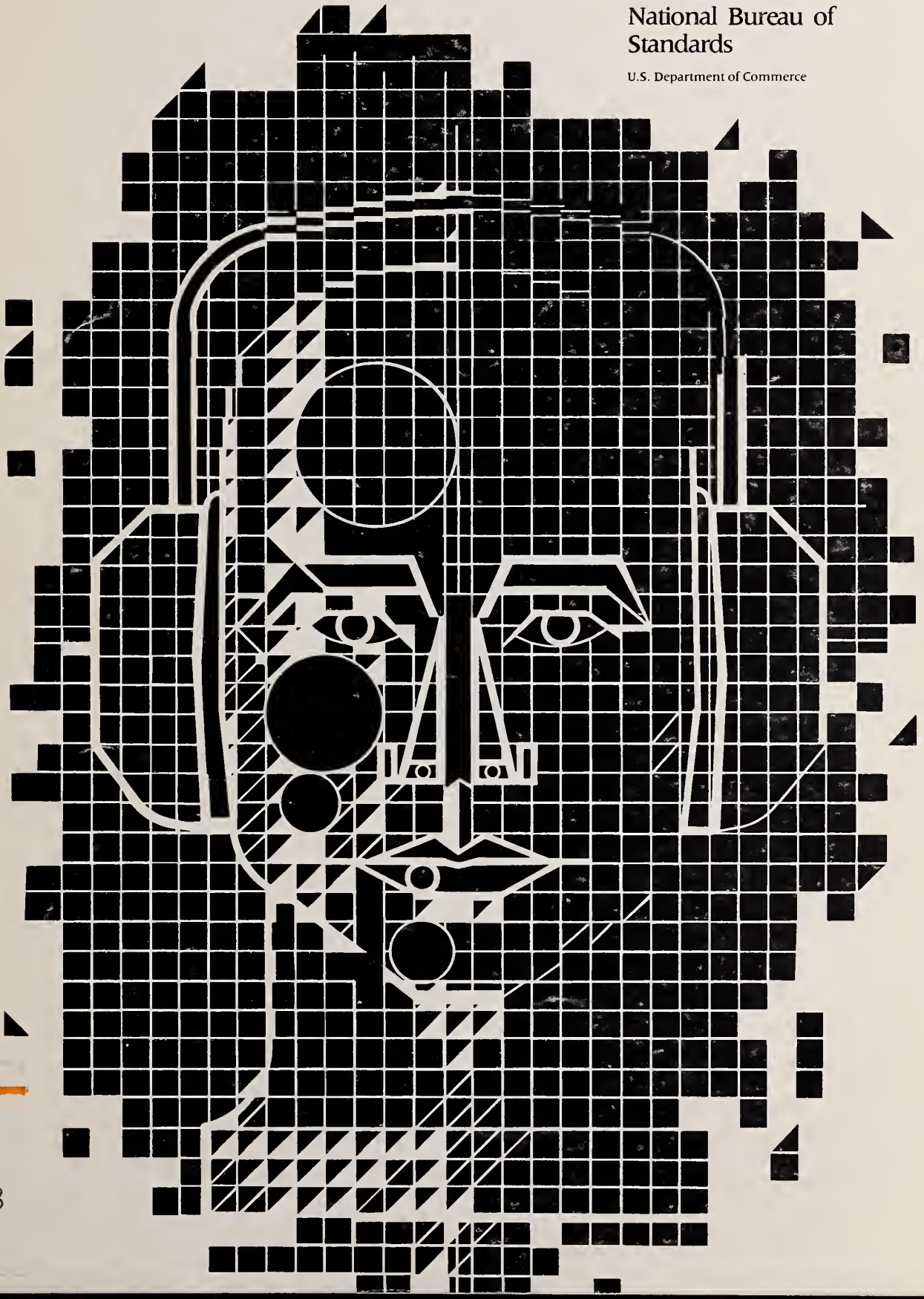
Science on Its Way to Work

Activities of the National Bureau of Standards

U.S. Department of Commerce



COVER: One of the major missions of the National Bureau of Standards is to make available to the public information gained during the course of its scientific and technical work. People . . . curious, concerned, and skilled people . . . are the essential bridge in this communications process that reaches from the laboratory into the marketplace for social and economic benefit.

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Contents

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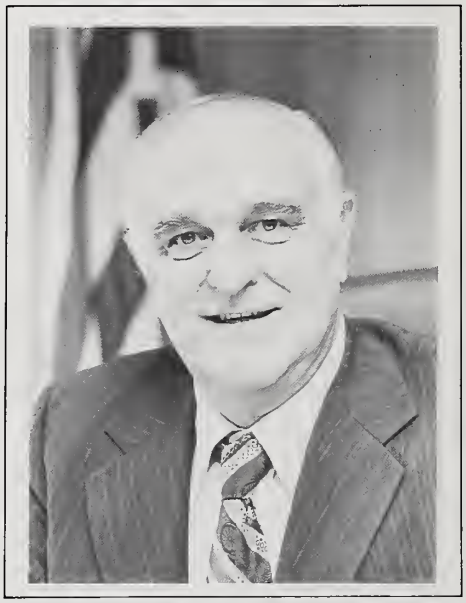
On Facilitating Technology Transfer

The benefits of science and technology are so commonplace in our daily lives that we take them almost for granted. High-speed machines using lasers cut the cloth for our suits and coats. Satellites bring events in remote parts of the world into our living rooms. Pocket calculators perform tasks that only a few years ago would have required a machine the size of a small car—and would have been beyond the reach of the average citizen's pocketbook.

It is a fact that the standard of living we enjoy as a Nation would not be possible without the many contributions of science and technology. At the same time, we are also aware that technology, if not properly used, can have detrimental effects.

We at the National Bureau of Standards, the Nation's central measurement and reference laboratory, recognize the need to maintain a balance between the adverse effects and the beneficial impact that science and technology have on our economy and our daily lives. By working closely with industry, universities, other Federal agencies, State and local governments, foreign countries, and the public, NBS is able to direct its programs to help maintain this balance.



This report deals with the kinds of work we do and the support we offer to the scientific and technological world. Numerous examples are given of the key role that people play in helping transfer the knowledge developed at NBS to a wide variety of individuals and the organizations they represent. In order to encourage that information exchange, we have added a directory of key NBS personnel, including their addresses and phone numbers. Let us hear from you.

E. Ambler.

Ernest Ambler
Director

NBS Gaithersburg laboratories.

Science on Its Way to Work

In November, 1976, the Federal Communications Commission (FCC) authorized the use of an NBS invention developed 5 years earlier—thus finally making it available for practical use. The action was a decision by the FCC to reserve room in commercial television signals for the transmission of "closed captions" along with regular programming.

These closed captions—supplied for deaf TV viewers—are similar to subtitles on foreign language films. They are transmitted in code in the television broadcast and only appear on the screens of TV sets equipped with special decoders.

Five years before the FCC decision, the closed captioning technology had been developed at NBS as "Tv-Time," a new system for disseminating accurate time and frequency information. Now, with the support of the Public Broadcasting Service, it is a potentially important new influence in the lives of millions of deaf Americans—television that can be viewed and understood without the help of an interpreter.

The progress of this TV encoder/decoder system from TvTime to closed captioning for the hearing impaired illustrates a special concept that is rapidly growing in importance in the management of Federal research and development laboratories. The concept is called *technology transfer.*

The phrase invokes the entire range of ways by which the research and expertise developed in government laboratories are applied to solve problems faced by State and local governments, by private industries, and even by foreign countries. It is putting tax-supported science and technology to work for the people.

At the National Bureau of Standards, the concept of technology transfer is a familiar story. The history of NBS is replete with examples of technological developments that left the Bureau to become major influences in daily life. In 1904, the first neon signs were developed by NBS, a byproduct of research on gas spectra. By the 1930's they formed the basis of a new industry.

Closed-captioning pioneers include information specialist Sandra Howe who captioned television shows to demonstrate the caption decoder and engineer Dick Davis who supervised construction of the units.

Other examples of NBS technology became equally ubiquitous. In 1922, it was an NBS invention that made it possible to use ordinary house current instead of storage batteries to operate a home radio. High-speed dental air drills, found in every dentist's office in the country, originated with a water-propelled device built at NBS in 1951. A probe developed by NBS in 1973 to simulate the response of the human finger to hot surfaces is now manufactured commercially. It is used by the Consumer Product Safety Commission to inspect appliances and by manufacturers to design their products. Sophisticated technology that may be commonplace in a few years is on NBS drafting boards today.

The Science Warehouse

Beginning with the Act that established the agency on March 3, 1901, the legislation that guides NBS requires it to maintain and develop the national standards of measurement and the means for making those measurements; determine physical constants and properties of materials that "are not to be obtained of sufficient accuracy elsewhere;" develop standard codes, practices and specifications for construction; and invent or develop devices and techniques to serve the special needs of government. (A summary of legislation affecting NBS is found on page 38.)

In principle, anything that needs to be measured in physical terms is within the province of NBS. Examples from current programs range from measuring truck noise to describing

For the decoders to be useful, there must be programming carrying the coded captions. The only broadcaster currently doing this is the Public Broadcasting Service (PBS). Below, a PBS employee, working with a captioning "script" and a precise clock, codes the times that each caption will appear.

low temperature fluids, from testing concrete strength to determining smoke detector efficiency, from designing automation systems to measuring laser power levels.

From the point of view of technology transfer, the science and information resources of the National Bureau of Standards can be roughly divided into three areas: "on-the-shelf" technology, directed research, and support technology. In practice, however, most projects require the use of various combinations of these resource areas.

"On-the-shelf" technology refers to the vast body of information and techniques developed at NBS that can be applied in areas other than those for which they were originally developed, a process often called "spin-off." The technology is already known and "on the shelf," where it can be applied to new uses with minor modifications. One NBS project is aimed at applying the computer techniques of image pattern recognition—originally developed for military purposes such as analyzing satellite photos of the earth—to the rapid on-line analysis of wet pulp in paper mills. The results of this project will greatly facilitate the processing of recycled paper in paper mills—a procedure requiring close monitoring of the pulp quality. In turn, increased use of recycled paper should lead to savings in energy use and reduction of water pollution.

Directed research is the development of new technology—finding answers to problems where no storeroom technology exists. Responding to a long-felt need in the medical community for a diagnostic tool with the capabilities of x-rays but without the hazards, NBS scientists developed the SonoChromascope, a unique new ultrasonic imaging device with unprecedented sensitivity and resolution. The instrument has the potential to bring a new measurement capability to some diagnostic procedures: the SonoChromascope can detect and monitor minute changes in tissue condition without itself damaging the tissue. The instrument is now undergoing clinical tests at the National Institutes of Health.

Once developed, the SonoChromascope's measurement capabilities become "on the shelf" technology, available for application in many other areas such as the nondestructive evaluation of materials and components in nuclear reactors.

Support technology goes to the heart of the reason for the existence of NBS. It refers to the complex of scientific and technological capabilities necessary to support basic research that can develop and deliver new technology. In other words, the underlying structure that makes it all work. Through its measurement and calibration capabilities, through its Standard Reference Data and Materials Programs, and in its research and development, the National Bureau of Standards is a major element of the technology infrastructure of the United States.

For example, technology already exists to re-refine used oils. The U.S. Department of Energy (DOE) estimates increased application of such processes could reduce U.S. petroleum imports by 25.5 million barrels a year. This technology is not used to any great extent, however, because there are too many unknowns about the quality of re-refined oil, such as: What factors make it different from virgin oil? Are test procedures for virgin oil really adequate to characterize re-refined oil?

Finding the answers to these and other questions is the goal of a new NBS program begun in response to the Energy Policy and Conservation Act enacted in 1975. NBS is currently working to provide test procedures that can be used to determine if a recycled oil intended for a particular end use is as good as virgin oil for that purpose.

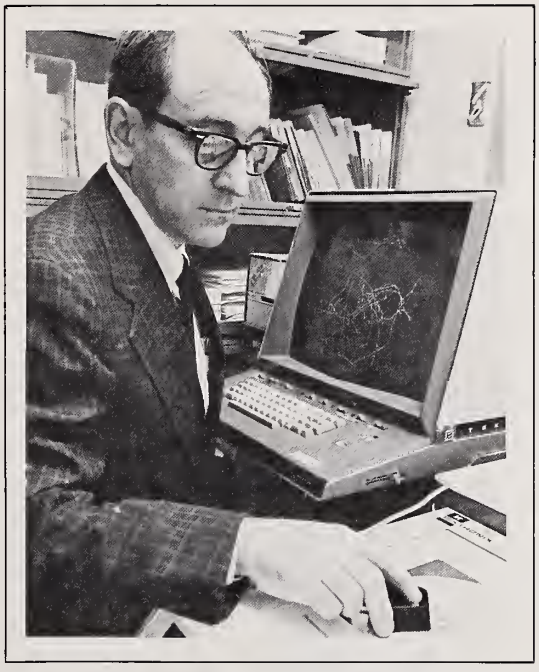
Getting From Here to There

Technology transfer, then, is a process, and its success depends on a number of factors. First the "client"—which may be a segment of the industrial community, a State or local government, or as is often the case, another Federal agency—must identify a specific need, such as a crucial measurement that must be made cheaply and accurately. Then the problem and the resources needed to find an answer must be identified. Finally, a mechanism for bringing the two together must be developed. And there must be very good communications all along the line.

Through cooperative programs with other government agencies at the Federal, State, and local levels and with industry, through its own work on many fronts to meet national needs, through memberships in technical societies and organizations on national and international levels, through publications and calibration services, the National Bureau of Standards is working to make science work.

Russell Kirsch, computer scientist, is developing a computing procedure that can be designed into special computers to enable them to analyze paper pulp fibers. Automated pulp analysis will allow the quality of pulp to be monitored continuously during paper manufacture, thus providing the opportunity to use more recycled paper in the process.

The following pages describe a few of the activities and accomplishments of the National Bureau of Standards, with the main focus on projects carried out during the past fiscal year, ending September 30, 1977. Particular attention is paid to the impact of these programs on industry, government, and the international scene, as well as the everyday lives of people. And attention is also paid to the transfer mechanisms—how technology gets from here to there.



Support to Industry

Seventy-seven years ago the National Bureau of Standards was established to, among other things, serve "...any...firm, corporation, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments."

Since that time, American industry has become one of the biggest users of NBS science and technology. A major reason for this is the Bureau's commitment to do things that for a variety of reasons industrial and commercial firms cannot do for themselves. Often the scientific or measurement skills involved are beyond the capabilities of private laboratories. In other cases, the research involved is too expensive for any one company to undertake, and anti-trust laws prevent cooperative ventures among several companies.

Sometimes commercial needs can be met simply by adapting on-the-shelf technology. For example, a satellite time code system operated by NBS using the National Oceanic and Atmospheric Administration's (NOAA) satellites was developed as an experimental broadcast system for time dissemination and as a method for coordinating NOAA's data gathering activities.

Now that agency, together with the National Aeronautics and Space Administration, is considering applying the time code to another experimental system called ASDAR for the benefit of the commercial aviation industry.

In the ASDAR (Aircraft to Satellite Data Relay) system, fully automated instruments aboard commercial aircraft will collect meteorological data such as wind speeds and temperatures and relay them—together with the aircraft's position and the time—through a network of satellites to a data processing station. Potentially, ASDAR offers commercial pilots fresh, constantly updated information important to efficient and safe navigation—such as where the jet stream winds are.

With accurate clocks aboard the aircraft to coordinate the transmissions, the ASDAR system can handle up to 30 planes on each satellite channel. Using the NBS time code broadcasts and special clocks that are controlled by the time signal, the system can serve at least 100 planes per channel—thus improving the system's accuracy and efficiency.

Nick Sanchez, NBS draftsman, works on the tables and charts for the LNG Materials and Fluid Users Manual. The users manual is the first of its kind for up-to-date, evaluated LNG data.

Solving Specific Problems

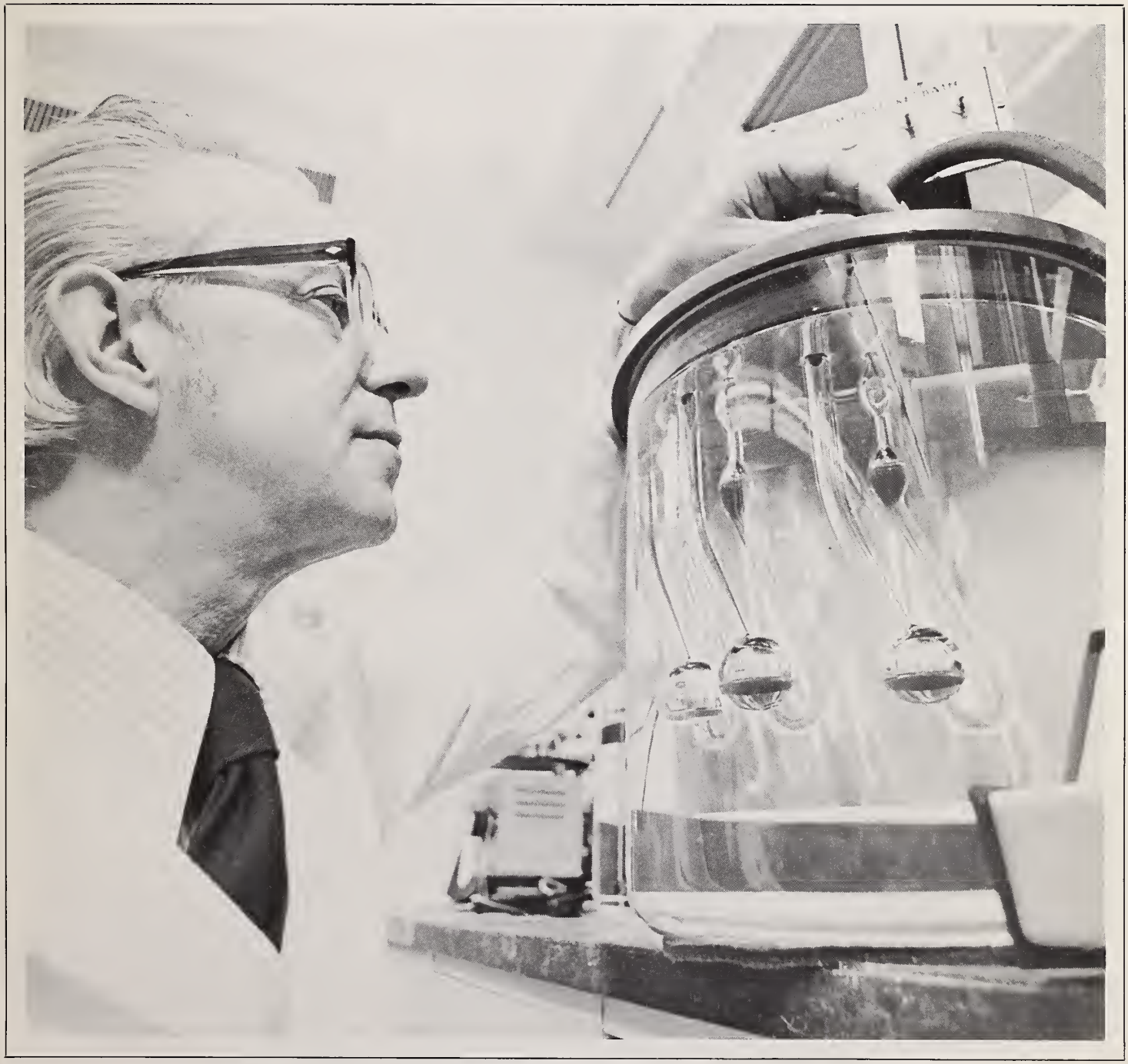
Other needs call for directed research. Over 150,000 Americans carry implanted pacemakers to regulate their heartbeats, and the number is growing by about 55,000 new users annually. Each year about 25 percent of the pacemakers have to be replaced, with the attendant discomfort, expense, and risk that such surgery implies. Some 70 percent of these replacements are required because of power cell depletion, which occasionally occurs earlier than anticipated.

Seeking a nondestructive test method for evaluating pacemaker batteries, NBS scientists built a specially designed calorimeter that measures the heat given off during self-discharge of a battery—in other words, its rate of self-discharge. It was discovered that of the total power delivered by the battery during actual use, as much as 20 percent could be lost through self discharge. Thus, a battery designed to provide 5 years of service might actually last only 4.

Complexion of Support

Support technology can be crucial to some industries. The use of liquefied natural gas (LNG) holds great potential for solving some important problems in energy distribution. Taking up 1/600 of the volume of the original gas, LNG can be an extremely efficient way to move natural

The Association of Petroleum Re-refiners is supporting an industrial research associate, Robert Pedall, to work with NBS scientists in developing test procedures to establish the substantial equivalency of recycled oil with virgin oil.



NBS Standard Reference Materials are used by automobile manufacturers to analyze automotive emissions.

gas across oceans or store it in areas of high energy use to reduce the impact of sudden surges in demand.

But LNG exists only at cryogenic temperatures (−162 °C) that present unique materials and design problems in storing, measuring, and handling the liquid. NBS, which houses the Nation's central laboratory for cryogenics research, has made a concerted effort over the past 5 years to characterize materials used to contain LNG and to devise methods for measuring accurately the volume and heating value of this fuel. The results of NBS' research are available in an LNG users manual titled "LNG Material and Fluids Users Manual," that gives up-to-date data on physical properties of methane, nitrogen, aluminum alloys, stainless steel, nickel steels, and invar. In addition, a number of current U.S. voluntary standards on metering LNG are based on this work.

NBS research into the problems of volumetric and flow measurement of cryogenic fluids will also have an effect on commerce in LNG. Today the custody transfer of a shipload of LNG can be in error by as much as three to ten percent, and at current prices the error can cost about $100,000 per percentage point. NBS research in the accuracy of LNG flow meters and the recent development by the Bureau of a novel thermometer for predicting the gross heating value of LNG flowing in a pipeline are expected to reduce that measurement error to one percent.

Now the Bureau's work on LNG is moving into the international arena, as NBS and the American Gas Association, an industry organization, share the administration of a newly formed technical secretariat for LNG measurement within the International Organization of Legal Metrology.

Idea Exchanges

Good communications are essential to the process of technology transfer. The National Bureau of Standards uses a variety of means to communicate with its "clients" in industry and commerce because the best research in the world is valueless if no one knows about it—and worth no more if it has been directed at solving a problem that doesn't exist. Publications, workshops, conferences, and people—always the essential ingredient—are the media through which the Bureau communicates.

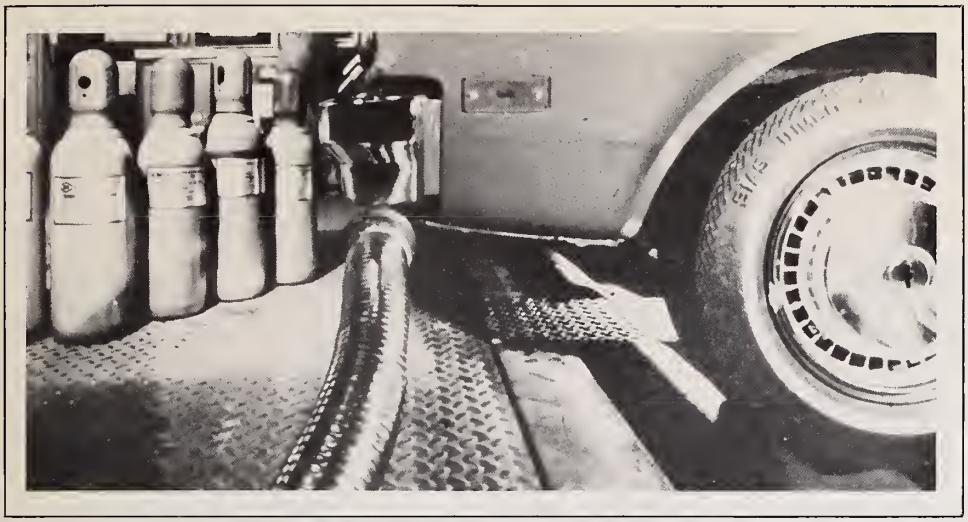
People, with their skills, knowledge, and experience, represent one of the most effective forms of technology transfer, and the NBS Research Associate Program recognizes that fact.

Research associates are trained scientists and engineers from industrial, trade, and professional organizations who come to NBS to work with Bureau scientists on projects of mutual interest. The program is almost as old as the Bureau itself, and some of the most dramatic developments to come out of NBS laboratories were the result of these cooperative ventures. In the field of dental materials alone, NBS research associates have contributed such advances as the panoramic dental X-ray machine for clinical screening tests and BIS-GMA, a monomer widely used to reinforce and seal teeth.

At present there are 23 active programs at NBS involving 73 research associates. The range of topics reflects NBS' broad interests. In a program recently begun with the Aluminum Association, Inc., and the American Electroplaters' Society, scientists are studying the problem of chrome plating aluminum. This issue is of interest to NBS because of its work in electrodeposition and corrosion phenomena and to the industry because successful results will make possible the use of aluminum bumpers on automobiles, which will reduce vehicle weight thus saving gasoline.

A research associate from the International Sugar Research Foundation is working on a new and more accurate determination of the "degree sugar," the scale by which buyers and sellers judge the composition—and in turn the price—of sugar. Interestingly, his work is a continuation of research performed at NBS during the First World War when Bureau researchers completed the theoretical and technical work which brought about large-scale manufacture of an almost chemically pure low-cost dextrose.

Other examples of Research Associate Programs include projects to develop test methods for assessing the fire safety of plastics (Society of the Plastics Industry), to provide Standard Reference Materials and techniques for measurement assurance for radio pharmaceuticals (Atomic Industrial Forum), to establish the basis for a commercially producible Josephson junction voltage standard accurate to one part per million (Superconducting Technology, Inc.), and to measure elements of particular importance in optical waveguide materials (Bell Laboratories).



Publications

The NBS publications program continues to play a major role in communicating with the Bureau's clients. Reports, surveys, and analyses issued have titles ranging from *Application of Infrared Frequency Synthesis Techniques With Metal-Insulator-Metal Diodes to the Spin Flip Raman Laser* to *Attacking the Fire Problem—A Plan for Action.*

Industrial managers worried about rising energy costs can take advantage of NBS research results contained in a series of books published over the past 2 years. The series began with the *Energy Conservation Program Guide for Industry and Commerce* (EPIC) and its supplement—of which more than 94,000 copies have been sold—that laid out a step-by-step plan for starting an energy conservation program in an industrial organization. Currently, the series also includes:

°*The Waste Heat Management Guidebook,* which describes actual case studies showing how a company can save 20 percent or more on its fuel bills by installing waste heat recovery systems;

°*Application of Thermography for Energy Conservation in Industry,* a technical publication detailing how modern techniques of infrared thermography can be used to spot heat losses that signal where repairs or redesign of plant equipment can save energy;

°*Energy Management Guide for Light Industry and Commerce,* a cost-saving textbook including case studies and techniques for economic analysis; and the

°*Energy Management Guide for Furnaces, Kilns and Ovens,* which provides case studies and economic analytic techniques for these particularly energy-intensive operations.

Some of the work published in this series was done in cooperation with the Federal Energy Administration, now a part of the U.S. Department of Energy.

That workers can also benefit from the NBS publications program was demonstrated recently when the United Auto Workers Social Security Department decided to reprint the third chapter of the NBS Handbook *Quieting: A Practical Guide to Noise Control.* The chapter, "Basic Principles of Noise Reduction," gives sample how-to-do-it suggestions for minimizing noise in home and industrial environments.

It is not unusual for an NBS publication to become a basic reference document for an entire profession or industry. Such was the case, for example, with the NBS *Handbook of Mathematical Functions,* first issued in 1964 and now in its tenth printing. A more recent example is *Color: Universal Language and Dictionary of Names,* published last year. The dictionary is an updated and expanded version of the original NBS work, first published in 1955, and is becoming the common reference for color terminology in science, industry, and art.

A listing of selected NBS publications produced during the year is found on page 37.

NBS conferences provide a common meeting ground where people from diverse fields can discuss problems and exchange ideas—vital interactions in a world where technical innovations in one area can have important, and sometimes unforeseen, consequences in another. For example, the increasing proliferation of electromagnetic devices, including industrial equipment, appliances, automobiles, and CB radios, has affected the performance of a wide variety of other products from pacemakers to truck brakes. A special workshop held at NBS on the general problem of electromagnetic interference drew representatives from such varied groups as automobile manufacturers, the telecommunications industry, consumer electronics manufacturers, law enforcement groups, medical instrument manufacturers, the Department of Defense, the Federal Communications Commission, the Food and Drug Administration, and the Environmental Protection Agency.

In yet another instance, a workshop on reliability technology for cardiac pacemakers was conducted at NBS in response to strong interest expressed by the pacemaker community. The workshop was held to facilitate greater interaction among the pacemaker, semiconductor, regulatory, and other groups concerned with high reliability electronics and to discuss technical problems affecting the improvement of cardiac pacemaker reliability.

During the year, NBS sponsored or cosponsored 73 such workshops and conferences, attended by over 14,000 people. The meetings covered such topics as roofing technology, the prevention of mechanical failures, asbestos measurement, flow measurement, ultrasonic tissue characterization, data management, computer security, and thermal analysis and its relation to human comfort.

To Other Government Agencies

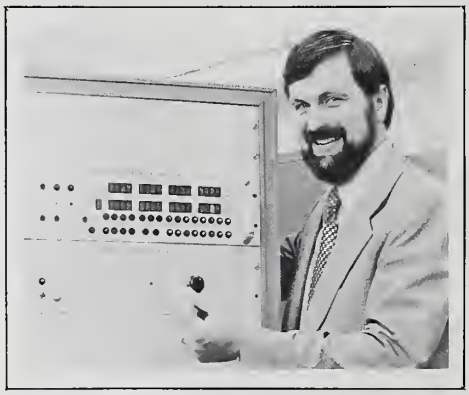
On June 26, 1977, a prisoner in the Maury County Jail in Columbia, Tennessee, set fire to the wall padding in his cell. Forty-two people died of smoke and toxic gases before the fire was extinguished.

The deaths were reminiscent of a number of fire fatalities in various institutions over the past few years. Incidents such as the deaths of four elderly patients at the Shenandoah Homes in Roanoke, Virginia, in 1976, and the deaths of ten prisoners and a guard from a set fire in the Seminole County Jail in Sanford, Florida (1975), led to considerable interest in the burning characteristics of the common element in these fires—mattresses and plastic padding materials.

In the Center for Fire Research at the National Bureau of Standards, similar fires have been taking place for the past year under more controlled conditions. In specially designed "burn rooms," researchers ignited wastebaskets with carefully standardized contents (newspapers, tissues, milk cartons, cigarette packets, and the like) next to beds neatly made up with different types of mattresses. As bedding and mattress caught fire and smoke began to fill the room, observers, cameras, heat detectors, gas sensors, and smoke meters recorded the progress of the fire and the combustion products.

So when Tennessee State fire officials came to NBS for help in determining the causes of the Maury County deaths they found an already functioning program prepared to supply the answers. NBS researchers tested samples of the materials left in the fire to learn what had been burning. The Maryland State Medical Examiner, who has been working with NBS to study the toxic effects of combustion products, analyzed blood samples from the fire victims, and the results of the tests were soon in the hands of the Tennessee officials to help them complete their investigation.

By September 1977, the NBS report on the comparative burning characteristics of institutional mattresses, used in hospitals and nursing homes as well as prisons, had been released to its sponsors: the Department of Health, Education, and Welfare; the Veterans Administration; the Department of Defense, and the Consumer Product Safety Commission.



A new data encryption standard, developed under the leadership of Dennis Branstad, became effective for Federal agencies on July 15, 1977. It is a product of NBS' responsibilities under the Brooks Act to provide uniform computer standards for improving the effective use of computers in the Federal government.

In the meantime, other Bureau fire researchers were finishing a report for the State of Kentucky on the Beverly Hills Supper Club Fire of May 28, 1977, in which 164 people were killed. An NBS official aiding the National Fire Prevention and Control Administration was on the scene working as a team member with State officials to determine the causes behind the tragedy. Later NBS furnished the investigators with a hypothetical model to explain how the fire had spread from its initial location to engulf the club.

Establishing a Facilitator

The range of scientific assistance from NBS that is available to State and local governments is much broader than sifting through the ashes of a disaster. For one thing, NBS and State governments have worked closely for years to develop unified building codes that protect the safety of the public while improving the economics of production.

In 1968, for example, NBS was instrumental in helping establish the National Conference of States on Building Codes and Standards (NCSBCS). After being supported by NBS for 7 years, NCSBCS became an autonomous organization of State officials dedicated to modernizing and unifying the building regulatory system. The Bureau still serves as the technical arm of the NCSBCS.

To help reduce the Nation's energy consumption, NCSBCS officials requested that the National Bureau of

NBS researchers assisted in an investigation into the causes of the fire that destroyed the Beverly Hills Supper Club and killed 164 people. United Press International Photo.

An experimental wall, built with 2000 stones from around the world, is used by NBS researchers to study the effects of natural weathering. Here, a workman prepares to move the wall from Washington, D.C., to the Bureau site in Gaithersburg, Md.

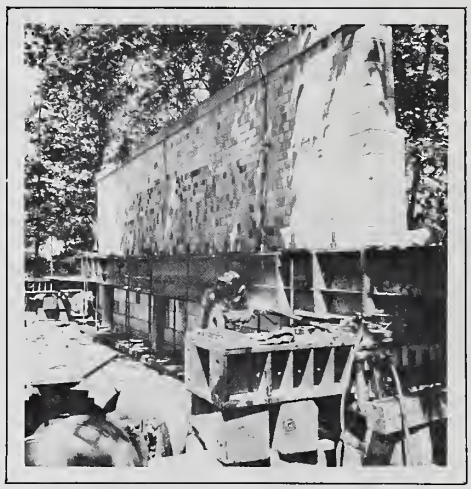
Standards develop energy conservation criteria to be used in designing new buildings that would guide the States in writing new legislation during the next year. In response, NBS issued the report *Design and Evaluation Criteria for Energy Conservation in New Buildings*. The report became the core of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers ASHRAE Standard 90-75, which in turn became the basis for most State energy conservation plans.

NBS researchers are now working with State and local government officials to develop model building codes for rehabilitating buildings that often cannot be renovated to meet modern building standards economically or without destroying their architectural or historic value.

Computer science is also an area where State governments can benefit from the national experience. NBS has among its duties the responsibility for developing uniform information processing standards for the Federal government. Such standards help improve the efficiency and effectiveness of Federal computer resources and insure that data systems developed in one agency are compatible with those developed in another.

Although developed primarily for Federal data processing systems, the FIPS (Federal Information Processing Standards) are coordinated with State and local government information systems and are often used by them. North Carolina's Department of Administration, for example, reports that a recent FIPS on computer documentation has been adopted as the standard for all its State agencies and institutions.

Last year NBS issued 10 standards and guidelines for information processing systems. One of these, the Data Encryption Standard (FIPS 46), is the first computer security standard—it specifies a method for protecting computer data in transmission and storage.



In addition, NBS provides metrology services for many other Federal agencies including the Department of Defense, the National Aeronautics and Space Administration, and the Nuclear Regulatory Commission. A major new standardization program undertaken by NBS to improve the quality of measurements made for nuclear safeguard purposes is sponsored by the Nuclear Regulatory Commission and the Department of Energy. These measurements are made in nuclear fuel cycle facilities to keep track of plutonium and uranium supplies and thus provide sensitive and timely methods for detecting loss or diversion of nuclear materials. The results of the NBS program will be disseminated both domestically and internationally as such measurements must be made in support of the U.S. safeguards program and the Nuclear Non-Proliferation Treaty.

From National to Local

As one of the central reference laboratories of the Federal government, NBS does a considerable amount of work to support the goals of other Federal agencies. Much of this research can be adapted for use by State and local agencies with similar objectives.

For example, preserving government-owned monuments and buildings from the ravages of pollution and weather is a problem common to every State government. Officials responsible for this work might take interest in a recent report prepared by NBS for the National Park Service. The report gives the results of 3 years of research into methods to test and evaluate materials that prevent erosion and decay of stonework. And in another Park Service project currently underway at NBS, researchers are looking for ways to protect historic adobe structures from their ancient enemy—water.

Weights and Measures

Although much of the work that is of interest to State and local governments was originally performed for the Federal government, several major programs are directed specifically at local government interests. As might be expected, some of the most important work performed for State governments at the National Bureau of Standards is in the area of weights

and measures. State weights and measures officials, organized in the National Conference on Weights and Measures (for which NBS serves as secretariat and sponsor), maintain close contact with the Bureau, which provides extensive training and calibration services. State metrologists are given some 80 hours of training in the NBS program, about half of which is spent in Bureau laboratories. A program begun in 1965 to modernize State measurement standards (some of which dated back to 1836) has been completed for all except four States and territories (which are waiting for the development of adequate State laboratory facilities). The program represents support technology in perhaps its most important sense—the development of a reliable, functioning measurement system.

NBS is also working to develop measurement capabilities on a State government level in areas outside of the traditional weights and measures office. For example, several pilot projects in radiation measurement were begun last year: in Illinois, to test the concept that a particular State laboratory can serve as a regional center for radiation calibrations for several surrounding States; in Florida, to develop a system for accurate calibration of instruments used by State officials to measure distributed sources of radiation, such as contaminated soil; and on a national scale, to develop a uniform system through the States for reporting environmental radiation data.

For All Levels

Developing a national measurement network is not the only area in which NBS and State governments work together on the problem of technology transfer. A project that can benefit both industry and government at all levels is the Bureau's Experimental Technology Incentives Program (ETIP).

ETIP began in 1973 as a research team that experimented with government policy instead of test tubes and electron accelerators. The ETIP mission is to learn how policies and procedures of government can be modified to encourage technical innovation in private industry to the benefit of supplier and consumer alike. ETIP experiments deal with such areas as government buying policies, methods of aiding private inventors and small firms engaged in research and development, and the streamlining of government regulatory proceedings.

Last year a cooperative program between ETIP and the Montana Public Service Commission studied ways the Commission could streamline the process of setting utility rates. The program is part of a larger ETIP experiment to test the idea that the complex procedures involved in updating government regulations deter investors from supporting innovative technologies. Changes made by the Commission as a result of the study meant that a major utility rate case was decided in half the usual time—and with a fifth of the usual paperwork.

Similarly, the New York Public Service Commission last spring used an ETIP analysis of procedures followed by Consolidated Edison to determine that the utility's request for a rate increase could be cut by four-fifths without the company losing money. As an added benefit, suggestions made by the ETIP team actually increased the utility's productivity.

A Special Program

The past year saw new emphasis at NBS on a program designed to increase cooperation between the Federal laboratory and State and local governments. Through the Intergovernmental Personnel Exchange Program, State and local government employees have the opportunity to work on collaborative projects with NBS scientists, using the Bureau's facilities. Or an NBS researcher can work on a specific project at the local level.

The program is open to all qualified government personnel, as well as members of the universities and public interest groups that serve them. Several State universities already participate in cooperative programs at NBS, including projects to develop accurate mathematical models of solar heating systems (University of Michigan), evaluate the effectiveness of lighting systems (University of New Hampshire), select appropriate performance attributes of textiles for a consumer product labeling program (University of Maryland), and measure power plant particulates using new micro-Raman spectroscopy techniques (Kansas State University).

The Intergovernmental Personnel Exchange Program can become one of the Bureau's most important links to the State and local governments. Like the Research Associate Program, it transfers technical capability in the best way possible, not just in machines and reports but in the minds of trained and skillful personnel.

On the International Scene

Building construction in the Philippines, earthquakes in Romania, power plants in the Soviet Union, scientific projects in Paris: the range of NBS interests abroad comes as a surprise to people who are familiar only with the Bureau's domestic programs.

But while the National Bureau of Standards is primarily geared toward meeting the Nation's measurement and scientific needs at home, its services to the U.S. technical community require NBS to have a broad concern with the world around it. Further, NBS programs support U.S. foreign policy in many areas in which science and technology influence international affairs.

NBS has, for example, worked on several projects for the Agency for International Development (AID). One 3-year project, concluded last year, focused on a problem of global scope: the often extreme damage done to low-cost housing by severe wind storms. Using the Philippines—an area plagued by frequent extreme winds—as a natural laboratory, the NBS researchers put together a comprehensive set of instructions on building—inexpensively—to resist high winds. The five volumes of the final report, *Building to Resist the Effect of Wind,* included not only design and engineering considerations to improve building practices, but also such factors as siting buildings to lessen the destructive impact of winds; making use of traditional, readily available building materials, and forecasting housing needs.

The same NBS expertise in building technology is often called on in emergency situations, such as the disastrous earthquake in southeastern Romania on March 4, 1977. Among the first groups to respond to the Romanian government's request for help was a team of U.S. earthquake and construction experts headed by two NBS engineers who studied the damaged sites and made recommendations on how to restore some of the structures. The team's report to the U.S. State Department became the basis for recommending appropriate U.S. assistance to the quake region.

Yoshiko Ohta, a guest worker from Japan, is participating in an NBS project to evaluate nonprecious and semiprecious alloys for dental materials.

A current program under AID auspices is an attempt to improve the quality of industrial standards in several developing countries. This sort of work—the development of a central measurement system capable of supporting modern technologies—is crucial to a nation's internal industrial development and international trade position. The NBS program transfers not only measurement standards but also the related technology through conferences, tutorial workshops, training programs, and evaluation surveys of standardization programs in developing countries.

Under special agreements with their respective governmental institutions, NBS provided assistance last year to the Korea Standards Research Institute and the Institute of Technological Research in Sao Paulo, Brazil, to improve the services they offer to industry in their countries. And, also last year, the Indian National Aeronautical Laboratory began calibrating independently flight control instruments and altimeters for its aircraft using NBS primary pressure standards.

Cooperative Exchanges

The Bureau's international activities are not a one-way street, as the number of cooperative research projects demonstrate. NBS joint projects with the USSR, for example, include three fields of major concern to the United States—energy research, environmental quality, and metrology.

Working under the sponsorship of the U.S. Department of Energy, NBS is involved in a long-term experiment

An earthquake devastated downtown Bucharest, Romania, on March 4, 1977. Two NBS engineers led a U.S. study team which made recommendations on how to restore some of the structures. United Press International Photo.

As part of a U.S.-USSR project to develop practical magnetohydrodynamic (MHD) power plants, NBS chemist Taki Negas tests an electrode material for its suitability in MHD systems.

with the Soviet Union to develop practical magnetohydrodynamic power plants. Together with colleagues at Westinghouse, Battelle Northwest, the Massachusetts Institute of Technology and the Institute for High Temperature in Moscow, NBS scientists are working to solve the difficult materials problems associated with this alternative method of energy production.

Several other NBS cooperative projects with the USSR were started as the result of the U.S.-USSR 1972 Agreement on Cooperation in Environmental Protection. The Agreement also includes an exchange of U.S. and USSR environmental standard reference materials and joint experiments to develop equivalent methods in each country to measure air and water pollutants.

The Research Associate Program and Intergovernmental Personnel Exchange Program have their international analog in the NBS Guest Worker Program. Last year the Bureau hosted 24 guest workers from 10 countries who worked on such projects as spectrochemical analysis using x-ray fluorescence, characterization of ultrasonic transducers, catalytic production of methane, and the study of bone and tooth minerals.

And, NBS was visited last year by over 900 representatives of foreign governments, standards-writing organizations, and industries including 70 visitors from the USSR, 130 from Japan, and 50 from France.

Coordinating Standards

Certainly the Bureau's most important international work stems from its position as one of the foremost measurement laboratories in the world. NBS is actively involved in several international standards-setting organizations including the International Bureau of Weights and Measures (BIPM), the International Standards Organization (ISO), and the International Organization for Legal Metrology (OIML) as well as a variety of international consulting committees in the various branches of metrology.

As the Federal agency entrusted with representing the United States in all activities resulting from the Treaty of the Meter, NBS contributes to the development and maintenance of international standards of measurement and, through the OIML, to ensuring the accuracy of instruments used in international metrology, such as those that measure liquefied natural gas (see page 8).

As a member of the U.S. delegation to ISO, NBS was one of the principal participants in the creation, late in 1976, of the International Standards Information Network (ISONET). When fully operational, ISONET will serve as an international reference service to the engineering and product standards of member nations. Any group interested in creating a new product or product standard will find ISONET an invaluable research tool.

Last year NBS also played a major role in the creation of a new international service to speed the dissemination of evaluated scientific data. Working through its membership in the International Council of Scientific Unions (ICSU), NBS helped activate the World Data Referral Centre (WDRC). Sponsored by the ICSU Committee on Data for Science and Technology (CODATA) and UNESCO, the WDRC will disseminate information on collections of scientific data and information on a world-wide basis.

In a more immediate area, the Bureau's expertise in developing standards such as Standard Reference Materials in the field of clinical chemistry was recognized last year when NBS was named a Collaborating Center for Research and Reference

The U.S.-USSR Joint Working Group on Cooperation in the Field of Metrology met recently to review progress made in metrology programs and to lay plans for future work. NBS physicist Richard Deslattes discusses the use of x-ray interferometry with a member of the Soviet delegation.

Services in Clinical Chemistry by the U.N.'s World Health Organization (WHO). WHO sponsors five such centers in the world: the only other center in the United States is the Center for Disease Control, an agency of the Department of Health, Education, and Welfare.

Also in progress is a cooperative fire research program between the Bureau's Center for Fire Research and Japan, which was begun at the Second Joint Meeting of the U.S.-Japan Panel on Natural Resources held in Tokyo in October 1976. The U.S. expertise in fire sciences such as toxicology, physics, dynamics, and chemistry complements the Japanese expertise in applying technology to the prevention of fires. The program's main areas of concentration are fire modeling, toxicity, and building design.

Through these and other activities on the international scene, NBS is working to ensure that the United States has access to the latest world developments in measurement science and technology and that the U.S. position is adequately represented in international standards bodies.

And in the Public Interest

Walk into a modern supermarket and pick up something quite ordinary, such as a plastic bottle of milk. To protect the buyer, the plastics in the bottle must be safe for use with foods, the bottle must be sterilized before the juice is poured in, and the volume of the contents measured and marked on the label among other things. Which of these safeguards is a concern of the National Bureau of Standards?

The answer, perhaps surprisingly, is all of them. Promoting the use of accurate weights and measures in commerce is the oldest function of NBS, but by no means the only way in which the Bureau has an effect on the marketplace.

Some plastic food containers today are regularly sterilized by radiation, an inexpensive process but one requiring delicate measurement and control. Too low a dosage won't adequately sterilize the container, but too high a dose may weaken the plastic. One answer—an answer becoming increasingly popular with the industry—is a new NBS dosimeter that uses a radiation-sensitive dye to make reliable measurements of the comparatively large radiation dosages used in these industrial applications.

And the safety of the plastics? One of the problems faced by the Food and Drug Administration in regulating the use of plastics with foodstuffs is knowing the extent to which chemicals in the plastic "migrate" into the food. Recently the FDA came to the Bureau for help with this problem and the result is a new research program at NBS to evaluate existing test procedures for measuring the migration of these chemicals, and possibly develop new tests. Ultimately, the NBS researchers hope to produce a general physical model that will allow scientists to predict the behavior of whole classes of plastics in these applications.

From the earliest days of the Bureau, a sizeable portion of the research at NBS has been directed not to the aid of any particular industry or government agency but simply to help make every citizen's life a little simpler, or safer, or less expensive.

Increased use of ultraviolet (UV) radiation in many areas, including the curing of new enamel in corrective dentistry, requires more accurate characterization of the irradiation. NBS programs in UV measurements cover the region from 4 nm to 400 nm, using a variety of standard sources and detectors.

Radiation Safety

In just one area of the health field, radiation safety, NBS activities last year ranged from conducting a program to test existing measurement systems, from developing a new radiation dosage measurement technique to disseminating educational material on the subject of radiation safety.

In a cooperative program with the Bureau of Radiological Health (a part of the Food and Drug Administration), NBS is conducting a mail survey of cobalt-60 teletherapy centers in the United States. Cobalt-60 radiation is an effective and widely used treatment for cancer patients—there are approximately 1000 such teletherapy units at present.

However, investigations by the Nuclear Regulatory Commission have shown that there can be major differences between the radiation dose actually given to a patient and the dosage calculated by the operator. The NBS survey, which is strictly voluntary, checks the accuracy of irradiation procedures by requesting the teletherapy unit to deliver a fixed amount of radiation to a dosimeter. (The development by NBS of a dosimeter that could be transferred by mail was a byproduct of the project.) The exposed dosimeter, together with the therapy unit's calculations of the dose delivered, is returned to NBS for evaluation. Those participants whose measurements exceed acceptable limits work with NBS to improve their measurement techniques.

Although the Nuclear Regulatory Commission has set up a new mandatory test program for cobalt-60 teletherapy units, it will exempt any group whose measurements are found

To help educate consumers on the role of local weights and measures officials in the marketplace, NBS cosponsored the production of a film that takes the viewer "on the rounds" with a weights and measures inspector.

Ruth Davis, former head of the Institute for Computer Sciences and Technology, and Alan Westin, professor at Columbia University, answer questions at news conference held to announce completion of NBS-sponsored study on privacy issues in medical recordkeeping.

to agree with NBS' to within 5 percent.

Because of the nature of ionizing radiation such as x-rays, accurate dose measurements are sometimes difficult to make. When accurate doses of radiation must be administered to areas near the joining of two different types of tissue—bone to bone marrow, or bone to muscle, for example—radiologists find that the scattering of the radiation beam at the interface makes accurate determination of doses difficult or even impossible.

Last year, however, in another collaborative program with the Bureau of Radiological Health, NBS developed a new type of radiation sensitive gel that will go a long way toward solving this problem. The new gel, which can be cast or molded into different shapes and densities, is used to simulate muscle, bone, or other tissues (and mimics the interface between two types of tissues). When exposed, it records a permanent, high-resolution image of the radiation dosage received at different parts of the sample.

In still another effort designed to encourage improvement in radiation safety, NBS is circulating a new radiation safety film—*The Double-Edged Sword*. This training film, in use for the past year and a half, demonstrates procedures designed to eliminate human error in using x-ray equipment. Gathering enthusiastic reviews from companies which borrow the film to show their employees, *The Double-Edged Sword* has been seen by more than 56,000 people.

Keeping It Private

Even after patients are cured they may still have problems—

specifically problems with their medical records: that was the warning of the landmark study *Computers, Health Records, and Citizen Rights* issued last year by NBS.

The report, by noted law and privacy expert Professor Alan Westin of Columbia University, was sponsored by the National Bureau of Standards to bring privacy issues in medical recordkeeping to the attention of policy makers. Westin's findings and recommendations are applicable to all health record systems, with or without computers.

The report, which has been circulated to at least 10,000 managers of health care institutions, includes 12 recommendations for protecting personal medical records against misuse and for guaranteeing people the right to know what information is in their records (not now an automatic right) and how that information is being used.

NBS has also sent copies of the study to the Federal Privacy Protection Study Commission (PPSC), which was established by Congress to investigate the entire privacy issue. PPSC plans to recommend to Congress legislation for safeguarding the privacy of all kinds of records, including medical records.

Lawn Mowers, Pressure Tanks, and Toys

Protection of personal safety is another important line of research at the National Bureau of Standards. Usually working under the auspices of either the Consumer Product Safety Commission, the Law Enforcement Assistance Administration, or the Occupational Safety and Health Administration, Bureau scientists and technicians conduct performance and safety tests on a variety of consumer goods. Information gathered in evaluating products is delivered to the sponsoring agencies, which are charged with reducing the number of deaths and injuries attributed to such products.

In the last year alone, NBS:

- tested lawn mowers to measure the time it took to stop the blade in an emergency situation and to evaluate the usefulness of existing tests for thrown-object hazards;
- studied pressure tanks used as gas containers and fire extinguishers to learn if existing safety standards were adequate;
- tested the components used in TV accessories that use household wiring as an antenna to learn if they presented a shock hazard from lightning effects (they did);
- began a new project to study the problem of eye injuries caused by ob-

An NBS study carried out in Gaithersburg, Md., on an existing house with limited insulation showed that winter heating bills could be cut by more than half through the addition of storm windows and more insulation.

jects thrown or propelled from children's toys;

- completed an extensive study of risks associated with certain sports activities as a preliminary step to developing product standards in these areas; and
- issued a comprehensive report on the performance of safety equipment designed to prevent falls.

In recent years, NBS has worked with industry, other standards-writing groups, and the Department of Commerce in the development of more than 100 voluntary product standards—nationally recognized industry standards for improving product performance. The latest standard to go into effect is aimed at reducing the risk of personal injury from shattering carbonated beverage bottles. Previously developed product standards cover such things as toy safety and playground equipment.

Also related to product standards, the Department of Commerce recently announced a 1-year pilot program to label products to assist consumers in making informed buying decisions on the basis of the product's strength, durability, and other performance characteristics. NBS is providing technical support for the program. This includes selecting the performance characteristics to be listed on the label and the test procedures to be used in measuring those characteristics.

Manufacturers, distributors, retailers, or consumers who want to request that a product be included in the program should write to the Consumer Product Information Labeling Program, Office of Product Standards, U.S. Department of Commerce, Washington, D.C. 20230.

Conserve, Conserve, Conserve

Energy costs continue to increase, and that makes energy conservation a topic of more than passing interest to every consumer. To help solve this national problem, NBS is evaluating energy conservation alternatives in many areas.

Two NBS projects, one just completed and one just begun, will be of particular value to homeowners. Done for the U.S. Department of Energy (DOE), the recently completed project resulted in the publication of *A Service Manager's Guide to Saving Energy in Residential Oil Burners.* Tests conducted for the NBS/DOE project revealed that virtually every residential oil burner was to some extent overfired—that is, burning more fuel than necessary to reach the desired temperature. In many cases the overfiring was as much as 100 to 200 percent.

The *Guide* is a working summary of research results that show service managers and technicians how a combination of smaller nozzle sizes and properly adjusted air flow can result in substantial fuel savings. NBS also prepared a version for the homeowner. Copies of *How to Improve the Efficiency of Your Oil-Fired Furnace* are available free from the Consumer Information Center, Pueblo, Colorado, 81009.

NBS research engineer Robert Berger is conducting a study for the Consumer Product Safety Commission to develop a test method that toy manufacturers can use to measure the force of a propelled object and insure that it is within a safe level.

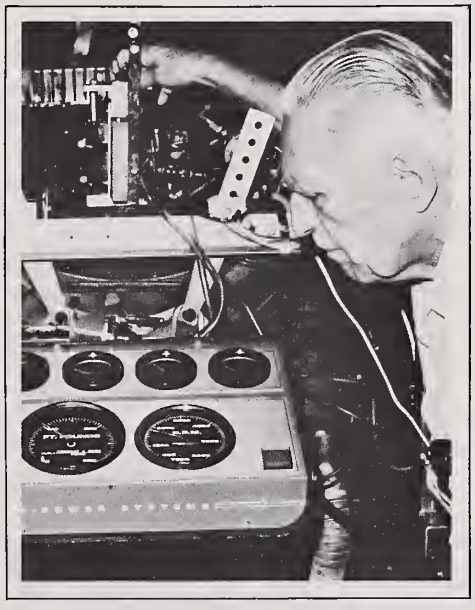
One energy-saving idea, evaluated by NBS and funded by the Department of Energy, was that of Albert ,below, and John Csonka who developed a "micro-carburetor" for automobiles that would decrease fuel consumption and the amount of the pollutants escaping into the environment.

Both heating and cooling efficiency are the subjects of a new 2-year program recently started at NBS to study the value of attic ventilation in combination with attic insulation. Although the use of both ventilation and insulation in attics to prevent either excessive heat build-up in summer or loss in winter are well-known conservation measures, the effects of using various combinations of the two are almost entirely unknown. Previous limited NBS studies of the problem have shown that the effect of a wide variety of variables must be known before useful cost-benefit decisions can be made by homeowners and builders. The new study, done in cooperation with Lawrence Berkeley Laboratory, Princeton University, DOE, the American Ventilation Association, and the Home Ventilation Institute, is designed to examine a variety of ventilation/insulation combinations in three different climate areas. Of particular concern in the study are the effects of such variables as air exchange, moisture condensation; indoor, outdoor, and attic temperatures; heat flow, and wind speed and direction.

In the meantime, homeowners who are interested in alternative energy sources will find useful information resulting from Bureau research into solar energy systems. Under the sponsorship of the Department of Housing and Urban Development (HUD) and DOE, NBS has studied not only the performance and design of solar energy systems, but also the economic considerations: In what areas of the country does solar heating make sense? How do you estimate whether or not installing a solar energy system will be a good investment?

And, to help protect the buyer, NBS has contributed to the development of standards for solar energy systems. Most recently, NBS proposed quality levels for solar heating and domestic hot water systems that were adopted by HUD as minimum standards for housing projects built under HUD programs.

Homeowners will also find imaginative assistance in this year's



publication of *Window Design Strategies to Conserve Energy,* which illustrates the wide range of options currently available commercially to conserve energy using proper window management.

Aid for Inventors

With the tradition of American ingenuity comes the perennial problem: getting someone to pay attention to your new idea. A cooperative program between NBS and DOE does just that.

The NBS Office of Energy-Related Inventions (OERI) was set up to encourage the development of new energy sources and technologies by aiding small businesses and individual inventors who have potentially worthwhile ideas for either producing or saving energy, but who lack the means to develop the invention.

Any individual can submit an invention or idea for a new energy-related device, material, or process of an energy-related nature to the OERI. There the invention goes through a two-step screening process to determine, first, whether or not it is technically feasible, and second whether or not it shows sufficient potential to warrant support from the Federal government. Inventions that pass the screening process are referred to the DOE, which makes the final determination as to the sort of aid that should be provided. The government support may range from a grant for further research and development to assistance in marketing the finished product.

As of the end of September 1977, OERI had received 6,260 evaluation requests. Of the 5,299 investigations completed, 46 resulted in recommendations to DOE for further support. Typical recommended inventions include a food waste disposal powered hydraulically by the water it uses instead of by electricity, a system for converting a standard gasoline engine into a diesel engine, and a system for reducing fuel consumption in motor vehicles by storing the kinetic energy of braking in a hydraulic system for use in acceleration.

Building the Foundations

The United States is a leader in the development and use of technology. What makes that possible? Useful technology depends on many factors. Some are cultural: the ability of a people to change, to accept innovation. Some are economic: the availability of investment capital to back technology development, and before that, the money necessary to train the scientists and engineers needed for that development. Economic influences of Federal financial and regulatory policies can also contribute to a climate that encourages innovation.

Some are scientific: the basic scientific competence necessary to solve technological problems, the scientific knowledge of the world that allows one to do something and know what is done.

At the heart of scientific progress is metrology—measurement science, the capability to express discoveries and accomplishments in numbers. Measurement science and the basic scientific know-how that goes with it, are important, even vital, parts of the support structure that makes technology work. And measurement in this country means, more than any other single organization, the National Bureau of Standards.

Accuracy is pursued to the limits of science in NBS laboratories: pressure to three parts per million, the length of a meter to one part in ten million, the speed of light to four parts in a billion, the length of a second to one part in ten thousand billion.

All this is done to provide our clients with the information they need to obtain the measurement accuracy they require, to understand the factors contributing to measurement uncertainties, and to know what measurement accuracies are necessary for specific jobs.

Building a Better Measure

Part of the NBS effort in this area is devoted to improving the instruments and methods of measurement. One program, for example, studies nondestructive evaluation (NDE) methods: techniques used to inspect materials and components for hidden flaws without damaging them in the process. When questions arose concerning the integrity of welds in the trans-Alaskan pipeline, the Department of Transportation turned to NBS to analyze NDE tests performed on the welds.

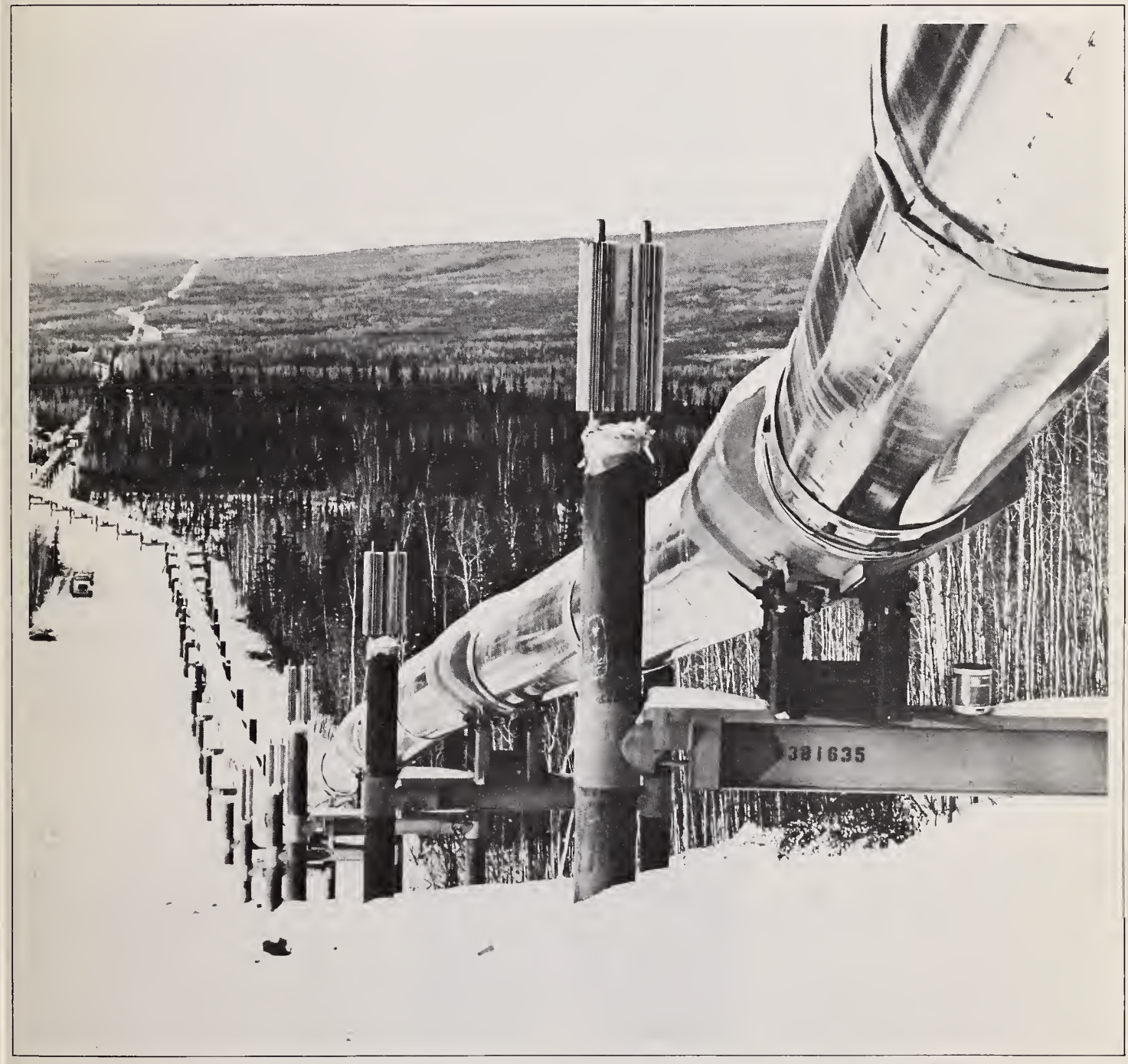
NBS scientist Willie May analyzes marine samples from Prince William Sound, Alaska, for trace hydrocarbons.

Last year, NBS researchers demonstrated a valuable new NDE technique called vibrational spectroscopy that can be used to check the mechanical integrity of plastic parts in critical applications, such as the cups used in artificial hip joints. The method involves measuring the vibrations of a test object that has been given a mechanical shock. The NBS workers found that the characteristics of the frequency spectrum of the object depend upon the presence or absence of internal flaws.

X-rays are another useful tool in NDE. For example, in a technique known as x-ray xeroradiography, radiation is passed through the object to be analyzed to form a charged image on a selenium plate behind the object. However, this technique doesn't work with dense metals such as lead, so last year NBS scientists demonstrated a way to use neutron radiation in xeroradiography. A successful application of this new NDE tool was the analysis of sealed ancient Chinese lead and bronze ceremonial urns for the Smithsonian Institution.

Some NBS test methods have become standards in the industry. In the field of semiconductor and electronic technology, for example, NBS scientists developed measurement procedures to check the integrity of the wire bonds that connect

NBS scientists participated in a project to determine natural levels of hydrocarbons in the Alaskan marine environment prior to development of the outer continental shelf and to the opening of the trans- Alaskan oil pipeline. Photo courtesy Alyeska Pipeline Service Company.



NBS scientists D. Wayne Hanson (left) and Joseph Cateora inspect the calculator circuits of the prize-winning satellite-controlled clock. The units shown receive the satellite's time signal and automatically compute the transmission delay and adjust the clock accordingly.

transistors and integrated circuits and to evaluate the effectiveness of heat sinks in microelectronic devices.

This work has been incorporated into formal standards by such groups as the American Society for Testing and Materials, the Electronic Industries Association/Joint Electronic Devices Engineering Council, and the Department of Defense.

NBS semiconductor test patterns are also becoming increasingly popular among the makers and users of microelectronic devices. These patterns, sold in the form of photomasks, are used to build specific test structures into silicon wafers along with the actual microelectronic devices. The patterns are then tested electronically as part of the quality control process.

Test procedures and devices like these are the result of a long process in which NBS scientists use everything from surveys and interviews to joint industry-government workshops to learn the actual measurement needs of the industry. They then work with industry to develop the necessary measurement capabilities. Frequent meetings and consultation during the development process help ensure that the test procedures, when finished, will be useful to a large segment of the industry.

New Measurement Devices

NBS takes pride in its work in measurement technology. Last year NBS researchers won three awards—all of which were for new measurement devices—in the *Industrial Research* magazine competition for the 100 most significant new technical products of the year.

One, the development of an accurate satellite-controlled clock for data gathering, was mentioned earlier on page 8. Another was the product of the Joint Institute for Laboratory Astrophysics (JILA), a long-standing cooperative research effort sponsored by NBS and the University of Colorado. JILA researchers were looking for a fast, accurate means of measuring the wavelength of continuous lasers, a need common to a wide variety of disciplines including laser isotope separation, laser chemistry, high-resolution spectroscopy, and air pollution measurement.

Their solution was the laser lambda meter, a novel use of laser interferometry that delivers four wavelength measurements per second with an accuracy that previously took a week or more to achieve.

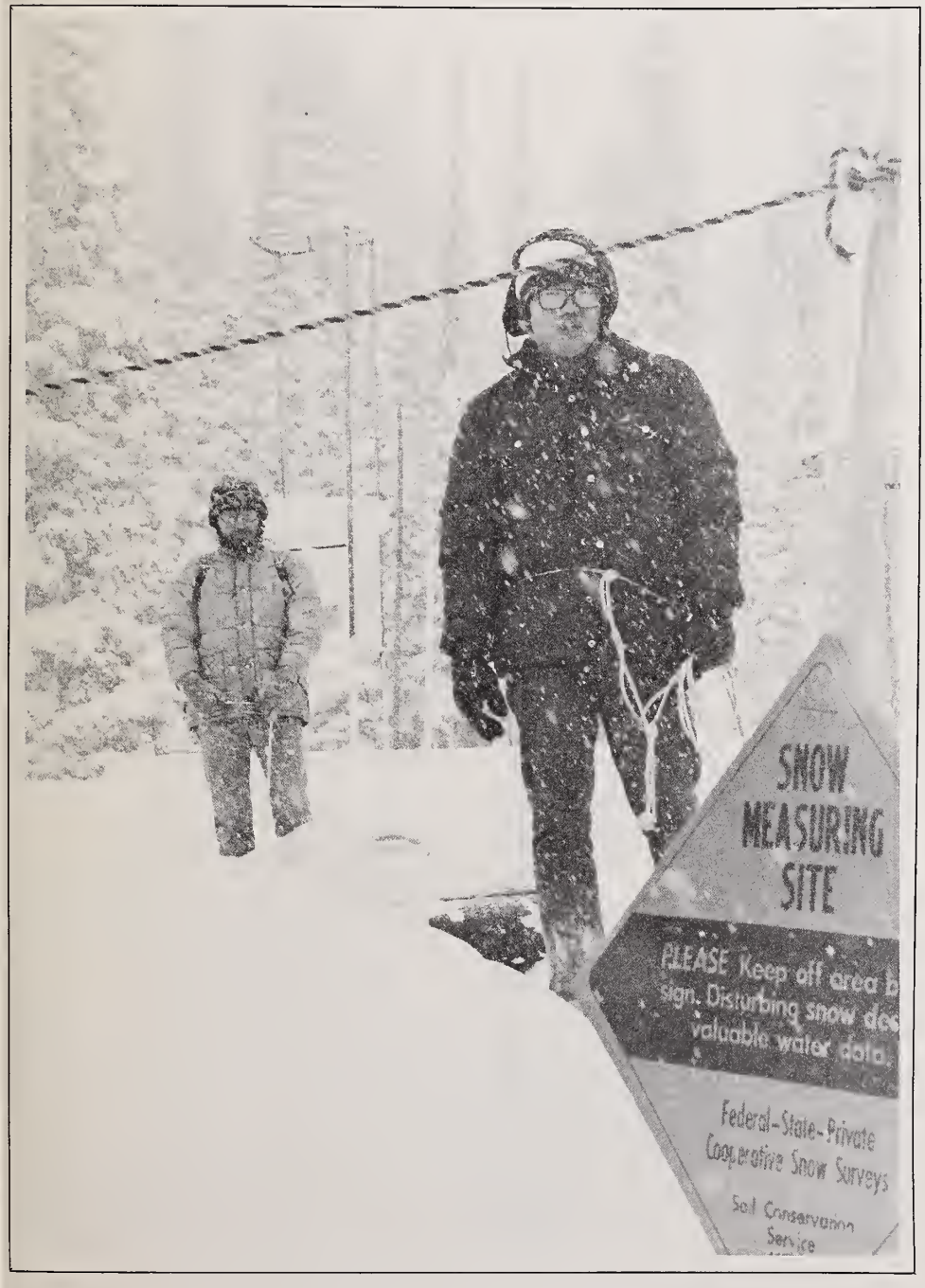
The third award was for the development of a scanning electron microscope (SEM) micrometer scale, essentially a very small, highly accurate ruler that allows researchers to calibrate the magnification of SEM's in the 2,000 to 40,000 magnification range with unprecedented accuracy. The award was for the novel fabrication technique used to make the micrometer scales sufficiently precise.

The micrometer scale is now available as an NBS Standard Reference Material (SRM). The SRM's represent another important facet of the Bureau's work in measurement technology—the development of ways to transfer accurate measurements from NBS laboratories to the workplace.

A World of Standard References

NBS Standard Reference Materials are recognized throughout industry and commerce as important and sometimes indispensable measurement tools. There are currently over 1000 different SRM's, all substances or artifacts that have been carefully analyzed and documented for their composition or mechanical and other properties. The SRM's are

A cooperative NBS-U.S. Forest Service program is aimed at improving avalanche-predicting techniques through better snow measurement methods. Fred McGehan and Douglas Tamura prepare to use an NBS-developed instrument based on microwave sensing, which will measure snow depth, water content, hardness, and stratification beneath the surface.



used in turn to calibrate or test other measuring instruments and evaluate the effectiveness with which they are used.

Last year 82 new SRM's were added to the list. The range of applications is quite broad. SRM 1821, for example, is 99.9+ percent pure ethanol, used to calibrate the blood and breath alcohol test equipment used by police departments. SRM's 1570, 1573, and 1576 are spinach, tomato leaves, and pine needles, respectively, that have been certified for their content of 16, 12, and 13 different trace elements such as manganese, phosphorus, copper, and lead. They are used to calibrate and test the analytic tools and measurement procedures used by environmental and agricultural scientists.

Chemists in the highly successful clinical NBS SRM program—over 20 clinical reference materials have been produced to date—added SRM's for bovine serum (926 and 927) which will be used around the world through the World Health Organization to check the performance of analytic methods for sera.

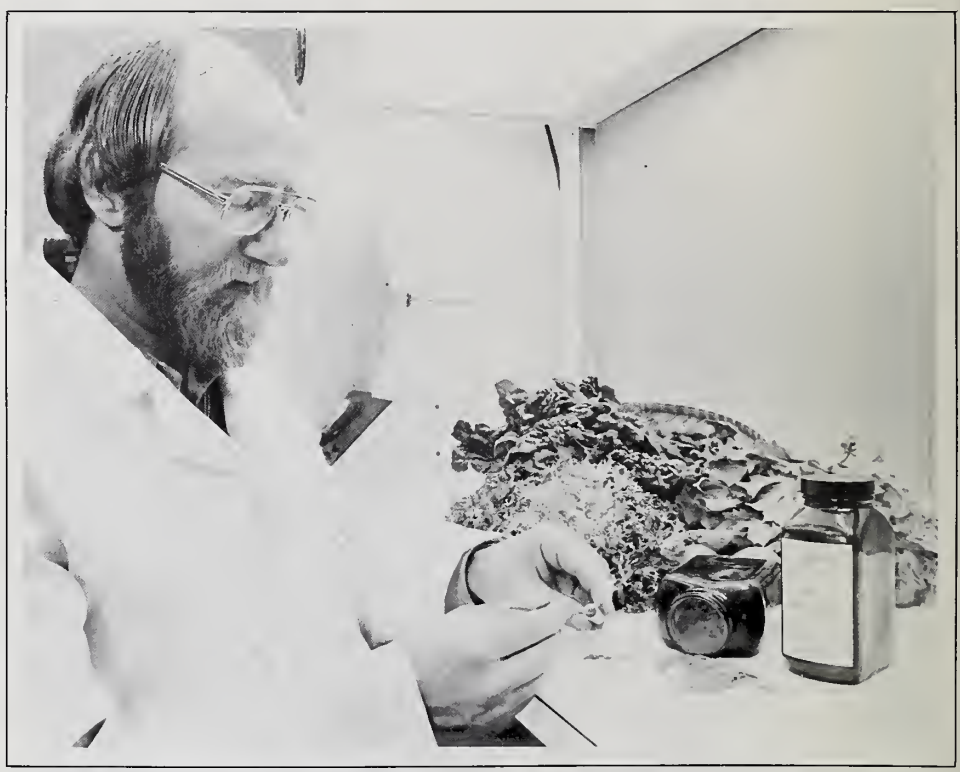
Standard Reference Materials can look like anything, from fine powders to thermometers nestled in velvet. An important thermometry SRM developed last year looks like silvery metal. SRM 1968 is 99.99999 percent pure gallium, a metal that can be used as a fixed temperature reference point because its melting point has been established—within 0.0007 degree—as 29.7723 °C. This reference standard is particularly important because it falls very near 30 °C, a temperature used frequently in diagnostic tests in clinical chemistry

NBS chemist Harry Rook checks bottle of "standard spinach" in which 27 trace elements have been determined. The standard is used to calibrate instruments that test for toxic substances present in minute quantities in the Food and Drug Administration's sample "market basket" survey of fruits and vegetables.

NBS researchers used a new nondestructive evaluation technique—neutron xeroradiography—to examine a ceremonial Chinese vessel for the Smithsonian Institution.

and one that must often be controlled accurately.

Also, NBS offers over 50 Standard Reference Materials related to the measurement of air pollutants, including such recent additions as SRM's for methane, propane, and sulfur dioxide concentrations in air.



In the Air

But the environmental SRM's are just one of the programs aimed at improving the quality of air pollution measurements—an important goal in the eyes of both the U.S. regulatory agencies and the industries they regulate.

Scientists in the NBS reactor radiation group have been working with colleagues from the University of Maryland to apply techniques of neutron activation analysis to the problem of tracing airborne particles of pollutants to their sources. Last year in the Washington, D.C., area, the group was able to trace no fewer than 30 separate elements—including things like lead, barium, arsenic, and mercury—to their sources. The method permits a quantitative analysis, so that the researchers were able to say, for example, that motor vehicles are the major sources of lead and chlorine, while coal combustion produces the most arsenic and vapor-phase mercury.

In related work, analytical chemists and physicists at the Bureau were applying the recently developed laser-Raman microprobe (an advanced type of spectrograph for work on a microscopic level) to the problem of identifying very small quantities of pollutants such as pesticides. This new

analytic technique allows scientists to identify pesticides—and even distinguish between two different pesticides with closely related structures—in samples as small as a single particle three-millionths of a meter in diameter and weighing as little as one-billionth of a gram.

Other chemists at NBS have turned to the laser to devise a precise new method to measure the size and distribution of airborne particles and aerosols. Called a particle Doppler shift spectrometer, the new instrument not only measures the size of particles drifting in a column of air, but also estimates the number of particles of each size. Particles from 3 to 10 micrometers in radius can be

measured with an accuracy of 0.08 micrometers and in quantities up to 10^5 per cubic centimeter.

Air pollution problems are also approached theoretically in the several NBS laboratories studying the chemical processes that go on in the earth's atmosphere. NBS research has contributed substantially to the study of the effect of halogens released from the breakdown of halocarbons on the planet's protective ozone layer. One such contribution was the discovery last year that small amounts of halogens that have harmful effects in the upper atmosphere can dissociate harmlessly at ground level if the molecules are first adsorbed onto sand or quartz particles. Although the amounts involved are comparatively small, the discovery of such a previously unsuspected photochemical reaction has important implications for atmospheric chemistry.

Careful studies of other ground level reactions last year resulted in the discovery of a previously unknown molecular species. Research on the complex chain of reactions that occur when hydrocarbons, from sources such as automobile exhausts, combine with ozone led to the development of a new analytic tool. By operating a microwave absorption cell at cryogenic temperatures, researchers were able to observe in "slow motion" reactions that at normal temperatures happen too fast to be analyzed. One result was the discovery of a previously unobserved ring form of methylene peroxide, dioxirane, an important step in identifying the reaction sequence.

Such studies of chemical processes result in one of the more important products of the National Bureau of Standards—accurate data.

Facts and Figures

In the field of nuclear fusion power, NBS has several efforts underway to supply the engineers and scientists designing these future energy sources with the reliable data they need. These projects deliver such information as spectral line data for highly ionized forms of metals and gases that is vital in diagnosing energy losses in reactors due to impurities in the plasma stream.

Other products include data on the mechanical and thermophysical properties at cryogenic temperatures of the materials that may be used in superconducting magnets for one type of fusion energy system.

Fusion research draws heavily on three unique data centers maintained at NBS: the center for atomic energy levels, one for transition probabilities (the shift of an atom from one energy level to another under excitation), and (at the Joint Institute for Laboratory Astrophysics) a data center of atomic collision processes.

These centers—internationally recognized as unique information resources—are part of the Bureau's National Standard Reference Data System (NSRDS).

Founded in 1963, the NSRDS is one of the Bureau's major elements in the Nation's scientific support structure. Through the NSRDS, the Bureau coordinates the activities of over 40 different data centers at laboratories, universities, and industrial firms across the country. The data centers not only collect, but more importantly, evaluate critically all the available scientific data in a variety of key areas.

NSRDS projects include, for example, the publication of surveys of data sources—comprehensive publications that emphasize the location of reliable sources of data, from handbooks and publications, to trade associations, to information centers. The fourth in the Critical Surveys series, *Electrical and Magnetic Properties of Metals,* was published last year.

Another NSRDS event last year was the establishment of a new data center—the National Center for Thermodynamic Data of Minerals. The center is run in cooperation with the U.S. Geological Survey, which has a recognized competence in the area. The information collected—data on thermodynamic properties of minerals and other geological materials—includes a large amount of data that, after being carefully evaluated for accuracy and reliability, will be disseminated to a large segment of the scientific or industrial community.

Accurate data—and accurate instruments—are the hallmarks of the National Bureau of Standards. These underlie the Bureau's major contribution to the art of technology transfer—the assurance that in any exchange of information or know-how both sides are measuring the same thing, using the same data, and speaking the same scientific language.

Funds and Facilities

To carry out its research and services, NBS operates modern physical plants in two locations. In Gaithersburg, Maryland, located north of Washington, D.C., NBS has 27 buildings in a campus-like setting on 230 hectares (1 hectare equals 2.5 acres). The Bureau has 14 buildings on 83 hectares in Boulder, Colorado. The Joint Institute for Laboratory Astrophysics, cosponsored by NBS and the University of Colorado, is also located in Boulder. Here scientists carry out studies in atomic and molecular physics.

In Ft. Collins, Colorado, NBS radio stations WWV and WWVB broadcast standard time and frequency information. Another station, WWVH, broadcasts from Kauai, Hawaii. The Bureau also has a facility in Clearing, Illinois, with a railway master track scale and two railway test cars that are used to calibrate master track scales owned by railroads around the country.

As one of the Nation's largest physical science laboratories, the Bureau houses a number of special facilities and equipment. A high flux nuclear research reactor is used daily by scientists from NBS, other agencies, and universities in projects ranging from nuclear theory to analysis of food contaminants. Another facility, the Synchrotron Ultraviolet Radiation Facility (SURF), is one of the few of its kind in North America. Having been converted into a storage ring, SURF is now capable of producing intense short wavelength ultraviolet radiation, which is especially useful for radiometry in studies of controlled nuclear fusion energy sources and atmospheric and space science programs.

NBS Boulder laboratories.

Among other NBS facilities are a cryogenic flow research facility, a fire research laboratory, an experimental computer facility, and anechoic and reverberation chambers. In addition, an extensive instrument shops division answers specialized research needs. Shop capabilities include glass blowing, optics, and metalworking.

Many of the Bureau's facilities are available for use by the scientific and engineering communities. These facilities are described more fully in *Special Technical Facilities at the National Bureau of Standards.* This 50-page booklet is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, and may be ordered by Stock No. 003-003-01601-2/1976 Ed., for $1.35.

The Bureau's budget for FY 1977 was $123.4 million. Direct Congressional appropriations accounted for about 55 percent of NBS funds, with an additional 40 percent resulting from work performed by NBS for other government agencies. The sale of NBS goods and services, such as Standard Reference Materials and calibrations, provided the final 5 percent. Support for Bureau programs from other agencies reflects NBS' role as a major physical sciences research laboratory for the entire Federal government.

TOTAL NBS OPERATING FUNDS (All Sources)
(in million of dollars)

	Fiscal 1976 (actual)	Fiscal 1977 (actual)	Fiscal 1978 (est.)*
Provide a national system for physical measurement	39.4	41.0	41.7
Physical measurements, units and standards	26.7	28.9	28.7
Reference measurements for physical quantities	12.7	12.1	13.0
Provide services to improve use of materials	28.2	32.1	33.2
Properties and performance of materials	21.3	24.0	24.5
Reference materials	2.5	3.0	3.1
Environmental pollution measurements	4.4	5.1	5.6
Provide services to improve the application of technology	30.3	35.0	36.1
State weights and measures services	.7	.7	.8
Voluntary engineering standards	2.0	2.4	2.9
Building science and technology	12.9	14.4	15.6
Electronic technology	3.8	3.8	4.1
Product performance and safety	6.4	7.3	6.0
Fire research	4.5	6.4	6.7
Improve the application of computer technology	7.7	8.8	8.7
Support services to other agencies	3.0	3.4	3.6
Experimental Technology Incentives Program	4.9	3.1	3.2
TOTAL	113.5	123.4	126.5

*Excludes facilities and pending supplementals for pay raise and recycled oil program.

People

Guided by the NBS Executive Board, the Bureau staff works to increase measurement competence and share its scientific and technical expertise with the scientific community, industry, and the public.

The NBS Executive Board oversees the efforts of the entire Bureau staff. The Executive Board is provided valuable aid in these oversight functions by a series of evaluation panels appointed by the National Academy of Sciences (National Research Council). At the top of these evaluation and advisory functions is the NBS Visiting Committee, created by the Bureau's Organic Act and responsible for reporting annually to the Secretary of Commerce "upon the efficiency of its scientific work and the condition of its equipment."

The staff has grown from its original 11 in 1901 to about 3100 full-time employees. Approximately 2600 are located in Gaithersburg, Maryland, with the remainder in Boulder, Colorado. More than 1400 Bureau staff members are physical scientists and engineers, and more than 44 percent of the research and scientific staff have earned doctorates. The research and scientific staff, the largest percentage of the NBS staff, is supported by administrative, clerical, housekeeping, and groundskeeping personnel. The staff also includes almost 300 technicians.

The contributions of NBS employees to the advancement of science and technology are often recognized by outside organizations. During the fiscal year, those staff members honored by independent and professional organizations included:

MARSHALL D. ABRAMS of the Computer Networking Section received the Honor Roll Award of the Institute of Electrical and Electronics Engineers for his active role in support of the highly successful Trends and Applications Symposia series.

ERNEST AMBLER, Director of NBS, received the President's Award for Distinguished Federal Civilian Service, which cited him as an internationally recognized scientist and scientific administrator, who has made major contributions to the field of physics and has effectively redirected NBS programs in such areas of high national priority as energy and materials conservation and consumer product safety. He was also the recipient of the William G. Wildhack Award from the National Conference of Standards Laboratories for outstanding contributions to the field of metrology.

DAVID B. BALLARD, FIELDING OGBURN, and JOHN P. YOUNG of the Metallurgy Division received an IR-100 award for development of a micrometer scale for calibrating scanning electron microscopes as one of the year's most significant new technological products from *Industrial Research* magazine.

JOHN L. HALL of the Joint Institute for Laboratory Astrophysics with Siu-Au Lee of the University of Colorado received an IR-100 award for development of a laser wavelength meter as one of the year's most significant new technological products from *Industrial Research* magazine.

PHILIP E. BLOOMFIELD and SEYMOUR EDELMAN of the Polymers Division received the 1976 Army Research and Development Achievement Award for contributions to national security through pioneering research on the use of piezoelectric polymers.

CAROLYN P. BROWN, chief of the Information Services Section, received one of 17 Fellowships awarded to outstanding mid-career librarians by The Council on Library Resources.

GRACE G. BURNS of the Institute for Computer Sciences and Technology was awarded a Princeton University Fellowship in Public Affairs.

ROBERT A. CRIST, chief of the Structures Section, was a joint recipient of the 1976 Raymond C. Reese award from the American Society of Civil Engineers for a paper on shear strength of reinforced concrete.

RUTH M. DAVIS, former director of the Institute for Computer Sciences and Technology, received one of ten Career Service Awards from the National Civil Service League for significant contributions and excellence in government service.

JOHN M. EVANS, JR., acting manager of the Office of Developmental Automation and Control Technology, was presented the 1976 Management Achievement Award by the Society of Manufacturing Engineers.

D. WAYNE HANSON, JOSEPH V. CATEORA, and DICKY D. DAVIS of the Time and Frequency Division

David Ballard, John Young, and Fielding Ogburn (l. to r.) demonstrate the micrometer scale for calibrating scanning electron microscopes for which they won an IR-100 award.

received an IR-100 award for development of a highly accurate satellite-controlled clock as one of the year's most significant new technological products from *Industrial Research* magazine.

LAFAYETTE K. IRWIN of the Mechanics Division received the American Society for Testing and Materials' (ASTM) Award of Merit and was named Fellow of the ASTM for accomplishments in advancing the standardization of methods of mechanical testing.

MADELEINE JACOBS of the Office of Information Activities received three citations from the Society for Technical Communications for authoring a pamphlet, a consumer booklet, and a DIMENSIONS/NBS article on different NBS programs.

DONALD R. JOHNSON of the Office of the Associate Director for Programs received one of the ten Arthur S. Flemming Awards presented each year to outstanding young people in government by the Washington, D.C., Jaycees.

JEROME KRUGER, chief of the Corrosion Section, received the 1976 Willis Rodney Whitney Award from the National Association of Corrosion Engineers for outstanding contributions to the science of corrosion and was the recipient of the Outstanding Achievement Award of the Corrosion Division of the Electrochemical Society for excellence in corrosion research.

STEPHEN R. LEONE of the Quantum Physics Division was awarded an Alfred P. Sloan Foundation Fellowship for exceptional potential to make creative contributions to scientific knowledge early in his career.

FREDERICK P. McGEHAN of the Program Information Office received an Achievement Award from the Society for Technical Communications for preparing the *Metric Style Guide for the News Media.*

MELVIN R. MEYERSON, chief of the Product Systems Analysis Division, received the American National Standards Institute's Standards Medal for 1976 for leadership in the development and application of voluntary standards.

GEORGE A. MOORE of the Metallurgy Division received the George Kimball Burgess Memorial Award for 1977 from the American Society for Metals for outstanding contributions to the field of metallurgy.

NORRIS NAHMAN of the Electromagnetics Division was named Fellow of the Institute of Electrical and Electronics Engineers for contributions to time domain metrology.

JOAN R. ROSENBLATT, chief of the Statistical Engineering Laboratory, was elected to membership in the International Statistical Institute.

THOMAS P. SHEAHEN of the Office of Energy Conservation was selected as a Congressional Fellow by the American Political Science Association.

ROBERT D. STIEHLER in the Center for Building Technology was elected an Honorary Member of the

Inventors Siu-Au Lee and John Hall with the laser lambda meter for which they won an IR-100 award. The laser lambda meter is capable of measuring the wavelength of a laser beam with an accuracy of up to seven significant figures at a rate of four times a second.

American Society for Testing and Materials (ASTM) for service to many interest areas of ASTM and contributions that have advanced the progress of ASTM and its principles.

BARRY N. TAYLOR, chief of the Electricity Division, was elected Fellow of the Institute of Electrical and Electronics Engineers for contributions to the understanding of electron tunneling in superconductors and for leadership in the development of Josephson junction voltage standards.

NBS EXECUTIVE BOARD
Dr. Ernest Ambler
Director

Robert S. Walleigh
Acting Deputy Director

Dr. Arthur O. McCoubrey
Director, Institute for Basic Standards

Dr. John D. Hoffman
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Dr. James R. Wright
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Associate Director for Information Programs

NBS VISITING COMMITTEE
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Chairman July 1, 1976 - June 30, 1977
Vice President
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Chairman July 1, 1977 - June 30, 1978
Senior Vice President
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Professor of Physics
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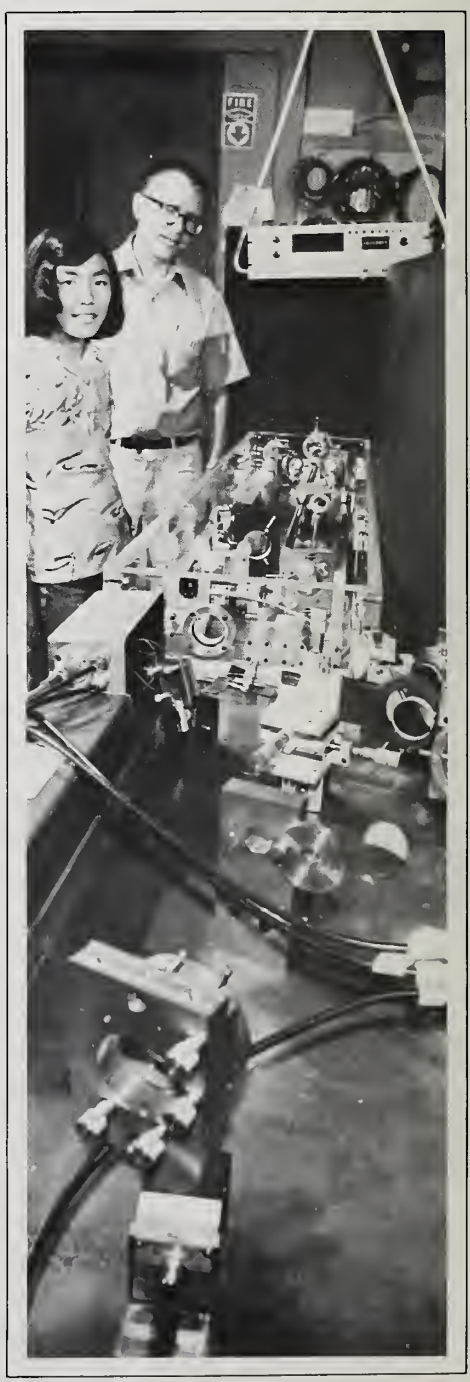

Selected Publications

During the fiscal year ending September 30, 1977, more than 1150 papers appeared in NBS publications and journals. An additional 700 papers were authored by NBS staff members for other journals, books, and proceedings. The following is a selected list of NBS publications issued during this period. Unless otherwise stated, all publications are available at the price indicated from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. There is a 25 percent charge for foreign mailings. For a list of NBS publications, write for Publications of the National Bureau of Standards, NBS Special Publication 305, Supplement 8, Stock No. 003-003-01743-4, $8.25.

Timely reports of both technical and general interest on the work of the National Bureau of Standards are available in the pages of DIMENSIONS/NBS, the Bureau's monthly magazine. A year's subscription is available from the Superintendent of Documents for $12.50.

Measurement Capabilities

Measurements for the Safe Use of Radiation, Sherman P. Fivozinsky, editor. Stock No. 003-003-01682-9, $5.15.

Accuracy in Trace Analysis: Sampling, Sample Handling, Analysis, Philip D. LaFleur, editor. Stock No. 003-003-01458-3, (two-volume set) $20.00.

Flow Measurement in Open Channels and Closed Conduits, Lawrence K. Irwin, editor. Stock No. 003-003-01845-7. (two-volume set) $12.25.

Time and Frequency Users Manual, George Kamas, editor. Stock No. 003-003-01781-7, $2.80.

Energy

Is Hydrogen Safe?, Jesse Hord. Stock No. PB 262551, National Technical Information Service, Springfield, VA 22161, $4.50.

LNG Materials and Fluids Users Manual. Cryogenic Division, National Bureau of Standards, Boulder, CO 80302. Make check or money order for $35 payable to National Bureau of Standards, Department of Commerce.

Energy Management Guide for Light Industry and Commerce, William J. Kelnohofer and Lawrence A. Wood. Stock No. 003-003-01667-5, $.70.

Waste Heat Management Guidebook, Kenneth G. Kreider. Stock No. 003-003-01669-1, $3.50.

Window Design Strategies to Conserve Energy, S. Robert Hastings and Richard W. Crenshaw. Stock No. 003-003-01794-9, $3.75.

Applications of Thermography for Energy Conservation in Industry, Charles W. Harley and Kenneth G. Kreider. Stock No. 003-003-01679-9, $.75.

Thermophysical Properties of Ethane from 90 to 600 K at Pressures to 700 Bar, Robert D. Goodwin, Hans M. Roder, and Gerald C. Straty. Stock No. 003-003-01732-9, $3.85.

Metric Information

Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction, Hans J. Milton. Stock No. 003-003-01761-2, $1.60.

Metrication and Dimensional Coordination-A Selected Bibliography. Stock No. 003-003-01684-5, $.75.

The International System of Units (SI), 1977 Edition. Stock No. 003-003-01784-1, $1.60.

Computer Science

Data Base Directions-The Next Steps, John L. Berg, editor. Stock No. 003-003-01662-4, $3.00.

Data Encryption Standard. FIPS PUB 46, National Technical Information Service, Springfield, VA 22161, $3.50.

Computer Science and Technology Publications (bibliography) L.P. 84, Institute for Computer Sciences and Technology, National Bureau of Standards, Washington, DC 20234, Free.

Computers, Health Records, and Citizen Rights, Alan F. Westin. Stock No. 003-003-01681-1, $4.55.

Health and Safety

Home Security Alarms: What They Are And How They Work. Consumer Information Center, Pueblo, CO 81009, Free.

Smoke Detectors: What They Are And How They Work. Consumer Information Center, Pueblo, CO 81009, Free.

Thermal Analysis-Human Comfort-Indoor Environments, B. W. Mangum and James E. Hill, editors. Stock No. 003-003-01849-0, $3.25.

Ultrasonic Tissue Characterization, Melvin Linzer, editor. Stock No. 003-003-01700-1, $3.55.

Voluntary Product Standard for Toy Safety (PS 72-76), Stock No. 003-003-01702-7, $1.40.

Building and Construction

Buildings to Resist the Effect of Wind: Volume I, Overview, Noel J. Raufaste, Richard D. Marshall, and S. A. Kliment. Stock No. 003-003-01717-5, $1.40.

Volume 2, Estimation of Extreme Wind Speeds and Guide to the Determination of Wind Forces, Emil Simiu, and Richard D. Marshall. Stock No. 003-003-01718-3, $1.30.

Volume 3, A Guide for Improved Masonry and Timber Connections in Buildings, S. George Fattal, G. E. Sherwood, and T. L. Wilkinson. Stock No. 003-003-01719-1, $2.00.

Volume 4, Forecasting the Economics of Housing Needs: A Methodological Guide, Joseph G. Kowalski. Stock No. 003-003-01720-5, $1.50.

Volume 5, Socio-Economic Aspects of Housing in Extreme Winds, S. A. Kliment. Stock No. 003-003-01721-3, $1.50.

Miscellaneous

Science and Technology in America-An Assessment, Papers of the NBS Distinguished Lecture Series. Stock No. 003-003-01728-1, $2.50.

Color: Universal Language and Dictionary of Names, Kenneth L. Kelly. Stock. No. 003-003-01705-1, $3.25.

Index of U.S. Nuclear Standards, William J. Slattery. Stock No. 003-003-01822-8, $2.75.

Summary of Legislation

Highlights of the NBS Organic Act

15 U.S.C. 271. Bureau established
The Office of Standard Weights and Measures shall be known as the National Bureau of Standards. Mar. 3, 1901.
15 U.S.C. 272, Functions of the Secretary
The Secretary of Commerce is authorized to undertake the following functions:

(a) 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 used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government.

(b) The determination of physical constants and properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

(c) The development of methods for testing materials, mechanisms, and structures, and the testing of materials, supplies, and equipment, including items purchased for use of Government departments and independent establishments.

(d) Cooperation with other governmental agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications.

(e) Advisory service to Government agencies on scientific and technical problems.

(f) Invention and development of devices to serve special needs of the Government...
15 U.S.C. 273, Functions: for whom exercised
The Bureau is authorized to exercise its functions for the Government of the United States and for international organizations of which the United States is a member, for governments of friendly countries; for any State or municipal government within the United States; or for any scientific society, educational institution, firm, corporation or individual within the United States or friendly countries engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments: provided, that the exercise of these functions for international organizations, governments of friendly countries and scientific societies, educational institutions, firms, corporations or individuals therein shall be in coordination with other agencies of the United States Government, in particular, the Department of State in respect to foreign entities.

Federal Fire Prevention and Control Act of 1974 (Public Law 93-498)

Fire Research Center

Sec. 18. The Act of March 3, 1901 (15 U.S.C. 271 et seq.), is amended by striking out sections 16 and 17 (as added by Title I of the Fire Research and Safety Act of 1968) and by inserting in lieu thereof the following new section: Sec. 16 (a) There is hereby established within the Department of Commerce a Fire Research Center which shall have the mission of performing and supporting research on all aspects of fire with the aim of providing scientific and technical knowledge applicable to the prevention and control of fires. The content and priorities of the research program shall be determined in consultation with the Administrator of the National Fire Prevention and Control Administration. In implementing this section, the Secretary is authorized to conduct, directly or through contracts or grants, a fire research program, including—

(1) basic and applied fire research for the purpose of arriving at an understanding of the fundamental processes underlying all aspects of fire,

(2) research into the biological, physiological, and psychological factors affecting human victims of fire, and the performance of individual members of fire services, and

(3) operation tests, demonstration projects, and fire investigations in support of the activities set forth in this section.

The Secretary shall ensure that the results and advances arising from the work of the research program are disseminated broadly. He shall encourage the incorporation, to the extent applicable and practicable, of such results and advances in building codes, fire codes, and other relevant codes, test methods, fire service operations and training, and standards. The Secretary is authorized to encourage and assist in the development and adoption of uniform codes, test methods, and standards aimed at reducing fire losses and costs of fire protection.

Members of NBS' Office of Energy-Related Inventions have evaluated thousands of ideas submitted by inventors and small businesses in a search for promising energy-related inventions. Those that are found promising are recommended to the Department of Energy for financial or marketing assistance.

Other Statutory Authorities of NBS Programs

Brooks Act (Public Law 89-306) 40 U.S.C. 759(f)

The Secretary of Commerce is authorized

(1) to provide agencies, and the Administrator of General Services in the exercise of the authority delegated in this section with scientific and technological advisory services relating to automatic data processing and related systems, and

(2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. The Secretary of Commerce is authorized to undertake the necessary research in the sciences and technologies of automatic data processing computer and related systems, as may be required under provisions of this subsection.

Resource Conservation and Recovery Act of 1976 (Public Law 94-580)

This Act establishes in the Environmental Protection Agency, an Office of Solid Waste to provide technical and financial assistance to State and regional agencies and to utilize information, facilities, personnel, and other resources of Federal agencies, including the National Bureau of Standards and the Census Bureau, on reimbursable basis, to perform research and analyses and conduct studies and investigations related to resource recovery and conservation and to otherwise carry out the Administrator's functions under this Act.

The Secretary of Commerce, acting through the National Bureau of Standards, and in conjunction with national standards-setting organizations in resource recovery, shall, after public hearings, and not later than 2 years after the date of enactment of this Act, publish guidelines for the development of specifications for the classification of materials recovered from waste which were destined for disposal. The specifications shall pertain to the physical and chemical properties and characteristics of such

materials with regard to their use in replacing virgin materials in various industrial, commercial, and governmental uses. In establishing such guidelines, the Secretary shall also, to the extent feasible, provide such information as may be necessary to assist Federal agencies with procurement of items containing recovered materials. The Secretary shall continue to cooperate with national standards-setting organizations, as may be necessary, to encourage the publication, promulgation and updating of standards for recovered materials and for the use of recovered materials in various industrial, commercial, and governmental uses.

Fair Packaging and Labeling Act (Public Law 89-755)

Informed consumers are essential to the fair and efficient functioning of a free market economy. Packages and their labels should enable consumers to obtain accurate information as to the quantity of the contents and should facilitate value comparisons. Therefore, it is hereby declared to be the policy of the Congress to assist consumers and manufacturers in reaching these goals in the marketing of consumer goods.

Whenever the Secretary of Commerce determines that there is undue proliferation of the weights, measures, or quantities in which any consumer commodity or reasonably comparable consumer commodities are being distributed in packages for sale at retail and such undue proliferation impairs the reasonable ability of consumers to make value comparisons with respect to such consumer commodity or commodities, he shall request manufacturers, packers, and distributors of the commodity or commodities to participate in the development of a voluntary product standard for such commodity or commodities under the procedures for the development of voluntary product standards established by the Secretary pursuant to section 2 of the Act of March 3, 1901 (31 Stat. 1449, as amended; 15 U.S.C. 272). Such procedures shall provide adequate manufacturer, packer, distributor, and consumer representation.

If (1) after one year after the date on which the Secretary of Commerce first makes the request of manufacturers, packers, and distributors to participate in the development of a voluntary product standard as provided in subsection (d) of this section, he determines that such a standard will not be published pursuant to the provisions of such subsection (d), or (2) if such a standard is published and the Secretary of Commerce determines that it has not been observed, he shall promptly report such determination to the Congress with a statement of the efforts that have been made under the voluntary standards program and his recommendation as to whether Congress would enact legislation providing regulatory authority to deal with the situation in question.

Standard Reference Data Act (Public Law 90-396)

The Congress hereby finds and declares that reliable standardized scientific and technical reference data are of vital importance to the progress of the Nation's science and technology. It is therefore the policy of the Congress to make critically evaluated reference data readily available to scientists, engineers, and the general public. It is the purpose of this Act to strengthen and enhance this policy.

The Secretary is authorized and directed to provide or arrange for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data. In carrying out this program, the Secretary shall, to the maximum extent practicable, utilize the reference data services and facilities of other agencies and instrumentalities of the Federal Government and of State and local governments, persons, firms, institutions, and associations, with their consent and in such a manner as to avoid duplication of those services and facilities. All agencies and instrumentalities of the Federal Government are encouraged to exercise their duties and functions in such manner as will assist in carrying out the purpose of this Act. This section shall be deemed complementary to existing authority, and nothing herein is intended to repeal, supersede, or diminish existing authority or responsibility of any agency or instrumentality of the Federal Government.

Noise Control Act of 1972 (42 USC 4907)

This Act authorizes the Environmental Protection Agency to develop improved methods and stan-

dards for measuring and monitoring noise in cooperation with the National Bureau of Standards.

Federal Nonnuclear Energy Research and Development Act of 1974 (Public Law 93-577, Sec. 14. Energy-Related Inventions)

The National Bureau of Standards shall give particular attention to the evaluation of all promising energy-related inventions, particularly those submitted by individual inventors and small companies for the purpose of obtaining direct grants from the Administrator (of the Energy Research and Development Administration which is now a part of the U.S. Department of Energy). The National Bureau of Standards is authorized to promulgate regulations in the furtherance of this section (42 U.S.C. 5913).

Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409)

Under various sections of the Act, NBS will assist the Department of Housing and Urban Development (HUD) in determining interim performance criteria for solar heating and combined solar heating and cooling components and systems to be used in residential dwellings and interim performance criteria (relating to suitability for solar heating and cooling) for such dwellings themselves. NBS will also work with HUD to establish test procedures and definitive performance criteria for solar heating and cooling components and systems and suitable dwellings. In addition, NBS will aid in monitoring and evaluating the performance and operation of solar heating and combined solar heating and cooling systems installed in residential dwellings under this Act.

Energy Policy and Conservation Act (Public Law 94-163)

This 1975 Act provides for an energy conservation program for consumer products other than automobiles. The Act states that the Administrator of the Federal Energy Administration (now part of the U.S. Department of Energy) shall direct NBS to develop test procedures for determination of (A) estimated annual operating costs of covered products....(B) at least one other useful measure of energy consumption of such products which FEA determines is likely to assist consumers....

In addition, the Act encourages the recycling of used oil and promotes the use of recycled oil. NBS shall develop test procedures for the determination of substantial equivalency of re-refined or otherwise processed used oil and new oil or additives with new oil for a particular end use. As soon as practicable after development of such test procedures, NBS shall report such procedures to the Federal Trade Commission.

Energy Conservation and Production Act (Public Law 94-385)

This 1976 Act amends the Energy Policy and Conservation Act providing that FEA shall direct NBS to develop energy efficiency improvement targets for major energy consuming household products. The Act requires the Department of Housing and Urban Development (HUD), in consultation with FEA, Commerce, NBS, and GSA to develop and promulgate performance standards for new commercial and residential buildings within three years. HUD is also directed to use services of the National Institute for Building Sciences.

Metric Conversion Act of 1975 (Public Law 94-168)

Under this law, it is provided that "Consultation by the Secretary of Commerce with the National Conference of Weights and Measures in order to assure that State and local weights and measures officials are appropriately involved in metric conversion and assisted in their efforts to bring about timely amendments to laws .... Financial and administrative services, ... needed by the Board, may be obtained by the Board from the Secretary of Commerce ...."

Consumer Product Safety Act (15 U.S.C. 2056)

This 1972 law directs the Consumer Product Safety Commission to "utilize the resources and facilities of the National Bureau of Standards, ..., to perform research and analyses related to risks of injury associated with consumer products, develop test methods, conduct studies and investigations, and provide technical advice and assistance ...."

Directory

As we were going to press, the NBS reorganization was approved and put into effect. The three major goals of the reorganization were to organize the Bureau along major functional lines, to consolidate technical competences, and to permit greater staffing flexibility. Organizational references made earlier in the text are to the structure that was in place during fiscal year 1977. This Directory reflects the new organizational structure.

NBS technical work is carried out in the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. These groups are supported by the Office of the Director of Administrative and Information Systems; the Office of the Director, NBS/Boulder Laboratories; and the Office of the Associate Director for Programs, Budget, and Finance. This amalgam of people and programs forms a community dedicated to service. The interdisciplinary approach allows NBS to provide the Nation with scientific measurements of high precision and accuracy, coupled with actual solutions for current technological problems.

This report has only highlighted some of the Bureau's programs. For more information on specific projects contact the people listed in this directory. To reach members of the Gaithersburg, Md., staff, dial (301) 921 + extension or write to the National Bureau of Standards, Washington, D.C. 20234. Bureau staff located in Boulder, Colo., can be contacted on (303) 499-1000 or at the National Bureau of Standards, Boulder, Colo. 80303. Boulder staff members are designated in the directory with asterisks.

General tours of the Gaithersburg facility are given at 1:30 p.m. on Tuesdays and 9:30 a.m. on Fridays. Special tours can be arranged by calling (301) 921-2721. For tours of the Boulder site, call (303) 499-1000 ext. 3244 to make arrangements. Members of the news media should call (301) 921-3181 for assistance.

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The Office of the Associate Director for Programs, Budget, and Finance plans, develops, and evaluates Bureau-level programs and formulates and carries out policies and strategies for programmatic, budgetary, and financial matters. It develops techniques for and coordinates the review of technical and overhead programs; serves as the NBS Director's staff for Bureau-level programmatic, budget formulation and execution, and finance matters; and develops and maintains mechanisms to monitor planned and actual use of resources by providing integrated, evaluated information on program progress, opportunities, and resources to the NBS Director. In addition, the Office advises management on significant changes and deviations and recommends program, budget, finance, and accounting priorities to the NBS Director.

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The Office of the Director of Administrative and Information Systems directs the management of Bureau-wide facilities and information and administrative systems including information and office services, procurement, technical and public information functions, Bureau-wide computing, personnel, and management consulting services, health, safety, and security functions, as well as physical plant, facilities, space management, and instruments shops functions. The Office also decides on policies and plans and directs implementation actions to assure the responsiveness of these services to the needs of the technical programs.

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Office of the Director, NBS/Boulder Laboratories

The Office of the Director, NBS/Boulder Laboratories, which is located in Boulder, Colo., provides administrative support to the technical programs of the NBS/Boulder Laboratories. These laboratories conduct research comprising work on measurement science for the National Measurement Laboratory in time and frequency, quantum physics, thermodynamics, materials science, and the development of essential technical data in quantum physics, thermodynamics, and materials science. The laboratories also carry out programs for the National Engineering Laboratory in electromagnetics and fluid dynamics.

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National Measurement Laboratory

The National Measurement Laboratory provides the national system of physical, chemical, and materials measurement; coordinates the system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce. It conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and government. NML also furnishes advisory and research services to other government agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services.

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Institute for Computer Sciences and Technology

The Institute for Computer Sciences and Technology conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in government operations in accordance with Public Law 89-306, relevant Executive Orders, and other directives. ICST carries out this mission by managing the Federal Information Processing Standards Program, developing Federal automatic data processing (ADP) standards guidelines, and managing Federal participation in ADP voluntary standardization activities. In addition, ICST provides scientific and technological advisory services and assistance to Federal agencies; furnishes the technical foundation for computer-related policies of the Federal government; and assists in the resolution of the issues of technology transfer and exportation of computers in international trade.

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The National Engineering Laboratory furnishes technology and technical services to users in the public and private sectors to address national needs and to solve national problems in the public interest. NEL conducts research in engineering and applied science in support of objectives in these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; and develops engineering data and measurement capabilities. NEL also provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; and develops and improves mechanisms to transfer results of its research to the ultimate user.

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