NBS 1971 ANNUAL REPORT

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

70 YEARS OF SERVICE

NBS 1971 ANNUAL REPORT

CONTENTS

Front cover: Ground breaking for the NBS Chemistry building, 1915, and an aerial view of the present Gaithersburg, Maryland site.

Back cover: The NBS Boulder, Colorado Laboratories.

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This Report necessarily presents only a glimpse of the National Bureau of Standards. We hope, however, that it provides the means of entree to NBS for anyone needing more detailed information. We encourage direct contact between you, our readers, and the NBS staff, and have provided phone numbers of key officials and project scientists throughout the text. To reach an individual at Gaithersburg, use area code 301, followed by 921 and the four digit extension provided in this Report. To reach the Boulder laboratories, dial (303) 499-1000, then ask for the desired extension. Mail addresses are:

National Bureau of Standards
Washington, D.C. 20234

and

National Bureau of Standards
Boulder, Colorado 80302

FOREWORD

This year—1971—the National Bureau of Standards celebrated its 70th anniversary. NBS is justly proud of 70 years of service to the public, and to the scientific and engineering community. We also welcome the challenges that face us in the problems of today and the complexities of tomorrow.

An anniversary provides a convenient opportunity to review the accomplishments of the past. In this Annual Report we have looked back over those 70 years with photographs from our files, and with descriptions of some major contributions to science and technology. These contributions cover the range from basic discoveries in fundamental physics to applied measurement and from the development of new technologies (such as the magnetic fluid clutch) to promotion of equity in the marketplace. We have, of course, included highlights of the significant events of the past year.

Although it would take a document many times this size to outline the future plans for all of our programs, we have tried in this Report to present a glimpse of the direction in which each major technical area is headed.

This Report can do little more than skim the surface of NBS. Should you want to know more about the Bureau or a particular program, your letter, phone call, or visit is welcomed. To help direct you to the proper contact, we have included the name and phone number of people whose work is mentioned, and have provided a brief directory following the text.

Lewis M. Branscomb, Director

U.S. DEPARTMENT OF COMMERCE
Peter G. Peterson, Secretary

James H. Wakelin, Jr. Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Lewis M. Branscomb, Director

This Report was prepared under the direction of Dr. Thomas M. Flynn of the NBS Office of Programs, with the assistance of Don Baker, Office of Technical Information and Publications.

Editorial Assistance provided by Dr. Howland Fowler, George Uriano, George Rothwell, and M. Zane Thornton.

Visual Editor, Charles Messina; special photography by the NBS Photographic Laboratory.

CONGRESSIONAL RELATIONS

THAT very diversity and utility which characterizes the programs of the National Bureau of Standards naturally bears on many areas of current major concern to the Congress of the United States. As a consequence, the NBS is being called upon with increasing frequency to help inform the Congress through Congressional hearings—both to describe its work, and to provide advice regarding a variety of technical subjects. During recent months, testimony by NBS representatives contributed to such wide-ranging hearings as those on noise control, conducted by the Subcommittee on Public Health and the Environment of the House Committee on Interstate and Foreign Commerce; on preventive detention, by the Subcommittee on Constitutional Rights of the Senate Committee on the Judiciary; and on problems faced by small business in converting to the metric system of measurement, held by a subcommittee of the House Select Committee on Small Business.

In addition to such ad hoc participation, the Bureau enjoys a special continuing relationship with certain committees of the Congress. Each year a request for appropriations to support the Bureau's work is presented to the Appropriations Committees of the House and Senate. Hearings concerning the NBS budget are conducted by each Committee's Subcommittee on Departments of State, Justice, and Commerce, the Judiciary, and related agencies.

Rule XI of the House of Representatives, which sets forth the powers and duties of committees, assigns to the Committee on Science and Astronautics jurisdiction over matters relating to the "National Bureau of Standards, standardization of weights and measures and the metric system." In the Senate, similar jurisdiction is assigned by Standing Rule XXV to the Committee on Commerce. Most legislation bearing directly on the functions and operations of the Bureau is considered by these committees.

However, some of the Bureau's continuing programs result from the delegation by the Secretary of Commerce of certain responsibilities assigned to him by laws falling under the jurisdiction of other committees. In particular, NBS witnesses have appeared frequently before the Subcommittee on Commerce and Finance of the House Committee on Interstate and Foreign Commerce in connection with the administration of the Flammable Fabrics Act. Similarly, Public Law 89-306, which is the basis for much of the Bureau's work in the automatic data processing field, is under the jurisdiction of the Subcommittee on Government Activities of the House Committee on Government Operations.

Rule XI of the House of Representatives also states:

> To assist the House in appraising the administration of the laws and in developing such amendments or related legislation as it may deem necessary, each standing committee of the House shall exercise continuous watchfulness of the execution by the administrative agencies concerned of any laws, the subject matter of which is within the jurisdiction of such committee; and, for that purpose, shall study all pertinent reports and data submitted to the House by the agencies in the executive branch of the Government.

In keeping with this legislative oversight responsibility, the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics conducted extensive hearings in September 1971. The objective of the hearings was to present the subcommittee with an in-depth, timely review of NBS, its goals, structure, operations, strengths, and problems and opportunities. This NBS Annual Report is based almost entirely on the testimony presented at those hearings by Bureau Management. For those who wish to dig deeper, the complete record of the hearings may be obtained by writing to: Committee on Science and Astronautics, House of Representatives, Room 2321, Rayburn Office Building, Washington, D.C. 20515.

Clarence Coates
Assistant to the Director for Congressional Liaison
(X2441)

NBS 1971

AN OVERVIEW

1971 saw the first comprehensive legislative oversight examination of the National Bureau of Standards by the House Committee on Science and Astronautics. The need for such hearings was amplified by the swift changes overtaking the Bureau as it attempts to respond to demands placed on it by public needs, established in new legislation, or reflected in changing national circumstances within our original statutory responsibilities.

The basic enabling legislation established in 1901 and amended several times, most comprehensively in 1950, establishes the main purposes and authorities of the Bureau as follows:

the custody, maintenance and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards including the comparison of standards; the determination of physical constants and properties of materials . . . of great importance to scientific or manufacturing interests . . . not to be obtained of sufficient accuracy elsewhere; the development of methods for testing materials, mechanisms, and structures and the testing of materials, mechanisms, and structures; cooperation with other Government agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications; advisory service to Government agencies on scientific and technical problems; and invention and development of devices to serve special needs of the Government.

Examination of this statute will show that NBS has both unique and special responsibilities in relation to the Nation's science and technology, and very broad responsibilities as well.

Our cornerstone responsibility is to provide for the United States the single authoritative source of accurate, compatible, and useful physical measurements and further to ensure their international compatibility. No nation in the modern world, much less the world's leading scientific and technological society, can prosper and function effectively if the national system of measurement is in a state of anarchy.

A nation cannot have two sizes for the inch, two weights for the pound or two values for the units describing electric power, temperature, frequency, time, or any of the 40 or more derived units and their many useful combinations. Only one laboratory can speak for the nation in the international community of metrologists who work together under the aegis of the Treaty of the Meter to produce a single, compatible world system of measurement units. The laboratory with this responsibility must be above suspicion in its integrity, its competence, and its independence from influences. It must be devoted entirely to

The NBS Administration Building, Gaithersburg, Md.

Dr. Lewis M. Branscomb
Director

1901

Dr. Samuel W. Stratton was the Bureau's Director from its founding in 1901 until 1922, when he left to become President of the Massachusetts Institute of Technology.

objective technical truth for it must be able to resolve conflicts when two people—or two companies—measure the same thing and get different answers. These principles are the life blood of the National Bureau of Standards and are strongly and deeply felt by each of our professional staff members.

THE PRICE AND VALUE OF ACCURACY

Accuracy is expensive and sometimes difficult to achieve. We put a lot of effort into discussing the needs of our "customers"—of American scientists, engineers, and businessmen and other Government officials—to be sure they really need the accuracy of measurement they say they must achieve. We believe that very large sums of money, reflecting countless engineering manhours, can be saved by adopting the philosophy: "Ask for no more accuracy than you need and be sure you get it."

MEASURES IN THE MARKETPLACE

If a free-enterprise economic system is to thrive in a modern industrial society, indeed if it is to survive, buyers and sellers in the marketplace need to have as much confidence in the quantity and performance of goods exchanged as they do in the amount of monies paid. A substantial part of the Bureau's measurement research is devoted to the validation of fair, objective, and useful measurement methods for application to both durable and nondurable goods in trade.

The commercial life of this country depends upon the Bureau's help with such measurement problems, because both buyer and seller need an unbiased, honest third party with the technical capability to say "This measurement is a fair and accurate one; that one may not be." Industry values the Bureau's third-party independence and integrity. The ADX2 case was of enormous significance to the National Bureau of Standards. It demonstrated that the Bureau does not shy away from technical problems of apparently low sophistication and potentially high controversy if they are important to the proper functioning of government, to the progress of science, or to the survival of the free enterprise system. It also demonstrated to every NBS scientist at that time and since that dedication to properly documented, objective, technical truth will result in the laboratory's vindication.

NBS GOAL: MAKE SCIENCE USEFUL

A laboratory of this type, with a 70-year tradition of scientific excellence and integrity, finds itself not only in great demand but acquiring additional major responsibilities that go far beyond the specific research requirements for the national system of measurement. We were established by the Congress to be helpful, and we find ourselves a critical link between

the basic research community and those who have put science to work for the benefit of man. As the decades have passed, the Bureau has responded to the country's problems as they arose, in war and in peace, in times of rapid scientific growth, in times of scientific retrenchment and serious domestic problems. Throughout the thousands of useful projects at NBS runs a common thread: *the Bureau helps others with applied research services to produce, diffuse, and enhance the value of practical knowledge. Our goal is to strengthen and advance the Nation's science and technology and to facilitate their effective application for public benefit*—in short to help make science useful and technology the servant and not the master of people. To achieve this goal the Bureau integrates its scientific and technological activities and gives special attention to the public and private institutions through which our applied research services will benefit people. We do not just assume that our research will prove helpful to others; we do what it takes to insure that it is.

NBS RELATIONSHIPS WITH THOSE WE HELP

It is important that I say a few words about how NBS insures that our work reaches the hands of those it is meant to serve and how it insures that the benefits intended for the public are actually realized.

Government Agencies.

The Congress has wisely chosen a statement of the Bureau's mission broad enough to allow the Bureau to respond to changing needs. By the same token, such a freedom of choice demands of us a continual appraisal of the most important problems to tackle. Of the criteria for choice, and therefore for action, four seem to be vital to success:

1. needs in relation to our statutory mission;
2. a timely technical opportunity;
3. adequacy of resources in manpower and facility;
4. availability of dynamic leadership.

Unless all these four criteria are met any problem that is tackled is not likely to have striking success.

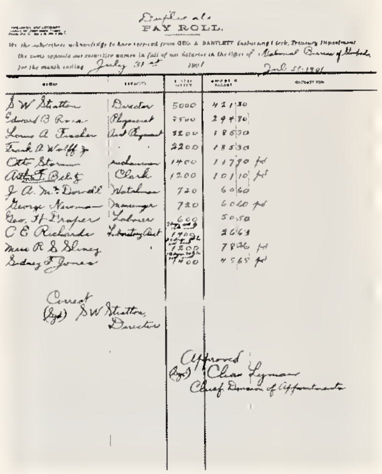
Thirty-eight percent of all the funds expended by NBS are transferred from other agencies in reimbursement for technical and research services. These services range from brief consulting tasks, often offered without reimbursement; to special tasks of days or weeks duration; all the way to formal continuing agreements to provide very substantial resources to another department of government.

State and Local Governments.

Our ties with State and local governments are also of vital importance to our usefulness and effectiveness. Our prime strategy has been a consistent one—to

1901

Copy of the first NBS payroll.


PAY ROLL.

This current balance was used by Drs. Rosa and Dorsey in 1908 for a precision determination of the ampere.

preserve the constitutional prerogatives of the States by seeking to bring them together into national conferences for specific problems so that we can provide our technical help fairly and effectively to all 50 States and, at the same time, promote compatibility between the regulations and practices of the States where this is clearly to the Nation's advantage.

The first example of this relationship was brought into being almost immediately after the founding of the National Bureau of Standards in 1901. At that time the weights and measures regulations of the States were in chaotic condition. NBS Director Stratton brought into being the National Conference of Weights and Measures, which today is a strong and technically competent organization of State weights and measures officials, working in close harmony with industry and consumer groups and the National Bureau of Standards.

In our encouragement of the National Conference of States on Building Codes and Standards, and our technical support of local and municipal code officials, NBS seeks to promote progress in the regulatory system for building construction. State and local governments have very limited research resources available to them, and it would obviously be wasteful if all 50 States had to establish parallel research capabilities. It is a logical, economical, and proper relationship for State and local officials to look to the NBS as a source of sophisticated technical help. Drawing on the entire Nation's scientific and engineering capabilities, NBS can help keep the authority for decisions at the local level while bringing the benefits of research at the national level.

ACADEMIC AND INDUSTRIAL RELATIONS

NBS relationships with the academic and industrial research community have always been very close. These relationships are most effectively established through participation of our scientists and engineers in the professional societies, the major private sector standards organizations, and by direct collaboration in joint research projects both with university scientists and with industry.

For academic and other scientists attempting the most sophisticated and demanding scientific research, we offer our talents and facilities on a cooperative basis. There are many physics experiments that simply cannot be done without direct access to our standards, our laboratory environment, and our talented staff.

We are particularly proud of our industrial Research Associate Program through which industrial firms, at their own expense, send top scientists or engineers to NBS for a program of jointly selected research.

INTERNATIONAL RELATIONSHIPS

Finally, I must say something about our international responsibilities and relationships. As the world's leading technological nation the United States has a

vital interest in insuring that the world system of measurement is not only internationally compatible but also is sufficiently sophisticated to meet United States needs. NBS helps assure this through our relationships to the General Conference of Weights and Measures, a triennial international diplomatic conference established by the Treaty of the Meter in 1875. The success of United States foreign commerce, as well as the success of international scientific cooperation, depends upon the continued progress of this cooperative international endeavor.

Because of our special interest in applied science and in applied research services for economic development, nations at all stages of development have expressed great interest in NBS. The recent visits of two senior staff members of the national metrological laboratories in Romania result from high-level diplomatic initiatives by the United States leading to bilateral cooperative agreements in science and technology.

MAJOR GOALS AND OBJECTIVES

The chart shows the six major goals and objectives of the Bureau of Standards. They describe not only what we do, but through what groups and institutions we work in order to achieve the desired results.

The first program helps scientists and engineers make *accurate, meaningful, and compatible measurements* and *provides* them with *data needed in research* and *engineering*. Among the programs listed under this heading are quite a number that are concerned with transferring into the user's laboratory the measurement standards or the measurement capabilities realized at NBS. This is the traditional way to transfer measurement accuracy. Increasingly we are finding that time and money can be saved and measurement accuracy and confidence improved if the Bureau can provide the scientist or engineer with a self-calibration capability.

Our services for industry and government are largely concerned with helping others make more effective use of science and technology in their achievement of identified priority goals. Many of these programs are designed to apply research to the elimination of barriers that inhibit the private sector, or the rest of government, from the most effective use of science in the public interest. The Bureau of Standards is not in competition with industry. We do not develop products or processes. We do solve problems of general concern, provide

Measurement Services for Science and Technology

Science and Technology for Industry and Government

Technical Services for Equity in Trade

Technical Services for Public Safety

Technical Information Services

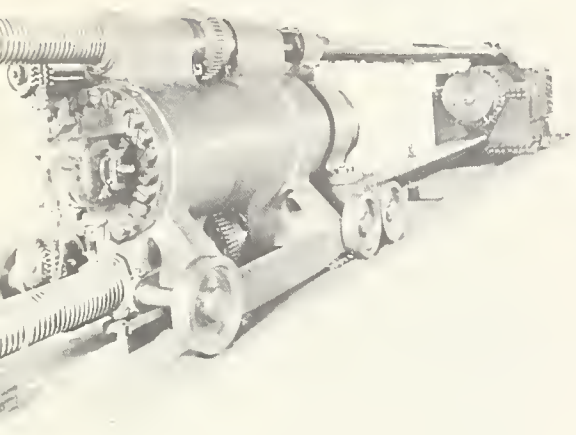
Central Technical Support

1910

NBS has long been a meeting place for a wide variety of scientific groups. This is the International Technical Committee of 1910, gathered at the Bureau to establish new values for the ampere, ohm, and volt. Director Stratton is sixth from the left.

1910

This machine, which was capable of exerting up to 2,300,000 pounds in compression, was used by the Bureau for many years in testing beams, girders and other structural components.



technical data and useful knowledge, and participate an an unbiased expert in the development of voluntary industrial and data processing standards. Our purposes are to promote fair competition, improve productivity in research, production and delivery of services, assist regulatory officials with objective, rational standards-setting and look for ways to release the innovative energies of this great nation to use technology to solve its problems.

Earlier in this testimony I referred to the importance of measurements used in commerce to the maintenance of confidence in a free enterprise economy. Programs of this type are conducted under the heading, *Technical Services for Equity in Trade*. Important among these is NBS participation in voluntary engineering and information processing standards activity. A healthy and effective national standards program can promote innovation and improve productivity in industry, and can provide the small businessman with a better opportunity to break into an established market or to bid on components and materials subcontracts. It can save millions of dollars in the writing of technical specifications for competitive bids and can improve the standards of industrial practice throughout our Nation. Since the system is a voluntary system, established in the private sector, it is sometimes disappointingly slow and occasionally even operates to impede commerce or competition. There is frequently a need for public interest

Russell Young (X2216) has developed a field emission probe for measuring the microtopography of replicas of diffraction gratings.

representation at the standards negotiating table. It is uneven in its technical quality and suffers from the lack of both financial and scientific support from both industry and government. But without a continually updated set of tens of thousands of standards prepared by private-sector organizations we would either have to revert to a preindustrial society, or establish the standards by decree as they do in many communist countries.

PRODUCT PERFORMANCE

We do *not* test consumer products at the request of either manufacturers or consumers. We believe that a free market is the best determinant of overall relative quality for consumer products. However, both industry and consumer advocates agree that the interests of all would be served by engineering progress in the development of criteria and methods for evaluating those types of product characteristics that are important to public safety and welfare, and that lend themselves to objective technical measurement.

With respect to safety programs, the Bureau works on problems assigned to us in our enabling legislation dealing with fire research and safety, on problems assigned to us by special statutes such as the Flammable Fabrics Act, and the Refrigerator Safety Act and, in collaboration with other agencies, in other fields where safety research and standards are needed. NBS has given a very high priority to implementing our responsibilities under the Flammable Fabrics Act. Our 1972 Flammable Fabrics expenditures will be over 10 times the budget level of 1969. But in spite of considerable progress in that field, we have made only a modest initial effort in tackling the whole fire problem.

SPECIAL PROBLEMS AND OPPORTUNITIES

During a time of rapid priority change and laboratory reorganization, our staff has proved admirably adaptable. Still, an annual reduction-in-force averaging about 1-1/2 percent of our total personnel in each of the last 2 fiscal years has been regrettable, but unavoidable.

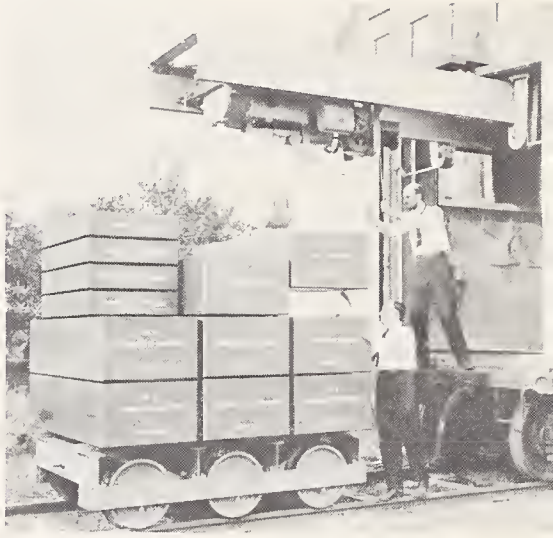
At the same time, we have permitted the state of the Bureau's equipment to fall far below the standard to which industrial laboratories maintain themselves, notwithstanding the fact that it is our responsibility to be the measurement reference laboratory for them. We have also seen severe attrition in discretionary operating funds over and above our basic technical and support payroll. This, in part, has forced the reductions-in-force as managers reduce staff to keeping operational efficiency. Despite these difficulties I believe the National Bureau of Standards faces the most challenging opportunity of any large research laboratory in this Nation. We have the right competence in the right organization at a right time. We are effectively engaged in a way that I think is unique in bringing science and technology to bear on national social and economic problems as well as on our scientific advancement. Our scientists understand the complexities of the social context within which their research must find application. We enjoy a generally excellent reputation among those who know our work, even though we have not been very active in making ourselves known to the general public.

I am deeply concerned that disillusionment may follow if government fails to promote innovation and the productivity of our technology and fails to guide the regulation of technology on the basis of objective evidence and fair and accurate measurements. We see the national measurement system and a system of industrial and engineering standards as dynamic systems calling not for more stewardship, but for leadership.

Lewis M. Branscomb

1914

This test car was sent around the Nation calibrating railway track scales, some of which were grossly inaccurate. A similar car is still in service.



INSTITUTE FOR BASIC STANDARDS

THE Institute for Basic Standards' mission is the *Custody, Maintenance, and Development of the National Standards of Measurement,* and the provision of *Means and Methods for Making Measurements Consistent with those Standards.*

This mission puts us at the heart of what we call the National Measurement System. The primary goal of a National Measurement System is compatibility—every participant (individual or organization) must be compatible in his actions and decisions with others. Consider the need for compatibility in the measurement of one quantity—time. One person might check his watch with a radio station, another by calling the telephone company, and a third by calling Western Union. Yet each of these three people would expect the time involved to be the same. It is the same because the radio station, the telephone company, and Western Union all get the correct time from radio station WWV, operated by the Time and Frequency Division. This same need for compatibility can be traced in the other quantities of measurement.

We are dealing with the highest levels of accuracy, for which it is hard to see the day-to-day utility. The utility is to be found in the needs for compatible measurement in a highly industrialized society, which typically become apparent only to the specialist.

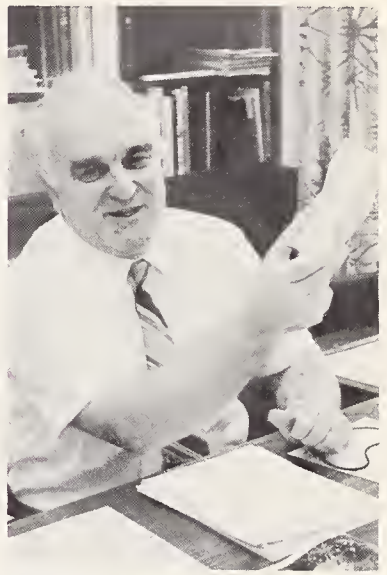
This 30-metre laser interferometer, located in a gold mine near Boulder, Colo., can detect vibration amplitudes as small as 5×10^{-13} metre. Earthquakes, solar and lunar tides, and rock deformation are being studied with this instrument (Judah Levine, Boulder, X3903).

Naturally, we relate most closely to the scientists and engineers who work on the National Measurement System, and the industries we relate to most closely are the instrument manufacturers. This is a $6 billion industry with a favorable trade balance. We feel that its growth and size illustrate its relative importance to the rest of industry and commerce, since *other* industries buy *instrumentation* to increase *their* own productivity.

All these instruments must be made to give compatible readings at levels of accuracy determined by the manufacturers' specifications. This is accomplished in general through the use of secondary standards, which in turn are calibrated against primary standards which we provide and maintain. The National Measurement System is thus a network that ensures compatibility—commercial, industrial, and scientific.

It is essential for me to point out that there is an intimate connection between the National Measurement System and science, in particular the so-called Laws of Physics. This connection leads to an *International System of Units* for physical measurement. At the core of the International System of Measurements there are *only seven base units.* From these seven are derived all of the other quantities used by science, engineering, technology, and commerce.

It will be impossible for me to describe all areas that IBS is involved in, in relation to



Dr. Ernest Ambler
Director, Institute for Basic Standards
(X3301)

1914

In 1914 Frederick Kolster developed a radio compass that enabled a ship to establish its position by determining the direction of broadcast stations.

the system of physical measurements, let alone all the ways in which this work relates to users. Therefore,

1. I shall discuss technical work and applications related to one of the seven base units, namely LENGTH.

2. I shall do a similar thing with regard to one of the derived units, namely ENERGY, and I shall specialize in energy in the form of electromagnetic radiation.

3. I shall attempt to take a crosscut of all our technical programs, showing how they can be grouped into different kinds of services. It is my intention in doing this to give specific examples that will illustrate how our work provides distributed benefits to government programs, the public in general, industry, and science and technology.

LENGTH—A BASE UNIT

There are a large number of length measuring devices available, ranging all the way from the Krypton Lamp which defines the unit of length, to lasers stabilized by saturated absorption (an NBS development which we fully expect to be the defined unit of length in the future) down through practical gages that the Bureau calibrates, thereby transferring to users in a directly useful, as well as compatible fashion, the international standard of length.

These length standards—gage blocks, balls, cones, rings, plugs, and angles—are workhorses of the engineering world. Of particular interest are the American Petroleum Institute thread gages, adopted as standards by the whole international petroleum industry, even in Iron Curtain countries. The specifications of these threads originate, in fact, from the API headquarters in Texas, and the threads are known worldwide as the "Texas Threads."

One of the most important improvements taking place at the present time is the use of the laser in length measurements. For length measurement, the laser can be used in two ways:

1. By sending out a short pulse of light, and measuring the time of travel back and forth between two points, as in the retro-reflectors left by Apollo 11, 14, and 15 on the moon. Peter Bender (X3846) at Boulder is the current team leader for this important experiment. From this work valuable information is being obtained on lunar motion and earth angular position, to an uncertainty of about 20 metres in a light path of nearly a billion metres. Potential improvements in accuracy can reduce this uncertainty to only a few centimetres. This work may lead to improved knowledge of crustal motions in the earth, even permitting a direct measurement of continental drift, which has both geophysical and astronomical importance.

2. By actually counting one-by-one the wavelengths of light. A commercial laser system is being presently employed at NBS for measuring long gage blocks and coil forms. This is the type of laser

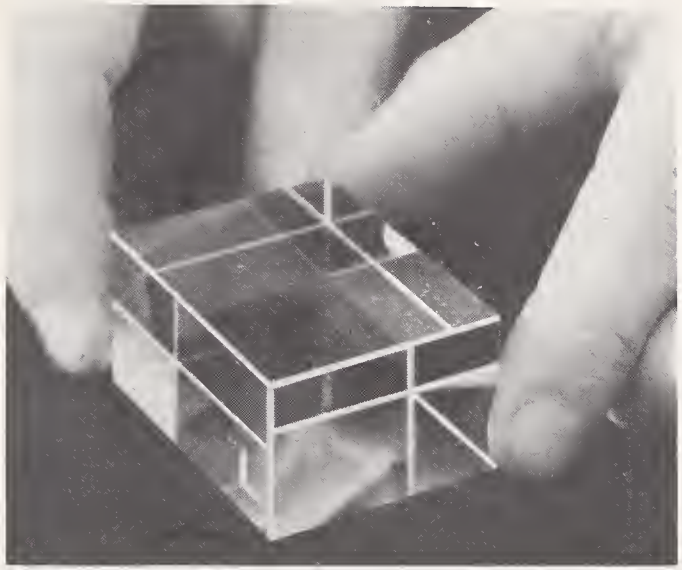
instrumentation which is evolving for the control of machine tools as they simultaneously gage and shape materials. The machine which *sees* and *measures* as it *cuts* is the embodiment of high-technology productivity—it does three jobs at once. All of these benefits from laser-control technology are potentially applicable to numerically controlled machine tools, which now represent 20 percent of basic sales of machine tools. Accuracy and precision are absolutely critical to this $1.6 billion tool industry, which is facing tough international competition.

ENERGY: A DERIVED UNIT

Energy comes in many forms: mechanical, thermal, electromagnetic, and in other ways. For the moment, I want to concentrate on the applications of measurements of electromagnetic energy.

For 60-hertz power, we provide calibration of reference standard watthour meters. To give some idea of the effect which this has, $22 billion worth of electrical power was sold in the United States in 1970. Reliable and accurate meters sell the output of this huge electrical system, and monitor its productivity. We also perform calibrations related to the metering of high ac and dc voltages, necessary for tying high power grids together.

In the radio-frequency part of the spectrum, we are active in telecommunications and antenna gain



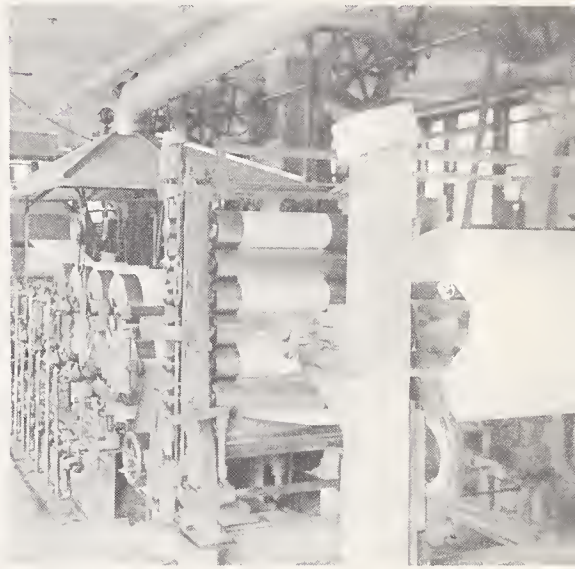
The velocity of sound was determined in this borosilicate block by measuring the time required for a sound pulse to cross the block and be reflected back to a transducer applied to one of the faces (Thomas Proctor, X3607).

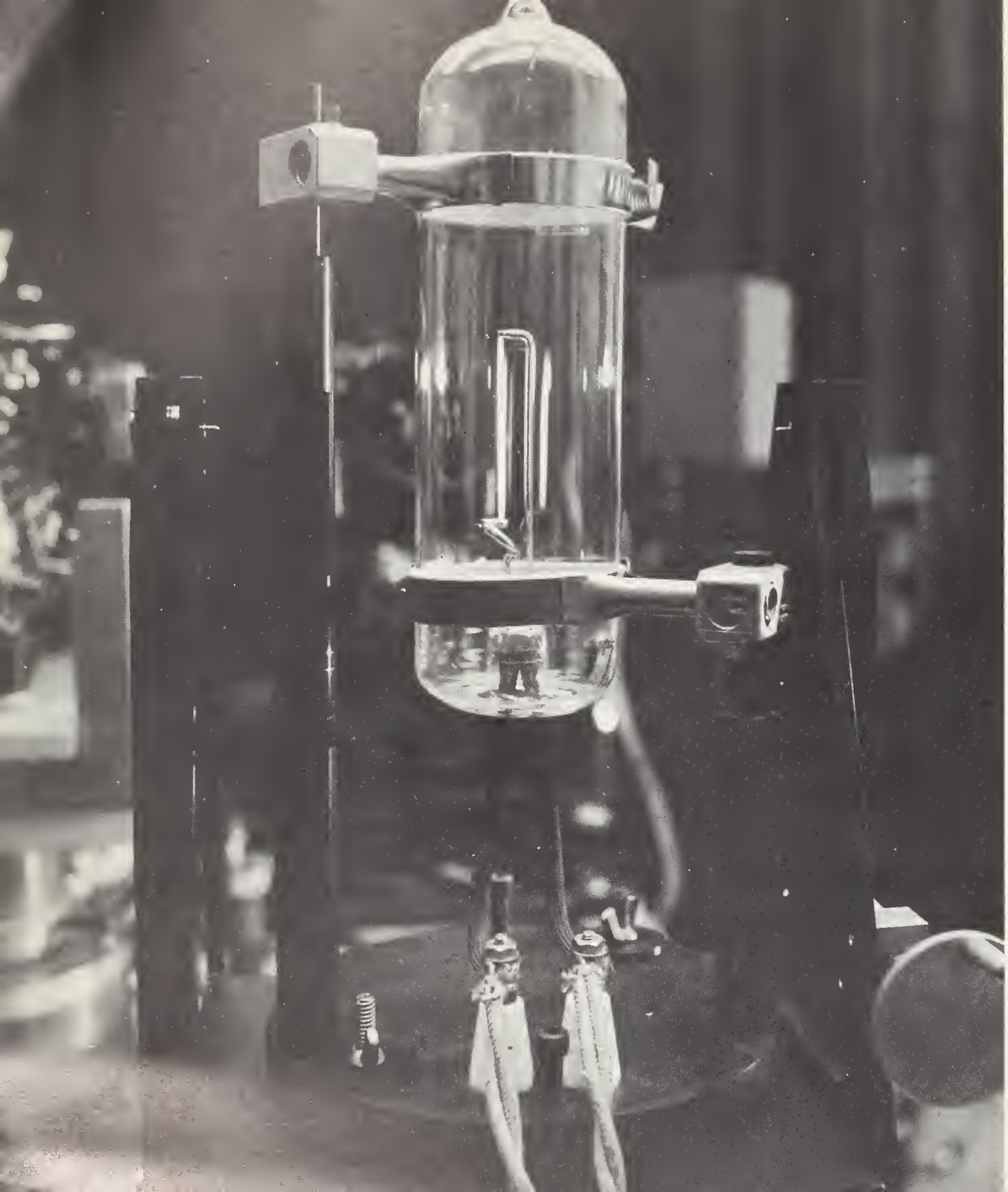
measurements. For example, we calibrated the small gain-standard measuring horn, part of the JPL Goldstone deep space tracking station. The cost of the horn is only a tiny fraction of the whole system expense. Many large communications antennae have had to be overdesigned and overbuilt (from an engineering point of view) because of a lack of capability for measuring their gain characteristics. Accurate information is also available in planning the performance and susceptibility to "jamming" of military radar systems.

In the microwave part of the spectrum we also take advantage of the interaction of electromagnetic fields with atoms to operate our cesium beam atomic clock. This type of

1917

At about the time of the first World War the Bureau established an experimental paper mill to study the effects of manufacturing conditions on the quality of the product. A descendant of this mill is still in operation at the Bureau.





Shown here is a highly stable tungsten-strip lamp that serves as a basis for realizing the International Practical Temperature Scale above the gold point and as a standard for spectral radiance measurements. (Dr. Henry Kostkowski, X2068).

clock embodies the international definition of the base unit, the second, which is now maintained with an error of 1 second in 30,000 years.

In the visible part of the spectrum, we have developed techniques to calibrate instruments that measure the power output of lasers. This is important, as lasers are rapidly coming into general use for eye surgery, cutting cloth for garments, and making tiny holes in diamond dies. Such widespread applications require accurate power measurements to determine and maintain safe radiation levels.

In the x- and gamma-ray region of the spectrum, we are involved with dosimetry measurements to protect the health of medical patients, and we have started work on new, sharp, high-intensity *k* x-ray beams, which will assist with giving finer control of x-ray machines, so that the patient may be submitted to less total exposure.

In this rapid tour across the ranges of the electromagnetic spectrum, I have shown many places where we are doing practical work, to make precise energy measurements more useful.

BENEFITS FROM OUR SERVICES

Now I would like to adopt a somewhat different approach by grouping our total

outputs and services under various headings.

First of all, with regard to Calibration and Testing, our general policy is to provide services only when they are not adequately available elsewhere from commercial sources. Nevertheless, we calibrate about 1,200 items monthly and our list of industrial and commercial customers reads like a directory of U.S. corporations. The value of the calibrations must be significant in commercial terms, and in fact, in some individual cases we have specific proof of a high leverage.

Our Measurement Assurance Program (MAP) is designed to see that the *user's* needs are actually being met in his own laboratory or on his test bench. The possession of an NBS calibrated standard does not by itself ensure good measurement, and in fact, in some cases, one has to worry whether the standard even survived the trip back home. MAP is a program to test the user's measurement processes as he performs them in his own laboratory. Its prime tool for doing so is a "round robin" in which a test object is measured by NBS and the members of a group of cooperating laboratories. Comparison of the results discloses those members who are obtaining anomalous results. Then analysis by NBS of how their measurements are affected by procedural variations and by environmental conditions in their laboratories serves to pinpoint the sources of the error. Periodic repetition of this process then monitors the members (including NBS) and ascertains if that segment of the measurement system remains under control.

Testing, which involves the properties of materials or structures, is carried out in adjustment with the needs of the user.

Consulting and Advisory Services are undertaken as a result of particular know-how which we may possess. NBS is one of the great laboratories of the world, we are justifiably proud of it, and our real purpose is to be helpful. These examples may show you how and where we help.

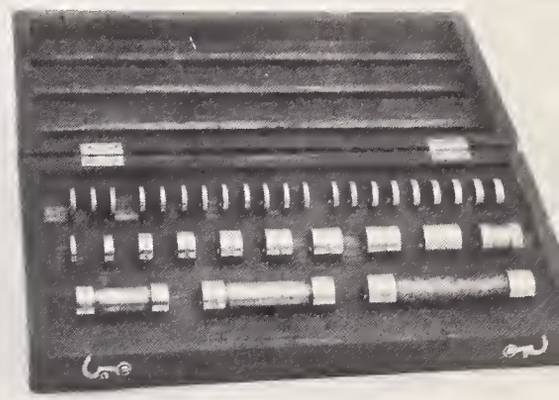
One example will be familiar to you from the newspapers—the "random calendars" used in the 1970 and 1971 draft lotteries were supplied to Selective Service by NBS mathematicians. This role of "independent 3d party" is one which we are frequently called upon to play. Only general confidence in NBS as a "disinterested" source of testimony made this contribution possible.

There is an intimate link between being able to make measurements and data on the properties of material. An example is our recent work on the thermal properties of oxygen, hydrogen, helium, and liquefied natural gas. Liquefied natural gas is difficult to store, to transport, and to meter. Our advisory services and the research behind them, partially sponsored by the American Gas Association, have contributed broadly to the healthy growth of the young cryogenics industry.

Next, in the field of Mine Safety, we are

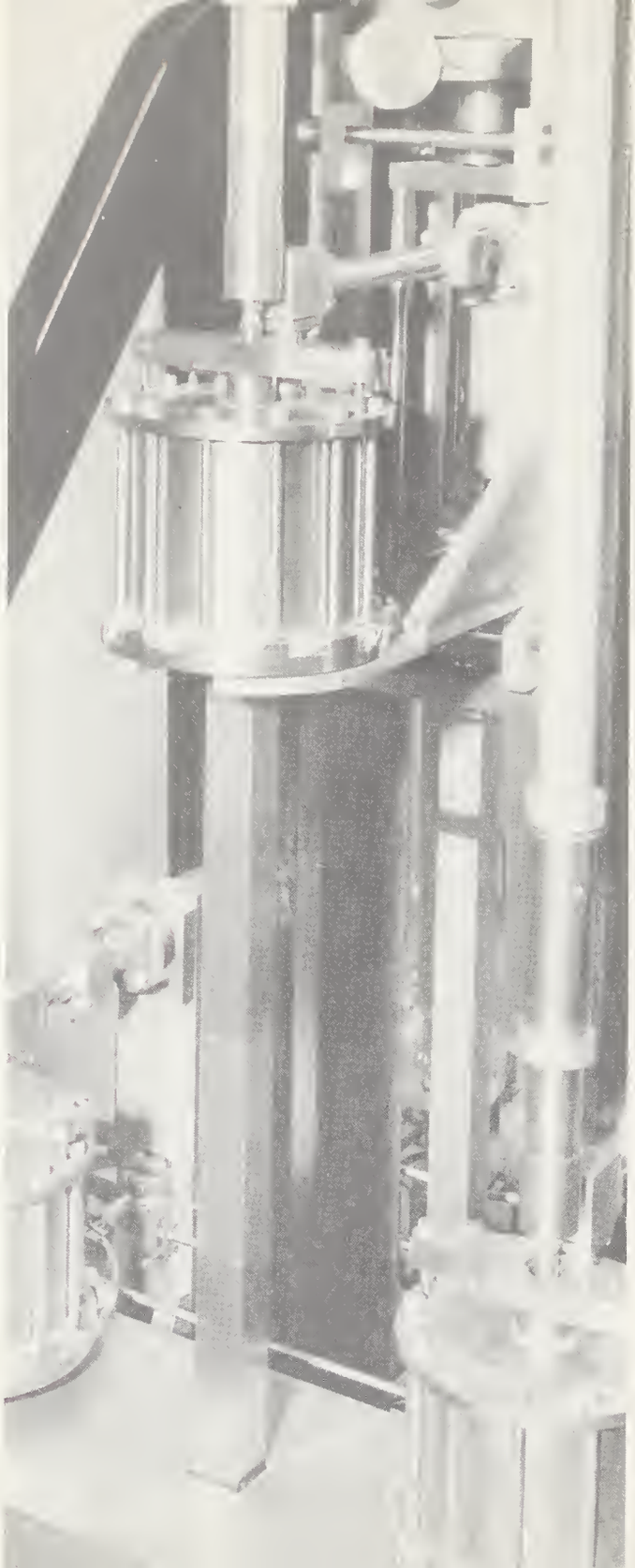
1918

Using a technique invented by William E. Hoke, the Bureau produced 50 precision sets of gage blocks for use by American industry during the first World War.



1918

Corner of Connecticut and Van Ness, with NBS Industrial Building in the background.



working with the Bureau of Mines to apply Very Low Frequency electromagnetic waves as a new way of locating and communicating with trapped miners.

In the field of Aircraft Safety, we have developed tests for evaluating locator beacons for planes which crash. We have a field station in Arcata, Calif., alleged to be the foggiest airport in the world, to examine runway lighting, in conjunction with the FAA and the Navy. We have developed standards to assure that all cockpit lights are above, but close to, the threshold for low-level vision. These low levels of illumination require a different scale and standard from normal-level lighting.

Time and Frequency, and their dissemination to users, are responsibilities specifically designated to NBS. In fact, the workhorses of the timing community are WWV in Fort Collins, Colo., and our recently rebuilt station WWVH in Kauai, Hawaii. NBS has made a comprehensive study of future methods for improving timing signals which will be generally available. One potential is the technique of carrying a time signal on commercial television broadcasts. Tests of this technique, in which time is displayed on the screen of specially adapted receivers or used to control a clock at the receiver, show great promise for a national system accurate to 1 μs or better.

Part of the accurate manometer used in the continuing gas thermometry project. A column of gage blocks is used to establish the height of the center cell (Dr. Leslie Guildner, X2076).

We develop Measurement Methods in many fields, but I shall confine my attention to standards related to nuclear energy. For the Integrated Safeguards Experiment, which assures that fissionable materials are not directed to unauthorized purposes, we have developed extremely accurate weighing and volumetric measurements for shippers and receivers of large amounts of fissionable material. For the Navy, we have, in connection with the McMurdo Station reactor in Antarctica, and in other connections, developed and operated continuously low-level radioactivity monitoring techniques for effluents.

With regard to neutron standards, particularly as they affect the fast breeder program, we have an expanding program centered around the measurement of neutron fluxes and precision neutron cross sections.

Over the years NBS experts have contributed to the work of several Nobel prize winners. In the summer of 1931 Harold Urey, lecturing at Johns Hopkins, discussed his newly detected satellite hydrogen line, that might be heavy hydrogen, with Fred Mohler of NBS. Fred suggested that Frank Brickwedde of the NBS Low-Temperature Lab, who was studying ortho-para conversion of hydrogen, might be able to help. Successive distillation of liquid hydrogen at NBS led to concentrations of heavy hydrogen sufficient for unambiguous proof—a finding announced by Urey, Brickwedde, and Murphy in the March 1932 NBS Technical News Bulletin. This event signalled the start of NBS involvement in atomic energy, and in contributing to the work of Nobel Laureates. Interestingly, the energy extremes—nuclear energy and near absolute-zero temperature—seemed a common feature.

In 1956, C. S. Wu brought the Bureau's capabilities in nuclear paramagnetic cooling together with Yang and Lee's suspicion that all was not right with parity conservation in weak interactions. This experiment, in which I was involved, together with Miss Wu and Messrs. Hayward, Hoppes, and Hudson of our staff, helped to trigger a Nobel prize for Yang and Lee.

More recently Luis Alvarez was gracious enough to say in his Nobel Laureate acceptance speech, when discussing problems involved in building and housing the 72-inch hydrogen bubble chamber, "We were also extremely fortunate in being able to interest the Bureau of Standards in the project. Dudley Chelton, Bascom Birmingham, and Doug Mann spent a great deal of time with us, first educating us in large-scale liquid hydrogen techniques, and later cooperating with us in the design and initial operation of the big chamber."

We are proud of our participation in these distinguished efforts, and we remember that we were able to contribute because good science and good measurements go hand in hand. Once we lose this connection we regress intellectually and our technical work gradually degenerates; if this should happen

1919

Calibration of clinical thermometers.

1920

Photographing a metallurgical specimen.

our efforts would be of no use to anyone! And I am pledged to assure that this never happens.

LOOKING FORWARD
IN BASIC STANDARDS

Modern metrology is becoming increasingly based upon the properties of atomic and molecular systems, it being accepted that such properties are the same everywhere and invariant in time. The behavior of such systems obeys the laws of quantum mechanics rather than classical mechanics, hence, the name "quantum metrology." The name also encompasses macroscopic quantum effects such as appear in superconductivity and the Josephson effect.

A concomitant result of the dependence of our basic standards of measurement upon quantum metrology is an intertwining of Base Units of Measurement and the Fundamental Physical Constants, such as the speed of light, which relates the unit of length to the unit of time. Indeed then, physical constants, or combinations of them, play an important central role as transfer constants relating measurable physical quantities of different kinds. Thus, accurate values of them are not only important to the program of science itself, but also to the progress of metrological science. Some consequences of the trend to quantum metrology follow:

New Definition of a Length Standard

We shall continue to pursue our program to have the 3.39 μm He—Ne laser, stabilized by saturated molecular absorption in methane, adopted as the new definition of the metre, while at the same time developing other lasers as secondary standards, particularly in the visible region.

Technological Implications

The stability of molecularly stabilized oscillators has proven to be such that their precision greatly exceeds that of the presently defined length standards and begins to rival that of time standards. Thus, the work we shall be doing should be reviewed in the broader sense of opening up the range of the electromagnetic spectrum by the development of highly stable and coherent oscillators. Of central importance in these technological developments is the frequency locking of a chain of oscillators from the microwave frequency standard up to lasers in the visible region.

Implications for New Physical Experiments

The ability to have optical frequencies stable to parts in 10^{14} or better opens up the possibility of verifying to a higher accuracy certain properties concerned with the isotropy of space.

Implications for the Definition of the Kilogram and Mole of the Accurate Measurement of Atomic Distances

The continuation of the program on measuring interatomic distances accurately by the simultaneous counting of x-ray and optical fringes will enable a more accurate value for the x unit to be obtained. Experiments aimed at characterizing highly pure silicon with regard to physical purity, chemical purity, and isotope ratio will be completed, which will enable a more accurate value of Avagadro's Number to be determined. The close connection between the kilogram, the atomic mass unit, the mole, and Avagadro's Number allows the possibility—albeit a distant one at present—of defining the kilogram in terms of the mass of silicon atoms. The possibility is a distant one since one is really aiming for a characterization of silicon comparable to the reproducibility of the prototype kilogram, i e., to a few parts in 10^9.

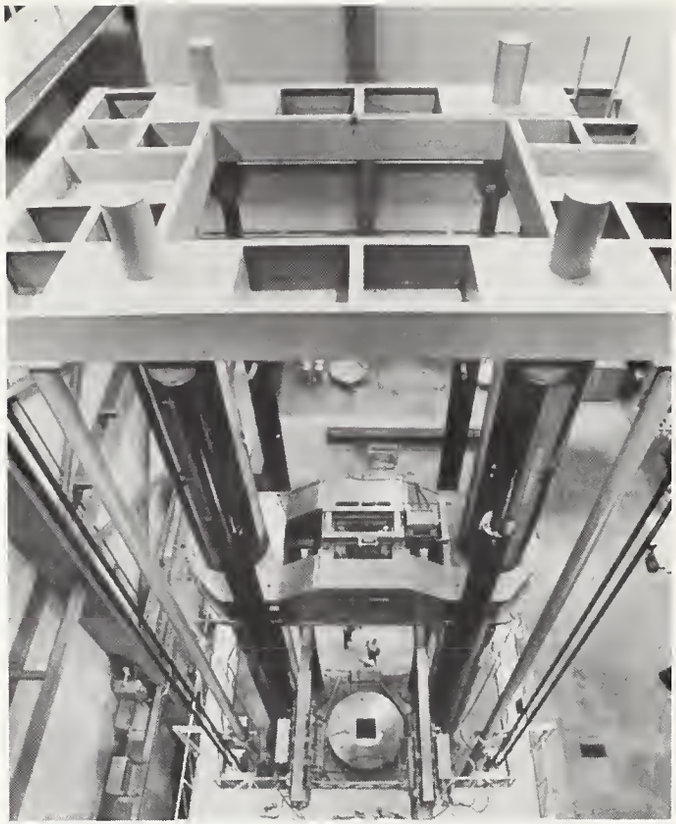
The Application of the Josephson Effect and SQUIDS to Electrical Standards and the Measurement of Fundamental Constants

The first step will be to monitor the legal volt by means of Josephson junctions. Should this prove successful, it is possible to go over to the Josephson emf itself as a definition of the legal volt. This would not be so easy to accomplish.

Fluid meter under test at the Cryogenic Flowmetering Facility, Boulder (Douglas Mann, X3652).

1920's

The children's picnic has been an annual event at NBS for many years.



The world's largest testing machine, capable of applying 12 million pounds in compression, 6 million in tension, was dedicated during the year (Roscoe Bloss, X2621).

Technological uses of SQUIDS (Superconducting Quantum Interference Devices, based upon the Josephson Effect and the quantization of magnetic flux) will find uses in precision magnetometry for applications such as cardiography, geophysics, etc.

SQUIDS will also prove to be useful in the accurate measurement of voltage, current, and power ratios from dc up to microwave ranges.

More precise values of the ratio of fundamental constants h/e and h/m will be obtained using these techniques.

The Josephson junction is being incorporated in a "noise thermometer" for the determination of very low temperatures ($\simeq$ .01 K) on the absolute scale.

PRACTICAL STANDARDS OF LENGTH AND SHAPE

A generalized three-dimensional measuring machine will be built. Novel designs of surface probes and the measurement of the position of the probe carriage within a volume $\simeq$ 1 metre cube, to an accuracy of 1 μm, or better, will be developed. The system will be fully servoed and automated.

Surface topography will be developed and capabilities to measure vertical irregularities of 30 Å will be exploited.

TRANSFER OF MEASUREMENT CAPABILITY

The NBS Measurement Assurance Program evaluates and improves the capabilities of industrial, commercial, and other-agency standards laboratories by analyzing their measurements of standards or instruments furnished by or exchanged with the NBS. It has been tested by measurements of mass and voltage and now is ready to be expanded to other physical quantities for which NBS maintains

standards. Also, the procedures will be extended so as to operate between different echelons of standards laboratories within, say, a large corporation or a military service.

TIME DISSEMINATION

The next decade will see time and frequency being disseminated with orders of magnitude greater accuracy and wide coverage using the TV networks and stationary satellites.

RADIATION SAFETY

Radioactive standards will be developed and applied to:

1. quality assurance in radiopharmaceuticals
2. accuracy of monitoring at very low levels of activity (environmental protection).

More precise methods of measuring x-ray dose will be developed, along with transfer instruments for assuring greater accuracy in medical and biological dosimetry, as the needs of the radiation processing field.

We have already developed an improved instrumental method for measuring stray microwave radiation (cooking ovens, radars, diathermy, and industrial heating equipment) and will promote its wider use in monitoring compliance with safety regulations.

We will develop instrumental methods for measuring ultrasonic power. These are urgently needed in medical diagnostics and also in industrial usage of ultrasonics, e.g., testing materials and structures.

NONDESTRUCTIVE TESTING

There are widespread needs for physical methods of testing materials and structures for flaws, with a view especially toward continuous monitoring during active service and the forewarning of imminent failures. We are especially fitted to proceed with acoustic, holographic, x-ray, magnetic, and electric methods of examination.

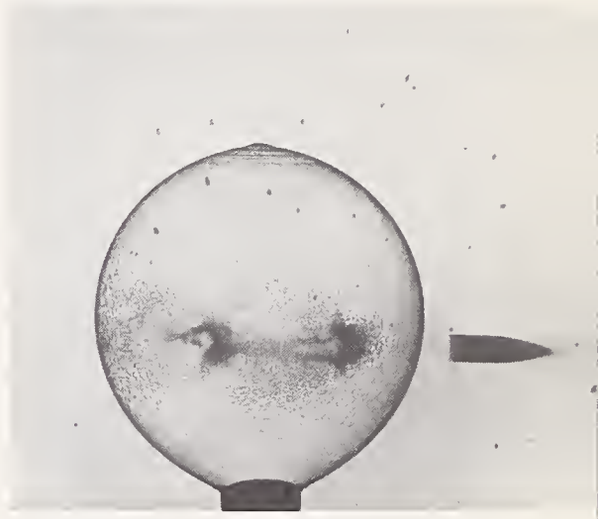
SURFACE PHYSICS

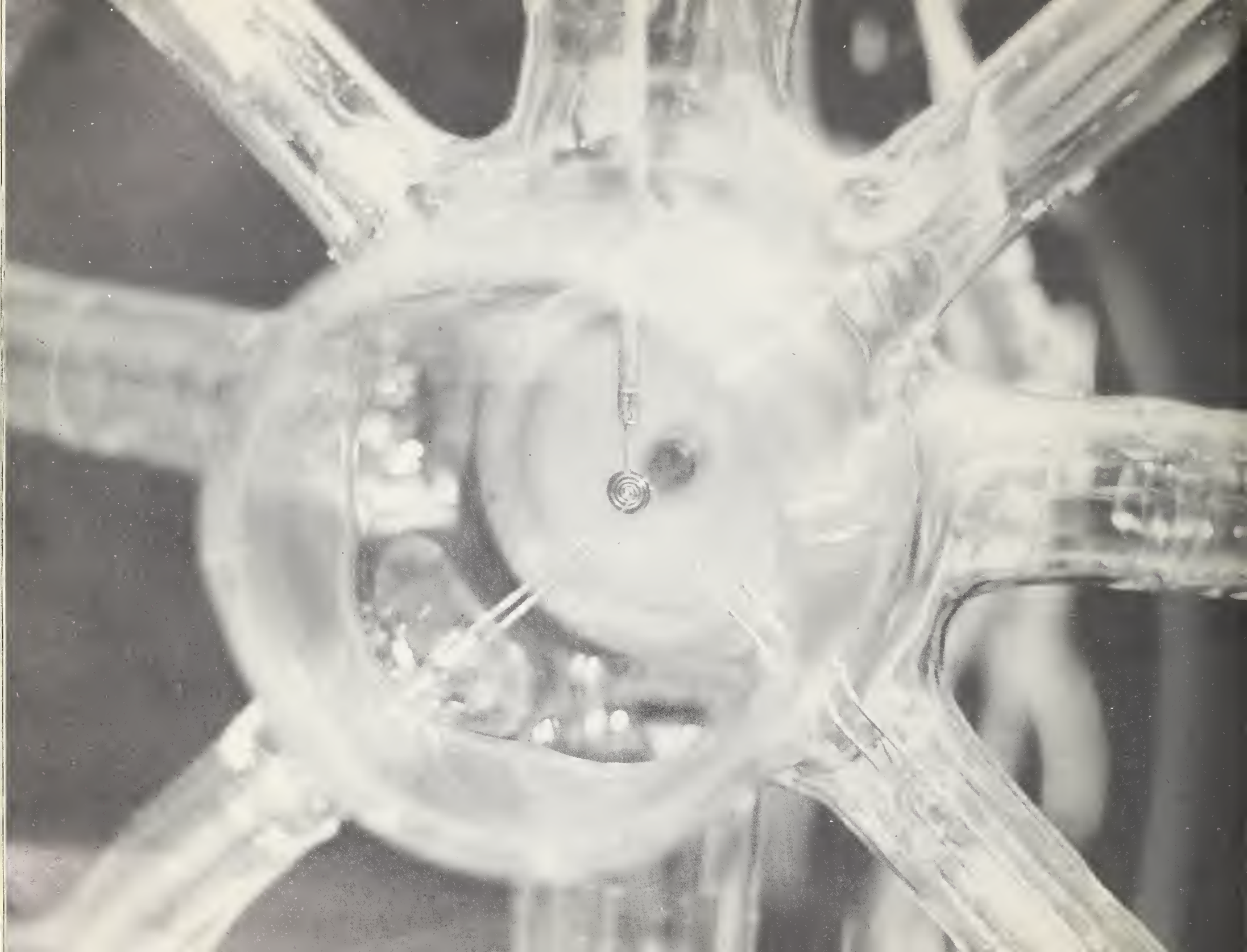
Phenomena at surfaces are of great practical importance, e.g., in solid-state microelectronics, heterogeneous catalysis, adhesion, and composite materials. They also are very challenging and elusive in the laboratory due to the necessity of dealing with single layers of atoms or even individual atoms. We will expand our research aimed at mapping surface states on metals, the effects of adsorbed atoms on field- and photo-emission of electrons, methods of producing atomically clean and flat surfaces, and the mapping of surface topography. The results will support the use of Auger electron analytical spectrometers, x-ray photoelectron analytical spectrometers, applications of electron scattering in biological materials, and will yield a new and very sensitive electron-emission surface profilometer.

E. Ambler.

1921

For many years the Bureau was a leader in the field of photographing high-speed projectiles. This photograph was taken by P. P. Quayle.





INSTITUTE FOR MATERIALS RESEARCH

Dr. John D. Hoffman
Director, Institute for Materials Research
(X2828)

THE function of the Institute for Materials Research (IMR) is to provide the materials science support to the NBS leadership role in three broad program areas: (1) providing more accurate, meaningful, and compatible measurements; (2) promoting a more effective use of materials science and technology in helping to solve national problems; and (3) providing central technical services and support to other Government agencies for the effective discharge of their statutory responsibilities.

The IMR mission is to:

- Furnish certified standard reference materials for the calibration of measuring instruments, and test methods, quality control, and research;
- Develop new and improved methods for measuring the properties of materials;
- Generate and evaluate scientific and engineering data on well-characterized materials;
- Relate the physical and chemical properties of materials to their behavior and their interaction with their environments;
- Provide advisory, consulting, research, and technical services to other Government agencies in support of their statutory responsibilities.

The mission of the Institute is carried out in six technical Divisions: Analytical Chemistry, Physical Chemistry, Reactor Radiation, Polymers, Metallurgy, and Inorganic Materials; and in two program offices, the Office of Measures for Air Quality and the Office of Standard Reference Materials. It is within our six line divisions that we maintain and advance our basic scientific and technological competences so that we can provide input to the National Measurement System and respond to materials needs in such program areas as Standard Reference Materials, Air and Water Pollution Abatement, Failure Avoidance and Biomaterials, of which more will be said later.

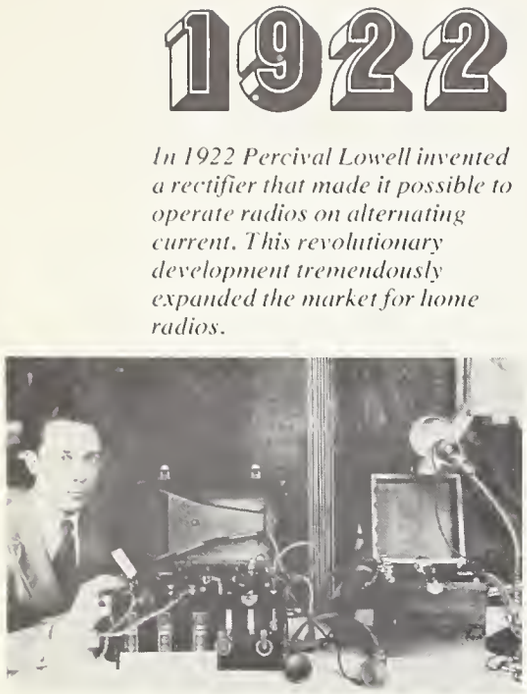
The Institute has a full-time staff of about 465 which includes 330 professionals of whom 175 have Ph.D.'s in science and engineering. In addition there is a part-time staff of about 125 scientific consultants, research associates and guest workers. We operate on a budget which, in fiscal year 1971, was over $16 million. This included over $10.5 million in direct congressional appropriations, $4 million in other-agency support and about $1.8 million for our Standard Reference Materials Program, most of which is reimbursed by subsequent sale of Standard Reference Materials.

IMR PROGRAMS

Our current technical activities are in the following program areas.

- Materials Science and Technology

Looking into the ultra-high vacuum environment of an instrument used in studies of metal oxidation. A metal specimen disk is heated by electrons from the wire coil, and then exposed to controlled amounts of oxygen while being examined by ellipsometry and low-energy electron diffraction (Dr. Allan Melmed, X2998).



In 1922 Percival Lowell invented a rectifier that made it possible to operate radios on alternating current. This revolutionary development tremendously expanded the market for home radios.

- Standard Reference Materials
- Measures for Air Quality
- Technical Services and Cooperative Research

These programs are described briefly below.

Materials Science and Technology

Our materials research activities provide the essential base on which all of our other programs depend. The Materials Research Program is concerned with the preparation and purification of materials; their thorough characterization as to chemical composition, impurity content, and physical structure; the development of new methods for measuring the properties of materials, and the generation and evaluation of needed data and information on the properties of materials; and the development of concepts which explain the properties and behavior of materials.

An excellent illustration of our work in the area of materials preparation is provided by our development of a series of new synthetic procedures that have led to the preparation of several new families of tungsten compounds in its highest oxidation state. The techniques developed by four IMR scientists overcame several problems that have been common in synthetic work on high-valent tungsten compounds and may provide general methods for rational synthesis of organo-derivatives of the transition elements in their highest oxidation states.

The generality of their approach to this problem offers a prospect for developing an extensive, rational chemistry of the transition elements in their high oxidation states. A better understanding of the chemical behavior of these elements offers the prospect for more effective utilization in technology. One possible application of this work, for example, is the use of the new reaction procedures to introduce heavy elements into organic materials to improve their flame-retardant properties.

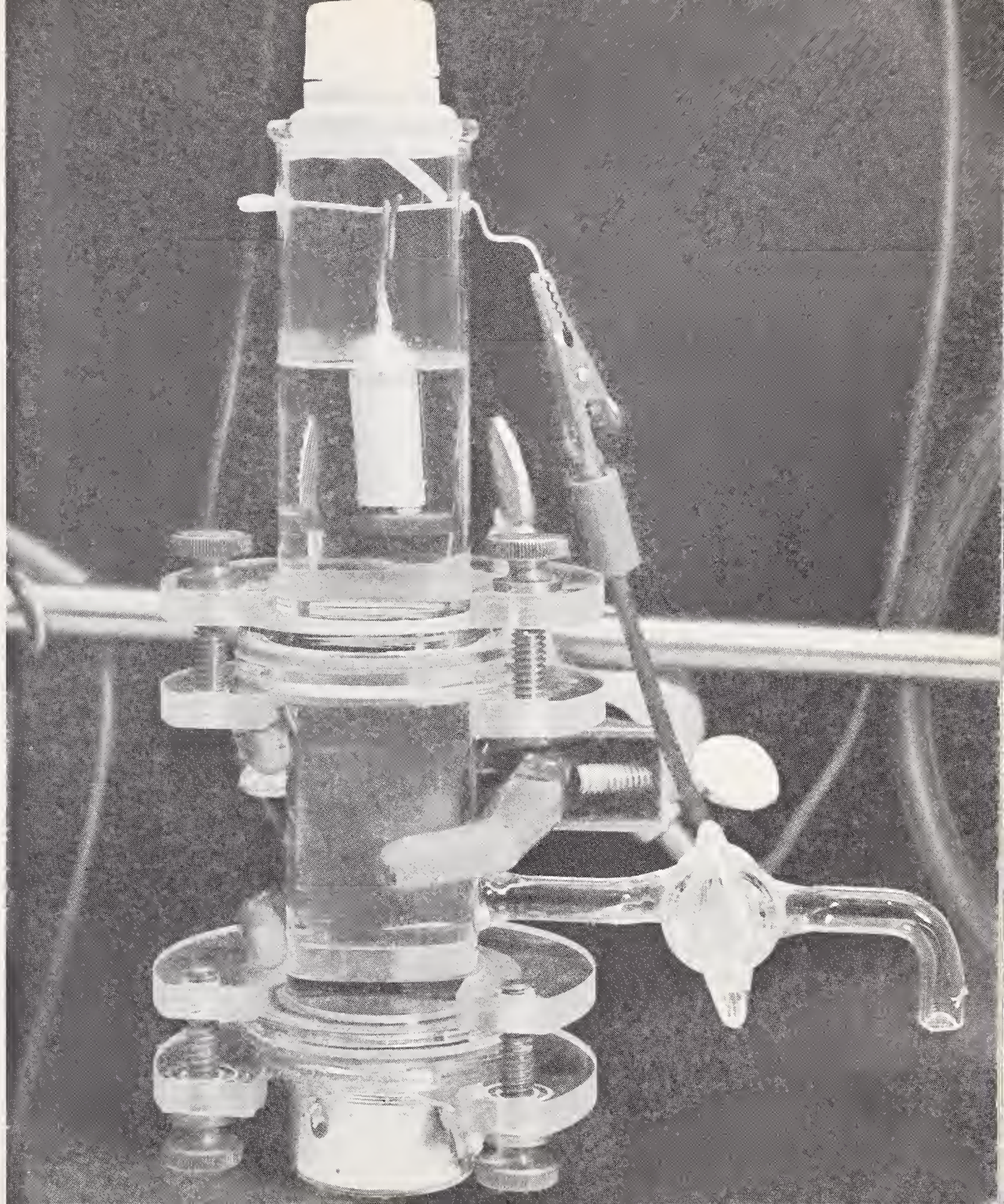
An example in the area of new measurement techniques is our research on the high-pressure properties of materials in our Inorganic Materials Division. This work exploits the diamond-anvil pressure cell, invented and developed by our scientists.

In the tiny cell between two diamond surfaces, pressures up to 50 kilobars (725,000 pounds per square inch) may be generated. The diamond window of the cell is transparent to x ray, visible, infrared, and ultraviolet rays, permitting direct observation of the changes that occur in materials as pressure is applied to them. This makes possible the acquisition of needed data and information on materials intended for use in a high-pressure environment.

This cell was used at the request of the Picatinny Arsenal to measure the high-pressure properties of the most commonly used explosive detonator, lead azide. IMR scientists found that lead azide was stable to pressures in excess of 20 kilobars (290,000 pounds per square inch) which is much

higher than is found in the chamber of a gun, even during firing. It was concluded that the detonation of lead azide was not a result of the absolute pressure, but was probably caused by the rate of change of pressure and possibly by the rapid generation of heat that occurs as the detonator is struck.

In the area of data generation and the acquisition of needed data on the properties of materials, an example is the work on the corrosion of metals which has been actively pursued for many years in our Metallurgy Division. Data which have been obtained on corrosion rates under various conditions are of extreme importance to the metals and construction industries. It is estimated that corrosion costs the U.S. consumer over $10 billion per year. A study of the corrosion of steel pilings in soils by this group led to the finding that you should drive the piles into the soil, thus depriving them of oxygen that causes rusting; instead of digging the soil loose, which admits oxygen, and then putting the piles in. The results of this study, which were reported in NBS Monograph 58, were received most enthusiastically by engineers in this country and abroad, as evidenced by the 35,000 requests received for the publication. These activities show the kinds of research we do in acquiring data at the forefront of science on the properties and behavior of materials. I feel that such activities are of considerable value to



The atomic weight of zinc was measured with high accuracy in this coulometric cell (George Marinenko, X2883).

Fifty years ago, even listening to a crystal set was a rather exciting experience. Shown here is Mrs. W. F. Harlow of the Bureau's Radio Division.

science, industry, and the public welfare, including defense.

An example of an accomplishment in the area of precise data acquisition is the precise determination of the numerical values in the Mark-Houwink equation which defines the relationship between the molecular weight (size) of a polymer (plastic) and the viscosity of a solution of the polymer in an organic solvent. This relationship is extremely important to the plastics industry for it provides a quick, simple, and accurate method for determining the molecular weight of the polymer chain as the solution viscosity is easy to measure. It is the molecular weight of the plastic which greatly influences its properties—for example, its mechanical strength. Scientists in our Polymers Division have carefully measured the constants in the equation defining the viscosity relationship in the case of polyethylene, a plastic produced in billion-pound quantities last year. Other important plastics are currently being studied.

As part of the Materials Research Program, we do some exploratory research that provides us with a better understanding of the behavior of materials. A good understanding of the behavior of a material is in general a boon to its eventual proper use. We also have a number of data compilation efforts that are closely associated with this program. Our Institute is one of the principal contributors to the National Standard Reference Data Program and provides carefully evaluated and meaningful data on the properties of materials and chemical compounds to the Nation's scientists and engineers.

Standard Reference Materials (SRMs)

Since 1910, NBS has provided a wide variety of materials that are used by science, industry, and technology to accurately calibrate many kinds of measurement systems. Over 800 different Standard Reference Materials are now available under this program, and about 30,000 units are sold each year.

SRMs are used in many areas:

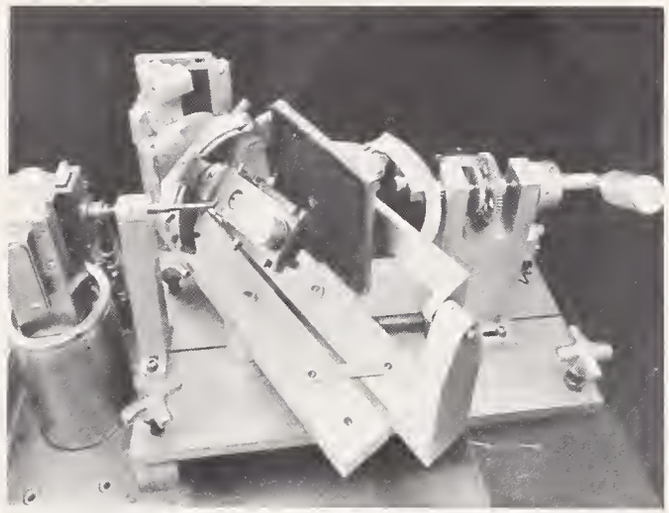
- For environment, we have the sulfur dioxide permeation tube, used for calibrating instruments designed to measure this pollutant in the field.
- For health, we have high-purity cholesterol, which is used to control accuracy of measurement of cholesterol in clinical laboratories.
- For agriculture, the example is orchard leaves, certified for trace elements such as calcium, copper, iron, and nickel.
- For productivity enhancement, we have steel standards used to calibrate rapid and accurate methods for analysis of steel during its manufacture.
- For energy production, we have uranium isotope abundance standards.
- For research, we have the tin freezing point standard used in realizing accurate temperatures in the laboratory.

• For defense (and incidentally, safety in transportation), we have metallo-organic compounds such as an oil-soluble copper SRM used to control analysis of engine and bearing oil for the purpose of preventive maintenance.

As an example of how an SRM is employed, the copper in oil SRM is used to determine the performance characteristics of engines in the trucking and railroad industries, and in aircraft of the Department of Defense. Chemical analysis, on a periodic basis, of the metal content of the lubricating oils of these engines can predict when failure of a bearing containing copper is imminent, as the sudden appearance of excessive amounts of copper in the oil would signal such an event. These oils are analyzed with a spectrometer whose accuracy and constancy of operation is assured through calibration with the use of the NBS oil-soluble copper SRM. An early success of this technique was the detection of an incipient failure in an engine in an aircraft used by a former President of the United States.

Measures for Air Quality

Our Measures for Air Quality (MAQ) Program was initiated 2 years ago. MAQ attacks the most urgent air pollution measurement and data problems with special emphasis on their quantitative basis and technical credibility to insure adequate but fair abatement and minimize unnecessary restrictions on industry and



The high-pressure diamond cell developed at NBS has been used for several years to study crystal and molecular structure of materials at pressures up to 60 kilobars. Here the cell is mounted on a goniometer in the precession camera so that it lies between the x-ray source and a photographic film (George Piermarini, X2950).

citizenry. Specific goals of MAQ are: (1) the development of a broad approach to the particulate measurement problem via the development of new methodology for particulate size and distribution measurements and for physical and chemical analysis of particulates; (2) the development of precise methods for the analysis of gaseous pollutants through the use of laser and optical methods and the adaptation of existing analytical techniques not now used for air pollution measurements; (3) the development of standard reference materials for the calibration of analytical instrumentation; and (4) the compilation, evaluation, and dissemination of critical data pertaining to air pollution.

1923

In 1923 Lewis B. Tuckerman devised an optical strain gage by which deformations as small as 2 millionths of an inch could be detected. This device is still in wide use.

1923

Dr. George K. Burgess, who had been at NBS since 1903 and had established a solid reputation in heat measurement and metallurgy, served as Director from 1923 to 1932.

Examples of recent accomplishments in this area include the development of a sulfur dioxide permeation tube that serves as a standard reference material to calibrate air pollution measuring instruments and the development of a light-scattering technique which measures the size and size distribution of particulates.

Technical Services and Cooperative Research

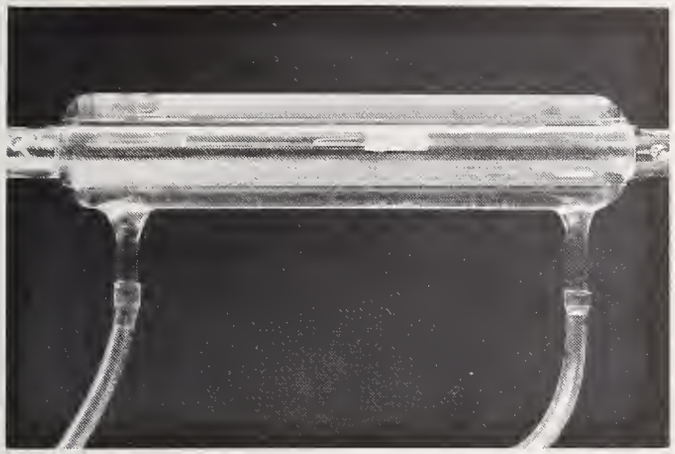
The research and standards capabilities and facilities of all IMR technical divisions have been utilized by other Government agencies, industry, national standardization bodies, and the general scientific community to help solve materials problems.

One example of a collaborative research program with a private organization is that of the NBS-American Dental Association joint Dental Research Program. The National Institute of Dental Research is also involved. This program, which has been in existence for more than 40 years, has resulted in many significant advances in both diagnostic and therapeutic dentistry.

These advances include two breakthroughs in dental instrumentation. The first is the development of a high-speed hydraulic dental drill which has helped to revolutionize dental practice by conserving the dentists' time and reducing patient discomfort. The second breakthrough was the development of a panoramic x-ray machine that produces an x-ray picture of the entire dental arch, with the supporting bone structure, on one large film, as opposed to the 18 separate pictures otherwise needed for a complete mouth examination. This machine reduces by a considerable factor the time required to x ray a patient's mouth and also reduces his exposure to x rays.

The Dental Research Program has also contributed extensively to our present understanding of tooth structure and the surface chemistry of teeth, and has made numerous contributions to the development of restorative materials.

The second example involves the NBS Nuclear Reactor, which is currently being used by many Government agencies. The U.S. Geological Survey is using it to determine trace constituents in geological materials. The Food and Drug Administration is using it for a variety of studies including the determination of fluorine in bone meal and mercury in foods. The Federal Bureau of Investigation is one of the primary reactor users in its studies of gunshot residues in criminal cases and bomb associated residues. The U.S. Postal Service has utilized the reactor and the services provided by our Analytical Chemistry Division for detailed examination of physical evidence involved in post office burglaries and for the examination of, for instance, bomb parcel mailings. The method of neutron activation analysis, which the reactor makes possible, has proven to be a powerful tool for obtaining information relating to crimes, and has provided a substantial amount of



Nitrogen dioxide permeation device being evaluated in the laboratory. The small tube within the condenser contains liquid NO which permeates through a porous plug at the right-hand end, the permeation rate being a function of temperature (Ernest E. Hughes, X2886).

evidence that has been accepted by the courts.

HIGHLIGHTS
FISCAL YEAR 1971

The word "material" has many different connotations. Materials Science and Materials Engineering are disciplines that are very broad in scope. Past advances made in Materials Science and Technology have contributed to the betterment of all aspects of human life including health, safety, and economic well-being. Thus it is understandable that there is a whole multitude of areas within the scope of Materials Science where various Government agencies either have a primary responsibility or at least play an important role in conducting basic and applied research on materials and in the experimental development of new and improved materials.

Within this broad context the Institute for Materials Research has played a rather unique role especially in the areas of materials standards, the development of improved measurement techniques, and the elucidation of concepts which explain the behavior of materials.

The following examples are a representative sampling of the many accomplishments of IMR during fiscal year 1971.

1200 Series Ferrous SRMs Issued

The 1200 series of iron and steel Standard Reference Materials (SRMs) has recently been completed. These SRMs are five essential "benchmarks" to the iron and steel industry for production control, customer acceptance, and research and development. The five standards provide for the "complete SRM package" needed for chemical analysis by the many techniques used in industry; for example, optical emission, x-ray fluorescence, flame emission, atomic absorption, polarography, gravimetry, calorimetry, neutron activation, microprobe, spark-source mass spectrometry, and vacuum and inert gas fusion.

These standards were developed at NBS through the efforts of many members of the Analytical Chemistry Division and with the collaboration of 21 outside laboratories.

1923

The Bureau developed a tire tester that became known around the world as the NBS machine. Descendants of this device are still in use here at NBS and elsewhere.

1926

Dr. K. S. Gibson of the Colorimetry Section built one of the first spectrophotometers in which a photoelectric cell rather than the eye was used to make accurate determinations of color.

The technical and support aspects involved in the preparation, certification, and issuance of these SRMs were coordinated through the Office of Standard Reference Materials by Robert E. Michaelis (X2082).

Contact: R. E. Michaelis (X2082)

Fluorine-18 Radiopharmaceutical for Bone Lesion Localization

Radioactive fluorine-18 (F-18) has been known for several years as the agent of choice for bone lesion imaging. The radioisotope administered orally or parenterally accumulates in bone in direct proportion to the bone flow and metabolic activity. Fluorine-18 scintographs demonstrate lesions far earlier than x-ray radiographs which require a 30 percent change in bone density in order to produce lesion images. Fluorine-18 also gives a sufficiently low radiation dose to patients to permit its use in skeletal surveys and benign lesion imaging. In comparison, the radiation dose of strontium-85, the readily available bone imaging agent, is so high that its use is restricted to patients with diagnosed primary carcinoma. Due to the short half-life (110 minutes) of F-18, however, it is necessary to produce it rapidly and near the location of use.

Fluorine-18 produced at the NBS reactor has been successfully used in patients at the Fairfax Hospital, Fairfax, Va.; Georgetown University Hospital, Washington, D.C.; the Johns Hopkins Hospital, Baltimore, Md.; National Institutes of Health, Bethesda, Md.; National Naval Medical Center, Bethesda, Md.; Walter Reed General Hospital, Washington, D.C.; Northern Virginia Pathology Laboratories, Fairfax, Va.; Veterans Administration Hospital, Washington, D.C.; and the Washington Hospital Center, Washington, D.C.

Contact: R. S. Carter (X2421)

F-18 Production, Processing and Patient Use—G. Dunson et al., J. Nucl. Med. **11,** 316 (1970).

Bone Scanning with Orally Administered F-18, A. E. Jones et al., J. Nucl. Med. **12,** 441 (1971).

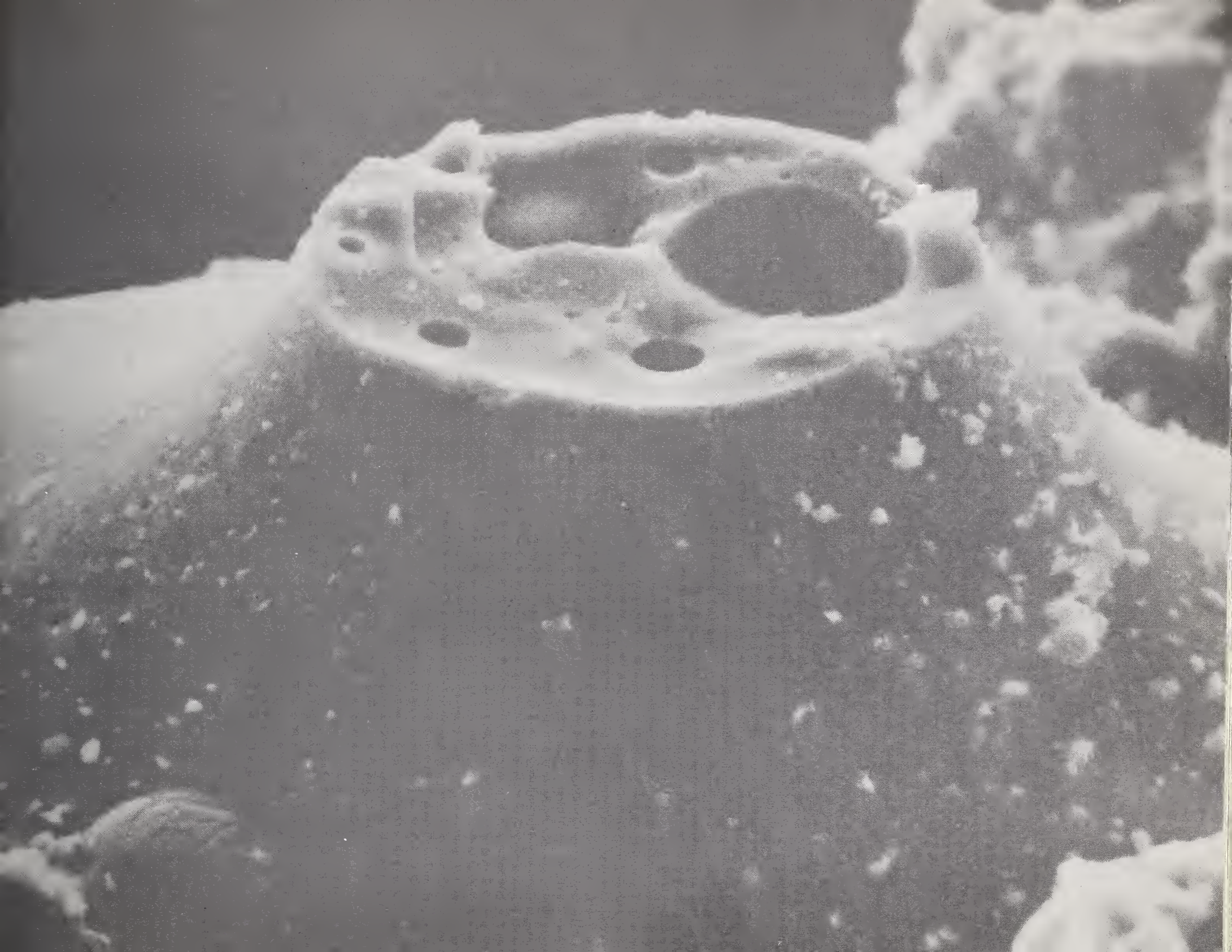
Production, Processing and Application of Research Reactor Produced F-18 Radiopharmaceutical, G. Dunson et al., Nuclear Medizin **13,** XIII, 256 (1971).

Chemistry of the Stratosphere

The Physical Chemistry Division has undertaken a study of the chemistry of the stratosphere. This work is in support of the Climatic Impact Assessment Program (CIAP) of the Department of Transportation. The purpose of CIAP is to study the possible environmental impact of high flying aircraft on the stratosphere. This is a topic of extreme national importance.

Photochemical processes control the composition of the stratosphere. They are responsible for formation of the ozone layer

This volcanic-like eruption on a lunar soil particle from the Apollo 12 mission was investigated with the scanning electron microscope (SEM). X-ray scanning with the SEM showed no metal on the surface. The particle was later cut and metallic inclusions were found inside, leading to the conclusion that the eruption was produced by stresses set up in the originally hot mass. These stresses resulted from differences in thermal conductivity of the included metal and the glassy host (Harvey Yakowitz, X2965).



1920's

NBS conducted fire severity tests on abandoned buildings in Washington during the 1920's. Observations were made on the structure itself and on office safes placed in the building as part of the test.

that filters out harmful ultraviolet radiation. Exhaust from high-flying aircraft will introduce small quantities of chemicals, such as water, carbon dioxide, and the nitrogen oxides, that might react with ozone and change the ozone shield.

It is not known now to what extent, if any, fleets of high flying aircraft will affect the stratosphere. But the answer to that question appears to be accessible (before the planes fly) through a series of laboratory experiments and tests in the stratosphere.

A task force of 10 scientists in our Physical Chemistry Division is studying the chemical aspects of this problem to obtain reliable values for the rates at which possible chemical reactions will occur. The study has already led to recommendations to the Department of Transportation about the chemical systems which must be investigated to fill in gaps in our existing knowledge. Experiments are currently underway at NBS to supply much of these vitally needed data.

Contact: D. Garvin (X2771)

Coulometry

The high accuracy and precision attainable by constant-current coulometry for the analysis of major constituents of materials has contributed to many aspects of our Analytical Chemistry Division program. For example, as part of an international characterization exchange coordinated by the Organization for Economic Cooperation and Development, George Marinenko

Dr. Allan Melmed (X2998) adjusts connection to low-temperature field-ion microscope. This instrument is being used to photograph the atomic details of metal and alloy structures in corrosion research sponsored by the Office of Saline Water.

developed a coulometric procedure for the determination of the stoichiometry (i.e., the gallium to arsenic ratio) of gallium arsenide with a higher degree of accuracy and precision than ever before. At present the gallium-arsenic ratio can be determined to better than one part in 10,000. Data such as these are of vital importance to progress in the semiconductor industry and to solid-state physics in general because the properties of semiconductors are as critically dependent on the major constituent stoichiometry as they are on dopants.

Mr. Marinenko has also employed coulometry for a redetermination of the atomic weight of zinc with an uncertainty of only 0.002 percent. On the basis of this study, the International Union of Pure and Applied Chemistry has recently revised the accepted value for this atomic weight. In modified form, this technique will be used for the precise determination of the atomic

weights of other elements and make an important contribution as a source of benchmark data.

Contact: G. Marinenko (X2883)

Surface Damage of Laser Exposed Glass

Under partial sponsorship of the Advanced Research Projects Agency, Department of Defense (DoD), investigations of surface lesions produced by high powered laser pulses on black alkali-lead-silicate glass were conducted by Drs. W. Haller and N. Winogradoff of our Inorganic Materials Division. They found that the explosive release of alkali oxide vapors from the shock-molten glass causes lesions which, macroscopically, resemble thermal spall fractures. The burn pattern consists of circular, concentric bands of roughened regions in the glass surface. Nonuniform energy distribution in the laser beam caused by wave mode interference produces this particular pattern. Small glass fragments are emitted from the lesioned area in the course of the damage process.

Because of the success of this method and because of the importance of glass as a material in laser technology, the mechanism of the burn pattern produced on the glass surface was investigated. The laser lesions were first examined in a scanning electron microscope. They showed many rounded edges and deep craters which suggested that the damage was caused by shock melting and the explosive release of gas or vapor and not, as may have been suspected, by a thermal microfracturing "spall" of the glass surface.

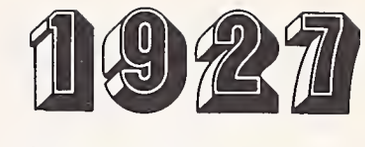
To verify this hypothesis, the surface of the glass was examined by an electron microprobe technique. The major constituents of the glass were silica, lead, and potassium. The concentration profiles for lead and silica across the glass surface were found to be substantially constant and not affected by the laser-induced burn patterns. The concentration of potassium, however, decreased significantly in the regions of the burn pattern. In a lesion caused by shock melting and explosive vapor release it would be expected that the damaged glass surface would become relatively depleted in one of its chemical constituents. The excellent correlation between the visible lesions and the recorded decrease in potassium concentration proves the postulated mechanism and provided DoD with needed information.

Contact: W. Haller (X2819)

Studies of Stress Corrosion Susceptibility

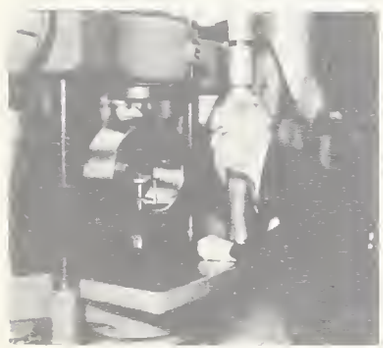
During the last year significant progress has been made in understanding the role of passive film growth kinetics and properties in stress corrosion susceptibility. This work was done by Dr. Jerome Kruger and Mr. John Ambrose of our Metallurgy Division.

Our ability to measure the rate of film repair after removal of damage of a surface film has improved in three major ways. First, the technique has been refined so that repassivation events occurring during a



These automobiles were used in studies of headlights and night visibility.

S. N. Petrenko (above) and H. L. Whittemore developed the proving ring for force measurements.



period of 10 milliseconds can be measured. Previously the speed of detection was of the order of 100 milliseconds. Secondly, the efficiency of film removal was markedly improved by the development of an abrasive pad that conforms to the specimen surface. Finally, the sensitivity of film thickness measurement was increased so that 3-5 Å (10^{-8} cm) films can be detected during a 5-10 millisecond time interval.

This newly refined technique, to which we have given the name "tribo-ellipsometry" has been applied to studies of low-carbon steel in nitrate and nitrite solutions at various temperatures. For these systems, tribo-ellipsometry has been able to separate the film repair process from the metal dissolution process that follows film removal. This was done by comparing the total current obtained from measurements to the current calculated from film thickness measurements. By this approach, it was found that, at elevated temperatures, where low-carbon steel is susceptible in nitrate but not in nitrite, the current transients for both anions were not too different. However, the amount of current going into metal dissolution was greater for the nitrate. Thus, in the susceptible solution both the rate of repair and the ability of the repaired film to stop dissolution were less than that for the nonsusceptible solution. Results of this sort can have great relevance in both predicting susceptibility and in achieving an understanding of the mechanism of stress corrosion.

Contact: J. Kruger (X2094)

Composite Dental Restorative Materials

One of the most dramatic developments in modern day dental research has been the development of direct-filling composite restorative materials, composed of an organic resin and inorganic reinforcing fillers. A cross-fertilization of expertise has been marshalled in our Polymers Division in an effort to meet the challenge of replacing silicate cements, an esthetically pleasing filling material, but one that is mechanically weak and is prone to early chemical disintegration in the oral environment. Leading the research has been Dr. Ray Bowen, Associate Director of the American Dental Association Research Unit at NBS. Mr. Given Cleek of our Inorganic Materials Division has contributed his extensive knowledge of glasses to the work of Dr. Bowen and his assistant, Mr. Argentar.

Experiments performed by these workers have provided the basis for private industry to produce seven composite restoration materials that are now commercially available and are finding steadily increasing use in the dental profession. Latest estimates consider the composite materials to have replaced the use of silicate cements to an extent of about 50 percent.

Contact: J. M. Cassel (X3336)

CURRENT TRENDS AND FUTURE OPPORTUNITIES

I would like to briefly discuss some opportunities that we see in the future. One

area is in failure avoidance and failure analysis. An example of our past accomplishments in failure analysis is our work on the bridge that collapsed into the Ohio River in December 1967, carrying 46 persons to their death.

NBS experts, at the request of the Department of Transportation, found that corrosion in the head end of an eyebar supporting the bridge led to the development of stress corrosion cracks. Over a period of years, one of these reached a depth of about 1/8 inch. At this point, the metal, of a type having low resistance to fracture once a "notch" of this depth had been established, failed catastrophically, causing the entire bridge to collapse. Evidence was found which indicated that sulfur compounds in the atmosphere may have played a role in the corrosion.

We believe that basic knowledge of the general causes of failure will assume an even greater importance as dwindling natural resources and mounting costs force the use of more substitute materials. Our program will be aimed not only at analysis of actual failures such as the example cited above but also at trying to more fully understand the causes of failures of materials in service by studying such phenomena as the wearing, degradation, and fracture of materials in order to prevent or minimize future disasters. The consumer should benefit (as in the bridge case) by increased safety and performance.

We see additional opportunities in environmental pollution abatement. Two IMR programs are concerned with pollution abatement—our Measures for Air Quality Program which was started 2 years ago, and our Water Pollution Program which we hope to initiate in the near future.

We feel that another opportunity is in the characterization of synthetic implant materials (biomaterials). Some major problems associated with the use of synthetic biomaterials in prosthetic devices and for implants in the human body are the incompatibility of foreign materials with body substances such as blood and tissue, the degradation of the implant material in the body, and catastrophic failure or fracture of the implant. Our program would be designed to help solve these problems by performing studies in such areas as chemical analysis of implant materials, physical characterization of implant materials as to microstructure and surface characteristics; studies of degradation or deterioration of implant materials, and stress corrosion and fracture of implant materials. We believe that this program would be efficient only if done in an atmosphere of appropriate arrangements with other Government agencies, and with the advice of appropriate professional groups—by analogy, with the type of relationship that proved successful in our Dental Materials Program.

John D. Hoffman

1928

NBS began producing optical glass when European supplies were cut off by WW I. This expertise led to the casting of a 69.5-inch telescope mirror for Ohio Wesleyan University, the largest made in this country to that time. Prof. Crump of Wesleyan University and Dr. Burgess, NBS Director, inspect the disk after a mounting hole had been drilled.

INSTITUTE FOR APPLIED TECHNOLOGY

Dr. F. Karl Willenbrock
Director, Institute for Applied Technology
(X3434)

THE Institute for Applied Technology (IAT), as its name implies, is concerned primarily with applications, although its activities cover a wide part of the basic-to-applied spectrum which characterizes the overall program of NBS. While IAT is responsible in NBS for a number of the more engineering-based programs, there is a strong interplay between its activities and those of the other Institutes and Centers.

TECHNICAL ASSISTANCE TO THE STATES

One example of the IAT's applications orientation, as well as its interplay with other parts of the Bureau, in this case the Institute for Basic Standards, is the program of our Office of Weights and Measures (OWM). OWM's task is to make sure that the weights and measures activities of the 50 States are compatible. It is a job which requires both technical and diplomatic skills. The weights and measures officials of the States, counties, and municipalities have the regulatory authority and responsibility. Under Mr. Tom Stabler's (X2401) guidance, the Office supplies these officials with technical information and provides training and a variety of other assistance. In support of the National Conference on Weights and Measures, an organization of State and local weights and measures officials, model regulations are provided for adoption by the States. The Office is in the technology transfer business. The staff supports the transfer of measurement science skills, which are under continuing development in the Institute for Basic Standards, to State and local government officials thereby giving them the skills needed to facilitate trade and honest commercial transactions. It is an activity which antedates the formation of the NBS and yet it has a very contemporary flavor since it clearly acts as a protective service to the consumer as well as to the producer and distributor of goods. It is a simple but clear example of an NBS service of direct help to the public.

The scanning electron microscope is being used in an evaluation of the bond between wire leads and semiconductor surfaces. Here an area of good adhesion surrounds an unbonded area (Kathryn Leedy, X3625).

BUILDING RESEARCH PROGRAM

The NBS Building Research Program is taking on a new, more public service-oriented emphasis. During most of its half century in building research, the Bureau directed its attention to the development of technical data for engineers working on materials and structures for the building construction industry. Over the past few years, Dr. James R. Wright (X3377) and his staff have broadened the pursuits of building researchers to include studies on the needs of building users. Research programs are now being carried on in environmental, sociological, and psychological areas, as well as building fire research, systems

Dr. Hugh Dryden (shown holding globe), aerodynamics expert, was asked by municipal authorities to determine why so many street light globes were blown away by high winds. One of the Bureau's wind tunnels is seen in the background.

engineering, building economics, materials, structures, and building information. In these programs, the performance approach to building is fostered. The performance approach defines performance in terms of function; function is defined by the attributes necessary to satisfy user needs. The means of delivering an attribute is left open; thus, innovation in building construction processes and materials is encouraged.

A series of events took place which put the NBS in a position to provide significantly increased support in the public service area. Among these was Operation BREAKTHROUGH, a demonstration project of the Department of Housing and Urban Development (HUD) designed to increase the volume of factory-built production in the United States. HUD elected to rely on the NBS building research staff as its technical arm in housing technology. An interdisciplinary NBS team developed the performance criteria for the evaluation of this housing and is managing the evaluation program itself which involves 22 industrialized housing systems.

In addition to working with HUD, the NBS is cooperating with a number of other agencies including the National Science Foundation's Research Applied to National Needs (RANN) program. It is our present endeavor to translate the research output of RANN's university-based program in earthquake engineering into the appropriate form so that it is useful to building designers and building code officials. The university-based earthquake engineering program complements our research program in structural design and together these programs should produce results of value to the building construction community in seismically active areas.

FIRE PROGRAM

Another area in which the potential contribution of the NBS is tremendous is the fire protection and safety area.

Leading fire experts in this country have made two major points:

1. the losses of life and property in the United States due to unwanted fires are very high. Among developed countries our death toll is three times the world average; our property losses are twice the world average.

2. this country is *underinvesting* in its R&D effort in this area. It is no coincidence that two countries whose per capita fire losses are substantially lower than ours, Japan and Great Britain, also have two of the best ongoing fire research programs. Both of these countries have well-equipped and well-staffed, government-supported fire research laboratories of top quality.

At NBS, we are developing a top-quality fire program. We have recently combined our three ongoing fire efforts into a single integrated program under the management of Dr. King Walters. The three programs are in order of their establishment; the fire research effort in the building research

program, the Office of Flammable Fabrics, and the activities under the Fire Research and Safety Act. These projects will retain their objectives of developing improved life-safety systems for buildings, the reduction of deaths and injuries due to fabric flammability, and the expansion of fire research knowledge plus improvement of the technology available to the fire services.

Our reason for combining the management of these projects are that they are all in need of a *substantial research effort* in such areas as the toxicity of the products of combustion, flame spread, fire-detection systems, and flame retardancy in fabrics. Another research area of utmost importance is the theory of scaling or modeling. At present, there is no satisfactory theory of scaling in the fire field, so that experimental results observed in laboratory experiments cannot be extrapolated to large-scale phenomena. We are in the same position that an aircraft designer would be if he were without a wind tunnel; that is, each experimental design could only be tested by building a full-scale model and attempting to fly it. In order for us to predict how a building will burn, we have, at this point in time, no alternative to building a full-scale model and burning it. A scaling theory for fire phenomena is a high-priority research need.

One spur to our efforts is the state of *technology developments* in the fire equipment field. We know that it is technologically feasible for men to survive in toxic atmospheres; witness the exploits of American astronauts who cope with the hostile environment on the moon's surface with equipment that is relatively light and very efficient. Yet, under hostile fire hazards, the breathing masks and bottles used by firemen only supply air up to 15 minutes on the average; the bottle weighs about 30 pounds and is so bulky that it is common practice for a firefighter to take off the mask and bottle as he climbs through the window of a burning building and have them handed to him when he is on the inside. While he is on the inside putting his mask back in operation his major source of protection is his turn-out coat. However, there is presently no flammability standard for the turn-out coats and some do not pass the flammability standard which the Department of Commerce promulgated recently for children's sleepwear! Our developing fire program at the NBS can be of direct help in improving this present lack of knowledge and outdated technology.

OTHER PROGRAMS

In describing two of the IAT's programs in some detail, I have, of necessity, had to neglect many others of importance. For instance, in our electronic technology program, we have recently developed test methods relating to the wire bonds used in integrated circuits. As a result of the application of our findings, there has been a dramatically decreased rejection rate for

Dr. Paul Heyl worked for many years on the redetermination of the gravitational constant, G.

components coming off the production lines. In our product safety program, we have started the difficult task of developing the criteria for a product safety technology. This is being done in conjunction with our support to HEW's Toy Safety Program. For the Department of Justices' Law Enforcement Assistance Administration, we have started the development of equipment standards to assist law enforcement agencies in their fight against crime.

NBS has the strongest and most diversified operations research capability in the civilian sector of the Federal Government. In the past several years, it has given convincing evidence of the great value of this activity to other Federal agencies and to State and local governmental agencies. This group, under Dr. Ed Cushen (X3563), brings together systems analysis techniques and the technical know-how of the various engineering and physical-science-oriented divisions of the Bureau.

The list of services performed is long and varied and includes planning and the allocation of resources for the Coast Guard's search and rescue activity; systems engineering and human factors studies of mail processing equipment for the Postal Services; the analysis of court reporting systems for the Department of Justice;

In lending technical assistance to the Food and Drug Administration in the area of toy safety, NBS has studied the susceptibility of clacker-balls to fracture or shatter under impact. Here 5-year-old Paul Calvano demonstrates their operation with a *safe* pair of clacker-balls (Karl Plitt, X2933).

analysis of airport runway capacities; key participation in the Northeast Corridor Transportation Project for the Department of Transportation; analysis of the proficiency of clinical laboratories; and the development of operations research packages to be implemented by State and local governments. The primary distribution mechanism for packages utilized by municipalities is the Technology Applications Program of the International City Management Association.

COMMONALITIES IN IAT PROGRAMS

Although IAT has rather diverse activities, there are commonalities which make these activities part of a coherent effort.

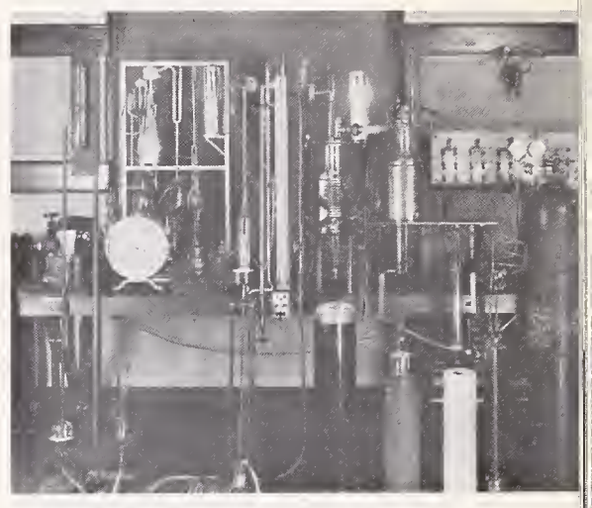
First and most obviously, our activities are strongly problem oriented. We undertake to solve technical problems for a number of other agencies as well as those derived from our own programs. The Institute for Applied Technology is much more heavily other-agency funded than the Bureau's other major operating units. This fact has a number of effects; one is that we are very closely tied into the problems of the other agencies, and another is that we frequently have to respond to short time deadlines. However, the other-agency funding permits us to expand our capabilities to meet changing technological problems of national significance and as these problems are related to our ongoing programs, there can be favorable synergistic results.

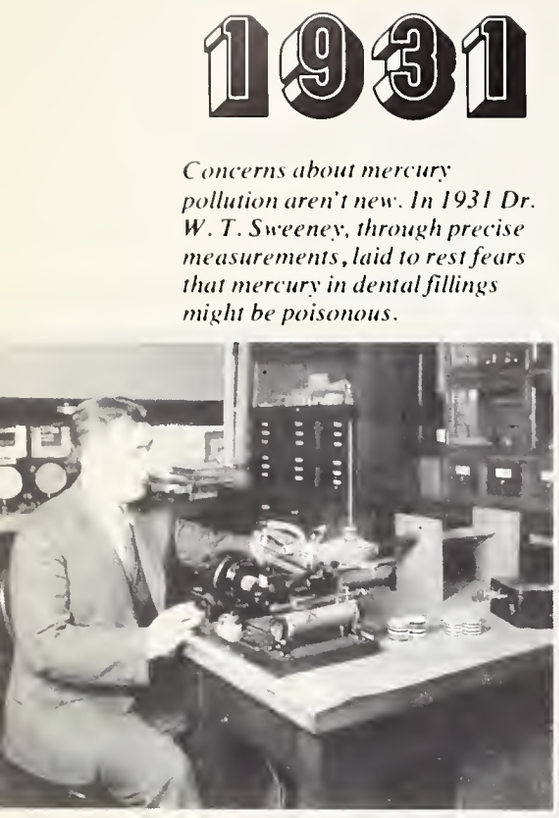
Second, we have strong ties to many parts of private industry, particularly with their R&D sectors. The Research Associates Program, by which industries supply full-time technical personnel to work at the Bureau for a period of 1 year or more, gives us valuable insight into industrial operations and problems.

Third, we have demonstrated a capability to work effectively with State and local governments. Through the National Conference on Weights and Measures and the National Conference of States on Building Codes and Standards, in our Fire Program, in the Law Enforcement Assistance Administration Program, and, increasingly, through our Technical Analysis Division, we are helping State and local officials in a number of ways. With the new Intergovernmental Relations Act we will be able to exchange personnel between our staff and State and local governments. This exchange, as in the case of the Research Associates Program, will lead to our having a better comprehension of the operational and technological problems of State and local governments.

Fourth, we are increasingly developing the ability to work successfully on problem areas which have important nontechnical as well as technical aspects. In such cases, nontechnical constraints must be identified and analyzed before workable solutions can be found.

With this apparatus H. Dickinson and F. Brickwedde produced the first liquid helium made in this country.





Concerns about mercury pollution aren't new. In 1931 Dr. W. T. Sweeney, through precise measurements, laid to rest fears that mercury in dental fillings might be poisonous.

PRESSING QUESTIONS

The question we face is how best to use and develop the unique resources of the IAT as part of NBS to respond most effectively to those national problems to which we can contribute. The Secretary of Commerce has stated that other nations have taken steps to assist technological development in civilian R&D and urged that "we accept the idea that it has become a proper sphere for governmental action." What part the IAT, as a major component of the Bureau, can play in such action is a question of interest and concern to us. It is our perception that the research services offered by the Federal Government through agencies such as the NBS should be such as to serve as an incentive to private industry to increase their R&D efforts rather than to become dependent on Federal R&D If research services of this nature are provided, they do not compete but rather supplement and promote private sector technical advances.

In order to consider these possibilities in a systematic way, we are undertaking a modest study effort to examine the influence of technology on industrial and service sector productivity with a view of identifying those factors which have limited technological progress. Our Office of Invention and Innovation assists the National Inventor's Council and has been concerned with questions of this type for some time. We expect that an interdisciplinary team will be needed to make such studies. We expect to involve experts from industry and universities in both technical and nontechnical aspects of the study. It is our present hypothesis that it will not be possible to generalize from one sector to another but that each sector will have its own characteristics which must be understood before barriers to technological progress can be removed.

Some milestones for the year were:

Consumer Information

Many IAT programs generate information of direct use by the consumer public, and during the past year our efforts to make this information available progressed significantly. A consumer guide series was started, and three widely distributed brochures were published. These are *Fibers and Fabrics; Tires: Their Selection and Care;* and *Adhesives for Everyday Use*. These brochures have been distributed through sales at the Government Printing Office, and the tire industry has also distributed thousands of the tire pamphlet through its market outlets. The brochures can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Homeowners and building operators want to reduce the costs of heating and cooling buildings. These costs are considerable, and for most buildings, higher than necessary. While this is wasteful in its own terms, it also represents a needless drain on the Nation's finite energy resources and an

unnecessary aggravation of the air pollution problems.

Environmental engineers in the Building Research Division (BRD) have found that if present knowledge and available materials are applied in the design and construction of new buildings, savings in fuel as much as 50 percent can be made. In the case of buildings already built, an average of 10 percent in fuel saving seems feasible.

The BRD collaborated with the Office of the Special Assistant to the President for Consumer Affairs to inform homeowners of ways to achieve greater comfort, while at the same time conserving energy resources in heating and cooling buildings. This information is published in two brochures: *7 Ways to Reduce Fuel Consumption in Household Heating . . . Through Energy Conservation,* and *11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling.* Hundreds of thousands of these brochures have been distributed by electric utilities under the auspices of the Edison Electric Institute. They are also available from the Superintendent of Documents in Washington, D.C.

Promoting Safety

Many IAT programs made significant contributions to the advancement of public safety during fiscal year 1971. The vehicle systems research group, recently transferred from NBS, prepared a standard for brake fluids which was made mandatory by the National Highway Safety Bureau of the Department of Transportation. In its ongoing programs, the IAT is concerned with product safety, fire safety, and the flammability of fabrics.

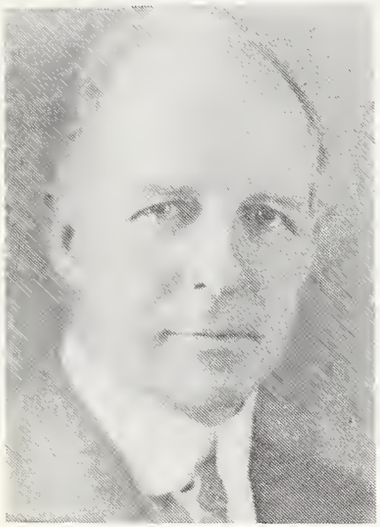
The responsibility for product safety rests with the Department of Health, Education, and Welfare (HEW). NBS and the HEW Bureau of Product Safety operate a cooperative program whereby the IAT program in Product Evaluation Technology serves as the HEW technical arm. Particular emphasis is given to *toy safety standards* as mandated by the Toy Safety Act. Investigation of toys was conducted, for example, for the sharpness of points and edges, the burn hazards of electrical toys such as irons or stoves, hearing hazards from toy caps, and injury hazards from plastic "clacker-balls" that shatter in use. The findings were used by HEW in carrying out its responsibilities under the Toy Safety Act. However, other public benefits are anticipated. For example, the temperature burn-hazard findings on toys may be applied to household appliances in the development of standards aimed at eliminating burn hazards in the home. Similarly, the research findings on measuring hazards from sharpness of points or edges are applicable to many consumer products.

Contact: Dr. Melvin M. Meyerson (X2907)

In the area of *fire safety,* the Department of Commerce issued a mandatory standard for the *Flammability of Children's Sleepwear.* This standard, established on July 29, 1971,

The first system for blind flying and landing of aircraft was assembled by NBS and demonstrated in actual flights. Harry Diamond, Frederick Kolster, Francis Dunmore, and others were involved in this and other pioneering aircraft instrumentation projects.

Dr. Lyman J. Briggs, was appointed Director in 1933, a position he held until his retirement in 1945. Dr. Briggs had been at NBS for many years, serving as Chief of the Mechanics Division and then as Assistant Director.



will become effective July 29, 1972 for mandatory labeling for noncomplying sleepwear items, and will be fully effective 1 year later. Plans for fabric and garment sampling are being developed that will permit a test level assuring both public safety and application feasibility in the industry.

In another step toward reducing fabric fire hazards, a Proposed Flammability Standard for Mattresses was published in the Federal Register on September 9, 1971. The proposed standard is now under review and industry and public comments have been solicited. It is designed to reduce the hazard from the smoldering combustion of mattresses ignited by cigarettes. Analysis of mattress fire cases showed that cigarettes are the major ignition source of such fires. Studies are underway on a flammability standard for blankets.

Contact: Dr. Joseph Clark (X3116)

Standards for Law Enforcement Agencies

Under terms of an NBS/National Institute of Law Enforcement and Criminal Justice (U.S. Department of Justice) agreement, the Bureau established a Law Enforcement Standards Laboratory (LESL). The laboratory conducts research to develop national voluntary standards to assist law enforcement agencies in their selection and procurement of equipment. The laboratory will also develop methods for measuring the required performance of items in various categories including, among others, warning and safety devices for vehicles, communication devices, sensors for crime detection, protective equipment for personnel, and alarms. Altogether some 14 categories of equipment have been identified for which standards and performance measures are needed.

Contact: Dr. R. B. Morrison (X3161)

Wire Bonds in Transistors and Integrated Circuits

Despite the technological sophistication of the semiconductor electronic industry, the technology of *measurement* required for control of material and device production and exchange is not fully adequate for present and future demands. This leads to limitation of the exploitation of electronics for the benefit of the Nation and sometimes to excessive costs. The IAT Electronic Technology Division Program is dedicated to providing the technical base required for productivity enhancement and cost reduction in the field.

One phase is the identification and elimination of faulty wire bonds—the largest cause of failure in transistors and integrated circuits. During the past year, uncontrolled factors in bond fabrication were identified, and means for controlling them were developed which will lead to greater uniformity and reliability. Use of these techniques in assembly line tests by manufacturers resulted in reduction of rejection rate at visual inspection by more than a factor of 2.

The Division's leadership in such activities for advancing standardization of measurement methods used to specify properties of electron devices materials, and processes in fabrication was accorded special recognition this year. Judson C. French (X3622) received the NBS Rosa Award for his contributions over the years to the understanding of the phenomenon of second breakdown, a new basis for specifying safe operating limits of power and high-frequency transistors, and to improvements in the four-probe method for measuring the resistivity of germanium and silicon slices.

Contact: M. G. Domsitz (X3357)

WHERE WE HOPE TO GO

Continued strengthening of our basic competence is a must. However, the wide variety of problems inherent in the advances and application of technology requires constant review of our programs and decisions on the priorities for use of our limited resources. The current emphasis on safety (e.g., structures, fire, and consumer products) will continue to use a significant part of our resources. Statutory responsibilities for fire research and safety and flammable fabrics in part dictate this, but it should be noted that NBS has long recognized the national need to reduce the tragic life and property losses from fires and for many years pioneered in the development of fire safety in buildings. We see this area as one in which significant contribution can be made in the prevention and control of building fires, in support for the greater effectiveness of the fire services, and in progress in fabric flammability standards.

Equally, there are contributions which can be made to assure standards for consumer product safety, although the definition of the problems and ultimate role of NBS is not as clear. In part, the legislative decisions made by the Congress will determine the degree of our participation and responsibilities under law for consumer safety standards in the product field. Nonetheless, our support of other Federal agencies with such mandates will continue and grow; and in the voluntary standards system, our technical support role will increase as the system is strengthened by industry's growing recognition of consumer safety demands.

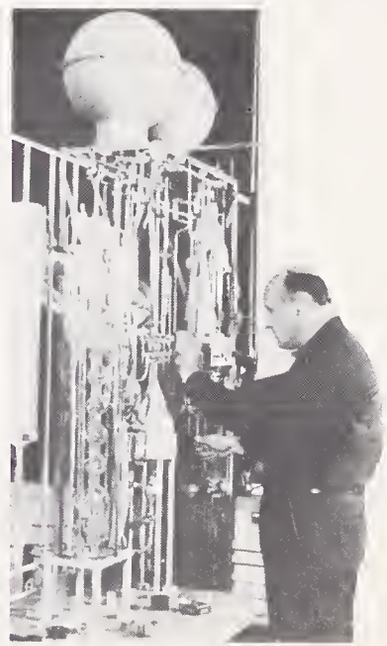
We anticipate that our technical support of Federal agencies in the housing and building field will continue at about the current level of activity.

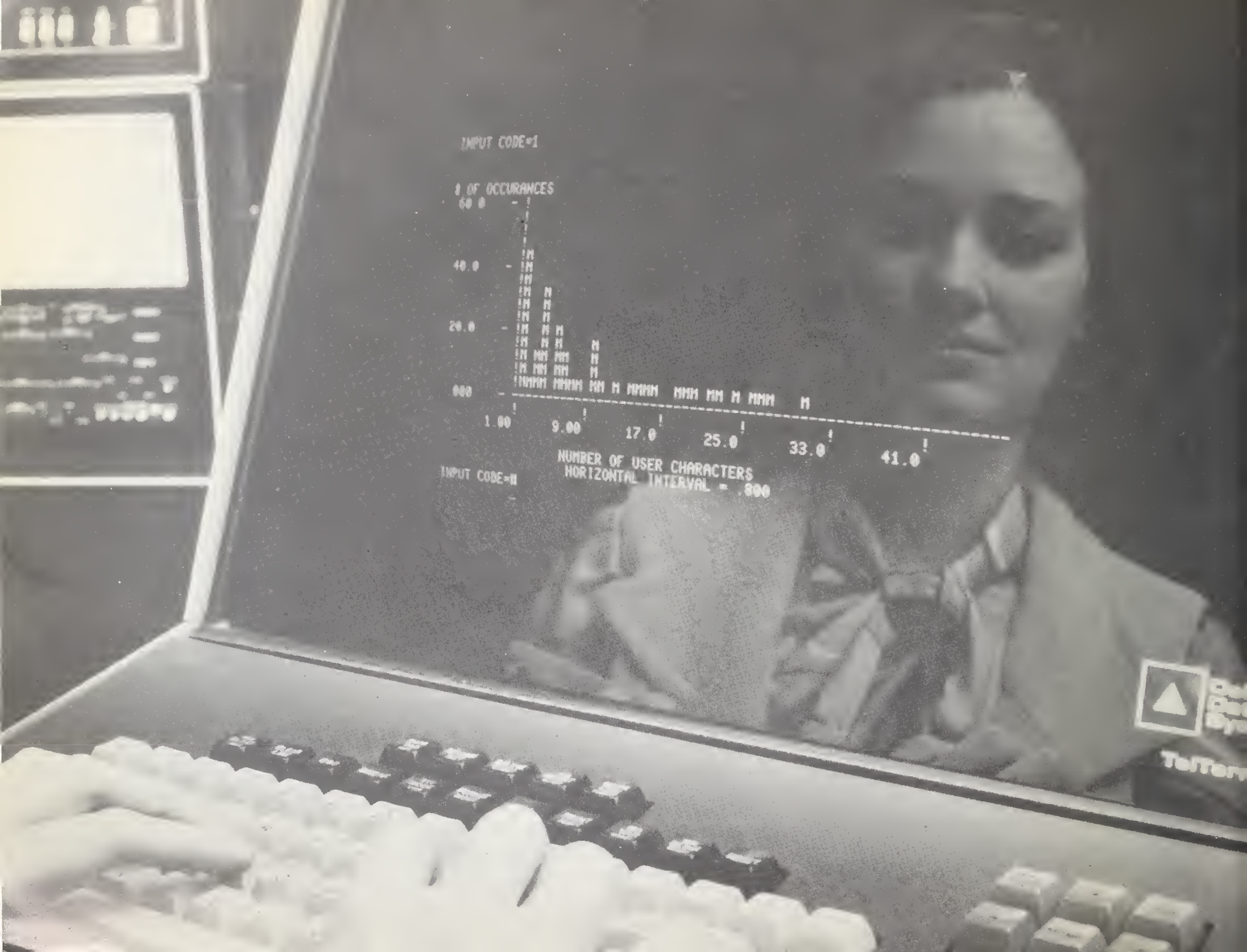
Finally, we expect that the IAT will continue to be more heavily engaged in other-agency supported projects than the other major operating units of NBS. This is inherent in the nature of our services which are weighted in the direction of solving technical engineering standards problems.

F. Karl Willenbrock

1935

The competence of Martin Shepherd and the Gas Chemistry Section in the field of atmospheric analysis resulted in their participation in early attempts to define the composition of air samples from the stratosphere. Samples were collected by the balloon Explorer II, flown to a height of 73,000 feet as a joint project of the National Geographic Society and the Army Air Corps (photo courtesy National Geographic Society).

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CENTER FOR COMPUTER SCIENCES AND TECHNOLGY

Dr. Ruth M. Davis
Director, Center for Computer Sciences and Technology
(X3151)

THE National Bureau of Standards has provided impetus and leadership for the development of major technologies over the last 70 years, but perhaps nowhere has its contribution been greater than in the field of computer technology. Starting with its development of the first automatic electronic computer, called the Standards Eastern Automatic Computer (SEAC), NBS has been at the center of the development and application of computer technology for the benefit of man and society. Today, at the end of the first quarter-century of the computer, NBS, through its Center for Computer Sciences and Technology, plays a strong and important role in improving the effectiveness of computer utilization and in providing solutions to the serious problems that have been created by the computer.

During the last year, I have concentrated on making the Center for Computer Sciences and Technology the scientific and technical conscience of the computer world. The computer world served by the Center is complex and sprawling, affecting every segment of our society, our economy and our Government. It is a world of far more than the equipment which we call the computer system; it is dominated by software, the schemata which makes possible the desired applications of any computer system. I see the computer world as a domain of services in which the customer is principally concerned with the quality of the services he receives from the computer; the customer is only secondarily interested in hardware and the programs written for specific applications. I am focusing the Center's resources and technical activities in areas which will insure that computer services meet the needs of the computer customer.

One of my principal concerns is with maintaining and improving the computer technological supporting system, i.e., the essential legal, economic, administrative, ethical, and intellectual arrangements through which computer power is made available to customers and subjected to society's controls. I believe our work in this area is extremely important because, at this moment in computer history, the technological supporting system and software have become the "Achilles Heel" in our attempts to channel the power of computers to serve our best interests.

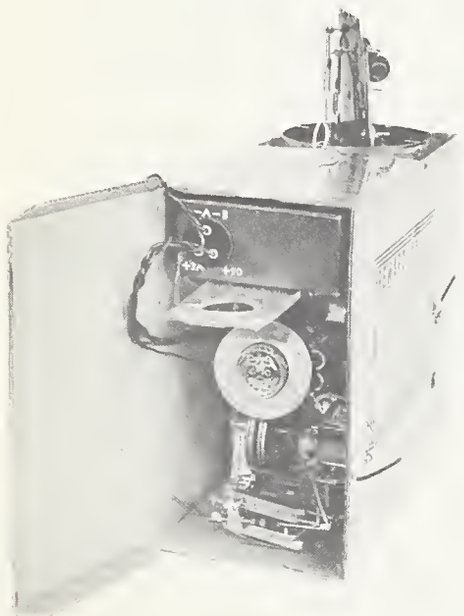
Another component of the computer world over which the Center for Computer Sciences and Technology watches is computer science and technology from which are derived improvements in computer applications and products.

Because of the great technological explosion in the computer field during and immediately subsequent to World War II, computer science was overwhelmed by the surge of computer applications. The current imbalance is highly visible in that our ability to produce computer equipment and computer programs has far outstripped our ability to measure and judge their quality.

CCST is participating in the ARPA Network as part of a program to evaluate alternative approaches to computer networking. Here Mrs. Shirley Watkins (X2601) is using a program located in a remote computer in the Network.

1930's

The radiosonde—a balloon-borne device that transmits data on cloud height, temperature, pressure, humidity, etc. from heights up to 15 miles or more. Thousands are used annually in weather forecasting. Developed during the 1930's by Allen Astin, Leon Curtis, Harry Diamond, Wilbur Hinman, and Francis Dunmore; shown here is a later model.



The Center, as the conscience of the computer world, attempts to decrease the problems now besetting the computer customer, and, most importantly, to predict and prevent the occurrence of additional problems to the extent permitted by conscious action.

The Center possesses its unique responsibilities and authorities partially through its congressional mandate, Public Law 89-306 (Brooks Bill), enacted in 1965 to improve the Federal management and utilization of computer technology. Under authorities delegated to the Secretary of Commerce by P.L. 89-306 and policy guidance issued by the Office of Management and Budget, the Center is specifically responsible for providing scientific and technological advisory services to the Office of Management and Budget and the General Services Administration to support the formulation of ADP management and procurement policies, and to other Federal agencies to assist in the solution of specific automation problems. The Center is responsible for recommending Federal Information Processing Standards and participating in the development of voluntary ADP standards, and for conducting research necessary to support the scientific and technical objectives of P.L. 89-306. Finally, the Center operates a computer facility to meet the computer services needs of NBS and to provide services to other Federal agencies on a reimbursable basis.

The Center also derives its responsibilities and authorities from the NBS Organic Act which allows it to share in the overall NBS responsibility for promoting strength in science and technology and applying them effectively for public benefit. Thus, the Center serves both the producers and the consumers of computer products and services, and has a special obligation for ensuring that computer technology serves the American citizen in ways that enrich and improve his life without encroaching on his right to privacy and dignity.

Within the Center's broad objectives, the resolution of outstanding issues and problems demands an immediate focus of our efforts on quality control and measurement of computer services and products, on increasing professionalism in the computer field, on intensifying the applications of automation technology, and on decreasing the enormous dissipation of skills in unproductive labor in the computer field.

There is an urgency here resulting primarily from a growing apprehension everywhere over undesired and unforeseen consequences of computer use. "Everywhere" is a most significant and meaningful term in the computer world. There are currently some 88,000 computers in the United States and an additional 56,000 in the rest of the world. The Federal government alone has more than 5,900 computers in its current inventory. In addition to Federal, State, and local

governments, which account for some 18 percent of total computer usage, computers are diffused broadly through the economy. Some 40 percent of all computer facilities are used in the manufacturing industries· the financial community, including insurance companies, accounts for another 16 percent; the remaining 26 percent is distributed among the utilities, wholesale and retail trade, health care facilities, and data processing firms.

With computers and their services so widespread and their customers so diverse and dispersed, it is apparent that any accompanying problems are going to be extremely costly to the economy as a whole. Computers have, in fact, become the major technological ingredient of progress in the world of today and it is the problems accompanying their services and utilization which must demand our attention and resources.

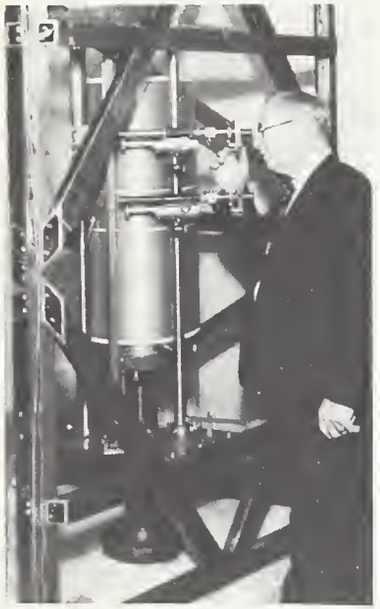
QUALITY CONTROL IN SOFTWARE

One serious problem is the inadequacy of computer software selection, procurement, and management procedures. There is probably no more elusive commodity bought and sold today than computer software. Included in software management are program production, measurement, testing,

Nicholas Goumas (X3494) performing a calibration measurement on a reference single platter used for quality control in the manufacture of multiplatter disk pack storage units. This work should lead to a calibration service for the industry and other users.

1940

Frank Wenner, world renowned electrical metrologist (at NBS 1907-1943), measures the inductor used in his ohm determination. The results were important in the 1948 assignment of the ohm in terms of the meter and second.



validation, documentation, control, transferability, legal and proprietary rights of buyer and seller, maintenance, and costing.

Although the United States is the world's greatest producer of computer software, there is virtually no quality control in the computer service industry. No one has yet paid adequate attention to software management in spite of the fact that it is through software management that a whole new dimension of efficiency is opened to the customers of computer services. A recent report by the General Accounting Office has stressed the seriousness of the software management problem and the associated lack of quality control.

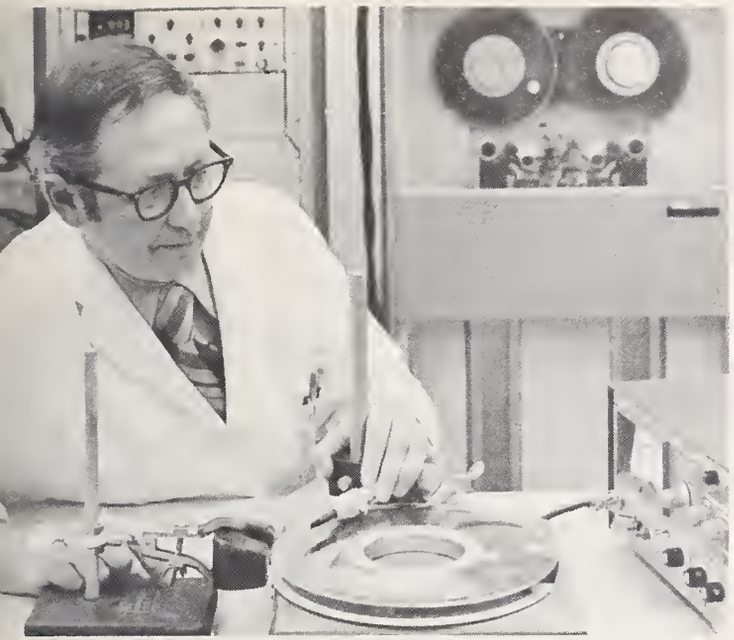
Software management is becoming increasingly complex because computer customers are being confronted by a rapidly growing number of alternatives in software products. Until quite recently, the customer had few alternatives available in the software area. But now, software is being produced in large quantities by computer manufacturers, computer users, independent software producers, research institutions, universities, and others. The customer's selection, utilization and costing problems are complicated and further compounded by the lack of measuring sticks or product "guarantees" by the seller. The urgency of solving the problems of software management is underscored by the fact that initial software costs invariably equal hardware costs for any application and that for a majority of applications initial software costs are estimated to run three to eight times hardware costs.

SOFTWARE DOCUMENTATION

Software documentation is the detailed description of a computer program. Standardized documentation procedures are crucial to good software management; without them the result is the kind of chaos that would occur in accounting if CPA's did not have standardized nomenclature and conventions. Effective documentation is essential to the buyer in evaluating software for purchase and application to his problem. There is an urgent need for standardized ways of describing computer programs so that potential users can make decisions on a program's applicability to the solution of a given problem. The ability to share computer software extensively is directly dependent upon the uniform documentation system for describing computer programs. The Center has placed high priority on the development of software documentation standards as an important part of the Center's program to improve the effectiveness of computer services and insure the customer equity in the computer marketplace.

SOFTWARE VALIDATION

Software validation is the process of determining the extent to which software conforms to certain stated conditions or requirements. Software validation services,



Sidney Geller (X3494) positions a probe over a reel of magnetic computer tape to plot the field produced by the magnet at the left. This work is part of a study of the danger of accidental erasure of data encoded on the tape.

in their totality, are an essential ingredient of effective computer utilization—none exist today. The result of the software validation process is software certification—designating which stated conditions or requirements the software has met.

The absence of software validation services has resulted in customers buying software without knowing the extent to which the software conforms to stated conditions and requirements. In most instances, each customer performs his own validation of the same piece of software. An example within the Federal computer environment will illustrate the problem. The fiscal year 1970 GSA ADP inventory shows that Federal agencies bought 180 computer systems for which the vendor maintains a COBOL compiler. Under present procurement practices, 720 COBOL validations were required, assuming there were four bidders for each procurement. At an average cost of $3,000 per validation, the total expenditure for all the required validations on a decentralized basis would have been $2,160,000. Since there are only about 33 unique COBOL compilers maintained by computer vendors, the entire validation process could have been performed for about $99,000—33 validations at $3,000 each—or a savings of more than $2 million.

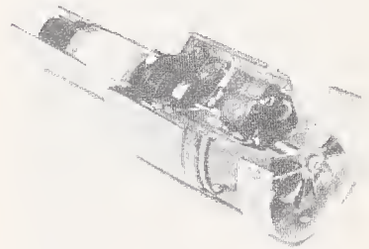
In response, the Center has initiated an effort to determine the best means for instituting COBOL and FORTRAN validation services, and is working closely with the General Services Administration in serving Federal customers.

PERFORMANCE MEASUREMENT OF COMPUTER SERVICES

Presently, the computer industry has few meters or gauges for measuring either hardware or software performance. After 20 years, there are only some half-dozen computer-hardware monitors which can provide data on how various components of a computer system are performing; these have been developed, generally, within the last 5 years. And yet, first tentative findings show that a 25 percent improvement in computer utilization can be expected from

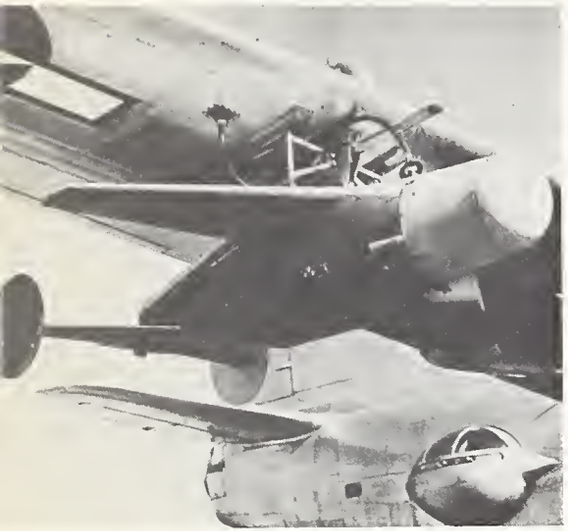
1942

The radio proximity fuze—developed during WW II to explode shells at a preselected height above a target. The fuze emits radio waves, which are reflected from the target back to a receiver in the fuze. When the received signal exceeds a predetermined intensity, an electronic switch is activated that detonates the fuze.



1944

The Bureau helped develop the Bat, the first guided missile ever used in combat. It was unpowered, gliding from the release plane to the target.



simple changes apparent from primitive analyses of the data produced by these hardware monitors. Grossly, this could mean a 25 percent decrease in the cost of computer services provided by a given installation.

The Center has included in its technical program an effort to develop and provide to the computer customer a body of techniques and guidelines for measuring the performance of computer systems.

STANDARDS

Finding the remedy for computer hardware and software incompatibilities is not an easy task. We believe that properly conceived ADP standards can usefully serve to resolve incompatibility problems. Standards in this sense are consensus agreements on how the design, performance and other characteristics of computer products, processes, services, and systems are to be described and, when possible, measured. Desired compatibility among computer hardware is achieved when one set of equipment can accept and process data prepared by another set of equipment without having to convert the data or modify its own program. The desired compatibility among software packages is achieved when the operating system of one computer can run programs written for another (compatible) computer and achieve the same results.

The standards program of the Center for Computer Sciences and Technology attempts to achieve these objectives through support of and cooperation with the Nation's voluntary ADP standardization activities, especially those of the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO).

To date, 15 standards which are aimed at resolving problems of ADP incompatibility have been issued as Federal Information Processing Standards. In addition, the Center is actively participating along with representatives from other Government agencies and industry in the standards committees of ANSI and ISO, where some 80 other ADP standards are in various stages of development. We intend to continue a vigorous technical participation in these standards activities.

PROFESSIONALISM IN THE COMPUTER WORLD

The effective utilization of computer technology to solve pressing national problems is directly dependent upon the availability of an adequate force of professional computer personnel capable of advancing computer science. Presently, there is a serious shortage of properly trained, experienced computer professionals. Current estimates are that the total need for computer personnel of all types will double in the next 5 years. The Department of Labor has estimated that there are currently about 500,000 computer personnel in the United States; most of these are applications oriented personnel

without formal education in computer science.

The trained professional manpower base capable of contributing to the advance of computer science is a small but increasing fraction of total computer personnel. As of 1969, only 4,343 computer science degrees had been awarded over the preceding 5 years; only 163 of these were at the Ph.D. level. As a result, the current ratio of application manpower without formal education in computer sciences to those who have formal degrees in computer science is at least 100:1. This imbalance is producing a drag effect on computer application and utilization. The Center endorses all efforts leading to increased computer manpower skills and to a respectable computer science.

DISSIPATION OF SKILLS

The dissipation of skills in the computer world today is enormous. This intolerable condition exists for several reasons. First of all, we cannot exchange software except in highly restrictive situations because of the lack of compatibility of computer equipment and software and our present inability to document and thus define a computer system. The result is duplicative costs for the same development and a waste of computer manpower. Our economy can afford neither.

A second reason for low productivity of computer professionals results from the inability of the computer customer to specify the performance he requires from the service he is buying. When this problem is coupled with the present lack of performance measurement tools and techniques for computer products we have the almost ludicrous situation of a marketplace where the buyer does not know whether his "purchase" is satisfactory and where the seller does not know how to describe his product. The result is the well known horror story of the organization with an unacceptable computer system after 2 years of contractual development and several million dollars outlay.

Still another reason for dissipation of expensive computer manpower skills is our inability to find ways of sharing the costly computer products and resources we as a nation now possess. We are taking the first steps toward removing the obstacles to remote sharing of costly computer resources developed through large manpower expenditures. The process of sharing is called teleprocessing and is accomplished through the networking of computers and customers by communications.

The Center for Computer Sciences and Technology is active in attempting to eliminate all these problems resulting in wasted resources and unsatisfied expectations. It has, as noted earlier, projects to increase compatibility of software and hardware and to develop and apply performance measurements to computer services. It is also developing teleprocessing as a radically better way of utilizing computers.

1945

Dr. Edward U. Condon came to NBS as Director in 1945, having established a reputation as an outstanding theoretical physicist. He resigned to return to private industry in 1951.

TELEPROCESSING

Not everyone who needs computer services can afford a computer, and, conversely, not everyone who has a computer needs all the services he has available. Similarly, those who do own computers cannot afford to develop all the software and data banks they would like to have to be completely self-sufficient. Clearly, then, there is a need for effective methods which will permit communities of customers to share expensive computer resources.

Resource sharing among computer customers is increasing but has not yet reached truly effective levels. Much of today's sharing is in the form of exchanging computer software and data files but even here effectiveness of sharing is severely limited by the lack of compatibility between hardware and software. Our ultimate objective is a set of procedures which permit the effective and efficient sharing of hardware, software, and data files without the necessity to physically move resources or perform any conversion or modification of resources.

Dr. Selden Stewart (X3491), a Postdoctoral Fellow, conducting experimentation via satellite with computers at a remote location.

A program is underway to certify secondary standard reference digital tape cassettes (foreground). The apparatus on which Amory Ericson (X3494) is preparing to calibrate an International Standard Magnetic Tape (sold by NBS as SRM 3200) will also be used to calibrate cassettes.

The most advanced current concept in computer resource sharing is computer networking. A computer network is a set of independent computer systems interconnected by telecommunications lines to permit interactive resource sharing between any combination of systems and customers. Teleprocessing is the popular term used to describe computer networking. Teleprocessing systems can be as simple as a single computer to which several remotely located access terminals are connected via standard telephone lines, or as complex as a nationwide network of large-scale computer systems interconnected by high-speed dedicated communications lines.

It is clear even at this early stage of its development that the future structure of teleprocessing usage will be affected by Federal policies and that these policies may well be the determining factor in future trends as teleprocessing is applied to increasing numbers of applications within our society.

The Office of Telecommunications Policy (OTP) was established just a year ago in recognition of the importance of Federal policies on communications practices and trends. On September 1, 1971, this Office asked the National Bureau of Standards to assume a distinct and special role in assisting the OTP in carrying out its functions assigned by the President in the area of computers and communications. In particular, the NBS was asked to provide technical advice and analysis in teleprocessing matters.

We consider this an extremely important assignment and appropriate for the Center for Computer Sciences and Technology under its congressional mandate.

There are many concerns with the technology and economics of teleprocessing. Some of these concerns are socioethical in nature and deal with questions of the privacy aspects of the information, and to the integrity of such information, especially when that information is transmitted from computer to computer. Very serious concerns exist with respect to the methodologies for verifying electronically stored information concerning an individual or business. Similar concerns arise regarding procedures for correcting erroneous information, especially if that information has been disseminated to locations where it may be used to respond to inquiries. We have classified this problem of privacy of data as one of controlling the accessibility to computer-maintained data bases.

CONTROLLED ACCESSIBILITY TO COMPUTER DATA BASES

The pervasiveness of the computer has raised widespread fear of the computer as a threat to the privacy of the individual. Teleprocessing has escalated such fears. Although the issue has been frequently exaggerated and charged with excessive emotion, there is a necessity for a rational

1945

Petrol, a jet powered air-to-surface missile having a range up to 35 miles, was developed for the Navy by Ralph Lamm, Harold Skramstad, and Hunter Boyd. It was carried by patrol squadrons until 1958.

1947

A magnetic fluid clutch, operating on the principle that a magnetized fluid medium (such as iron particles in oil) can transmit torque between movable plates, was developed by Jacob Rabinow. This device has had widespread commercial application.

approach to the problem of security, privacy, and confidentiality of information contained in computer data banks.

The problem of controlled accessibility of data bases has two major facets, the technical problems of protection by use of hardware or software techniques and the social or legal aspects of privacy and the protection of property rights. It appears that the technical aspects of the problem, while significant, are not insurmountable although their adequate resolution will require analysis of the social or legal problem to determine what limitation on access must be provided for.

The social or legal problem has two major facets—the protection of privacy and property rights. In the first case, all of us have misgivings about the accumulation of vast amounts of personal data about ourselves in an information system with that data made available to users of the system. The uses of this data by properly motivated people could be of immense social value; however, the potential for abuse of the information by unscrupulous individuals is equally immense. Such misuse may range from using credit-rating information to determine likely prospects for making unauthorized charge account purchases to blackmail through use of collected and correlated facts about past conduct which individually are insufficient to prove anything but when taken in the aggregate tend to circumstantially show some undesirable conduct.

In the case of protection of property, the problem involves not only the use of the data but the control of the data base.

The technical issues underlying all aspects of privacy of data are a major program thrust of the Center for Computer Sciences and Technology.

The Center has initiated substantive scientific and technical programs in each of these problem areas and has begun to record significant progress over the last year. The development of techniques and guidelines for the centralized validation of COBOL and FORTRAN compilers has reached an advanced stage. Similarly, the Center has made significant progress in the development of a detailed methodology for resolving interface problems through the use of performance specifications to be employed in the acquisition of computer systems and components. The Center has initiated a comprehensive program to develop techniques for measuring the performance of computer systems and services. Research in performance measurement is a crucial part of the Center's teleprocessing program which uses the Advanced Research Projects Agency's nationwide computer network as one experimental vehicle. The Center, through a terminal interface message processor (TIP) located at the NBS, can access computers in the ARPA network and also can provide access to other Federal agencies wanting to use the network.

We will continue to expand and intensify

our technical program and to place heavy emphasis on developing the tools, techniques, and procedures which will enable the customer to increase the effectiveness of computer utilization. Toward this end, the Center has requested an increase in its fiscal year 1973 budget of more than 40 percent.

HIGHLIGHTS
OF FISCAL YEAR 1971

The Center for Computer Sciences and Technology made significant progress in several areas of its assigned responsibility during fiscal year 1971. In terms of overall impact and continuing benefit to the Federal computer customer, the reorientation of the Center's technical program to focus resources on the high priority problems and issues currently confronting the computer customer is a major accomplishment. In fiscal year 1971, the Center also initiated specific scientific and technical projects to: develop techniques and guidelines in the areas of performance measurement, software management, and computer utilization; explore problems in teleprocessing and computer networking related to the effective sharing of expensive computer resources, i.e., hardware, software, and data banks; and develop automatic data processing standards. These projects, which are representative of the major new initiatives being undertaken by the Center, have both near-term and long-range objectives and will generate outputs over an extended period.

Selected specific examples of fiscal year 1971 accomplishments are:

Completion of Six Federal Information Processing Standards

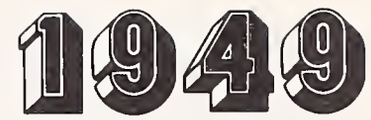
The Center completed the development of six Federal Information Processing Standards (FIPS) and forwarded them to the Director, Office of Management and Budget for approval:

- FIPS PUB 16: Bit Sequencing of the Code for Information Interchange in Serial-by-Bit Data Transmission
- FIPS PUB 18: Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication
- FIPS PUB 17: Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in Code for Information Interchange
- FIPS PUB 14: Hollerith Punched Card Code
- FIPS PUB 15: Subsets of the Standard Code for Information Interchange.

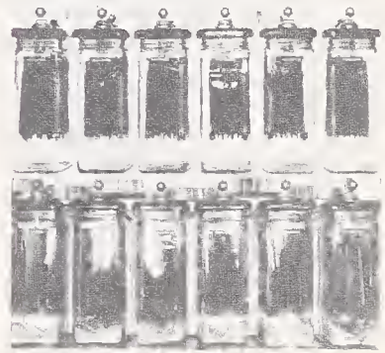
Contact: Harry S. White, Jr. (X3551)

Development of a Teleprocessing Dialogue Monitor

The Center completed the development of an initial version of a hardware/software device for monitoring, recording, and analyzing the "dialogue" between a user at a remote terminal and an on-line computer



In 1949, Bureau test on battery additive AD-X2 showed it—like all other additives tested over the previous 30 years—had no positive effect on battery life or performance. In fact, a negative effect was found during a 10-year field trial. Three of the batteries used as part of the NBS dc power supply (top) were treated with AD-X2 and returned to service; three companion cells were not treated. After 10 years of routine service the treated cells cells (second, third and sixth, left to right, bottom) showed more deposit and their averaged electrical capacity was but 3.5% of the untreated cells.



The first atomic (ammonia) clock, with its developer Dr. Harold Lyons (right) and Dr. Condon.

system. The monitor, inserted between the user and a remote computer system, provides data about user behavior, system performance, and communications facility utilization. Four types of data are acquired: total time required and number of characters transmitted during user input; system delay time before beginning to respond to user input; time required and the number of characters transmitted during system output; and time until user starts again transmitting characters to the computer system. The monitor time-tags each character and through a post-processor program prints the entire dialogue. The dialogue monitor is an important tool to assist in measuring the performance of teleprocessing systems.

Contact: Thomas N. Pyke, Jr. (X2601)

Preparation of a Comprehensive Study of the Role of the National Bureau of Standards in Federal ADP Operations

During fiscal year 1971, the Center for Computer Sciences and Technology completed a comprehensive study of the role of the National Bureau of Standards in Federal ADP operations and how to increase NBS's effectiveness in achieving greater efficiency and economy in Government ADP operations under the Brooks Bill. The study describes the Federal computer environment, discusses the Center's authorities and policies to implement P.L. 89-306, presents the Center's technical program, and summarizes the Center's major accomplishments. The study directly supports the Center's fiscal year 1973 budget request and provides a foundation for a 5-year development program.

Contact: Dr. Ruth M. Davis (X3151)

CURRENT TRENDS AND NEW ACTIVITIES

The Center's program is directed toward the objective of insuring that computer services meet the needs of the customer and that the computer technological supporting system keeps pace with computer technology itself. Against the background of a services-oriented computer world that is dominated by software and its management, the Center will concentrate on developing and making available to the customer those techniques and tools which will enable the customer to measure the performance of computer systems, exercise effective quality control over computer services, determine the cost-effectiveness of computer services, simplify computer system selection and acquisition, and produce more effective software with greater capability for transferability. The Center, as the Federal scientific and technical focal point for computer sciences and technology, will emphasize its technical support to the Office of Management and Budget, General Services Administration, Office of Science and Technology, National Science Foundation, Office of Telecommunications Policy, General Accounting Office, and the Department of State in formulating policies regarding ADP management and

procurement, teleprocessing, international computer technology, and advancement of computer science. Selected examples of current and future activity are:

Development of Centralized Validation Service for COBOL and FORTRAN Compilers

The Center, in concert with other Federal agencies, is at an advanced stage in the development of centralized services for validating COBOL and FORTRAN compilers. The Center is developing the specifications, techniques and guidelines for these services and will designate specific Federal agencies to perform the actual validation. The routines developed by the Department of Defense will be used for COBOL validation; the Center's own routines will be used for FORTRAN validation. Centralized COBOL validation services will be available by fiscal year 1973; FORTRAN validation services will be available by fiscal year 1974.

Contact: Harry S. White, Jr. (X3551)

Development of Performance Measurement Techniques

The Center is currently experimenting with hardware performance monitors and is developing techniques and guidelines for the application of these monitors to improve the effectiveness of computer utilization. This work will be expanded to include software monitors. In addition, the Center will continue its development of devices and techniques for calibrating computer recording media, e.g., magnetic tape, tape cassettes, disks, etc. This work benefits both the buyer and the seller of recording media.

Contacts: Dr. Selden Stewart (Performance Monitors) (X3491)

James P. Nigro (Calibration Services) (X3476)

Experimentation in Computer Resource Sharing

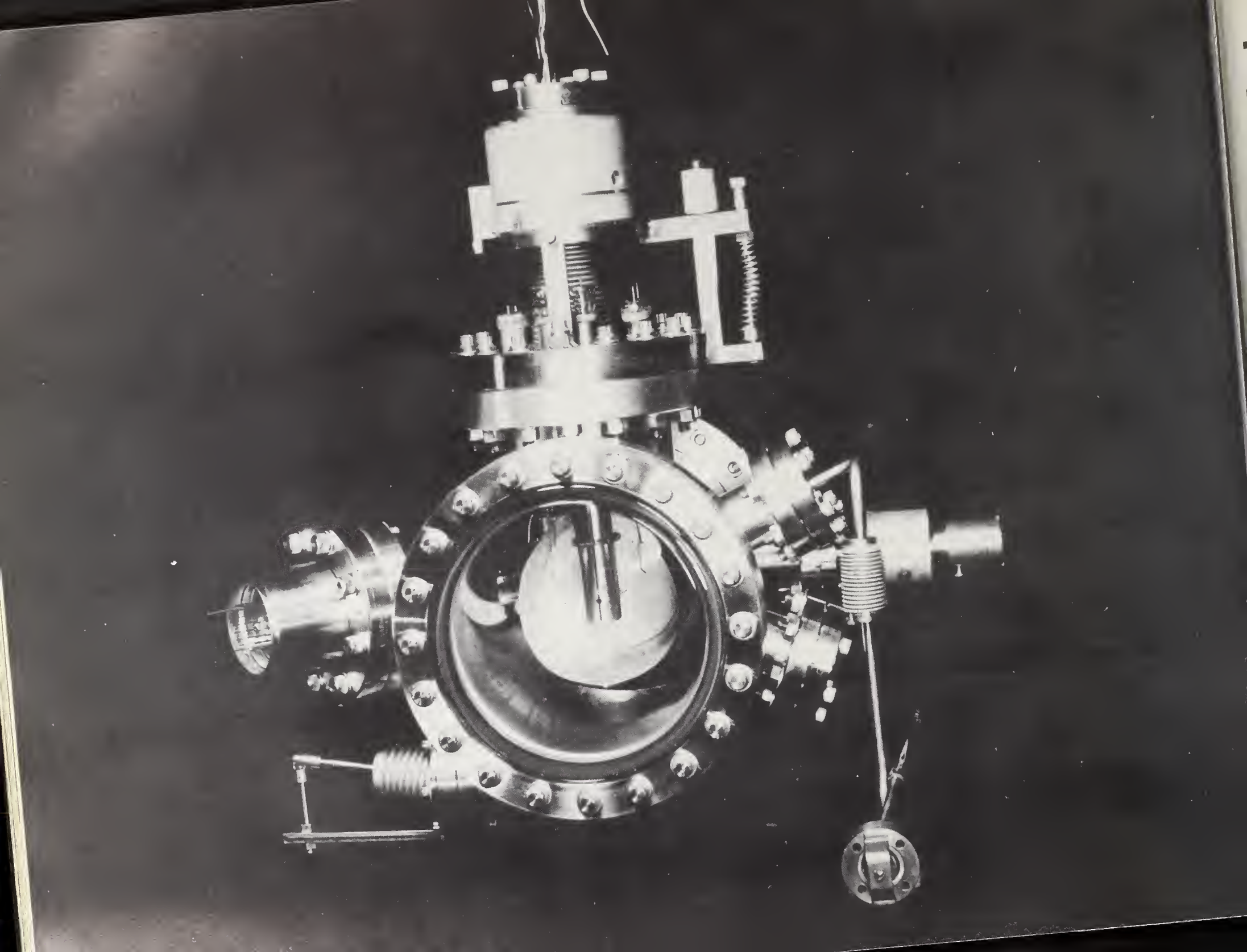
The Center has initiated a major program in teleprocessing and computer networking in order to advance the understanding of this most rapidly growing segment of computer technology and to develop techniques for improving the effectiveness of its utilization. The program will include experimentation with a number of teleprocessing systems and computer networks. The Center has a terminal interface message processor (TIP) which gives it access to the Advanced Research Projects Agency (ARPA) computer network and, in turn, provides a means for other Federal agencies in the Washington area to gain easy access to the network. Using its dialogue monitor and other techniques, the Center will study user behavior, system response, and data transmission to provide a technical base for measuring performance and developing techniques and guidelines for effective sharing of equipment, software and data banks.

Contact: Thomas N. Pyke, Jr. (X2601)

Ruth M Davis

1950

SEAC—Standards Eastern Automatic Computer—the first general-purpose, internally sequenced electronic computer, was completed in 1950. Shown in front of SEAC is Samuel Alexander, who initiated the NBS computer group that evolved into the present Center for Computer Sciences and Technology.



PROGRAM OFFICE

THE Office of the Associate Director for Programs has celebrated its first birthday. The purpose of the Office is to support the Director and Executive Board in focusing the Bureau's activities. Priority was placed during the first year on conceiving and establishing a Bureau-wide infrastructure for the systematic planning, formulation, evaluation and promotion of agency programs. The role of the Office in the infrastructure is to (1) develop and interpret agency-level policies and objectives; (2) analyze and evaluate programs (proposals, plans and progress) in context of policies and objectives; (3) manage the annual cycle of program review, planning and budget formulation; and (4) promote NBS programs.

The basic nature and purpose of the Office dictates that practically all activities, to be successful, must be carried out in close collaboration with some combination of the Director, the Executive Board, line managers, or staff.

SOME PRINCIPAL ACCOMPLISHMENTS

Working definitions were developed for the elements of the new Program Structure developed by the Director and Executive Board in 1970. The Structure documents the goals and objectives toward which the line managers address their plans and services. Together with criteria for selection of Bureau programs developed by the Executive Board, the Structure is used by the Director in allocation of NBS resources.

The Office of Programs was particularly active during this year in collaborating in many important ways with the Department of Commerce, Office of Management and Budget, and the Office of Science and Technology in the planning and evaluation of national level programs.

PROGRAM PLANNING, REVIEW, AND BUDGETING

A program planning and reporting system was conceived and instituted which will provide data for allocation of resources within NBS and the justification of budget submissions. The system was initiated with the Director's assignment of responsibility for each major program area to the appropriate Institute or Center of the Bureau, and their subsequent assignment of program managers or representatives. The Program Office then developed guidelines for the program managers and representatives.

With the extraordinarily high level of cooperation and assistance from the NBS Budget Division, the Office was able to introduce an improved level of quality and effectiveness into the budget process, i.e., the preparation and presentation of NBS proposals and their justification.

To facilitate the use of the Evaluation Panels provided each NBS division and

Dr. Howard E. Sorrows
Associate Director for Programs
(X2446)

The sophistication and cost of scientific equipment is constantly increasing. Dr. Sanford Newman (X3130) of the Program Office made an extensive study of NBS equipment needs and policies, finding that the fraction of NBS funds spent on equipment, approximately 3 percent per year, is far less than that of industrial laboratories, which average about 10 percent.

1951

Procedures were developed at NBS, in cooperation with Libby-Owens-Ford, for the preservation of the original parchment documents of the Declaration of Independence and the Constitution.

institute by the NAS/NRC, the Program Office prepared charters for each of the Panels as a guide to the issues on which their assistance was required; and the Office provided the necessary interface for coordination and communications with the Panels.

PROGRAM ANALYSIS

Scientists from the Bureau staff were assigned the responsibility for coupling between the Bureau's major technical programs and the line organizations. They provide a critical communications interface between the Director's Office and line organizations, allowing more adequate consideration of program alternatives and assuring feedback on program evaluations and agency level guidance for program development. Their contributions, based primarily on their ability to understand and articulate the programs, in representing the new budget initiatives to the Department of Commerce and Office of Management and Budget were a major factor in the Bureau's unprecedented success in achieving its fiscal year 1973 budget objectives. For information about the Bureau's operating goals: Measurement Services for Science and Technology, and Technical Information Services, contact Dr. David T. Goldman (X3134); Science and Technology for Industry and Government, contact Dr. Joseph A. Coleman (X3133); Technical Services for Equity in Trade, and Technical Services for Public Safety, contact Dr. Sanford B. Newman (X3130).

During the year, the Bureau completed a number of in-depth studies of fundamental problems or opportunities. The Office developed guidelines for systematic conduct and presentation of the studies, coordinated the efforts, and actively participated in the studies where appropriate. The studies were particularly effective in supporting successful new program and institutional initiatives, e.g., a long-range plan for the modernization of the Bureau's laboratory equipment was developed under the direction of a member of the Program Office, forming the essential support for acceptance by the Department of Commerce and OMB of a major NBS initiative.

PROGRAM PROMOTION

An experienced scientist, Dr. Thomas Flynn (X3191), was given responsibility for agency-level coordination of program promotion activities. The primary responsibility of this office is to represent the programs of NBS as a whole to any audience in keeping with their need and understanding, to convey the nature of the scientific worth and public worthiness of our programs, and to assure up-to-date policy content, appropriate program emphasis, and inter-program coordination. For example, this office managed the NBS Oversight Hearings; managed regional workshops on NBS for business and State and local government officials in Hawaii and Colorado; conducted workshop seminars on NBS services and on advanced technology

planning methods for top-level planners and research directors in 15 major cities (in cooperation with the Commerce Department Office of Business Services); prepared a fact book, "NBS at a Glance" for wide distribution; established or renewed 11 Research Associateships (Peter de Bruyn, X3541); designed and gave briefings on the goals and services of NBS for our Department of Commerce management, Evaluation Panels, and distinguished visitors such as the President's Science Advisor and members of the House and Senate committees having concern with NBS.

MAJOR THRUSTS OF THE OFFICE IN THE NEXT YEAR

1. The major challenge will be to fully implement and thereby realize the potential of the 1971 initiatives; the newly inaugurated program planning and reporting system will be refined and more clearly documented. Policies and procedures will be evolved to define the management relationship of program and organizational elements of the Bureau, and the process by which planning, reporting and budgeting is accomplished. Project and program reports and reviews will receive increased attention. All NBS Project Resumes will be published in an indexed book for internal use, and an automatic storage and retrieval system for project information will be established.

2. The definition of major objectives and programs will be improved. Program elements of the Program Structure will be aggregated into a smaller number of more easily describable entities for external communications.

3. To obtain improved efficiency in program evaluation activities and preparation of budget materials, the distribution of tasks between the Program Office and the Budget Division will be modified; the program analysis staff will be realigned to provide more assistance to the senior analysts.

4. Additional regional workshops will be held to improve communications with Bureau clientele and to obtain better understanding and broader use of NBS services.

5. The Bureau's National Academy of Sciences Evaluation Panels will be better integrated into the Bureau's planning and budgeting cycle to insure efficiency in Bureau planning and effectiveness in the involvement of the Evaluation Panel in Bureau decision-making.

6. Means will be conceived for better assessment of the mesh of NBS services with national need in the private and governmental sectors. The Office will attempt to enlist the assistance of economists and other experts, both in the Government and private sector, to more clearly define and document the NBS role in stimulating the Nation's research, technology and economic development.

Howard E. Sorrows

1952

A magnetic Compton spectrometer was developed by Drs. H. Wyckoff, J. Motz (X2201) and W. Miller for accurate analysis of x rays with energies between 0.2 and 12 MeV. The detection efficiency of this device was 100,000 times that previously possible.

INFORMATION PROGRAMS

TECHNICAL information is one of the most important products of all the activities at the National Bureau of Standards. Our communication of information is a two-way process; it includes the outward transmission to the public of information produced at NBS and the inward transmission to NBS of information about new developments in industry and in universities, newly appearing needs of society, and new opportunities for NBS.

The members of the NBS staff give formal talks, write papers, consult on the telephone with callers, write letters, and discuss technical problems with visitors. They publish papers in technical journals and in the public press. Approximately 50 major conferences and a few hundred seminars are held at NBS each year. We operate more than 30 specialized information centers, many of them as part of the National Standard Reference Data System. In selected areas we organize precision measurement seminars and training courses.

The three basic principles guiding the NBS information program are: (1) Quality of information—that is, its reliability and credibility—is more important than access to great masses of unevaluated information; (2) Information must be appropriately packaged and interpreted for each community of users; (3) A variety of information from many sources is needed for decision makers at all levels throughout society. NBS also has a responsibility to help the user apply the information to his problems. In the fire research program, for example, good information properly interpreted by NBS will not reduce losses of life and property due to fires. The information must be actually applied to real conditions in order to have an impact. Making sure that it has that impact is part of NBS responsibility too. We work with professional associations, State and local officials, and industry representatives to assure that potentially useful information is put to work.

The NBS Library is an important element in the flow of information. It is one of the most complete physical science libraries in the country, with a collection of 100,000 volumes and 2,500 periodicals.

In many NBS "information" activities, information is collected from a variety of sources, processed in a variety of ways, interpreted and analyzed and disseminated for the outside community of scientists and engineers to use. Our largest program of this type is the National Standard Reference Data System. It comprises a network of more than 2-dozen information analysis centers, plus other related activities, all producing critical reviews and compilations of critically evaluated data. The scope is not just one specialized area of technical information but the entire broad field of physical and chemical properties of substances.

The NSRDS helps to answer thousands of questions that arise every day in the work of scientists and engineers. It is a good example of application of the basic principles mentioned earlier—it is oriented to the needs of specific groups of users, and

Dr. Edward L. Brady
Associate Director for Information Programs
(X3641)

1952

Dr. Allen V. Astin was Director of NBS from 1952 until 1969. Dr. Astin had been at NBS since 1932, and had made substantial contributions in such areas as electronic instrumentation and ordnance development.

it focuses exclusively on high-quality, reliable data.

Broad as the present scope of the NSRDS is, it does not encompass all the types of property data needed by engineers and scientists. It is focused upon well-defined properties of well-defined materials. But there are other sets of properties and materials that are not well defined, though they are very important indeed. Examples are the tensile strength of steel, or the melting point of a plastic, or the reflectivity of a paint. As resources grow in the future and as some present activities come to fruition, plans will be made to undertake a major effort in this vital, but extremely difficult, field.

Sometimes NBS work reveals a potential hazard that should immediately be brought to public attention. A recent example was that of picnic coolers, a rather innocent household device, but a potential death trap for children. Several children suffocated when a tightly fitting or self-latching lid closed, imprisoning them. The solution is not difficult; put partitions in the coolers so children won't fit, put pop-out sections in the cover or walls, easily removable from the inside by the struggles of a child, and eliminate self-latching lids. The industry, NBS, and other interested parties worked out a new design standard for picnic coolers which has already been issued as a Department of Commerce Voluntary Product Standard.

In the meantime, however, the need for parents to be aware of this danger had to be brought to the attention of the public. Press releases were issued, and were used by newspapers all over the country. A 30-second TV-spot announcement was prepared and sent to stations with a request to let NBS know if they used it. One hundred and sixty stations reported they would use the spot one to 10 times each week during the summer. An estimated additional 50 stations used it without telling us.

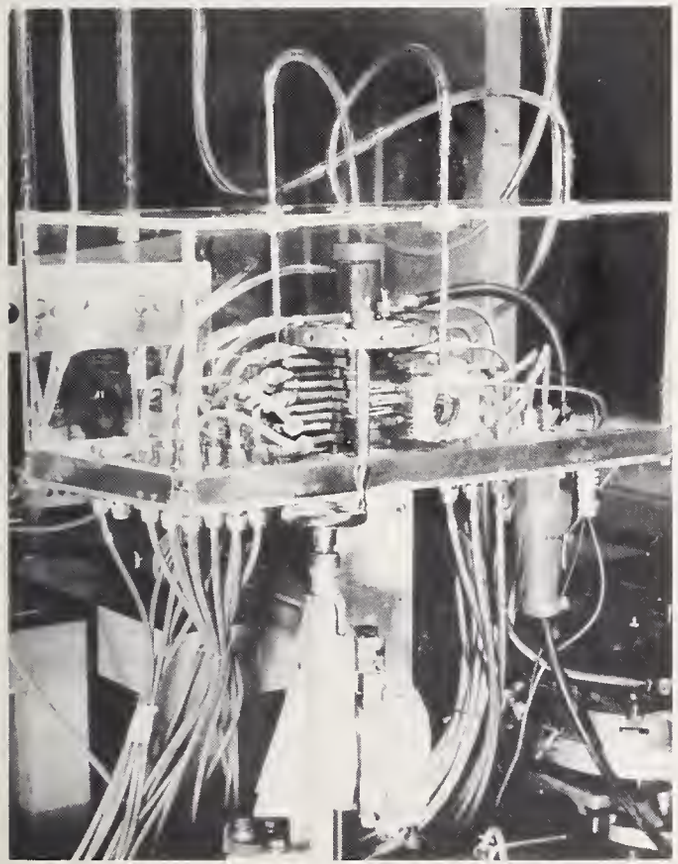
CONSUMER INFORMATION

In the research programs of NBS, information is often produced or collected that may be of direct interest to the public. On instruction from the Secretary of Commerce, NBS has embarked upon a systematic effort to make this information more readily accessible. We have initiated publication of the Consumer Information Series, a series of pamphlets written in a style to make them most valuable to the individual, nontechnical citizen. Four pamphlets have been issued so far: *Fibers and Fabrics; Tires, Their Selection and Use; Adhesives for Everyday Use;* and *Facts About Hearing and Hearing Aids;* and *Care of Books and Documents* is in press. Another is planned on metric tools and measures used around the house, and several other titles have been suggested.

Closely similar to these pamphlets are two that were prepared in close collaboration with the Office of President Nixon's Special

Assistant for Consumer Affairs, Mrs. Virginia Knauer. They are entitled: *7 Ways to Reduce Fuel Consumption in Household Heating* and *11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling*. These two pamphlets were written primarily by members of the Building Research Division of NBS. They are distributed through the Superintendent of Documents and the White House Office for Consumer Affairs. The "7 Ways" pamphlet, which had an initial print run of only 10,000 copies, is now being reprinted for sale by the Superintendent of Documents. Its major distribution has been made by nongovernmental agencies—by the National Home Improvement Council, which reprinted 200,000 copies, and by Owens Corning which reprinted 45,000 copies for free distribution. For the "11 Ways" pamphlet, distribution by NBS, the White House, and the Superintendent of Documents has totaled 20,000 copies; Owens Corning has distributed 55,000.

Data taken in many NBS programs are candidates for analysis by the National Standard Reference Data System. An example is the spectral measurements made on various species generated in this arc plasma source. (W. Wiese, X2071)



COMMUNICATION WITH TECHNICAL AUDIENCES

In communicating with technical user groups NBS reaches a much higher fraction of the community. We use a variety of techniques—publication in technical journals, publication of technical material through the Government Printing Office, conferences and seminars, training courses, talks, letters, and personal consultation.

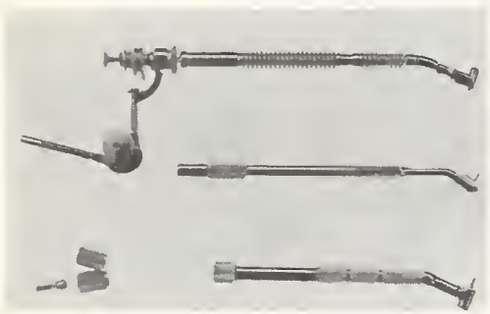
NBS organizes "Precision Measurement Seminars" in several areas of metrology. The purpose is to share with those specialists in industry, government, and academic laboratories what we know about how to measure certain quantities accurately and reproducibly. For effective training only 30

1952

Under the direction of Dr. Horace Isbel, a technique was developed for the economical synthesis of sugars labeled with radioactive carbon. D-glucose-1-^{14}C, for example, was urgently needed for studies of intermediary metabolism.

1953

The high-speed turbine drill now so familiar in every dentist's office is a direct descendent of the first hydraulic-turbine handpiece developed at NBS (top; center), shown here with a conventional handpiece.



to 50 persons can be accommodated in a seminar, and usually more applications are received than can be accepted. A typical example of a seminar of this type is that held at Boulder each year on Laser Power and Energy Measurements. This seminar lasts 2 days, and the fee is $100.

Conferences constitute another important way in which NBS communicates with technical specialists. Each year at Gaithersburg 40 to 50 major conferences are held with from 100 to 1,000 participants each. In fiscal year 1971, for example, 41 conferences were held with a total of 8,400 participants. Literally hundreds of smaller seminars are conducted at NBS or are participated in by NBS speakers at other institutions.

These conferences and seminars are a very important mechanism for maintaining a two-way flow of informal technical information between NBS and the outside communities that we serve. Without these, it would be much harder to remain responsive to the needs of American science and technology, and to maintain the current awareness of new developments throughout the world that is essential to the effective performance of our responsibilities.

NBS also communicates with the technical community through the traditional medium of the printed page. Over the past several years 800 to 1,000 separate publications each year have appeared. The number of pages published fluctuates considerably but totals approximately 20,000 pages per year.

We also publish a journal to help communicate with managers and technical people who may not be specialists in NBS fields but want to be kept informed—the National Bureau of Standards *Technical News Bulletin*.

When people throughout the country have a problem or want some information from the Government, they sometimes come directly to NBS. We do not have a complete record of all the inquiries coming to NBS because letters and telephone calls are received by almost everyone. However, if the inquiry is not directed to a specific person, it is referred to the Office of Technical Information and Publications (X2318). In fiscal year 1971 this office handled 8,100 inquiry letters and 15,400 telephone calls. Sometimes a reply can be given to an inquiry immediately; sometimes, however, information may require hours to track down.

Research staff members are often consulted by colleagues in industry, universities, and other government laboratories. These interactions are an important part of our communication process and the NBS staff is strongly encouraged to develop close relationships with colleagues in many laboratories. Such consultation is by no means a diversion from our primary tasks; it is an essential element of our continuing responsiveness to the needs of society.

The types of information activities undertaken by NBS have just been described but some of the more important specific developments of our largest network of information analysis centers—the National Standard Reference Data System—should be given in more detail. Perhaps the most significant new development was the establishment of a new publication and distribution mechanism. After exploration of various alternatives, the Office of Standard Reference Data concluded that a serial publication would be most desirable. In June 1971, an agreement was concluded with the American Institute of Physics and the American Chemical Society, under which these organizations, together with the National Bureau of Standards, will publish a *Journal of Physical and Chemical Reference Data*. Initially this journal will be a quarterly containing about 1,200 pages per year. The first issue is scheduled for February 1972. The establishment of this journal represents a new departure in the dissemination of government-produced information, which is expected to produce major benefits for the Standard Reference Data Program. In addition to the royalties returned to the program, which will offset some of the costs, the output of reference data should become more visible and more readily acceptable to all potential users. Furthermore, since the journal will be open to contributions from the scientific public, data evaluation efforts from individual scientists will be encouraged.

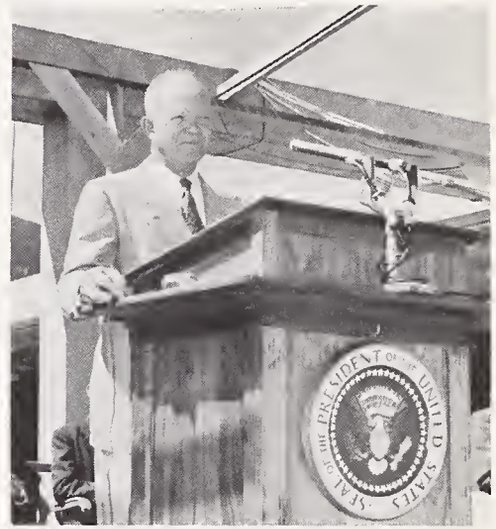
Other new program developments which have taken place during 1971 have been concerned with the subject orientation of the Standard Reference Data Program. Planning has been initiated for data compilation efforts covering subjects of particular use for applied technology. If program expansion proves possible, this planning will permit activation of data efforts directly keyed to the solution of technical problems and to the improvement of the nations' technological efficiency. Examples of such problem areas include new and improved sources of electrical energy, reduction of air and water pollution, fire research, and failure avoidance.

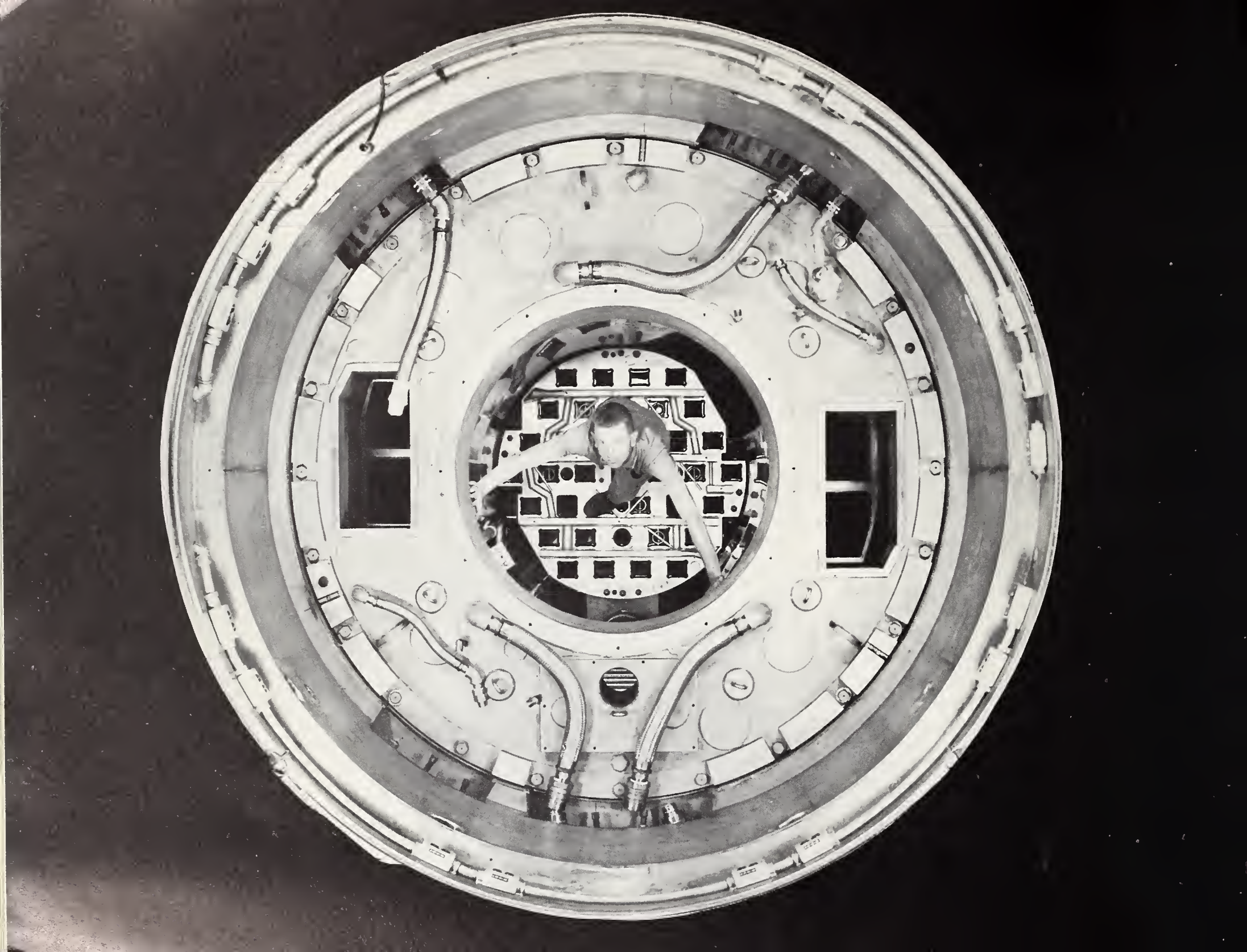
Continued emphasis has been placed on data evaluation which, via its fundamental nature, proves useful to the solution of a wide variety of problems. An example is a project undertaken at the request of the American Society of Mechanical Engineers, whose objective was to compile data on heats of combustion which could be incorporated into a handbook for designers and operators of waste incinerators. The resources of the NBS Thermochemical Data Center, which has been actively compiling thermochemical and thermodynamic data for more than 20 years, permitted the NBS to turn to this special field and assemble the needed data in a rapid and efficient manner.

Edward L. Brady

1954

President Eisenhower dedicated the Boulder laboratories on September 14, 1954.





THE Bureau's principal facilities are located at Gaithersburg, Md., and Boulder, Colo. On the 576-acre Gaithersburg site are 23 buildings containing 1,200,000 square feet of working area and representing a total investment of $145 million for land, buildings, and equipment. We chose a large site because many of our measurements require maximum isolation from such interference as noise, vibration, and electromagnetic radiation; and one of the best means of ensuring isolation is to provide distance between the experiment and interference sources. We are very proud of these facilities and have been told by many that we have one of the finest laboratories in existence. But getting here was hard work. The site was acquired in 1956, and planning and construction took place over a number of years. The move from our Washington site, involving approximately 3,000 people and a vast amount of equipment and supplies, was in itself a massive operation.

Our second major facility at Boulder, Colo., carries on such work as cryogenics, electromagnetic measurements, time and frequency, and quantum electronics. The Boulder site consists of 205 acres, 14 buildings, and 302,000 assignable square feet of floor space. The land was donated by the Boulder City Chamber of Commerce in 1950, and the major building was dedicated in 1954. At Boulder we also occupy and staff jointly with the University of Colorado a laboratory and office building which is built on the grounds of and owned by the University. This venture, the Joint Institute for Laboratory Astrophysics, was established in 1962 to solve the measurement problems of astrophysics, atmospheric physics, plasma physics, aerodynamics, chemical physics, and other similar fields.

In addition, we have a 385-acre field station at Fort Collins, Colo., for our Standard Frequency and Time Interval Broadcast Stations WWV, WWVB, and our experimental station WWVL. A similar facility for station WWVH was recently completed on the Island of Kauai in the Hawaiian Islands on land occupied by permit from the U.S. Navy.

We also have a Master Railway Scale Facility in a small building of 3,400 square feet at Clearing, Ill., and another small building on land occupied by permit from the U.S. Army at Fort Belvoir, Va., in which we perform work on a classified project for the U.S. Air Force.

The work of the Bureau is carried out by a total staff as of June 30, 1971, of 3,749 employees of which 3,176 are full-time permanent. Eighty-two percent of the staff is at Gaithersburg, 1 percent is still in the District of Columbia, and the remaining 17 percent is at Boulder, Colo. The relatively few persons who are in the field stations are included in these totals.

The staff comprises some 44 percent scientists and engineers, 14 percent

NBS has many unique facilities. Shown here is the reactor vessel of the 10-megawatt, heavy-water research reactor.

ADMIN-ISTRATION

Robert S. Walleigh
Associate Director for Administration
(X2477)

1954

In cooperation with the U.S. Air Force, NBS developed a panoramic x-ray machine that produces a single picture of the entire dental arch in 22 seconds, and cuts absorbed dose by a factor of 10 over multiple film techniques. The machine is widely used by the armed services, the Veterans Administration, and wherever mass screenings are conducted. Here an x ray is about to be taken of Rebecca Morehouse.

technicians, and 42 percent administrative and support personnel. Our scientific and engineering staff consists of 34 percent physicists, 20 percent chemists, 23 percent engineers, 5 percent mathematicians, and 18 percent others. Thirty-six percent of our scientists and engineers have Ph.D. degrees and by any standards—indeed, by our own high standards—we have an exceptionally well-qualified staff which includes many of the world experts in their specific fields of science. Our staff, of course, is the country's most valuable asset in NBS.

In addition to our own staff, we had working at the Bureau as of June 30, 1971, 120 Research Associates and Guest Workers engaged in projects of direct interest to the Bureau.

Funding for the work of the Bureau is provided by congressional appropriations and by reimbursements from other Federal agencies and private organizations. In fiscal year 1971 about 57 percent ($42.7 million) of the operating program was financed by congressional appropriations, and 43 percent ($31.7 million) was from reimbursements.

The reimbursement program covers two kinds of work. One part, research and development services which we perform for other Federal agencies, comprises about 35 percent of our operating program. The other part, consisting of the sale of standard reference materials and calibrations, testing, and computer services, covers 8 percent of our operating program. About half of this latter program is reimbursed by other Federal agencies and half by private organizations.

The other-agency research and development type program is financed by many Government agencies. During 1971 the Department of Defense provided about 34 percent of the total, Department of Transportation 14 percent, NASA 8 percent, other parts of Commerce 6 percent, HEW 8 percent, AEC 5 percent, Housing and Urban Development 13 percent, and others 12 percent.

In years past, some of our work for other agencies reached such a level that an entire activity became self-sustaining and was transferred out of the Bureau. The largest example was the transfer of 1,500 employees to the Army Ordnance Corps to create the Harry Diamond Laboratories in 1953, followed closely by the transfer of 400 employees in 1954 to the Navy to create the Naval Ordnance Laboratory at Corona, Calif. An organizational change within the Department of Commerce in 1965 transferred more than 500 employees of our Central Radio Propagation Laboratory at Boulder to the then newly formed Environmental Science Services Administration. In 1968 a small group of 20 employees were transferred to the General Services Administration to create the Materials Evaluation Laboratory. The most recent example was the transfer in fiscal year 1972 of the 50-man Office of Vehicle Systems Research to the Department of Transportation. Spin-offs such as these have

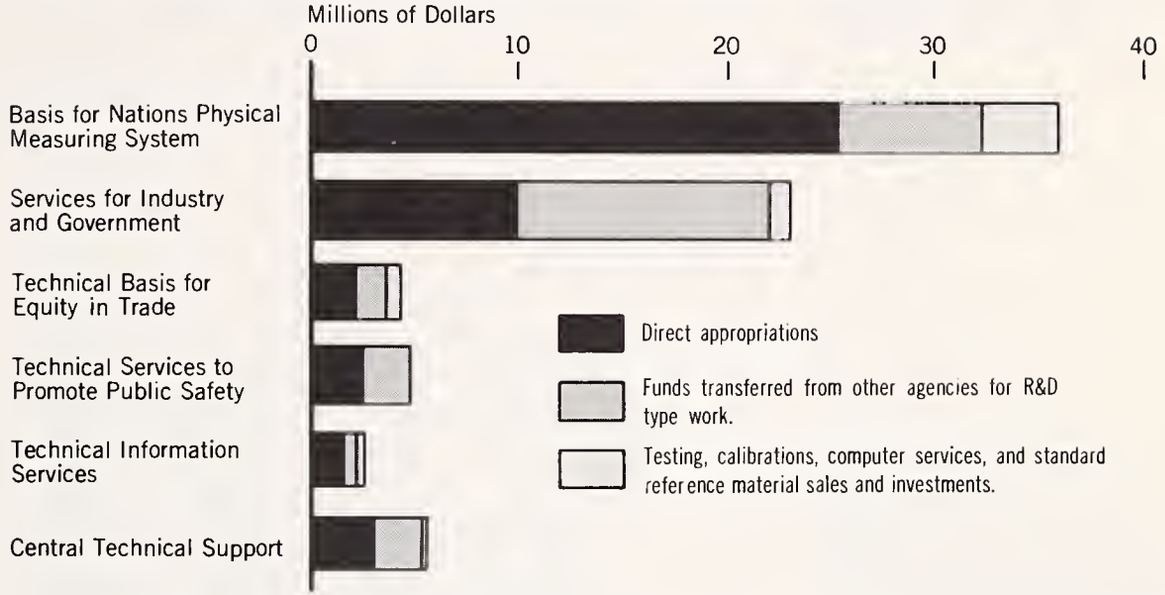
caused fluctuations in our total staffing level over the years and, indeed, our staffing level is less today than it was many years ago when we had much larger programs for the Defense agencies.

In addition to the operating program, we receive each year a congressional appropriation called Plant and Facilities. This appropriation, which finances construction and improvement costs and major items of equipment, has amounted to about $1 million a year for the past several years. The major item in 1971 was about $420,000 for completion of our new Frequency and Time Broadcast Station (WWVH) on the island of Kauai in the Hawaiian Islands. The total cost of this facility, including equipment, was $1,400,000.

While major items of equipment (over about $100,000) are purchased from a special congressional appropriation, other items are acquired as an investment of the Working Capital Fund and recovered by depreciation charges to projects. For the past 4 years our investment in equipment has been about $2 million per year with the exception of 1969 when about $1 million was invested.

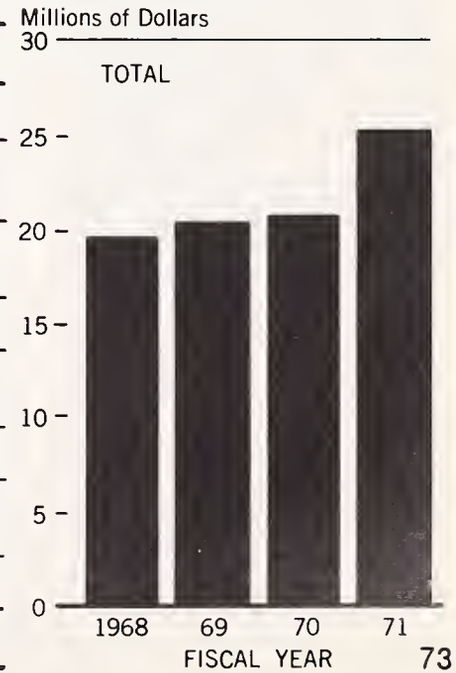
Many Federal agencies, operating under the typical appropriation accounting and budgeting procedures, have a separate appropriation for costs of general administration, program direction, staff services, etc. This is not the case in NBS. Such costs are distributed to all research or other productive projects as an overhead

FY 1971 OPERATING PROGRAM BY PROGRAM CATEGORY



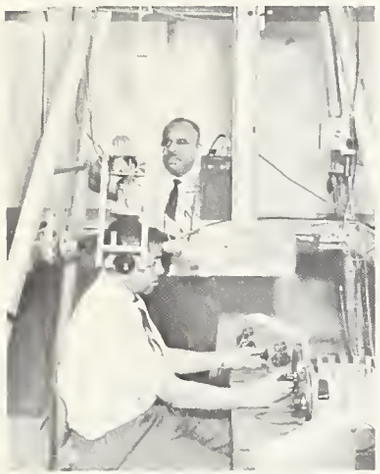
FUNDS TRANSFERRED FROM OTHER AGENCIES BY SPONSOR

FISCAL YEAR	1968	1969	1970	1971
Department of Defense	7.6	7.7	8.4	8.8
Department of Transportation	2.7	2.6	2.5	3.0
National Aeronautics and Space Administration	2.7	2.0	1.8	2.2
Department of Commerce	1.6	1.7	1.9	1.7
Health, Education and Welfare	0.9	1.3	1.4	1.9
Atomic Energy Commission	1.2	1.5	1.5	1.4
Housing and Urban Development	.2	.1	.7	2.9
Other	2.5	3.5	3.5	4.1
TOTAL	19.4	20.4	21.7	26.0

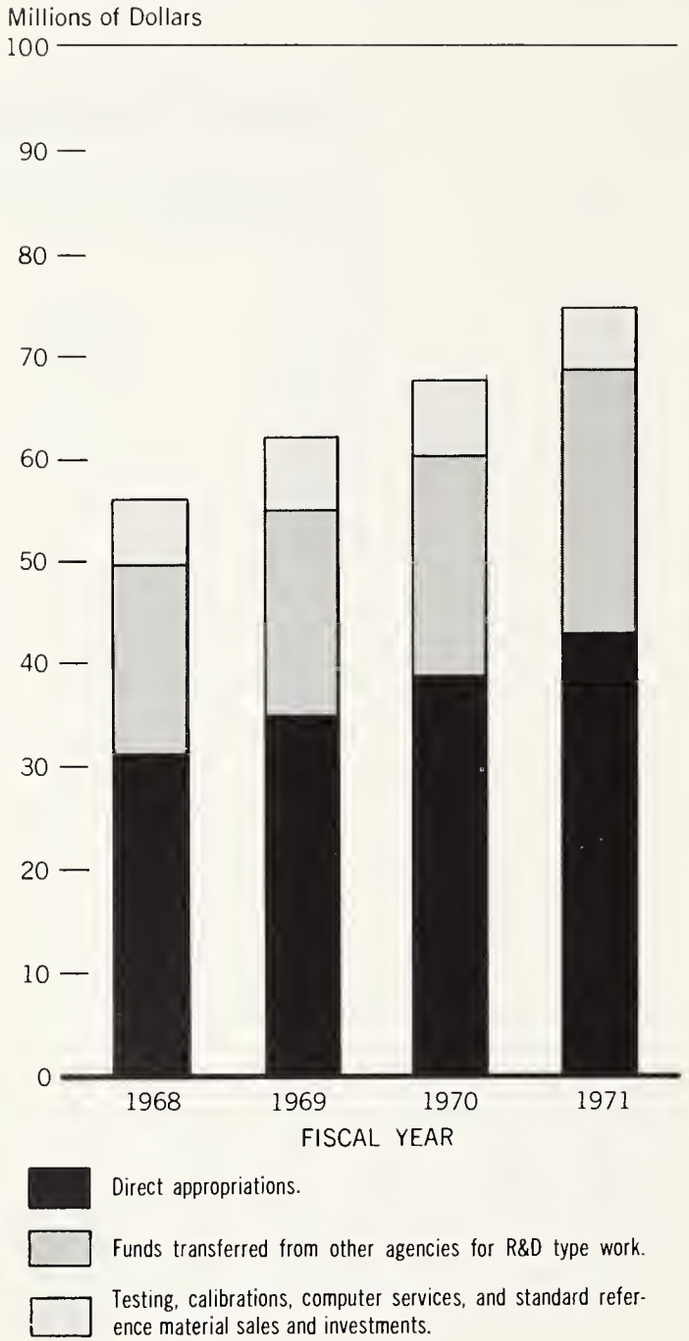


1955

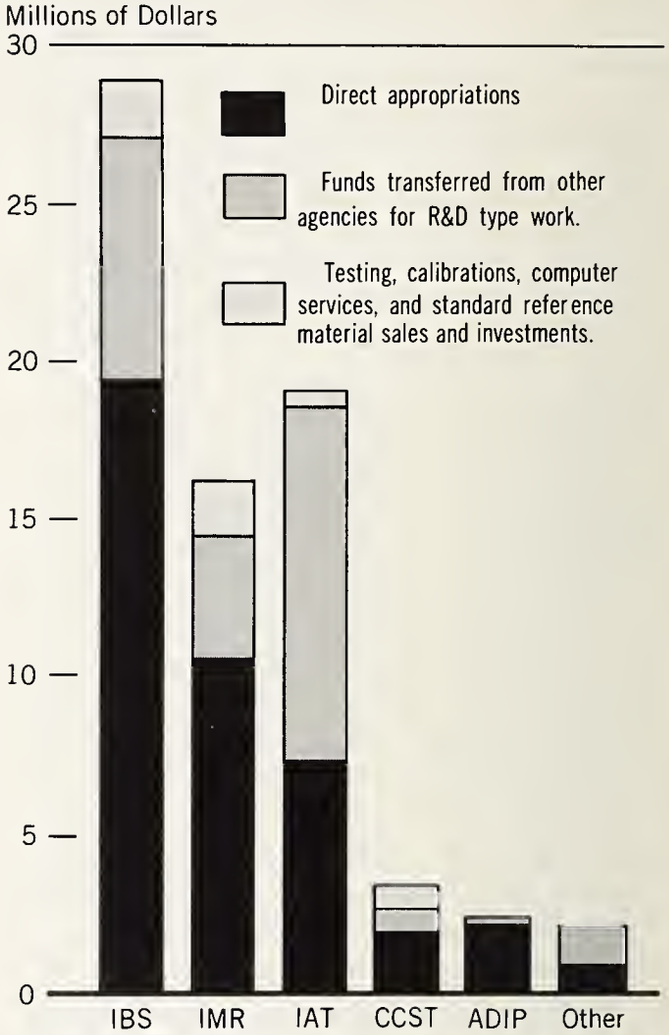
Edith Corliss (X3607) and Walter Koidan (X3607) made pioneering studies of the complex mechanical impedance of the human head, leading to the design of an artificial mastoid used for calibrating audiometric bone vibrators. Here H. S. Bowman prepares to make a bone conduction measurement on Ernest L. Smith, with a method they developed as an extension of the earlier work.



TOTAL OPERATING BUDGET



FY 1971 OPERATING PROGRAM BY ORGANIZATION AND SOURCE



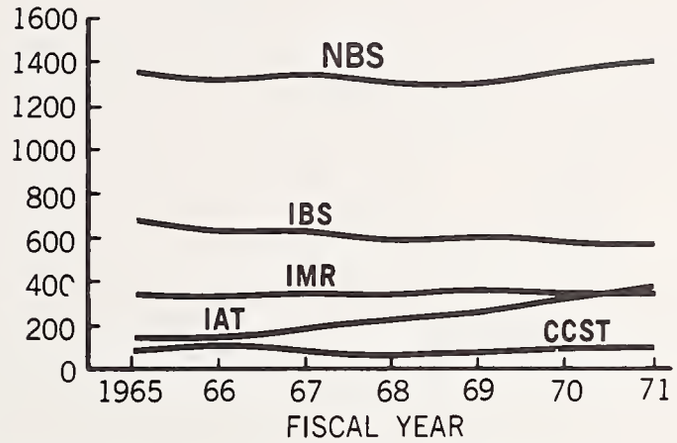
IBS—Institute for Basic Standards
IMR—Institute for Materials Research
IAT—Institute for Applied Technology
CCST—Center for Computer Sciences and Technology
ADIP—Associate Director for Information Programs

charge. Furthermore, our overhead program includes services that are not normally considered as part of the administrative and executive direction common to most Government agencies. These include: (1) technical services, such as editorial preparation and publication of technical reports and periodicals, statistical services, and research instrumentation assistance; and (2) housekeeping services which are provided to most agencies by the Public Buildings Service without cost to the agency. These include janitorial services, provision for heat and power, and maintenance of buildings and grounds. At NBS these GSA-type services are provided by the Bureau and are included in our overhead.

Overhead programs are reviewed and agreed to by the technical staff since the costs come out of their technical program allocations. In fact, since every dollar spent on administration is money that could have been spent on research, NBS management has a powerful incentive to cut overhead to the bone. I am confident that we have an unusually efficient overhead operation as a result.

We are experiencing, at the present time, a problem with respect to our equipment needs. Even with the flexibility inherent in our funds, we have not been able to keep up with the needs of our programs for additional working capital to purchase equipment. A part of the reason for this is that there has been a steady inflation in

FULL TIME PERMANENT PROFESSIONAL STAFF

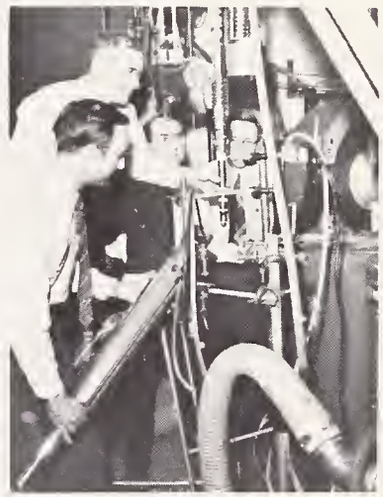


costs of equipment over the past several years and, in addition, experimental procedures are requiring more sophisticated equipment. A study by our Office of Programs shows that a selected sample of industrial laboratories spend, on the average, about 10 percent of their operating costs on new equipment purchases. By contrast, NBS, from 1954 to the present, has spent an amount for equipment which has ranged between 2 and 8 percent of its operating costs. It appears necessary that the Bureau seek additional appropriations for transfer to the Working Capital Fund for the next several years to make up the difference between what is available from the Working Capital Fund and our current equipment needs.

Robert S. Wallihan

1956

The first experiment demonstrating non-conservation of parity in weak interactions was conducted by (left to right) Ralph Hudson (X2034), Ernest Ambler (X3301), Dale Hoppes (X2651) and Raymond Hayward (X2651). They determined that the beta emission distributions for cobalt-60 polarized in opposite directions was not the same, proving parity was not conserved.




ATTENTION
THIS VEHICLE USES METRIC PARTS.
SEE THE OWNER'S MANUAL OR SHOP
MANUAL FOR SPECIFIC LOCATIONS
ATTENTION
2000 cc 2V
1006S

A METRIC AMERICA

Metric America, the report of the U.S. Metric Study, was presented to Congress on July 30, 1971. In his letter of transmittal, Secretary of Commerce Maurice H. Stans agreed with the report's conclusion that the United States should change to the metric system through a coordinated national program, and recommended:

- That the United States change to the International Metric System deliberately and carefully;
- That this be done through a coordinated national program;
- That the Congress assign the responsibility for guiding the change, and anticipating the kinds of special problems described in the report, to a central coordinating body responsive to all sectors of our society;
- That within this guiding framework, detailed plans and timetables be worked out by these sectors themselves;
- That early priority be given to educating every American schoolchild and the public at large to think in metric terms;
- That immediate steps be taken by the Congress to foster U.S. participation in international standards activities;
- That in order to encourage efficiency and minimize the overall costs to society, the general rule should be that any changeover costs shall "lie where they fall";
- That the Congress, after deciding on a plan for the Nation, establish a target date 10 years ahead, by which time the United States will have become predominantly, though not exclusively, metric;
- That there be a firm Government commitment to this goal.

The report, prepared by the NBS Office of Metric Study in response to the Metric Study Act of 1968, was the culmination of 3 years of intensive effort. Our goal in planning the Study was to give every sector of society an opportunity to express its views. Literally thousands of individuals and organized professional, educational, business, labor, and consumer groups answered questionnaires, were interviewed, and participated in a series of conferences that were widely publicized in advance. Our conclusions and recommendations are based on the outcome of these efforts.

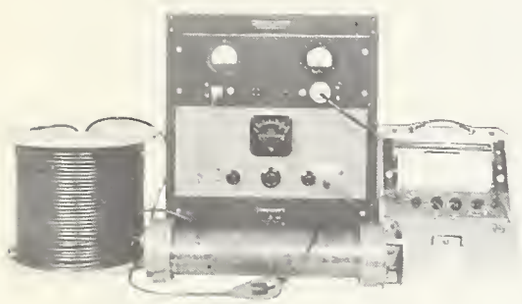
It is perhaps surprising that any general pattern of agreement should have emerged from this effort. Nevertheless, on three fundamental questions there was a clear consensus:

1. Increased use of the metric system is in the best interests of the United States;
2. The Nation should change to the metric system through a coordinated national program;
3. The transition period should be 10 years, at the end of which the Nation would be predominantly metric.

Daniel V. De Simone
Director, U.S. Metric Study
(X3611)

1957

This device was developed by Martin Greenspan (X3607) and Carl Tschiegg (X3607) to measure the underwater speed of sound. Widely used in oceanographic research, it is the standard instrument of its type.



Of a representative sample of manufacturing firms, 70 percent (80%, if weighted in terms of employment) believe that increasing use of the metric system would be good for the country as a whole.

A majority of the rest of business and industry surveyed—nonmanufacturing businesses ranging from agriculture to utilities—also believe that increased use of the metric system is in the best interests of the United States. Educators are nearly unanimous in their endorsement of the metric system.

A survey of representative American households shows that people who know what the metric system is about tend to favor it, and people who know little or nothing about the metric system tend not to favor it. This dramatizes the fact that a program of public education would be essential to the success of a national conversion program.

The Metric Study Act asked many questions, which may be paraphrased as:

- What is the effect on the United States of the worldwide swing to metric?
- What does it mean to our international relations and balance of trade?
- How does it affect Americans in every walk of life?
- Would it be desirable for the United States to use the metric system more widely than it does?
- Should this be done deliberately in some coordinated way?
- Or should the Nation take no action to promote the use of metric weights and measures?
- Or, as another possibility, should the United States try to persuade the rest of the world to make use of the Customary system?
- What can be said about the benefits and costs of deliberately changing to metric in comparison with doing nothing at all?

These questions, at first, seemed fairly straightforward. Actually the quest for answers proved extremely complex and challenging. Technology, economics, sociology, international relations, and many other factors are involved.

The choice of a measurement system affects people in so many different ways that the questions posed by the Act cannot be reduced to a simple issue and settled to everybody's satisfaction. As with most major assessments, the answers depend largely on subjective thinking and personal preference, on balancing possible future gain against current inconvenience. There is yet no way for drawing up a reliable national balance sheet, in dollars and cents, for deciding complex social issues. Going metric is one of these.

Many courses of action are conceivable, including an abrupt and mandatory conversion to metric or a program to promote more use of the Customary system in the world. But an abrupt conversion would be so difficult to achieve and so disruptive as to not merit serious consideration, and it would be fanciful to expect that metric countries could be

persuaded to convert to inches, yards, pints, and pounds.

The metric system is slowly but steadily increasing in use in the United States. Let me give you some examples.

- The pharmaceutical industry changed to the metric system more than a decade ago.
- By and large, the language and tools of U.S. science are entirely metric.
- The National Aeronautics and Space Administration now uses International Metric in its documents and reports.
- Automobile mechanics have added metric tools to their toolboxes, because foreign vehicles have metric parts and even some automobiles made in the United States are being assembled with parts built to metric specifications.
- Statutory standards for automobile emissions of pollutants are stated in "grams per mile."
- Swimming pools for outdoor competition are being built to metric dimensions so that our swimmers can practice for international metric-distance events.
- The width of photographic film is expressed in millimetres.

Thus, the feasible courses of action for our Nation are really narrowed to two main alternatives:

The United States goes metric according to plan or it drifts to a metric status over an indefinite period without cooperation among industries, educational institutions, labor, and government.

SOME GROUPS THAT PARTICIPATED IN THE METRIC STUDY

1958

Dr. Briggs, long interested in aerodynamics, continued his research after retiring as Director. A special fascination was the amount of curve that could be put on a baseball by a skilled pitcher. To determine the spin on a ball, flat tapes were attached and the number of completed turns counted after a pitcher's delivery. Here Dr. Briggs is seen with Ossie Bluege, comptroller of the Washington Senators.

Suppose the Congress decided to foster the changeover. If schools were to give greater attention to metric than to Customary, if a large number of industries were to convert to metric, if our traffic signs were to read in kilometres instead of miles, if milk were sold by the litre and meat by the kilogram—then the metric system would, in a few years, become as widely used by the public as the Customary system.

That is really what is meant by changing to the metric system: becoming predominantly metric. It is neither necessary nor desirable that the goal be to become a purely metric country—100 percent. For industrial engineers, factory workers, carpenters, people in almost every walk of life, going metric would thus mean acceptance of the metric system as the preferred system of measurement and, ultimately, thinking primarily in metric terms instead of primarily in customary terms, as we do now.

An adequate understanding of what a change to metric entails depends on some appreciation of what engineering standards are. Engineering standards are agreements that specify characteristics of things or ways to do things. Taken together, engineering standards serve as both a dictionary and a recipe book for a technical society. Without them we would have chaos, inconvenience, and higher costs for almost everything.

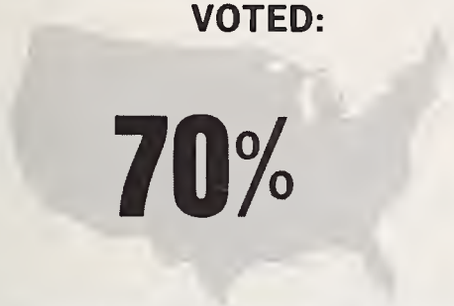
Engineering standards are developed by many organizations or groups at different levels: a single firm, a national group such as a trade association, or an international group. The leading international groups are the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), in which all major nations participate.

U.S. participants in international standards negotiations need to be adept in the use of metric units, for the International Metric System is the official primary measurement language of both IEC and ISO. It would be economically beneficial for the United States to play a more vigorous role in the making of international standards. Our opportunity to exert further influence to promote international acceptance of U.S. technology is great. To date, relatively few international standards have been adopted. But in the next decade the number on the books is expected to multiply roughly tenfold.

In summary, the U.S. Metric Study concludes that eventually the United States will join the rest of the world in the use of the metric system as the predominant common language of measurement. Rather than drifting to metric with no national plan to help the sectors of our society and guide our relationships abroad, a carefully planned transition in which all sectors participate voluntarily is preferable. The change will not come quickly, nor will it be without difficulty; but Americans working cooperatively can resolve this question once and for all.

The basis for the conclusion that the United States will eventually be metric lies in

MANUFACTURERS VOTED:



INCREASING USE OF METRIC GOOD FOR COUNTRY

the findings of the study that America is already metric in some respects; that we are becoming more so; and that the great majority of businessmen, educators, and other informed participants in the study reported that increased use of the metric system is in the best interests of America. They also believe that it is better for the Nation to move to metric by plan rather than by no plan at all.

There will be real costs and difficulties in the change, whether or not it is done by plan. The study indicates that such difficulties will in any event have to be faced as metric usage reaches substantial proportions in America. Thus, without a plan the United States would experience all the difficulties of dual inventories, dual education, dual thinking, dual sets of tools, and dual production—perhaps not so soon but over a much longer period of time.

Developing a national program for change would require a great deal of forethought and discussion. But the study finds that two major activities should be begun immediately, because they would be pivotal in preparing the Nation for increased use of the metric system.

The first is education. Every schoolchild should have the opportunity to become as conversant with the metric system as he is with our present measurement system.

The second concerns international standards. High-quality American industrial practices should be much more vigorously promoted in international negotiations that are beginning to establish engineering standards on a worldwide basis and will increasingly affect world trade.

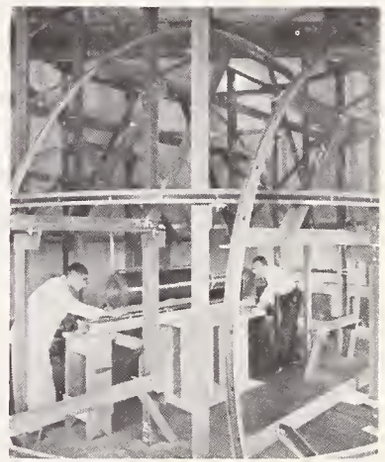
While the majority of the American people are not well versed in the metric system, the study shows that those who are informed about it tend to favor it. This demonstrates a need for public education to help all citizens to cope with the trend to metric and poses a challenge to the Congress to point the way for all Americans.

A Metric America, the 192-page report of the Metric Study, is available from GPO for $2.25. Use SD Catalog Number C13.10:345 when ordering.

Daniel De Simone

1958

Raymond Driscoll (left, X2007) and Peter Bender (Boulder, X3846) redetermined the gyromagnetic ratio of the proton with increased accuracy. The known magnetic field of the solenoid (center) causes the protons in water to precess. The larger outer coils counterbalance the earth's magnetic field.



ENGINEERING STANDARDS

Dr. Lawrence M. Kushner
Deputy Director
(X2451)

THE existence of a satisfactory set of engineering standards and a satisfactory mechanism of generating them can do a great deal to assure that a country's use of technology in its commercial products and industrial processes lives up to its full potential yet does not do violence to the public interest.

Engineering standards are documents which reflect agreements, most commonly between producers and purchasers, on the dimensions, design, performance, physical characteristics, descriptive terminology, and the test methods which describe and specify the things we manufacture and sell. Sometimes such standards concern the manufacturing process, itself. The term engineering (or industrial) standards includes some more specific kinds of standards which you have no doubt heard of, such as product standards, commercial standards, and safety standards. The vast majority of such standards are ordinarily not matters of law or regulation, except in areas of public health and safety; and, therefore, they are developed in the private sector, and most Government agencies participate in their development only from the standpoint of their being consumers of the items in question. The use of such standards is voluntary. Their widespread acceptance, however, can give them considerable commercial force.

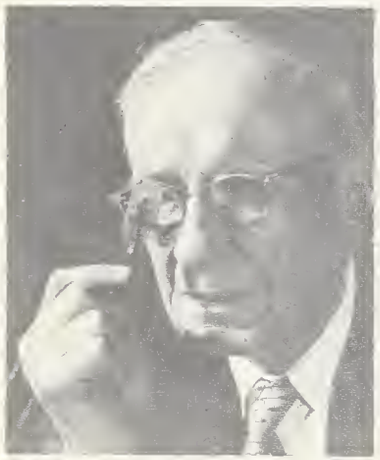
The complexity of modern technology, whether it be electronics, manufacturing, or building construction, is made manageable through the formulation and use of engineering standards.

NBS does support the development of some of the mandatory standards which the Government issues, such as for fabric flammability and for the safety of toys and other products, and we have research programs to assist the Environmental Protection Agency in the development of antipollution standards. In the computer field, we assist the Government to develop its own standards for the compatibility, interchangeability, and performance of automatic data processing hardware, software, and total systems. Our efforts to support the development of performance-based building standards could permit a more rapid rate of innovation in the building industry. However, let me repeat, except where the development of an engineering standard is required as the basis for the issuance of a regulation or a mandatory standard by the Federal Government, or the Government develops its own standards for its internal use or in its procurement, the initiative and the mechanisms for the development of these many thousands of engineering standards reside in the private sector. They are developed voluntarily, and their use is voluntary.

It is a fact, however, that some standards, while voluntary in principle, become so widely adopted that they, in effect, become mandatory. For instance, military procurement specifications (the so-called MILSPECS) virtually control the U.S. production of many electronic components. And building standards, which are voluntary,

1959

During his half century at NBS, Dr. William F. Meggers made substantial contributions in the fields of spectroscopy and atomic structure. Notable achievements were the interferometric measurement of absorption lines in the solar spectrum, development of the mercury-198 lamp for precise length measurements, use of dyes to record spectra in the near infrared, and development of spectrochemical analysis as a useful technique. Here he is shown examining an early microscope (courtesy Dennis Mallon).



have the effect of law when embodied in building codes.

In the United States, voluntary engineering standards are written by a large number of organizations. The Directory of the U.S. Standardization Activities (NBS Miscellaneous Publication 288, 1967) lists over 400 of these organizations that either write or sponsor voluntary standards. Those organizations whose primary role is writing and promulgating engineering standards have produced about one-third of the nearly 20,000 voluntary engineering standards that are currently in use and are writing over a thousand standards annually in a great variety of technical areas. The American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) are the most important of these organizations. Professional societies, such as the Society of Automotive Engineers (SAE) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE), have produced about one-third of the voluntary standards that are currently in use. They are writing over 500 new standards annually. Many members of the NBS staff are involved in these activities of the standardization bodies and of the scientific and professional organizations. Trade associations, such as the Electronics Industries Association (EIA) and the Business Equipment Manufacturers Association (BEMA), have produced about one-third of the voluntary standards that are currently in use; they write over 300 new standards annually. Relatively few members of the NBS staff participate in the standardization activities of these trade organizations.

Let me digress for a moment to say a few words about the consensus principle in standardization. The consensus principle refers to giving all parties who have a legitimate interest and concern with a proposed standard the opportunity to either participate in developing the standard or to comment on it before it is issued and have their views taken into account. Some form of consensus principle is embodied in the procedures of many, but by no means all, of the organizations which develop standards. This has become particularly important today since our private sector standardization activities have been under attack for not adequately reflecting the interests of all concerned parties. A spokesman for the individual consumer or the general public is omitted most often. In addition, the use of the consensus principle has been held by both the Federal Trade Commission and the Department of Justice to be an important factor in determining whether a particular standardization activity is in restraint of trade.

Organizations which do not, themselves, use consensus-type procedures in developing their standards have the option of submitting their proposed standards to the American National Standards Institute (ANSI) which will submit the standard to a broad public review. If the proposed

These are the symbols of but a few of the many organizations that develop national and international standards.

standard passes this review, it is then eligible for listing as a national consensus standard by ANSI.

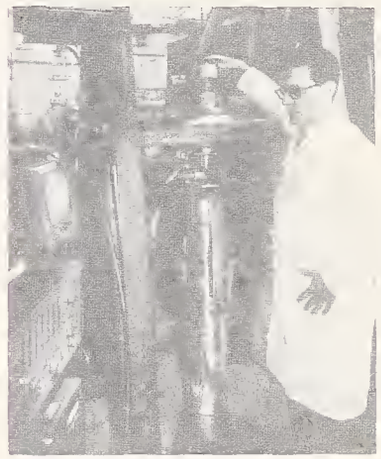
The development of engineering standards is done in committees on which representatives of manufacturers, producers, distributors, and users are normally represented. By and large, the people on these committees are technical people.

Approximately 350 members of the technical staff of the National Bureau of Standards serve on some 950 standardization committees sponsored by private standards-writing organizations. This is not to imply that these NBS people are full-time committee participants. Most of them are scientists and engineers fully engaged in their own research and technical activities at the National Bureau of Standards. Their service on these committees is part time and only rarely, if ever, becomes a large fraction of their total activity. Notwithstanding this, the estimate of the total cost of NBS participation in the development of voluntary engineering standards in the private sector was approximately $2 million in fiscal year 1970. Although this number is, in itself, a small fraction of the total number of people engaged in standardization activities on a national basis, the impact of NBS participation is important. Bureau people hold 129 committee officerships; that is, as chairman or secretary—clearly, the leadership positions in these committees. Such participation is an important and desirable way for the technical expertise of the NBS to be reflected in industrial practice.

Our participation, however, is not restricted to technical considerations. We also have substantial representation in the major standardization bodies at the policy-making level. For instance, the Director of the National Bureau of Standards, is, by virtue of his office, on the Board of

1962

An acoustical thermometer was developed by Dr. Harmon Plumb (X2801), George Cataland (shown here, X2017) and others that has been used for some years to establish a provisional temperature scale in the 4-20 K range.



1963

Douglas R. Tate (X2621) determined the acceleration of gravity at both the NBS Washington and Gaithersburg sites to high accuracy by a timed free-fall technique.

Directors of the American National Standards Institute. We also have membership on the Board of Directors of the American Society for Testing and Materials and hold a variety of important committee assignments at the policy-making level in both these and other standards-making organizations.

NBS also operates an Engineering Standards Information Center (X2587) which provides an information service on standards. Each year, it handles upwards of 5,000 inquiries from the public and from other Government agencies on the availability and source of national, international, foreign national, industry, State and Federal Government standards. The Center maintains a library of more than 85,000 standards and publishes general and specialized indexes of standards. These indexes allow one to quickly identify the title, identification number, publishing organization, and the year of publication of each standard. The standards, themselves, are usually copyrighted by the issuing organization which offers them for sale.

Having stressed that the vast majority of voluntary engineering standards are developed in private-sector organizations, let me now state that the Department of Commerce, through the National Bureau of Standards, does operate a program called the Voluntary Product Standards Program, through which private groups can develop voluntary engineering standards if the private-sector standardization organizations are unwilling or unable to develop the required standards. We administer a set of consensus procedures (Part 10 of Title 15, Code of Federal Regulations) providing for input from all of the important groups concerned with the proposed standard. I should say at this point that our definition of and procedures for obtaining consensus are the most rigorous that we know. The proposed standard is announced publicly and sent for comment to a list of representative producers, distributors, and users. "Consensus" is obtained if there are no substantive objections which are held to be valid and if there is acceptance by at least 70 percent of each of the three groups with the average of the three being 75 percent or higher. When these procedures have been satisfactorily completed, we issue a Department of Commerce Voluntary Product Standard. Once again, let me emphasize that this is a voluntary standard. Legally, it has no more status than any voluntary standard developed in the private sector through comparable procedures. The Government accepts no responsibility to use the standard, but we do maintain procedures to continually review it and keep it current. This is a modest program as measured by the number of standards produced per year—only about 20. Measured by the difficulty of getting consensus for a standard over which major private interests have been deadlocked for years, as in softwood lumber, it calls for substantial effort. We are now reorienting the program so as to supplement the ability of the private-sector organizations

to generate voluntary standards in areas of particular concern to the Government—most immediately in the field of product safety.

Because of the many facets of the Bureau's involvement in voluntary engineering standards activities, and because of the rapidly increasing appreciation of the importance of these activities, we have recently created the position at NBS of Program Manager for Engineering and Information Processing Standards. We are fortunate to have serving in this newly created position Mr. William Andrus (X3662) who has had an outstanding career with IBM and is highly respected in the U.S. standardization community. In addition to helping the Bureau manage its internal activities which relate to voluntary standardization in the private sector, Mr. Andrus serves as the focal point for the Bureau's relationships with the rest of the standardization community.

From the earliest days of NBS at the turn of the century, we have been an important factor and participant in this country's voluntary standardization activities. We were original members of the American Engineering Standards Committee, which has evolved over the years into ANSI. But our active participation and influence has never been more necessary than today.

The issues of consumer safety, pollution control, and standards as barriers to international trade have focused attention on the shortcomings of the U.S. standardization system. Most other industrialized nations have a more highly unified system than we—most often with a single organization through which the private sector meets its standardization requirements and to which the government also turns to meet its needs. Direct financial support from the government to these organizations runs from as low as 5 percent in Germany to as high as 100 percent in Japan. I've mentioned that in the United States we have more than 400 bodies which produce standards; and although ANSI is intended to be the overall coordinating body for all of these, it has yet to achieve the degree of private or Government support and recognition in this role that would be desirable. The Government provides no direct financial support to ANSI.

The advantages to the Government of having close cooperation with the private sector in developing standards for consumer safety, occupational health and safety, and for foreign trade considerations, are manifold. Benefits would accrue to the public in terms of lower costs for the development of the standards, a broader participation of technical experts in the development of the standards, and less likelihood of disturbing the free, competitive interplay of the marketplace through the imposition of a patchwork of mandatory standards in response to emergencies.

The present situation has much of the character of the chicken and egg paradox. The Government does not turn to ANSI for assistance because ANSI does not represent

1963

Since early 1963, Drs. Dolplus E. Milligan (X2754) and Marilyn E. Jacox (X2754) have obtained infrared spectra of many free radicals through isolation in cold inert gas matrices. Such spectra are important in air and water pollution analyses.

1966

A long-range program is being conducted in gas thermometry to aid in more accurately determining the relationship between the thermodynamic and International Practical Temperature Scales. The NBS gas thermometer was developed under the direction of Drs. Harold F. Stimson and Leslie A. Guildner (shown here with the thermometer, X2076).

the totality of standardization bodies in the private sector; and on the other hand, one of the principal reasons ANSI does not enjoy such full support from the private sector is that the Government has been slow to use it. Nevertheless, there are encouraging signs of change. Under the threat of proliferation of Government mandatory standards, which are frequently developed with little or no industry participation, industry groups do appear to be becoming more inclined to support ANSI. The trend in discussions of proposed legislation is to give the private sector the opportunity to develop standards which may subsequently be made mandatory by the Government. This is a particularly strong stimulus to the private sector to put its standardization house in order and is strongly supported by NBS.

The initiative taken by the Department of Commerce several years ago to organize the Interagency Committee on Standards Policy has provided a forum within which the various Government agencies can arrive at consistent policies with respect to standardization issues. There appears to be a growing interest in the Department of Defense and in the General Services Administration to use privately developed standards for their procurement where these standards would do the job. And finally, ANSI is considering a restructuring of its Board of Directors which would result in greater Government representation on the Board. All of these are constructive steps toward a more effective system through greater industry-government cooperation.

Now let me turn to the international development of engineering standards. This subject has been discussed in hearings held in connection with the Administration's proposed International Voluntary Standards Cooperation Act of 1971 (S. 1798 and H.R. 8111). This bill would enhance U.S. participation in international standardization through increased Government involvement, administered by the Secretary of Commerce. The principal international standardization bodies are the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) in which the United States is represented by ANSI and the U.S. National Committee for IEC, respectively. NBS staff serve on U.S. delegations to international standardization meetings by invitation of the latter groups. Some 55 members of our staff are presently so involved. On behalf of these organizations, NBS administers four committee or subcommittee secretariats.

I would like to close now by discussing briefly a new need that has emerged and to which NBS is making a response. As the number of standards which deal with consumer products increases, both manufacturers and consumer groups express increasing need for greater consumer confidence in statements that the products that are manufactured and sold do, as claimed, conform to the relevant standards. One approach is through a system of certification to this effect. Such

certification rests on independent testing laboratories whose ability to make the appropriate tests satisfactorily can, itself, be attested to. Recently issued standards under the Occupational Health and Safety Act (Federal Register, May 29, 1971) make many references to approval, certification or inspection by "nationally recognized" laboratories; yet, there is no system for the approval or accreditation of testing laboratories. As we move toward building codes which are increasingly performance oriented, rather than design oriented, manufacturers of building materials, components, or entire systems must be able to go to qualified laboratories with their new products to determine that they meet the requirements of applicable performance standards. If so, they can be appropriately certified and, thereby, made acceptable to local building regulatory officials. Such laboratories need to be highly qualified in order that their findings have credibility. International product certification schemes, such as one being developed in Western Europe for electronic components, have requirements for quality assurance programs built into them. These quality assurance programs involve the use of accredited laboratories.

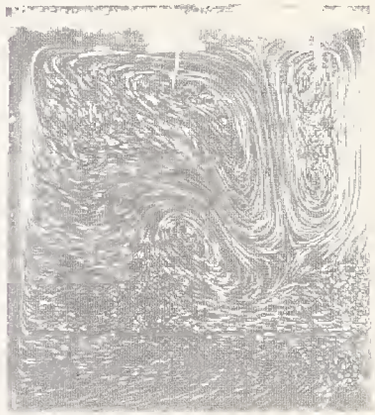
In September 1970, NBS called a conference which was attended by representatives of some 46 organizations we felt would be concerned with this problem. As a result of that meeting, agreement was reached on the need for, and desirability of, establishing a National Testing Laboratory Accreditation Program. A committee representing both government and private bodies has been established to design and propose steps to implement the needed program. It would build on NBS experience in the evaluation of testing laboratories for cement, concrete, and asphaltic road building materials. It would also incorporate the proposed program for laboratory evaluation under the National Conference of States on Building Codes and Standards.

I opened this statement by saying, in effect, that a country's engineering standards reflect a continuous process of technology assessment. They determine in a very substantial sense to what extent available technological potential is put to use in the country's products and processes, and they establish limits for the impact of technology on its citizens. I have tried to stress the desirability of a strong private-sector standardization system bolstered by close cooperation with the Government. We believe that the public interest aspects of voluntary engineering standards—in health and safety, in equity for all in the marketplace, and in environmental considerations—demand a substantial, yet not overbearing, presence by the Government. It is in this spirit that NBS proposes to go forward.

Lawrence M. Kushner

1970

Convection patterns of air in an enclosure are simulated by injecting aluminum particles into water that has been heated until its dynamics closely match that of air. This technique has been used by Everett Barber (X3521), D. Bettge, and Frank Powell (X3501) to study convection and ventilation.



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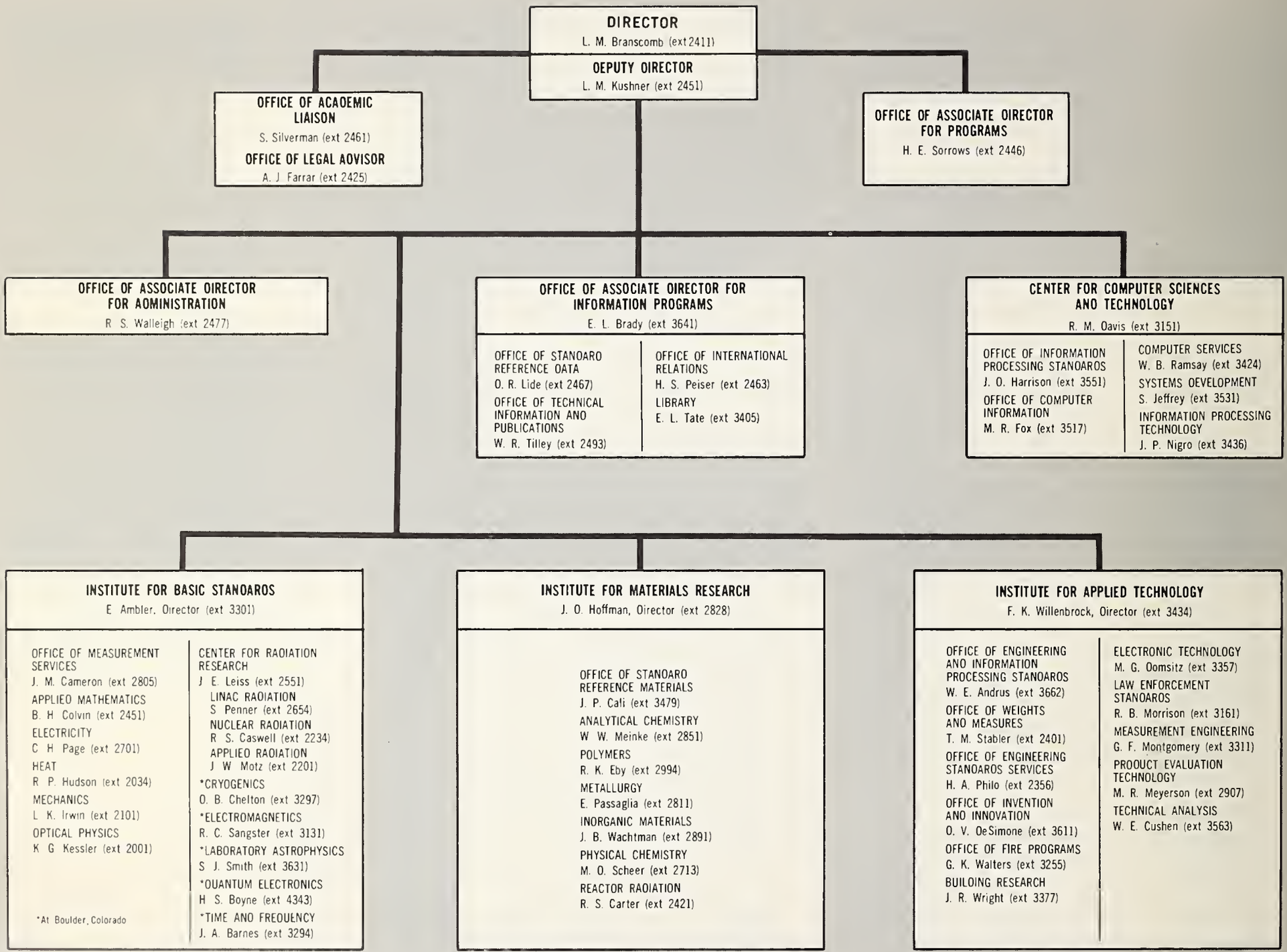
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