented. The tabulation shows month-hour median and decile values of the power and the median values of the other two parameters as deviations below the power. The month-hour median values for all three parameters are averaged over a three-month, four-hour period to give seasonal time-block values corresponding to the time-block values presented in CCIR Report No. 65. March 14, 1960. 61 p.

TN19 (PB151378). Analysis of ionospheric vertical soundings for electron density profile data. II. Extrapolation of observed electron density profiles above $h_{max}F2$, J. W. Wright

A tentative model of the F region above h_{max} is provided to permit extrapolation of electron density profiles into this region. The model corresponds to a simple "Chapman" curve, and may be fitted to true height data (obtained in part I) by a simple graphical process. June 1959. 8 p.

TN20 (PB151379). A preliminary analysis of amplitude scintillations of radio stars observed at Boulder, Colorado, R. S. Lawrence and J. L. Jespersen

Variations in the apparent flux from the radio source Cygnus-A are recorded at 53 and 108 mc/s using a two-element phase-sweeping interferometer located at Boulder. An ionospheric sounder operating at Ellsworth, Nebraska, provides simultaneous vertical-incidence measurements of the ionosphere along the path. Amplitude scintillations observed at Boulder over a six-month period are compared with the ionograms taken at Ellsworth. Positive correlation is found between amplitude scintillations and spread F, while a small negative correlation is found with sporadic E. The present result appears to be significant but a full year's data are being accumulated to disclose seasonal or diurnal effects. Detailed analysis of the scintillations indicates that the probability distribution of the amplitude can be represented by the Rice probability distribution function. The scintillation rate for 108 mc/s seems to be more rapid than for 53 mc/s. July 1959. 19 p.

TN21 (PB151380). Variations of gamma cassiopeiae, S. R. Pottasch

The variations of gamma Cassiopeiae between 1890 and 1950 are summarized and discussed. The variations of visual magnitude, color temperature, radius and electron density of the shell, and the spectral variations are depicted. August 1959. 29 p.

TN22 (PB151381). Precise time synchronization of widely separated clocks, A. H. Morgan

This paper describes known precise methods of setting a group of widely separated clocks to precisely the same time and keeping them in close agreement indefinitely; most of the proposed methods are now available. An estimate of the accuracies of each method are given. Also, there is some discussion of high frequency radio propagation theory pertinent to two of the methods and a few sets of measurements of the propagation delay time of high frequency signals from WWV to WWVH are given. Several graphs and tables are included to simplify some of the calculations. July 1959. 65 p.

TN23 (PB151382). Design of single frequency filters, F. F. Fulton, Jr.

Efficient procedures are shown for designing filters formed by a number of identical resonant circuits loosely coupled together, and which are required to accept one narrow band of frequencies and reject another narrow band somewhat removed in frequency, without any special requirements on the shape of the attenuation curve in between these regions. The design is based on using a large number of sections. August 20, 1959. 10 p.

TN24 (PB151383). Radio wave propagation in an inhomogeneous atmosphere, J. R. Wait

A self-contained treatment of the theory of radio waves in an inhomogeneous atmosphere is given. The refractive index is assumed to vary with height above the earth in a monotonic fashion. Variation according to an exponential law is used for illustration of general principles. For this case, rigorous series formulas are developed for the distance to the horizon for an elevated point in the atmosphere. September 10, 1959. 20 p.

TN25 (PB151384). Communication theory aspects of television bandwidth conservation, W. C. Coombs

New concepts of communication bandwidth utilization and conservation are in prospect through difference signal modulation systems in which only relative changes information is transmitted in lieu of absolute amplitudes. By

these systems, the changes data function is made one of time as well as of amplitude, so that better advantage can be taken of redundancies in the video signal.

Advantageous conversions of information rate are made feasible by reason of a tremendous disparity existing between the extremely high information capacity of conventional television systems and the relatively very low perception capability of a human observer channel. Information conversions more consistent with perception capabilities of the human channel are achieved in difference signal modulation without usual great expansion of bandwidth that would be required to reproduce every possible absolute amplitude of each datum in the whole video picture mosaic directly.

Conversion to binary digital form accrues the further advantages of binary systems, including greater immunity to noise, greater adaptability to discrete data storage media, greater ease of scrambling for security, and greater amenability of encoding to optimum parametric controls for most advantageous transmission. August 1959. 26 p.

TN26 (PB151385). Survey of Central Radio Propagation Laboratory research in tropospheric propagation 1948–1956, J. W. Herbstreit and P. L. Rice

This report summarizes and abstracts publications concerned with the National Bureau of Standards tropospheric propagation research program dating back to the formation of the Central Radio Propagation Laboratory. Some technical papers are reproduced here as supplements to this report and excerpts from some of the longer technical reports are also included. September 1959. 211 p.

TN27 (PB151386). Distribution of mail by destination at the San Francisco, Los Angeles, and Baltimore Post Offices, N. C. Severo and A. E. Newman

This report presents the results of the application of the sampling method presented in a paper by Norman C. Severo and Arthur E. Newman entitled "A statistical chain-ratio method for estimating relative volumes of mail to given destinations", *NBS Journal of Research 64C*, No. 1, 37, January–March 1960. These studies were made at the San Francisco, Los Angeles, and Baltimore Post Offices. December 1959. 55 p.

TN28 (PB151387). A history of vertical-incidence ionosphere sounding at the National Bureau of Standards, S. C. Gladden

This is an attempt to treat in chronological order the development of vertical incidence ionosphere sounding at the National Bureau of Standards through 1957. Of necessity many phases of the radio work of the Bureau have been omitted or treated lightly as not being germane to the principal purpose of this history. With the exception of early workers in the field, names of individuals are to be found only in the references.

Source material includes the monthly, quarterly, and annual reports of Section 6, Division 1 (the old Radio Section), and of the Central Radio Propagation Laboratory; reports of the Interservice Radio Propagation Laboratory; the declassified reports of the International Radio Propagation Conference; the National Bureau of Standards Journal of Research; the NBS Technical News Bulletin; published and unpublished reports of NBS; periodical literature, such as the Proceedings of the Institute of Radio Engineers, the Physical Review, Nature, Journal of Geophysical Research (formerly Terrestrial Magnetism and Atmospheric Electricity), and Science. September 1959. 134 p.

TN29 (PB151388). Photographic dosimetry at total exposure levels below 20 mr, M. Ehrlich and W. L. McLaughlin

Assemblies of commercial photographic material sandwiched between two plastic scintillators can be used to measure high-energy X- or gamma-ray exposures down to 1 mr and less. The energy dependence of the assemblies' response is much less than that of a conventional photographic dosimeter, in some instances allowing an exposure interpretation with an accuracy of ± 25 percent over the energy range from about 0.1 Mev to 1.25 Mev. However, low-intensity reciprocity failure limits the range of applicability of the system.

Conventional photographic dosimeters, not incorporating scintillators, are usually preferable for routine personnel dosimetry. By extending the monitoring period, it may be possible to avoid personnel dosimetry below 20 mr entirely. However, by doing this, one introduces additional difficulties because of instabilities in the photographic image. In some instances, an increase in effective emulsion thickness, achieved by using stacks of identical films, may lead to an increase in emulsion sensitivity sufficient to extend the useful range of a film badge well below 20 mr, without the use of a scintillator. October 1959. 23 p.

TN30 (PB151389). Aerodynamic phenomena in stellar atmospheres—A bibliography

A bibliography and short abstract of papers appearing in the astronomical literature between 1920 and 1960 on the subject of aerodynamic phenomena in stellar atmospheres. Prepared collaboratively by P. Ledoux, Institut d'Astrophysique, Liege; B. E. J. Pagel, Royal Observatory, Herstmonceux; J. Tuominen, University of Helsinki; C. Pecker, Institut d'Astrophysique, Paris; R. Lust, Max Planck Institut, Munich; G. Righini and G. Kalamai, Observatorio Astrofisico di Arcetri, Firenze; S. Miyamoto, Kwasan Observatory, Kyoto; S. A. Kaplan, University of Lwow, and S. B. Pickelner, University of Moscow and Simeis Observatory; C. A. Whitney, Smithsonian Astrophysical Observatory, Cambridge; and L. L. House and R. N. Thomas, National Bureau of Standards, Boulder, in an attempt to provide a working bibliography for the Fourth Symposium on Stellar Atmospheres, to be held during August 1960 at Varenna, Italy, under the sponsorship of the International Astronomical Union and International Union of Theoretical and Applied Mechanics. September 1959. 89 p.

TN31 (PB151390). An atlas of oblique-incidence ionograms, W. Agy, K. Davies, and R. Salaman

This atlas is intended to serve a twofold purpose: first, to provide a compilation of records, of a type becoming standard in the field of ionospheric research, for those workers who are not now familiar with them, and second, to present records which are characteristic of the specific paths used by the National Bureau of Standards for consideration by those using other paths. November 1959. 135 p.

TN32. (PB151391). Canceled.

TN33 (PB151392). Distribution of incoming lettermail at the Baltimore, Md. City Post Office, B. M. Levin and A. E. Newman

Lettermail at the Baltimore, Md. post office was sampled and studied for the purpose of estimating the distribution characteristics of letters for local delivery. Separate studies were conducted for first- and third-class mail and the results are reported both separately and combined. The study demonstrated an effective method of sampling incoming lettermail. It also yielded data needed for the design of efficient procedures for sorting mail using machinery now being developed. October 1959. 114 p.

TN34 (PB151393). Resistance diode bridge circuit for temperature control, L. H. Bennett and V. M. Johnson

The conventional ac bridge gives irregular performance including loss of temperature control when the temperature error exceeds a certain critical value. The present

note describes a simple method of achieving stable temperature control over a large range of temperatures. October 1959. 4 p.

TN35 (PB151394). Service area of an airborne television station, M. T. Decker

As a step in the evaluation of a proposed airborne television network, the service to be expected from an airborne station has been calculated for a wide variety of operating conditions. The use of basic transmission loss to describe the radio propagation effects enables the results to be used when equipment parameters are changed as system requirements and economic considerations dictate. October 1959. 43 p.

TN36 (PB151395). A multiplet table of astrophysical interest (Revised Edition). Part I. Table of multiplets and Part II. Finding list of all lines in the table of multiplets, C. E. Moore

The leading lines in 143 atomic spectra of 85 chemical elements are listed in related groups called multiplets. For each spectrum the multiplets are arranged in order of decreasing wavelength. Estimated intensities, excitation energies, and multiplet designations are given for the individual lines, and each multiplet is assigned a number. An extensive bibliography covers the source material used for the compilation.

The table is presented in two parts:

Part I includes the multiplets, with the spectra of each element being given in order of increasing ionization, and the elements in order of increasing atomic number.

Part II is a Finding List in which all the lines in Part I are entered in order of increasing wavelength, with their multiplet numbers.

The range of the Table is from 2951 A to 13164 A. A supplementary table of "Forbidden Lines" extends from 2972 A to 12645 A. November 1959. 256 p.

TN37 (PB151396). Application of RF micropotentiometers for calibration of signal generators to 1000 Mc, L. F. Behrent

With the RF Micropotentiometer, signal generator output voltage can be calibrated to 1000 Mc simply and accurately if the procedures outlined in this paper are carefully followed. The sources of error are discussed and methods for minimizing or eliminating them are described. Topics discussed include: rf shielding, selection of a suitable rf detector, impedance matching and the proper selection of voltage reference planes. January 1960. 14 p.

TN38 (PB151397). Design and construction of a liquid hydrogen temperature refrigeration system, D. B. Chelton, J. W. Dean, and B. W. Birmingham

Maintaining a liquid hydrogen bubble chamber at 27° K has been achieved with an automatically controlled closed circuit hydrogen refrigeration system of 300 watts capacity. The system is sufficiently flexible to be used on other experimental apparatus requiring refrigeration at liquid hydrogen temperatures. Several control systems are discussed. Experimental evidence is compared to predicted performance for design operating conditions.

General design charts are developed that enable heat exchanger lengths and associated operating parameters to be determined for the pertinent heat exchanger configuration when employed in liquid hydrogen refrigerators of other capacities. January 12, 1960. 37 p.

TN39 (PB151398). Helium refrigeration and liquefaction using a liquid hydrogen refrigerator for precooling, D. B. Chelton, J. W. Dean, T. R. Strobridge, B. W. Birmingham, and D. B. Mann

Consideration is given to the use of a hydrogen refrigerator to assist in the production of temperatures below those obtained with hydrogen. A hydrogen refrigerator is used to maintain a precooling evaporator at or near 21° K in a helium gas circuit. The helium circuit may be arranged to produce liquid for external use or to produce refrigeration between 21° K and 4.2° K in a closed system.

Charts have been developed that show the requirements of the composite helium-hydrogen system and the effect of heat exchanger performance. The relative quantities of refrigeration (hydrogen and helium) at various temperature levels have been determined. January 27, 1960. 31 p.

TN40–1 (PB151399–1). Mean electron density variations of the quiet ionosphere, I—March 1959, J. W. Wright and L. A. Fine

The CRPL has initiated a program for large-scale computation of electron density profiles from ionospheric vertical soundings. Scaling is performed at field stations permitting computation of hourly profiles at the central laboratory. These profiles are combined to form hourly mean quiet profiles for each station and month. The results of this program for one month are illustrated graphically. This report is the first of a series illustrating the electron density variations in the mean quiet ionosphere between latitudes 15° N and 50° N along the 75° W meridian. February 1960. 50 p.

TN40–2 (PB151399–2). Mean electron density variations of the quiet inosphere, 2—April 1959, J. W. Wright and L. A. Fine

The CRPL has initiated a program for large-scale computation of electron density profiles from ionospheric vertical soundings. Scaling is performed at field stations permitting computation of hourly profiles at the central laboratory. These profiles are combined to form hourly mean quiet profiles for each station and month. The results of this program for the month of April are illustrated graphically. This report is the second of a series illustrating the electron density variations in the mean quiet ionosphere between latitudes 15° N and 50° N along the 75° W meridian. February 1960. 50 p.

TN41 (PB151400). Expendable modules as bases for disposal-at-failure maintenance, R. O. Stone, P. Meissner, and K. M. Schwarz

The maintenance of future electronic equipment will more than likely exceed the capabilities of existing maintenance activities if present maintenance procedures are continued. Design trends such as miniaturization, printed circuitry, encapsulation, and modular construction all point toward disposal-at-failure maintenance. Disposal-at-failure modular design would help to solve some of the future maintenance problems and would also be compatible with future design trends.

It has been suspected that disposal-at-failure maintenance would be too costly to be practical. This report compares the costs to procure, support and maintain an equipment designed with expendable modules to the costs to procure, support, and maintain a similar equipment designed with repairable modules. It was found that the total costs in either case were approximately equal. Since the cost factor is not important in the decision between expendable assembly or repairable assembly maintenance, other factors, such as improved reliability of equipment, smaller size, lighter weight, and improved maintenance, all advantages that may be gained through the use of expendable design, should be carefully studied. These advantages may be so important as to completely determine a decision in favor of expendability.

Modules of various electrical sizes (from 1 to 12 tubes) have been compared from the standpoint of total over-all procurement cost, in order to determine an optimum

module size. On the basis of calculations made, it has been concluded that the optimum module which would lead to lowest over-all procurement cost and at the same time be of aid in the solution of logistic and maintenance problems would be one containing from 4 to 8 tubes. This is true for both disposal-at-failure and repairable modules. February 1960. 79 p.

TN42 (PB151401). Analog-digital conversion equipment for electrocardiographic data, L. Taback

A corrected orthogonal 3-lead system has been used to record electrocardiograms directly from patients at Veterans Hospitals, using three FM channels of magnetic tape. A pilot facility has been designed and assembled by NBS to permit a medical technician to inspect these on an oscilloscope and select a significant cardiac cycle. This is automatically sampled at millisecond intervals and the numerical values are stored in digital form on magnetic tape acceptable to an electronic computer. Upon writing various programs for the digital computer, the cardiac researcher will have a flexible tool for objective analysis of large quantities of biological data by a variety of possible criteria. April 1960. 40 p.

TN43 (PB151402). A summary of VHF and UHF tropospheric transmission loss data and their long-term variability, D. A. Williamson, V. L. Fuller, A. G. Longley and P. L. Rice

Cumulative distributions of hourly median basic transmission loss are presented for 135 beyond-line-of-sight radio paths in the United States. In order to allow for seasonal trends of transmission loss, the year is divided into a summer period, May through October, and a winter period, November through April.

The long-term variability of observed hourly medians is compared with predicted variability based on empirical curves by Rice, Longley and Norton. March 1960. 174 p.

TN44 (PB151403). Tables for the statistical prediction of radio ray bending and elevation angle error using surface values of the refractive index, B. R. Bean, B. A. Cahoon and G. D. Thayer

Radio ray bending, T, and elevation angle error, E, have been calculated for a wide range of meteorological conditions at 13 climatically diverse U.S. radiosonde stations. The parameters in the observed linear regression equations of T and E upon the surface value of the refractive index are given for heights of 0.1 to 70 kilometers and initial elevation angles of the ray from 0 to 900 milliradians. March 16, 1960. 22 p.

TN45 (PB151404). Operating instructions for ARN–2 auxiliary log-linear noise recorder, R. T. Disney and C. A. Samson

Auxiliary equipment has been added to the noise power recorder, ARN–2, to measure the average voltage of the noise envelope and the average logarithm of the noise envelope. These two additional parameters of the noise give enough information to determine the average characteristics of the noise. The operation of the equipment is discussed and standard operating procedures are outlined. January 1960. 30 p.

TN46 (PB151405). Experimental plating of gun bores to retard erosion, V. A. Lamb and J. P. Young

Methods for plating the bores of gun barrels are described, including details of fixture design, solution composition, and operating conditions. Extensive firing tests were performed, which show that chromium plate increases the life of barrels about 2- to 5-fold, depending on the type and caliber of barrel. Optimum thickness of plate ranges from 0.0015 inch in the smallest calibers to 0.015 inch in cannon.

Certain modifications of the barrels enhance the improvement provided by the chromium plate. Choking of the bore at the muzzle produces a marked improvement in accuracy life of caliber 0.30 and 0.50 barrels. It is less effective in barrels of larger caliber. Specially shaped lands, designed to reduce the concentration of engraving stresses at land corners, significantly improve the performance of 20 mm barrels. Other modifications, such as hardening of the basis steel by nitriding and increasing the length of the land "run-up", result in moderate improvements in some types of barrels. Physical properties of the chromium plates tested were varied. Ordinary "hard" chromium yields the best performance in most types of barrels.

Chromium plating has been adopted as standard production practice for caliber 0.30, 0.50, and 20 mm barrels, and for several calibers of cannon. May 1960. 99 p.

TN47 (PB151406). An improved hydrogen atom beam furnace, R. Klein and J. Pararas

An improvement in the construction of the tungsten furnace for use in a hydrogen atom-beam apparatus has been effected by fabricating the furnace from a tungsten rod. This avoids the possibility of leakage of molecular hydrogen which may occur when the tungsten tube is made from rolled tungsten sheet, the technique used heretofore. The fabrication of the seamless furnace and the method of mounting are described. May 1960. 7 p.

TN48 (PB151407). Report on the IGY oblique-incidence sporadic-E and F-scatter program, J. W. Finney and E. K. Smith

The IGY Oblique-Incidence Sporadic-E Measurements program was instigated to test the longitude effect in temperate zone sporadic E. To accomplish this two CW 50 Mc circuits, both approximately 800 miles in length, were installed, one between the Philippines and Okinawa in the Far East, and the other between Panama and Cuba in the Caribbean. In addition to sporadic E a very peculiar evening signal was observed during the equinoxes on the far eastern circuit which we have referred to as the "evening signal anomaly" or the "Far Eastern Anomaly". Sporadic E, as expected, was three to five times more frequent in the Far East than in the Caribbean, the factor depending upon what transmission loss level is taken. The evening signal anomaly appears to be of F-region origin and is at least 100 times more frequent over the Far Eastern circuit. March 1960. 94 p.

TN49 (PB151408). Dynamic measurements of the magnetoelastic properties of ferrites, V. E. Bottom

The relations between the mechanical and magnetic properties of a ferrite are derived for the small signal or reversible condition using thermodynamic principles. The equation of motion of a ferrite ring driven in its fundamental mode is set up and solved leading to the equivalent electrical circuit of the magnetostriction resonator. From mechanical measurements of the density and dimensions of the ring and electrical and frequency measurements of the resonator, the elastic modulus, permeability, magnetostriction coefficients and loss factors in the ferrite can be determined. Apparatus is proposed for performing the above measurements. 1960. 43 p.

TN50 (PB151409). Magnetic drum directory and programming system for codesorting letter mail, P. C. Tosini

This report is an analysis and extension of the Rabinow Engineering Company's proposal for a magnetic drum file-directory and special purpose computer to be used in

a test coded-address ("codesorting") letter-mail sorting system scheduled for late 1960 installation at the Washington, D.C. Post Office. The report is composed of 6 major sections that successively examine the major considerations involved. A short introduction is presented first. Then the general problem of coding the fields composing addresses is discussed. This area is analyzed in terms of facilitating both the human coding process and the computer coded address-to-bin-number translation. Addresses are classified into two types: "standard" and "non-standard". When coded, their fields must be unique and yet be sufficiently flexible to specify a variety of addresses. They must furthermore adequately specify some more common forms of misaddressed mail that is presently correctly sorted manually. A slightly amended form of Coding Plan E–1 is then presented and analyzed in terms of the conditions specified for coded addresses in general.

After the presentation of the coding area, the local mail sort translation program of the Rabinow proposal is discussed in detail. It is then extended to include the outgoing mail translation program and non-standard and special address forms. The information and instruction characters necessitated by the programs are listed in detail and the effects of the file-directory source document preparation determined. A coding keyboard is then suggested.

The programming is then reexamined and it is determined that all addresses can be treated as special cases of the standard address forms at an increased cost in memory space and with a saving in the special instruction symbols required. Finally, alternative methods of file-directory information storage are explored and evaluated in terms of memory space requirements, table look-up and directory access times, and conceptual simplicity. June 1960. 54 p.

TN51 (PB161552). Isotopic abundance ratios reported for reference samples stocked by the National Bureau of Standards, F. L. Mohler

The National Bureau of Standards maintains a stock of reference samples of isotopic abundance and this paper gives results that have been reported on measurements of these samples. Some information has been received on 24 of the 32 samples. The paper includes a list of the reference samples and tables of the results reported with notes on these results. May 1960. 14 p.

TN52 (PB161553). Field strength calculations for E.L.F. radio waves, J. R. Wait and N. F. Carter

The mode theory of propagation of electromagnetic waves at extremely low frequencies (1.0 to 3000 c/s) is briefly reviewed in this paper. Starting with the representation of the field as a sum of modes, approximate formulas are presented for the attenuation and phase constants. At the shorter distances, where the range is comparable to the wavelength, the spherical-earth mode series is best transformed to a series involving cylindrical wave functions. This latter form is used to evaluate the near field behavior of the various field components. The effect of the earth's magnetic field is also evaluated using a quasi-longitudinal approximation which is particularly appropriate for propagation in the magnetic meridian. In general it is indicated that if the gyro frequency is comparable or greater than the effective value of the collision frequency, the presence of the earth's magnetic field may be important for E.L.F. In this case the attenuation may be increased somewhat. The influence of a purely transverse magnetic field is also considered.

This technical note is actually a numerical supplement to the paper "Mode Theory and the Propagation of ELF Radio Waves," by J. R. Wait, J. Research N.B.S., *64D*, July–Aug. 1960; however, for sake of completeness the relevant theory is reviewed. March 1960. 35 p.

TN53 (PB161554). Carrier frequency dependence of the basic transmission loss in tropospheric forward scatter propagation, K. A. Norton

A further interpretation is given of certain Lincoln Laboratory data obtained in an experiment using scaled antennas as presented in a recent letter to the Proceedings of the IRE from Bolgiano. This paper has four objectives: first, to clarify the significance of these data from the standpoint of the engineer developing long-range tropospheric scatter systems; second, to apply a further statistical analysis to these data; third, to consider their significance as regards the theory of radio propagation through a turbulent atmosphere; and fourth, to describe a suitable method for the measurement of the meteorological parameters entering the theory. May 12, 1960. 64 p.

TN54 (PB161555). Determination of a general index of effort in sorting mail by conventional methods, S. Henig

The conventional method of sorting letters in stages is described. It is shown, through reference to available statistics, that about 90 percent of letters originating within the areas served by several large post offices will be involved in no more than five stages to be completely sorted to a carrier, firm or section of boxes. A method is presented for the accounting of each stage's individual letter readings which are defined as the units of measurement for the index of sorting effort. It is found that the upper bound average number of readings per letter for three large post offices varies from 3.16 to 2.98 and that these bounds are applicable to 96.2 to 92.4 percent of the local originating first class letters. It is anticipated that the values of such indexes for all large post offices will be consistently close to the range already determined. June 1960. 9 p.

TN55 (PB161556). Investigation of bearing creep of two forged aluminum alloys, L. Mordfin, N. Halsey, and P. J. Granum

Fourteen bearing specimens of 7075–T6 and 2014–T6 forged aluminum alloys were tested in creep at 400° F. The 2014–T6 specimens had greater creep resistance and less ductility than the 7075–T6 specimens.

For each material the bearing creep resistance varied directly with edge distance and bolt tightness. Prior exposure of the 2014–T6 alloy to elevated temperature reduced its bearing creep resistance.

The validity of a previously proposed theory of creep in bolted joints was examined using the test data together with results from an earlier study. The theory was found to hold for 7075–T6 but not for 2014–T6. August 1960. 31 p.

TN56 (PB161557). A bibliography of the physical equilibria and related properties of some cryogenic systems, T. M. Flynn

A bibliography of approximately 700 references is presented on the physical equilibria and related properties of several important cryogenic systems. The systems considered are the pure components and mixtures of: Hydrogen, Helium, Nitrogen, Carbon Dioxide, Carbon Monoxide, Methane, Ethane, and Propane. May 1960. 123 p.

TN57 (PB161558). Variable capacitor calibration with an inductive voltage divider bridge, T. L. Zapf

The use of an inductive voltage divider bridge for the calibration of three-terminal and two-terminal variable air capacitors is discussed. May 1960. 6 p.

TN58 (PB161559). A survey and bibliography of recent research in the propagation of VLF radio waves, J. R. Wait

This report presents a general, but brief, survey of the field. Attention is confined primarily to terrestrial propagation, and thus solar and exospheric phenomena are generally excluded although certain germane references are given in the bibliography.

First a brief description of recent advances of ground wave propagation is given. This is followed by sections on ray and mode concepts of ionospheric propagation. The research dealing with the waveforms of atmospherics is also considered. Finally some recent applications of VLF propagation are described. While the emphasis is on the theoretical approaches used, reference to corroborating experimental work is included. It is hoped that the shortcomings in a brief article of this kind are partially compensated by the inclusion of an extensive bibliography on the subject arranged under subject classification. While attention is confined primarily to the triennium (1957–59) a number of basic references prior to 1957 are included.

The VLF band is here defined as the decade 3 to 30 kc/s whereas the ELF band covers the range 1.0 c/s to 3 kc/s. May 1960. 44 p.

4. TITLES OF PAPERS PUBLISHED IN OUTSIDE JOURNALS 1950 TO 1959

On pages 75 to 160 are listed papers by the Bureau staff that have appeared in outside journals during the period 1950 to 1959. The listing is alphabetical by title under year of publication. Each paper is preceded by a number that serves to key the paper to the index. These papers are not for sale by the Government, usually they may be obtained directly from the author or from the publisher of the appropriate journal.

1. A class of mean value functions, E. F. Beckenbach. Am. Math. Monthly 57, No. 1, 1 (1950).
2. A comparison of meteor activity with occurrence of sporadic E reflections, V. C. Pineo. Science 112, 50 (1950).
3. A new method for determining the value of the Faraday, D. N. Craig and J. I. Hoffman. Phys. Rev. 80, 487 (1950).
4. A new technique for cutting very thin sections and its application to the electron microscopy of fibers, S. B. Newman. ASTM Bull. 163, 57 (1950).
5. A note on the four by four Latin squares, W. J. Youden. Biometrics 6, 289 (1950).
6. A recording microwave refractometer, G. Birnbaum. Rev. Sci. Instr. 21, 169 (1950).
7. A reduction of area gage for use at low temperatures, G. W. Geil and N. L. Carwile. ASTM Bull. 163, 75 (1950).
8. A remote-control method of opening ampoules of active materials, J. E. Sherwood. Rev. Sci. Instr. 21, 570 (1950).
9. A resistance-temperature relation for low temperature thermometry, H. J. Hoge. Rev. Sci. Instr. 21, 815 (1950).
10. A source of error in radio phase measuring systems, R. Bateman, E. F. Florman, and A. Tait. Proc. IRE 38, 612 (1950).
11. A sulfate susceptibility test for portland cements, W. C. Taylor and R. H. Bogue. Portland Cement Assoc. Fellowship 58, 223 (1950).
12. A survey of ceramics for nuclear reactors, R. F. Geller. Nucleonics 7, No. 4, 3 (1950).
13. A thickness gage for ceramic coatings, C. C. Gordon and J. C. Richmond. J. Am. Ceram. Soc. 33, 295 (1950).
14. A versatile pneumatic instrument based on critical flow, W. A. Wildhack. Rev. Sci. Instr. 21, No. 1, 25 (1950).
15. A VHF match meter, P. G. Sulzer. Television Eng. 1, No. 7, 4 (1950).
16. Acceptance sampling by variables, with special reference to the case in which quality is measured by average of dispersion, J. H. Curtiss. Acceptance Sampling: A symposium given at the 105th annual meeting. Am. Statistical Assoc. (Washington, D. C.) (1950).
17. Unassigned.
18. Adjustment of high-precision frequency and time standards, J. M. Shaull. Proc. IRE 38, 6 (1950).
19. Aging of Karakul and seal fur skins, E. T. Steiner and E. R. Hosterman. J. Am. Leather Chemists Assoc. 45, 579 (1950).
20. American Dental Association Specification No. 9 for dental silicate cement, First revision, effective July 1, 1950, G. C. Paffenbarger, A. C. Swaney, I. C. Schoonover, and G. Dickson. J. Am. Dental Assoc. 40, 186 (1950).
21. Amerikanische Kunststoffentwicklung im Jahre 1949, G. M. Kline. Kunststoffe (Munchen, Germany) 40, No. 2, 59 (1950).
22. An analysis of some anomalous properties of equiphase contours, G. A. Hufford. Proc. IRE 38, 614 (1950).
23. An elementary introduction to the calculus of variations, M. R. Hestenes. Mathematics 23, No. 5, 249 (1950).
24. An instrument for mechanically differentiating curves, A. H. Scott. Rev. Sci. Instr. 21, 397 (1950).
25. Analysis of natural gas, M. Shepherd. Anal. Chem. 22, 885 (1950).
26. Apparatus for determining freezing points at saturation pressure from time-temperature freezing and melting experiments, A. R. Glasgow, Jr., N. C. Krouskop, and F. D. Rossini. Anal. Chem. 22, 1521 (1950).
27. Application of photoelectric multiplier tubes to the sensitive measurement of absorption or of changes of relative light intensities, O. Oldenberg and H. P. Broida. J. Opt. Soc. Am. 40, 381 (1950).
28. Atomic definition of primary standards, R. D. Huntoon and U. Fano. Nature (London, England) 166, 167 (1950).
29. Attenuation due to rainfall, H. E. Bussey. FM-TV Radio Commun. 10, No. 2, 12 (1950).
30. Background eradication in thick-layered emulsions, M. Wiener and H. Lagoda. Rev. Sci. Instr. 21, No. 1, 39 (1950).
31. Calibration of audiometers, E. L. R. Corliss and W. F. Snyder. J. Acoust. Soc. Am. 22, 837 (1950).
32. Calibration of precision airplane mapping cameras, F. E. Washer and F. A. Case. Photogrammetric Eng. 16, 502 (1950).
33. Cascade-connected attenuators, R. W. Beatty. Proc. IRE 38, 1190 (1950).
34. Characteristics of the Institute for Numerical Analysis Computer, H. D. Huskey. Math. Tables and Other Aids to Computation 4, No. 30, 103 (1950).
35. Chemical spectroscopy. 1950 Edgar Marburg Lecture before the American Society for Testing Materials, W. R. Brode. Am. Soc. Testing Materials Proc. 50, 513 (1950).
36. Coefficients for polar complex interpolation, H. E. Salzer. J. Math. and Phys. 24, No. 2, 96 (1950).
37. Color phase contrast microscopy: Requirements and applications, C. P. Saylor, A. T. Brice, and F. Zernike. J. Opt. Soc. Am. 40, 329 (1950).
38. Color television, N. Smith. Sci. Am. 183, No. 6, 13 (1950).
39. Comparative tests in a single laboratory, W. J. Youden. ASTM Bull. 166, 48 (1950).
40. Comparison of variously derived solar indexes, H. S. Moore and M. Stein. J. Geophys. Research 55, 423 (1950).
41. Coupling chart for solenoid coils, P. G. Sulzer. Television Eng. 1, No. 6, 20 (1950).
42. Coverage of standard frequency station WWVH, E. L. Hall. Television Eng. 1, No. 8, 16; No. 10, 20 (1950).
43. Degradation of high polymers, R. Simha. J. Polymer Sci. Letter to Editor 5, 515 (1950).

44. Depolymerization as a chain reaction. R. Simha, L. A. Wall, and P. J. Blatz. J. Polymer Sci. 5, 615 (1950).
45. Determination of attenuation from impedance measurements, R. W. Beatty. Proc. IRE 38, 897 (1950).
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47. Device for filtering and precise dispensing of solutions in closed systems, S. Rothman. Anal. Chem. 22, 367 (1950).
48. Dispersion in NH_3 in the microwave region, G. Birnbaum. Phys. Rev. 77, 144 (1950).
49. Dissociation constant of aqueous ammonia at 0° to 50° from EMF studies of the ammonium salt of a weak acid, R. G. Bates and G. D. Pinching. J. Am. Chem. Soc. 72, 1393 (1950).
50. Effect of fuel-immersion on laminated plastics, W. A. Crouse, M. Carickhoff, and M. A. Fisher. Trans. Am. Soc. Mech. Engrs. 72, 175 (1950).
51. Effects of acid treatment on acid and abrasion resistance of porcelain enamels, W. N. Harrison, J. C. Richmond, and J. R. Crandall. J. Am. Ceram. Soc. 33, 314 (1950).
52. El sistema I. C. I. para la especificacion del color, D. B. Judd. Anales de la Real Sociedad Espanola de Fisica y Quimica (Madrid, Spain) 46, 123 (1950).
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HOW TO USE AUTHOR AND SUBJECT INDEXES
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Author-index citations to papers published in outside journals (non-NBS) give the journal designation followed by the assigned number corresponding to the paper listing beginning on page 75. Subject-index citations to outside papers are designated by the assigned number only (page 75).

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7. SUBJECT INDEX

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U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

ANALYTICAL AND INORGANIC CHEMISTRY. Pure Substances. Spectrochemistry. Solution Chemistry. Analytical Chemistry. Inorganic Chemistry.

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

ORGANIC AND FIBROUS MATERIALS. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

METALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics. Electrodeposition.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Crystal Growth. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

PHYSICAL CHEMISTRY. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry. Molecular Structure and Radiation Chemistry.

• Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High Frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Interval Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.