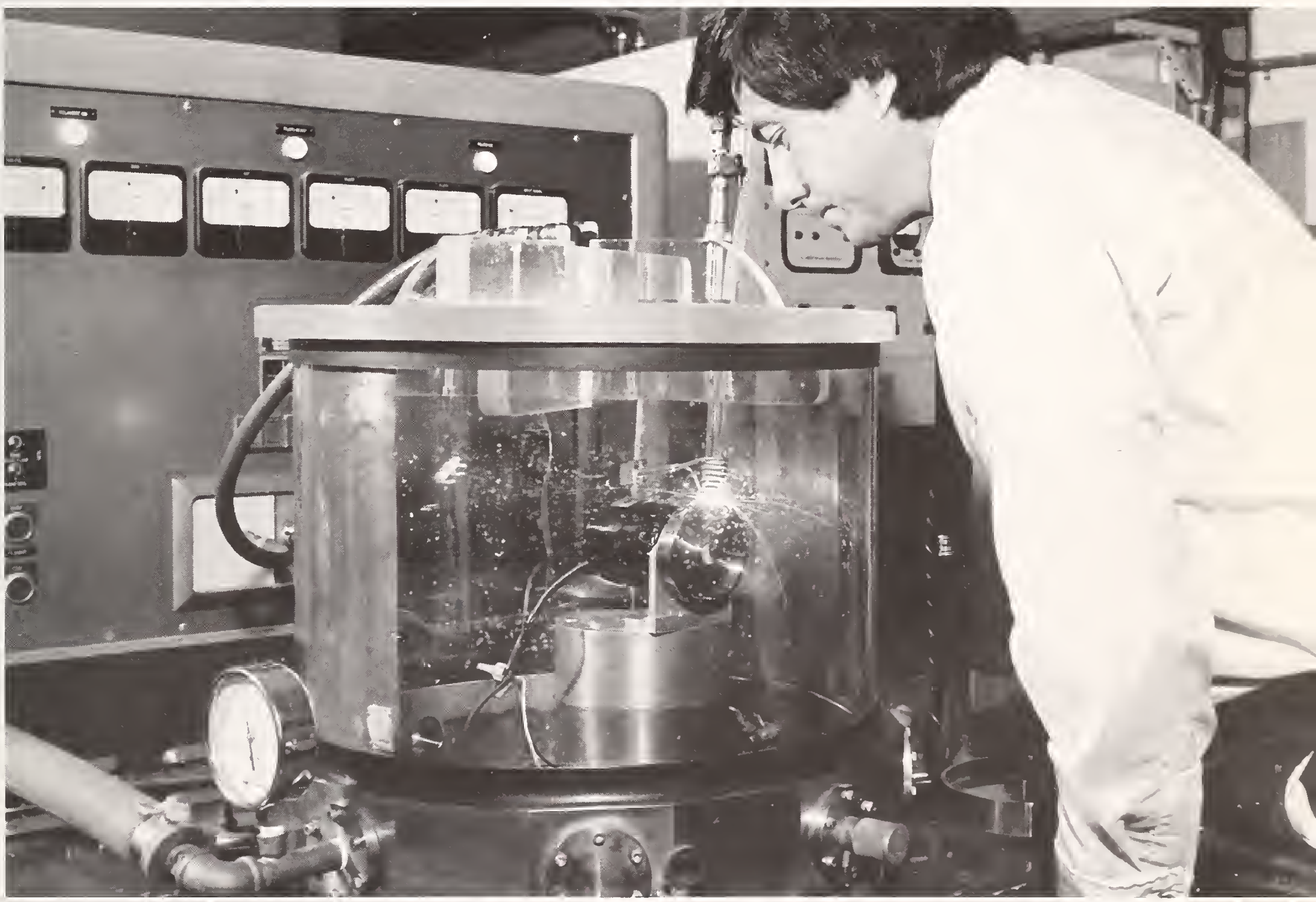
NATIONAL BUREAU OF STANDARDS

NBS Research Reports



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
NBS SPECIAL PUBLICATION 680-2

Cover photo: Metallurgist Frank Biancaniello prepares a rapidly solidified metallic glass ribbon on a melt spinning apparatus for studies on the properties of rapidly solidified metal alloys.
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NBS Research Reports

U.S. DEPARTMENT OF COMMERCE
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RADIATION DAMAGE TO DNA MEASURED WITH NEW METHOD

A research associate at the NBS Center for Radiation Research has developed an improved method for measuring radiation-induced damage to specific sites in the DNA molecule. Dr. Miral Dizdaroglu uses a technique called capillary gas chromatography-mass spectroscopy to isolate and identify radiation-induced products of all four DNA bases in a single experimental run. The technique is expected to be particularly useful to researchers seeking to understand biochemical mechanisms for repairing damaged DNA. Changes to the four DNA bases—adenine, guanine, thymine, and cytosine—whether caused by radiation, chemicals, or natural processes, are believed to play an important role in processes that cause cancer or mutation.

REFERENCE MATERIALS DESIGNED FOR "THIN" SPECIMENS

Laboratories that use x-ray fluorescence spectrometry for elemental analysis of "thin" specimens such as airborne pollutants or toxic particles in waste water can now calibrate instruments reliably using either of two new NBS Standard Reference Materials (SRM's). Developed in cooperation with the U.S. Environmental Protection Agency (EPA), the materials were produced initially to assist EPA in measuring various elemental particles from ambient air samples gathered on filters. But besides being used to calibrate x-ray spectrometers, the SRM's may be used by manufacturers as a "yardstick" in the production of commercial secondary standards, which have not been traceable to an internationally recognized standard before now.

Each SRM consists of a 0.55-micrometer-thick glass film deposited onto a polycarbonate filter mounted on an aluminum ring and contains known concentrations of various elements. One of the new materials, SRM 1832, is certified for the concentrations of aluminum, silicon, calcium, vanadium, manganese, cobalt, and copper. Its companion, SRM 1833, is certified for silicon, potassium, titanium, iron, zinc, and lead. The new SRM's are $398 each and are available from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Gaithersburg, MD 20899, 301/921-2045.

NEW GENERATION OF SMALL ATOMIC CLOCKS DEVELOPED

Scientists in the NBS Time and Frequency Division have developed a new generation of miniaturized, passive hydrogen clocks that are far superior to presently available portable cesium clocks; they keep time to within less than 4 nanoseconds (billionths of a second) per week versus 20 nanoseconds for portable cesium clocks. The new hydrogen clocks have a frequency stability and timekeeping ability which is far superior to any presently available portable cesium device, according to a recent NBS report.

The NBS clock weighs 30 kg and is 26.7 cm tall, 66 cm deep, and 49.5 cm wide. It will be used for precision timing in conjunction with satellite-based navigation and communications systems, where portability and precision are especially crucial. Commercial production of a clock based on the NBS design is expected shortly. A copy of a paper describing the new clock is available from Fred McGehan, Division 360.2, National Bureau of Standards, Boulder, CO 80303.

FIRST COMPOSITE SUPERCONDUCTOR SRM ON SALE

The first composite superconductive wire Standard Reference Material (SRM 1457) has been certified for critical current at various magnetic fields from 2 to 8 tesla and temperatures between 3.9 and 4.24 K. The SRM consists of 2.2 m of multifilament niobium-titanium wire, stabilized with copper, and evaluated for 34 parameters relating to current, voltage, magnetic field, temperature, strain, and physical sample characteristics. Used with ASTM standard test method B714-82 (D-C Critical Current of Composite Superconductors), the SRM will provide calibrations of instrumentation used for measuring key parameters of superconductor products. Orders may be placed with the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Gaithersburg, MD 20899, 301/921-2045. Price is $219 per unit of 2.2 m.

ADVANCED CERAMICS OFFER LARGE MARKET, REPORT SAYS

U.S. shipments of advanced ceramic products could grow more than five-fold to reach $10 billion annually by the end of the century if key technological barriers can be overcome, according to a new study prepared by Charles River Associates (CRA) for NBS. The development of the new class of high-performance materials could bring about substantial productivity and market gains for a variety of industrial sectors, leading to improved U.S. competitiveness in world markets. Advanced ceramics also could reduce U.S. dependence on foreign sources of supply for scarce or critical resources, although not to the extent some have suggested previously, says the report. "Ceramics often have been considered to be low-technology products with little potential for advanced applications," notes NBS economist Gregory Tassey. "This study shows that new, advanced types of ceramic materials offer a wide range of applications for industry with a substantial market value." The development of standard test procedures, well-characterized standard reference materials, and improved nondestructive evaluation technology were listed by CRA as the most important measurement and standards barriers keeping U.S. industry from reaching the substantial economic potential of advanced ceramic materials.

STRAIN-RESISTANT SUPERCONDUCTORS FOUND

A class of superconducting compounds offering greatly improved strain characteristics has been discovered and its application patented by NBS and Westinghouse researchers. The discovery means that the windings of superconducting magnets, coils, motors, and generators and other superconducting devices such as transmission lines can be made to withstand much more tension or compression than present design limits allow without losing their superconductivity.

When common (A15) superconductors used in high-magnetic field applications are subjected to tensile or compressive strains of as little as 0.5 percent, they can lose more than half of their capacity to carry current. The newly patented materials, of the B1 and C15 crystal classes, show no degradation in critical current or ability to withstand high-magnetic fields, even when strains of 1.0 to 1.2 percent are encountered. B1 and C15 compounds include NbN, NbCN, and V_2 (Hf,Zr). Patent and exclusive and non-exclusive licensing information is available from Robert Auber, Office of Federal Patent Licensing, Box 1423, National Technical Information Service, Springfield, VA 22151, 703/487-4732.

NBS, ILL TO COLLABORATE ON COLD NEUTRON TECHNOLOGY

NBS and the Institut Max von Laue-Paul Langevin (ILL) of Grenoble, France, have agreed to set up a 5-year program of collaborative research to develop the use of cold neutron beams for materials research and similar experiments. Cold neutron beams are required in advanced materials research to study such things as the magnetic properties of new alloys and the microstructure of new high-performance ceramics and semiconductor materials. They also have important applications in chemistry and biotechnology.

The two laboratories will exchange information and guest researchers and work out joint programs to develop specific instrumentation and techniques for cold neutron research. Low-temperature neutron-scattering equipment, neutron guides, and neutron optical devices are typical research topics. ILL operates the world's best research center for the use of very low-energy ("cold") neutrons. NBS is developing what will be the largest cold neutron facility in the United States.

JOINT PROJECT AIMS AT BETTER USE OF PAPER BY-PRODUCTS

The paper industry should be able to use the heavy fuels produced in the paper manufacturing process more efficiently following a 5-year joint project recently begun between NBS and the Institute for Paper Chemistry (IPC). Heavy fuels, or "black liquor," are by-products of wood digestion in the papermaking process. These are later burned in a fixed-bed reactor (recovery boiler) to produce steam for energy conversion and to recover some of the paper process chemicals, such as sodium sulfide, for reuse.

Scientists in the NBS Center for Chemical Engineering are collaborating with IPC to develop a scaled-down laboratory reactor for studying heat-induced chemical changes and the behavior of fuel particles that occur in the larger fixed-bed reactors. Using techniques such as laser diagnostics, the NBS/IPC team hopes to understand better the fundamentals of the chemical recovery process so that recovery and energy conversion efficiency can be improved.

POWER CALIBRATION CAPABILITIES EXTENDED TO 400 HERTZ

The NBS Center for Electronics and Electrical Engineering has developed new capabilities for calibrating power-measuring instruments at 400 hertz. As commercial and military aircraft, as well as spacecraft, are powered at 400 hertz, aerospace and power instrument manufacturers need accurate meters for measurements at this elevated frequency level. To develop this specialized capability, the Bureau has used NBS power measurement standards, which were shown to have overall calibration uncertainties of less than 0.05 percent, and the NBS-developed phase-angle calibration standard.

The phase-angle standard is a precise and stable two-channel signal source which generates phase-related voltages. Amplifiers are used to convert one low-level signal voltage to a high-level signal (at 120 volts) and the other to a current signal (at 5 amperes). Comparison measurements between the responses to these signals of the instrument being evaluated and the NBS power measurement standard provide the calibration. For technical details, contact Dr. Robert E. Hebner, B344 Metrology Building, National Bureau of Standards, Gaithersburg, MD 20899, 301/921-3121.

INDUSTRY TO STUDY THIN FILMS FOR SEMICONDUCTORS AT NBS

GTE Laboratories, Inc., Waltham, Mass., is sponsoring a research associate at NBS to study and develop the growth of thin film layers on semiconductors. Dr. Brian Ditchek of GTE will use the NBS Center for Materials Science thin film facility to develop materials that are more consistent in quality and have better electrical properties for use as metallic connectors in integrated circuits. He will assist in the preparation and analysis of thin film materials and provide NBS with information on industry needs. The NBS Research Associate Program provides an opportunity for scientists and engineers from industry, technical societies, and other organizations to conduct cooperative research at the Bureau on projects of mutual interest, with their salaries paid by the sponsor. ■

NBS and Steel Producers Join in High-Risk Research

As fast and thick as honey draws flies, a venture on the upswing draws glad-handers and one on the downswing draws finger-pointers.

The U.S. steel industry has had a "bellyful of retrospective criticism, thank you," says Dr. William Dennis, vice president for manufacturing and research of the American Iron and Steel Institute (AISI), in answer to a question about industry problems. "Look at the problems only for what they can tell us about the future," he says.

Then he turns on his questioner with a smile and asks, "What do you think is the biggest internal problem facing the industry today? The biggest external problem?" The answers, which he later supplies, are residual inertia (internal) and the strength of the dollar (external).

Not everyone would agree with his assessment, but Dennis speaks with a bluff authority born of some 30 years' varied experience in the industry. He says the inertia problem resulted from decades of being the unchallenged top dog, when the winning formula was "Tonnage pays for all." The clear objective in those years was to maximize output for a steel-hungry world.

Now it's time to change the formula. New technology is undoubtedly part of the answer, according to Dennis. The steel industry, through the American Iron and Steel Institute, began in 1981 to develop a set of long-range research priorities and to seek research partners within and outside the industry. The resulting collaborative steel technology program, now well under way, involves many steel-making companies, private organizations such as the Electric Power Research Institute and the Gas Research Institute, and several federal laboratories, including the National Bureau of Standards.

Robert Jeffress, AISI metallurgical engineer in manufacturing and research, explains some of AISI's goals for collaborative research: "We want to develop and exploit technologies that will improve the quality and reduce the cost-per-ton of producing steel. This is one way to make domestic steel more competitive." Specifically, AISI wants to advance basic technologies, such as ladle metallurgy; develop money-saving waste-recycling and resource-recovery techniques; and develop sophisticated automatic sensing devices for computer-controlled processing.

"These are long-term, non-product-oriented, high-risk projects," Jeffress says. "Steel companies don't have the money or the people to go it alone in high-risk ventures any more. AISI's strategy is to pool industry money, work with other organizations, and get government support to leverage our limited resources for high-risk research."

"We want to develop and exploit technologies that will improve the quality and reduce the cost-per-ton of producing steel."

Dr. Lyle Schwartz, director of NBS' Center for Materials Science, views the Bureau as a natural player in this cooperative research scenario. NBS is the single federal laboratory whose mission in part is to conduct basic and applied research in support of American industry.

"The great strength of this country is its scientific superiority," says Schwartz. "The steel industry wants to take advantage of this strength and extend its technology. In certain areas, NBS—the materials center in particular—has capabilities and expertise that are both unusual and essential to that effort."

Many of the Bureau's programs relate to the steel industry, either directly or indirectly, but Schwartz points to three in particular that, he feels, are "central to the whole thrust of improving steel-making technology": a process sensor program being carried out in cooperation with AISI; a phase diagram program to collect, certify, and disseminate data on metal alloys, which is a collaborative project with the American Society for Metals funded by industry and government; and a materials research effort exploring metals-processing technologies for producing new and improved alloys.*

Schwartz says, "These kinds of programs are the very heart of what NBS is about." The sensor project is an outgrowth of two basic, ongoing Bureau activities: metallurgical research and measurement method development. The phase diagram work relates to NBS' responsibility for data collection and dissemination. The metals-processing program produces basic data on materials properties—and it is also a showcase of direct technology transfer. NBS researchers, who are quantifying the effects of rapid-solidification technologies on the properties of materials, are joined in the unique NBS metals-processing laboratory by researchers from universities and other organizations, including private companies.** (Companies may cooperate with NBS in public, generic research, or they may

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* The metals-processing facility and the phase diagram program are discussed in separate articles on page 8 and page 9, respectively.

use the Bureau's metals-processing facilities for proprietary research under a reimbursable plan.)

Inside Steel: Temperature and the Speed of Sound

The steel industry would like to have an automatic sensing device that generates profiles of the internal temperature of hot steel. Internal temperature is now estimated from surface temperature measurements made with pyrometers. Both the surface temperature measurements and the techniques that relate them to internal temperature are inaccurate. With an accurate method for detecting internal temperature, mills could reduce energy consumption and increase productivity—for an estimated annual savings of $275 million industry wide, according to an industry survey.

NBS metallurgist Dr. Haydn Wadley heads a team of researchers, including research associates from three steel companies, who are working on promising new temperature-measuring techniques. In one technique, they direct a pulsed laser beam at a hot steel sample; as the light beam strikes the hot metal (1000 °C or more), it causes an audible pop—the sound of sudden metal evaporation. The sound wave so generated propagates (passes) through the steel, causing molecules to vibrate. A device called a

NBS researchers view one of the steel samples used in data gathering experiments in the NBS steel sensor laboratory. Shown from left are metallurgist Dr. Haydn Wadley, project leader; technician Kurt Sandstrom; and physicist Floyd Mauer.

**Under the NBS Research Associate Program, established in the 1920's, scientists and engineers from private companies, trade associations, technical societies, and other organizations conduct cooperative research at NBS on projects of mutual interest, with salaries paid by their respective employers. For further information, write or call the Industrial Liaison Officer, A402 Administration Building, National Bureau of Standards, Gaithersburg, MD 20899, 301/921-3591.

transducer can transform the mechanical energy of the moving molecules into electric signals. Such signals, when fed into a computer and processed, translate into a temperature reading.

"There is a definite correlation between the speed at which sound propagates through a solid and the temperature of that solid," Wadley says. "All you need to know is distance and time of propagation to calculate velocity. If this velocity is measured at different temperatures, you obtain a correlation between quantities."

Actually, the procedure is more complicated than it sounds. The speed of sound varies not only according to temperature but also according to material. For every type of steel, the correlation is slightly different. "We are developing these correlations as we go," Wadley says. "They will become part of the databases that will ultimately be necessary for automated process control."

Reducing Energy Use and Waste

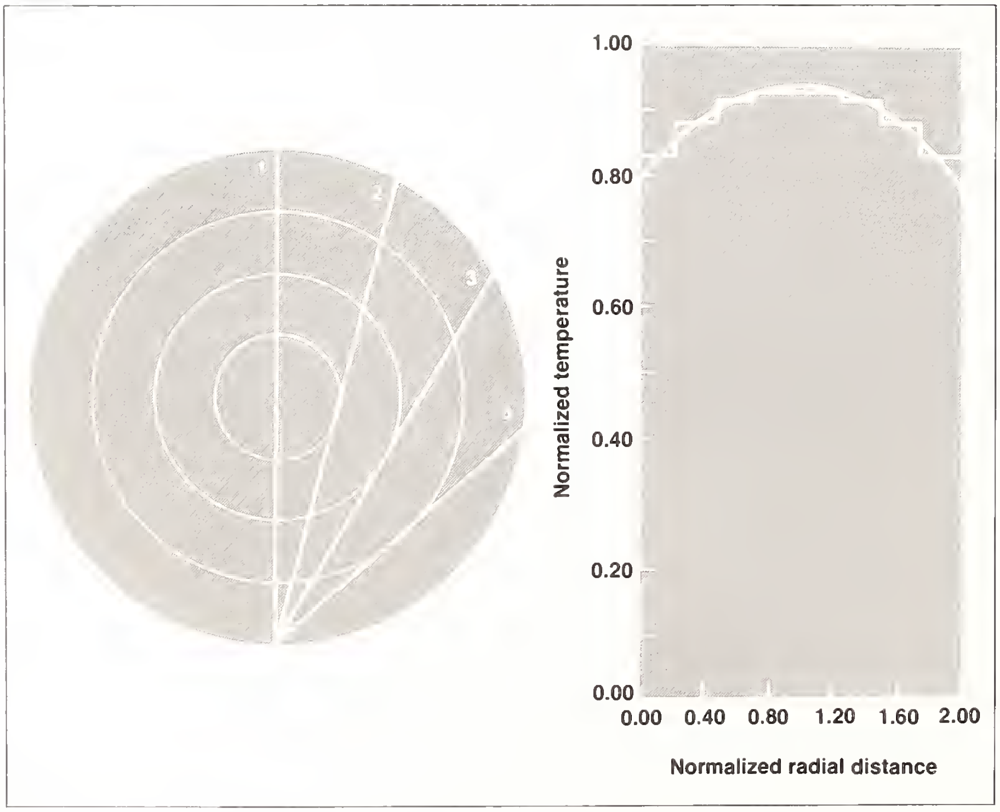
Wadley explains why development of this kind of sensor is a high priority: "There are times during steel production when knowing the internal temperature of hot steel could reduce both energy use and waste. For example, after casting, hot slabs of steel go into a reheat furnace to get their temperature up to about 1000 °C. Then they go through rollers as part of the process of making sheet steel. If a slab going into the reheat furnace is too hot, it overheats and gets 'burned.' This ruins it, and you can only use it for scrap. If a slab comes out of the reheat furnace and it's too cool, it may be too hard to roll properly. Then you end up with bad steel whose properties don't suit the intended application."

This kind of problem occurs in all mills from time to time. It could be eliminated if accurate automatic sensors were used to determine internal temperature as the steel slabs enter and exit the reheat furnace.

With an accurate method for detecting internal temperature, mills could reduce energy consumption and increase productivity. . . .

Temperature sensors might also increase productivity and quality during continuous casting. This operation involves the rapid cooling of molten steel—a process that improves the ultimate properties of the metal and reduces production time. In continuous casting, molten steel goes from a ladle into a tundish—a large crucible. It flows from the tundish through a nozzle and into a narrow, chilled copper mold.

As steel passes through the mold, hot liquid comes in direct contact with cold copper, causing a skin of solid steel to form around a still molten core. Thus,



This figure shows how closely the NBS sound-pulse method of temperature reconstruction matches results achieved by directly measuring the internal temperature of a hot steel cylinder. Temperature distribution was reconstructed using four time-of-flight values for the rays shown on the left. As shown on the right, the actual temperature (smooth curve) and the reconstructed temperature (stepped curve) are within 5 percent of each other.

the steel strand pulled from the mold is initially part solid, part molten. If the solid surface skin is too thin, the strand will rupture as it leaves the mold, spilling the contents of the tundish—as much as 150 tons of liquid steel. This catastrophic accident, known as a breakout, is avoidable, but only if the rate of continuous casting slows to well below the optimum. Accurate monitoring of the internal temperature of the strand at the mouth of the mold would permit greater control over the process. Casting could run closer to optimum speed, thus increasing productivity and product quality without risking a breakout.

The laser sensor method can give two kinds of internal temperature measurements: a simple measure of average temperature or a more complicated map of temperature distribution. Average temperature requires only a single measurement; the temperature profile, Wadley says, "depends on creating numerous intersecting paths of sound propagation to get a spatial distribution of temperature. Average temperature might be good enough for some applications, but others require the more sophisticated computer-based measurements."

Detecting The Signals

The AISI/NBS temperature sensor team already has perfected a pulsed infrared laser system for initiating sound waves in solidifying steel. They are working on the transducer—the device for converting the motion of molecules associated with the sound waves to electricity. This challenge is the only remaining technical obstacle impeding development of a prototype "average" temperature sensor.

"We're making do with piezoelectric materials for the first sensor because they are readily available," Wadley says. Piezoelectric materials directly convert mechanical energy to electricity. The big drawback with them is that they have to come in direct contact with the hot steel.

Wadley says, "We are now near a prototype, and once we can demonstrate the value of our technique, we will explore noncontact options, like EMAT's [electromagnetic acoustic transducers]. EMAT technology is not far advanced, however."

With EMAT's, a strong magnetic field would have to be induced at the surface of the steel. Then, as the steel moves because of the sound wave, an electric current would be generated in a nearby coil.

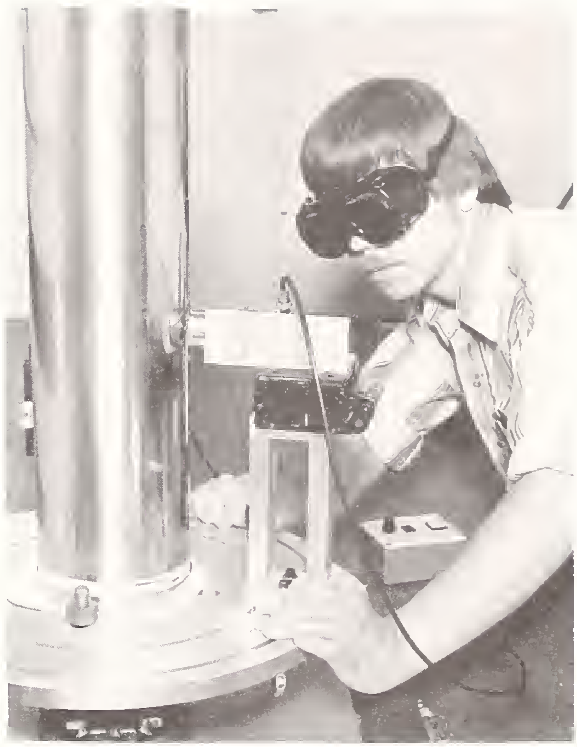
Ultimately Wadley envisions totally remote sensor systems composed of high-intensity lasers for inducing sound waves in the steel and laser interferometers for measuring the resulting effects.

Cropping With Precision

The principles of the temperature sensor system apply not only to temperature measurement but also to the detection of gross defects—internal voids, or pores—that form as steel cools and solidifies in large castings. As a steel ingot solidifies, for instance, it shrinks and internal pores form in the upper portion of the ingot. They must be "cropped" off to produce a uniform, quality product.

Experience and educated guesswork are the only guides for cropping at present. To assure quality, the producer has to overcrop—crop until several cuts reveal no pores. The expense of such waste drives up the cost of steel.

Measuring ultrasound reflections from within various sections of a piece of steel would quickly reveal the presence and location of pores, replacing guesswork with a precise basis for cropping. The technique is analogous to sonar techniques for detecting undersea objects.



To measure the internal temperature in a steel billet, laboratory assistant Christian Turner combines a piezoelectric detector with a rapidly scanned laser.

The sensor work at NBS is not aimed at producing an industrial instrument, whether for measuring temperature or detecting flaws. "We are developing concepts, proving their validity, and working on laboratory prototypes," NBS' Wadley says. "The evolution from the proven concepts to the plant floor is up to industry. It's a transition only industry can make."

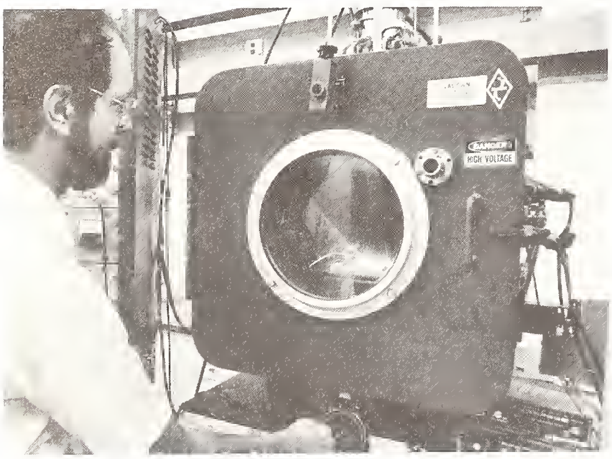
Industrial research associates, like Bernie Droney from Bethlehem Steel, David Rogers from U.S. Steel, and James Cook of Armco work at NBS in the laser sensor program. They will be the agents of that transition.

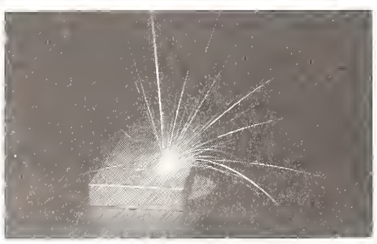
by Julianne Chappell
NBS Writer-Editor

Metals-Processing Technology for the Future

Between the world wars, NBS had nine small, experimental "factories" operating at once, producing optical glass, rubber, paper, cement, clay products, gages, cotton, wool, and alloy metals. Today's manufacturing activities are modest by comparison, but NBS is again making metal alloys, using unconventional rapid-solidification processes.

NBS' purpose, however, is highly conventional: to study materials in relation to the process that produces them—measurement intensive research to support industrial advances.





In the metals-processing laboratory, physicist Robert Schaefer uses an electron beam surface melting technique to produce alloy coatings on metals for improved resistance to wear and corrosion. A test chamber close up shows the electron beam melting a metal surface (detail).

Rapid-solidification processes speed the transition from molten to solid metal, thus preserving to a large extent the even distribution of alloy elements character-

NBS' purpose, however, is. . .to study materials in relation to the process that produces them. . . .

istic of the liquid state. Depending on the process and the combination of elements, rapid solidification may even produce a "new" material such as metallic glass. Metallic glass—like all glass—is technically not a solid; it is a supercooled liquid that "froze" before the natural transition to the crystalline phase could begin.

In general, rapid solidification can improve materials properties like strength or wear resistance. It can also induce unusual properties, such as low magnetic loss in materials that normally show a high loss. NBS researchers are determining how, and quantifying the extent to which, processing parameters (such as differences in solidification rates) affect the alloy microstructures that control such properties.

Rapid-solidification technology has been in experimental use for nearly 25 years, with limited application over the past 10 years in the manufacture of specialty metal parts. In the 1980's, however, alloy metals producers worldwide have begun to explore the technology's broad untapped potential for competitive advantage. One domestic corporation estimates, for example, that its new energy-efficient electric transformers, made using rapid solidification, can save the electric power industry $1.5 billion a year.

Not surprisingly, NBS rapid-solidification research and the Bureau's unique metals-processing laboratory are attracting a growing clientele from the industrial community.

"We make our facilities available to industrial scientists for exploratory types of measurements on new alloys," says Dr. John Manning, head of the metals-processing laboratory. "People can come here, do an experimental run, and take the results back to their own labs for further investigation if they want."

Manning explains that companies have several other opportunities for making use of the NBS facility. There is, of course, the Research Associate Program. The fruits of research done under this and other cooperative arrangements are "shared" by the associates and NBS scientists. Now, however, the Bureau is opening the laboratory to proprietary research, on a cost-reimbursable basis.

Manning says, "We have a very sophisticated laboratory, and we want to give all kinds of companies the opportunity to use it for exploration. By making proprietary research possible, we hope to get more participation by companies that aren't in the Fortune 500 and can't afford to experiment on their own. The exposure could give them new options."

The NBS laboratory contains apparatus for several different rapid-solidification processes: microparticle atomization, melt spinning, and surface melting. A hot isostatic press is available to consolidate atomized powder into metal parts. A plasma-transferred arc system is used to study surface-coating processes.

For further information on laboratory facilities or research opportunities, write or call Dr. John Manning, Room A153 Materials Building, National Bureau of Standards, Gaithersburg, MD 20899, 301/921-3354. J.C.

Diagrams for Designing Alloys

The good data issue has never heated the air of a political debate or electrified a social gathering. But ask Ernest Ambler, director of the National Bureau of Standards, and he will tell you reliable technical data are the bedrock of science and engineering and the most important product of NBS research. Ask Edward Langer, managing director of the American Society for Metals (ASM), and he will tell you what can happen when good data are not used in industry.

"Every electronics manufacturer remembers the 'Purple Plague,' " Langer says. "It virtually crippled the electronics industry. It appeared on transistors and integrated circuits where electrical contacts were made. The contact was made by aluminizing a portion of the circuit and attaching a gold wire."

The problem was, no one checked the gold-aluminum alloy phase diagram. "Had someone checked it," Langer points out,

NBS metallurgist Dr. Joanne Murray displays a typical alloy phase diagram (for the combination of iron, nickel, and chromium) on a computer terminal.

"they would have known that the gold and aluminum elements would fuse together." And fuse they did, forming a purple bimetallic compound on the circuit and causing failures in millions of components throughout the industry.

In the Purple Plague instance, a reliable phase diagram was available. It takes time, however, for engineers or metallurgists trying to select or design an alloy for a particular application to search the literature for a phase diagram they can trust. As Langer points out, someone can search for months and come up empty handed.

Depending on many factors—including the urgency of market demand—some people buckle to a possibly arduous and time-consuming research task, and some, like those responsible for the plague, choose instead to wing it.

But what is a phase diagram? A phase diagram is a graphic representation of information about the physical and chemical states of materials and the thermodynamic transitions between phases. (Thermodynamically speaking, phases are stages of the three fundamental states of matter: liquid, solid, and gas.) The principal focus of a phase diagram is on which crystalline phase(s)—the solid state has several crystalline phases—a metal or ceramic alloy will exhibit depending on temperature and composition. With such information, a metallurgist or engineer can design or specify an alloy that has properties suited to a particular application.

Seldom are the penalties for ignoring phase diagrams as blatant as in the case of the Purple Plague. But the lack of readily available, current, reliable phase diagrams is thought to cost the U.S. economy millions of dollars every year, according to the American Society for Metals—dollars wasted on failures, needlessly duplicated research efforts, and unnecessary overdesign of alloys and metal products.

The metals society and NBS agreed in 1978 to buckle to the task of getting good, comprehensive, up-to-date data to phase diagram users in easily accessible forms—printed compilations and a computerized graphic database. The two organizations launched a small pilot project in 1981. Today, a full-scale cooperative ASM/NBS program—to which organizations and individuals have, collectively, pledged $4 million (100 percent of the ASM goal)—operates worldwide from its NBS home base.

. . .the lack of readily available, current, reliable phase diagrams is thought to cost the U.S. economy millions of dollars every year. . . .

"NBS provides the overall technical direction," says Dr. Gilbert Ugiansky, deputy chief of the NBS Metallurgy Division. Ugiansky is acting head of the NBS Alloy Phase Diagram Data Center. The center is now the focal point for the ASM/NBS cooperative effort. "This systematic effort is really an extension of the Bureau's long-standing commitment to industry to produce and disseminate data on metals and ceramics," he adds.

Twelve Bureau staff members and three industry research associates devote at least part of their time to the cooperative program, and ASM and NBS also support individual evaluation programs in other laboratories. "We have 37 category editors located all over the world just to evaluate binary [2-element] phase diagrams," Ugiansky says. NBS sets up the guidelines and standards for evaluation, which rely on thermodynamic models and reported laboratory data, and conducts quality-control checks of the evaluations submitted by the outside editors. "We have three NBS category editors who serve as models," Ugiansky says. "We evaluate all titanium-based, aluminum-based, and iron-based binary phase diagrams right here." NBS researchers also conduct experimental and theoretical work on alloy systems.

So far 300 evaluation manuscripts have been submitted and approved; the critically evaluated phase diagrams have been published, with accompanying bibliographic material and supporting data, in the *Bulletin of Alloy Phase Diagrams*. The bulletin is a bimonthly publication produced by ASM as part of the collaborative data program. A prototype computer database is being developed.

He hopes the binary systems, totaling about 2,800, will be finished in 5 years—although he cautions that "handling 500 manuscripts a year, with all the detail work involved, is a formidable challenge." The nearly 3,500 ternary (3-element) systems have not yet been broached. Barring unforeseen obstacles, however, all the groundwork will be completed in 10 to 15 years.

Ugiansky says, "NBS will always be the quality-control point for the database; that's an organic function of this institution. And from time to time, ASM may sponsor research associates to help update the system. Otherwise, the program will become self-sustaining on the basis of publications and computer-service charges."

The big pay off is that metallurgists and engineers in need of a phase diagram will no longer have to choose between a time-consuming (and therefore costly) foray into the library stacks or a possibly fatal stab in the dark. They will know where to go for good data. J.C.

Sponsors of the Data Program for Alloy Phase Diagrams

ASM set $4 million as its fund-raising goal for the ASM/NBS Data Program. It recently met that goal, thanks to contributions from the following supporters:

Principal Associates ($200,000 and above)

The Aluminum Association, Inc.
American Iron and Steel Institute
Battelle Memorial Institute
Cabot Corporation Foundation, Inc.
Carpenter Technology Corporation
Defense Advanced Research Projects Agency
Howmet Turbine Components Corporation
IBM Corporation
Inco Limited
NASA—Lewis Research Center
Teledyne, Inc.

Associates ($100,000–$200,000)

ARCO Metals Company
ASM Members & Chapters
Buehler Limited
GTE Corporation
Rockwell International Corporation

Affiliates ($20,000–$100,000)

Allegheny Ludlum Steel Corporation
Allied Corporation
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Electric Power Research Institute
Fansteel, Inc.
Ford Motor Company
General Electric Company
General Motors Corporation
H. H. Harris Foundation
Interlake, Inc.
Lindberg Corporation
Lithium Corporation of America
Lockheed Corporation
National Forge Foundation
Perkin-Elmer Corporation
Reading Alloys, Inc.
RMI Company
Special Metals Corporation
Standard Oil Company (Indiana)
TIMET
TRW, Inc.
Wyman-Gordon Company

Contributors ($4,000–$20,000)

Chase Brass & Copper Co.
Detroit Chapter, ASM
International Metallographic Society
International Precious Metals Institute
Massachusetts Materials Research, Inc./Lehigh Testing Laboratories
Northrop Aircraft Division
Packer Engineering Associates, Inc.
Pittsburgh Chapter, ASM
Rolled Alloys, Inc.

Radiation: Keeping the Genie Under Control

The word "radiation," for many of us, means medical procedures or nuclear power plants. So you might be surprised to learn that radiation also is a tool for an increasing segment of American industry and agriculture. A somewhat complex and tricky tool.

In addition to familiar uses—killing cancerous cells, probing the body's innards, checking for cavities—radiation helps to sterilize medical equipment without the use of harmful chemicals, helps engineers to find bad welds in pipelines, helps to destroy insect pests in foodstuffs, and even helps to wrap the holiday turkey.

One expert estimates that everyday uses of radiation are growing at a rate of 20 to 25 percent per year in this country.

Radiation, like the genies of folk tales, can be very useful or very harmful. Careful, accurate measurements are needed to keep the genie under control, so a small group of specialists at the National Bureau of Standards is working to make sure that those measurements are possible.

NBS, through its Office of Radiation Measurement, is campaigning to get those who use or regulate radiation into a carefully organized system of checks and cross-checks that will help to ensure that accurate measurements of radiation exposure can be made wherever radiation is used in the United States. As a nonregulatory agency, NBS is looked to by government and industry alike for advice on measurement.

Elmer Eisenhower, chief of the NBS Office of Radiation Measurement, and Dr. Wayne Cassatt, deputy director of the NBS Center for Radiation Research, talked recently about this new system.

Question: You say that you're working to improve the system of radiation measurements in the United States. Why?

Cassatt: The quality of radiation measurements in critical areas like health care is in pretty good shape. In a number of areas like industrial processing with radiation, however, the availability of measurement calibrations and support is really in need of improvement. In other words, we need to make sure that good measurement support services are available in a timely fashion to ensure that radiation measurements are as accurate as they should be.

Physicist Paul Lamperti adjusts an ion-chamber type detector in an x-ray calibration facility (laser beam is used to align the detector). The ion chamber will be used as a "transfer standard" to calibrate x-ray sources and other detectors.

Dr. Wayne Cassatt, deputy director, NBS Center for Radiation Research

Eisenhower: We have done tests over the last 10 or 15 years. They were usually very limited tests of some groups to see how well they were performing measurements, but in every case we found that there were some people who were way out in left field as far as the accuracies of their measurements were concerned. That's the kind of thing that can be corrected under this system, because the people who choose to participate will be tested periodically.
Question: Is the use of radiation in the United States increasing?
Eisenhower: It increases at a rate of 20 to 25 percent each year. In some areas, like industrial radiation processing, it is probably increasing even faster than that. And if processing food with radiation catches on commercially, it'll just go out of sight. Nuclear medicine is growing rapidly too, at about the same rate.
Question: What are some of the industrial uses of radiation?
Cassatt: Sterilization of medical supplies is perhaps the most important, but in terms of volume, the radiation enhancement of plastics is probably the biggest single use of radiation.
Eisenhower: That refers to processes that turn monomers into polymers, for example, or that build "shrink" characteristics into plastics. You can slip a tube of these plastics onto a pair of pliers for a handle, or onto a bundle of wires, heat it, and have it shrink to fit. The holiday turkey that you buy may be wrapped in that kind of plastic.
Cassatt: In the area of agriculture, the Food and Drug Administration has suggested a new regulation that would allow foods to be irradiated up to a total dose of 100 kilorads and spices up to 3 million rads. This kills insects and their eggs and thereby preserves the food for long-term shipment and storage. There appears to be no damage to the food itself at these radiation levels. It also may make it possible to sell products from areas where there is known infestation to places that would normally quarantine those products.
Question: How important are accurate measurements in these cases?
Cassatt: They are usually very important. Accurate measurements help ensure that you've given enough radiation for the purpose—sterilizing medical equipment, for example—and that's important.

Also, in most cases too much radiation damages the material—causes embrittlement of plastics, for example. So to be effective you have to keep the process between those two limits.
Question: You mentioned a need in some areas to improve "measurement calibrations and support." What do you mean by "measurement support"?
Cassatt: What we call "measurement assurance procedures." Performing a calibration can help you determine the capability of a given instrument, but a measurement assurance procedure, which is more thorough, helps you to determine how well that instrument is actually being used by the people making the measurements. There are two levels of measurement quality assurance that are very important. One is to determine that the calibrations of the instruments themselves are being done accurately—as accurately as needed. The other is to determine that the instrument, in the hands of the user, is producing accurate measurements.

". . .we need to make sure that good measurement support services are available in a timely fashion. . . ."

Eisenhower: Typically, in a measurement quality assurance program, we will calibrate an instrument here and send it out to the users and ask them to calibrate it themselves. Then we compare the two answers to see if their calibration agrees with ours. We decide with them ahead of time how close that agreement needs to be for their purposes. If their measurement is not good enough, then we look into why it isn't and help them to correct it. This sort of quality assurance procedure hasn't generally been done in the past.

Rather, people have made statements—and they still do—that their measurements are "traceable to NBS" without ever defining what that means. Usually it doesn't mean anything except that someone, at some time, had an instrument calibrated by NBS, and they have a piece of paper in their files to prove it. But they have no idea whether or not they are really making good measurements, because that larger system of making measurements has never been tested.

Now we intend to help provide the sort of documentation that shows exactly what people are doing, if they participate in the system. Their measurement procedures—how they interact with their clients—will be documented. The interaction between them and NBS will be documented. Their quality control procedures will be documented.

Question: You'll do this for every laboratory and company in the United States that wants to make accurate radiation measurements?

Eisenhower: That's not possible. There is only one NBS, and there are more and more people getting into the business of making radiation measurements at the field level.

The only solution that we can see is to bring into play an intermediate level of so-called "secondary" laboratories. They will get their calibrations and performance checks from NBS and, in turn, provide calibrations and measurement quality assurance services for people in the field.

Our idea is to have three separate components of the system, one for users in the private sector, one for the federal government, and one for state governments. Four components if you count medical and industrial users in the private sector separately. It makes sense to break it up this way because one then avoids any potential problems with conflict of interest between the regulators and those being regulated.

NBS works with each of these groups more or less separately, helping to set up secondary laboratories in each sector. We have things going on in each of these sectors at the moment, so we have a start at getting the whole system going, but we still have a long way to go.

Question: And you regulate the performance of these secondary labs?

Eisenhower: No. NBS is not a regulatory agency, we simply provide measurement services. In each of these sectors, we try to work with an appropriate organization which sets up a program to accredit the secondary-level laboratories.

For example, since 1975 we have been working with the Conference of Radiation Control Program Directors, CRCPD, which is the national organization to which the individual state radiation control officers belong. Our major project has been to set up a number of "regional" secondary laboratories in the state government sector.

The regional radiation calibration laboratory in Springfield, Illinois, which was accredited by the conference last June, was the first of five to be developed in this fashion. We are also working with the states of Washington, South Carolina, California, and Arkansas to develop secondary radiation calibration labs in those regions.

In July, we sponsored a workshop for companies and organizations in the private sector to get started working with them. In this case we still need to identify the appropriate organization to work with on accreditation.

That is for the non-medical part. In the medical area, radiation therapy in particular, we have a good program with the American Association of Physicists in Medicine. The AAPM accredits laboratories, based partly

"When we sit down and work closely with these people, have periodic tests and compare results, we find that the system can do very well."

on NBS measurement quality assurance programs, to calibrate the instruments that are used, in turn, to calibrate the radiation therapy machines. That's a good example of how the entire system should work. The AAPM laboratories are tested every year, so we know and can demonstrate that their measurements are reliable and that the calibrations that they provide to hospitals and clinics are consistent with NBS standards.

Question: Take a public health case—the machines that are

Elmer Eisenhower, chief, NBS Office of Radiation Measurement

Procedures for Performance Evaluation			
To evaluate ability to	**Participant should**	**Evaluator should**	**And the evaluation should**
Calibrate dosimetry instruments	Calibrate an instrument	Calibrate the same instrument	Compare calibration factors
Measure radiation fields (radiation units)	Measure an unknown field	Measure the same field	Compare measurement results
Measure radioactivity (activity units)	Measure activity of a source	Measure the same or an equivalent source	Compare measurement results
Calibrate sources (radiation or activity units)	Calibrate a source	Calibrate the same source	Compare calibration results
Administer radiation dose	Administer a nominal dose to a dosimeter	Calibrate and read out the dosimeter	Determine accuracy of administered dose
Read-out dosimeters	Calibrate and read out a dosimeter	Administer a known dose to the dosimeter	Determine accuracy of read-out dose

used to make dental x rays. What sort of accuracy is required when you're measuring the performance of that kind of machine so that you know it is not a danger to the patients?

Eisenhower: We have accuracy charts that we've worked out in consultation with the people who use these measurements. In the area of medical x-ray diagnosis, the field accuracy that we shoot for is 10 percent, which requires an accuracy of 5 percent at the secondary level. Each step in the calibration chain costs you something in accuracy.

In the general radiation protection area—things like employee exposure monitoring at power plants or environmental measurements—they're only shooting for 15 percent accuracy at the field level. They're measuring much lower levels of radiation, so achieving accuracy is more difficult. This is an area that the state radiation control laboratories deal with, and we've found that sort of accuracy is very easy to get under the system that we've set up with the CRCPD. It requires a calibration accuracy of 10 percent at the secondary level, and we can provide 4 to 5 percent in our measurements.

In the case of radiation therapy measurements, we can deliver accuracies of $1\frac{1}{2}$ percent at NBS, 2 percent at the secondary level, and 3 percent in the field. Those are very tight limits, but that's one of the advantages of a program like this. When we sit down and work closely with these people, have periodic tests and compare results, we find that the system can do very well.

Question: What sort of reaction do you get from private industry about all these plans?

Eisenhower: Very positive. Everybody that we talk to in all of these sectors is in favor of what we propose to do—their biggest complaint is that they'd like to see it happen faster than we can manage with our resources.

One of the important benefits from these programs—in addition to ensuring the quality of radiation measurements—is that you have documentation that demonstrates that you are doing a good job, that your measurement performance or calibration performance or whatever you are offering is in fact adequate for the purpose.

If someone comes along and says he was overexposed to radiation and is now suing a company, that firm will have documented performance data with which it can defend itself. That's important in the radiation industry, and it's one of the reasons we're getting such strong support from the people in the measurement community. They see this as a way of protecting themselves in the future from unfair claims.

Question: How long does it take to set up these programs?

Eisenhower: We learn a lot in each sector that we can apply to others. It took about 7 years to get the first state laboratory accredited. The next will take a year or two less from start to finish, with accreditation scheduled for completion later this year.

The private industrial area probably won't take as long, because we'll have our experience from the state sector to build on. I would guess that we could have that whole system set up within about 4 years.

Question: Do you think the radiation measurement system in the United States is safe right now?

Cassatt: The system is in good shape, but there are people who have to wait a considerable amount of time before they can have an instrument calibrated and get it back in service—largely because of our limited resources here. During that time, you're not terribly certain that things are being done as well as they could be. Our efforts to set up a system of secondary calibration laboratories should reduce that turnaround time.

Then, too, there are a lot of people who are relying strictly on calibrations and calibrated instruments rather than tests of actual, routine performance. They are using carefully trained people and well-calibrated instruments and following established practices, but there's nothing that can quite replace the confidence that comes from an actual measurement performance test. We'll be providing that extra level of confidence.

Tools and Technology for the Building Industry

Remember the old WW II movies where a submarine and surface ship played cat and mouse? The ship would use sound to determine the location and depth of the sub. All would be quiet except for the "ping! ping!" of the sonar. Today, variations of this pulse-echo detection method are being used routinely to search for cracks in steel structures and to scan the human body.

Now researchers at the National Bureau of Standards are looking at the technique to determine whether it can be used reliably to detect flaws in concrete structures such as buildings or bridge columns.

It is possible to look for defects in concrete by drilling a core sample or using x-ray or gamma radiography, but these methods are expensive, often destructive, and cumbersome. According to Dr. H. S. Lew, an NBS engineer, "There is a real need for a nondestructive system for flaw detection that is reliable, economical, and easy to operate. We think the pulse-echo method has the potential to fill this need."

But there are problems with using this technique for detecting flaws in concrete. Not enough is known about how sound waves move through concrete or how to interpret the signals. And the instruments for sending the pulses of sound and for receiving signals have not been fully developed.

Lew is confident the problems can be overcome. "We've developed a transducer to 'thump' the surface the same way every time, and we will be testing it under field conditions next year. Also, we are working on ways to make it easier to interpret the signals."

In fact, Lew believes this research may lead to a development that sounds like it is straight out of science fiction. He says, "Eventually we may be able to use acoustic imaging which will make it possible for us to get a three-dimensional view of the in-

Here researchers test structural components to determine the cause of the collapse of two walkways in the Kansas City Hyatt Regency Hotel.

Kyle Woodward, a research structural engineer, studies data from a computer-directed test facility. The special tri-directional facility is part of the Bureau's earthquake hazards prevention research.

side of a concrete structure."

Research such as this conducted by the scientists and engineers in the NBS Center for Building Technology leads to safer buildings which are more economical to build and maintain. But NBS does not promulgate or enforce building standards or codes. "What we do is develop the tools and technology to predict, measure, and test the performance of structures," says Dr. Charles Culver, chief of the center's Structures Division. "We're working to improve building codes and standards by providing the technical information to organizations that write them."

While NBS experts often are called upon to investigate major building failures, such as the 1981 collapse of two walkways in a Kansas City hotel, most of the research in the Structures Division is aimed at developing improved building practices so that such tragedies do not occur.

For example, NBS engineers have been developing ways to determine when poured concrete is strong enough for the construction formwork to be removed. This is important from both a safety and economic standpoint. Says Lew, "A builder wants to remove the formwork as soon as possible so he can get on with the building. But he doesn't want to risk the safety of the construction workers."

NBS has come up with two tools that will help builders make this decision. One is a standardized test for pulling small concrete samples out of the structure, which Lew feels is the most reliable method of determining the strength of concrete. The other is a method of analysis that soon will be available as a computer program. ASTM is considering adopting both as voluntary standards.

Each year more than 200 construction workers die and many more are injured as a result of excavation cave-ins. With the support of the U.S. Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health, NBS developed ways to classify soil and investigated the lumber used in bracing trenches. The outcome was a series of practices recommended by NBS to make trenching excavation work safer.

OSHA is revising its construction safety regulations based on the NBS research, and the American National Standards Institute (ANSI) is considering using the recommendations to form the basis for a voluntary industry standard.

Understanding the properties and behavior of soil is also important to understanding "soil liquefaction." This phenomenon occurs during an earthquake when the soil loses its firmness and begins to flow like a liquid, sometimes causing buildings to topple.

Soil liquefaction has occurred in seismically active areas around the world and is part of the Bureau's earthquake hazards reduction program. This research is aimed at helping builders and engineers determine how stable soil will be during an earthquake. "This is becoming increasingly

OSHA is revising its construction safety regulations based on the NBS research. . . .

important," says Dr. Riley Chung, NBS geotechnical expert, "as suitable land for building becomes scarcer and people are considering land they once might have rejected."

One of the ways engineers determine whether a soil could liquefy is through the use of a Standard Penetration Test (SPT). The test is used in about 90 percent of all structural foundation investigations conducted in the United States.

In studies funded by NBS, the National Science Foundation, the Bureau of Reclamation, the Naval Facilities Engineering Command, the U.S. Army Engineer Waterways Experiment Station, and Japanese industry and government, Chung and his colleagues evaluated U.S. and Japanese SPT practices and compared test results from both countries. They found that much of the information on soil liquefaction design charts, based on SPT data gathered over the years, needs to be re-evaluated. Chung is now working with the University of California at Berkeley to develop revised design charts and a set of recommended procedures for the test.

He also is working with an ASTM committee to develop a standardized test method.

In addition to the soil liquefaction research and participation in several industry-government interagency projects to develop seismic design standards, a part of the Bureau's program to reduce earthquake hazards is understanding the effects of earthquakes on masonry structures. "When you design a masonry wall to resist earthquake forces you first need to know how much force it will take to crack that wall and if it will fail immediately or continue to deform," says NBS engineer Dr. E. V. Leyendecker. The researchers are using a unique computerized facility designed and built at NBS to measure the seismic resistance of both reinforced and unreinforced masonry. Using large hydraulic jacks, the tri-directional facility can simulate the twisting stresses an earthquake causes in a building. The facility can handle test specimens as large as 10 feet long by 10 feet deep by $10\frac{1}{2}$ feet high.

"Right now there is no complete technical base for designing masonry structures to resist the combination of stresses caused by earthquakes," says Leyendecker. He adds, "Groups such as the American Concrete Institute and the American Society of Civil Engineers are very interested in the recommendations we are developing."

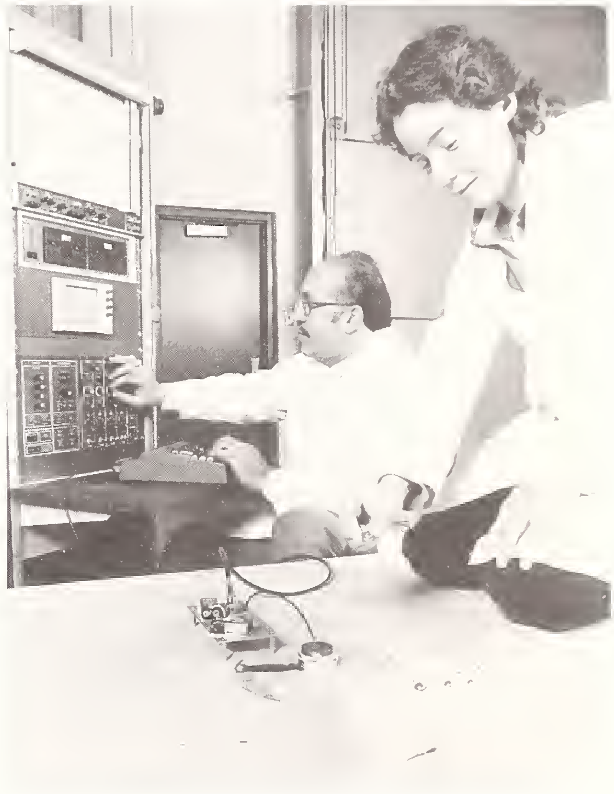
In another building at NBS, a similar although much more massive facility was completed recently. This large-scale seismic test facility will enable researchers to test full-scale bridge and building components under conditions simulating earthquake forces. Sponsored by the National Science Foundation, the Federal Highway Administration, and the California Department of Transportation, testing of full-scale bridge columns will begin in the spring of 1985.

How do you determine how much "load" a building can withstand and still be safe? Loads are forces or actions on a structure from the weight of the building itself, occupants and their possessions, and environmental forces such as wind, snow, and earthquakes. Answering this question will be easier as a result of research conducted by an NBS group under the direction of structural engineer Dr. Bruce Ellingwood.

Until recently, building codes specified the minimum requirements for loads and structural design according to the materials used. For example, if you were building with wood the load and stress factors required would be different than if you were using steel or reinforced concrete. This diversity complicated the building design process, particularly if your building plans called for a mix of construction materials.

Ellingwood and his colleagues have developed a system which can be used to calculate the design strength required for a structure regardless of the materials used. Ellingwood says, "In terms of structural design this means that safety and performance can be determined according to what is an acceptable level of risk or a required level of reliability." This new approach for calculating loads has been incorporated into the latest ANSI standard on loading.

The construction industry is one of this country's largest. About $260 billion was invested in construction-related activities last year. To guard that investment against damage and to protect the workers who build the structures and those who occupy them, the building industry needs sound technical information on which to base decisions.



NBS researchers Dr. Nicholas Carino and co-op student Mary Sansalone from Cornell University are studying a technique known as pulse-echo detection to determine whether it can be used reliably to detect flaws in concrete structures such as buildings or bridge columns.

"Both dollars and lives are at stake here," says Culver, "and the most important way we can help is by providing the tools and technology the industry and professional groups need to make those decisions."

by Jan Kosko
NBS Public Affairs Specialist

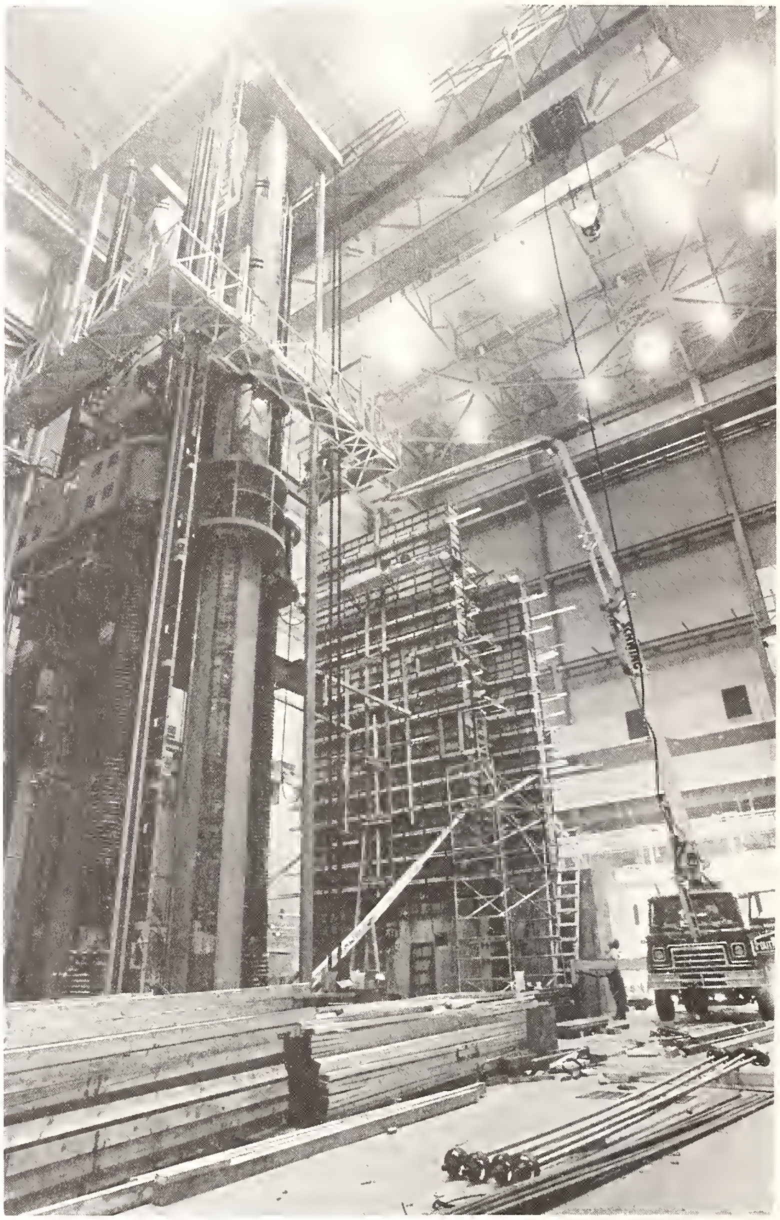
New Facility Used to Simulate Earthquake Forces

A computerized facility designed to test how full-scale bridge and building components perform during earthquakes has just been completed at NBS. In the first project to be run in the facility, NBS researchers, under the sponsorship of the National Science Foundation, the Federal Highway Administration, and the California Department of Transportation, will test three 30-foot-high bridge columns under conditions simulating earthquake forces.

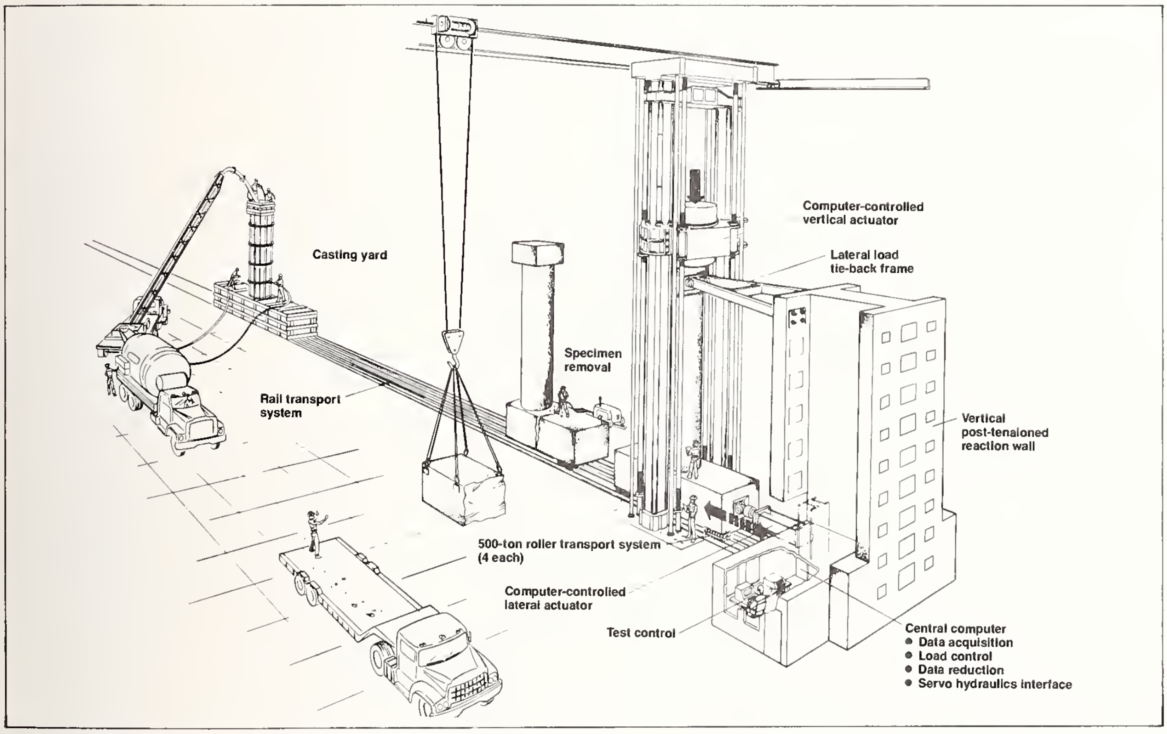
A massive, reinforced concrete wall, which stands 45 feet high and weighs 2 million pounds, was constructed as part of the Bureau's new large-scale seismic test facility. The huge "reaction" wall was built to resist the force being applied to the side of the bridge columns.

One of the reasons for the testing is to evaluate bridge design changes developed by the state of California after the 1971 San Fernando earthquake. During that earthquake, five bridges collapsed and 42 others were damaged significantly. Since 1971, the requirements for column design have been changed and now provide more stringent reinforcing steel requirements. But the design changes have never been tested at full scale.

"In fact," says Dr. Charles Culver, chief of the NBS Structures Division, "most of the research done on the behavior of bridge columns has been done on much smaller specimens and the results have been extrapolated to predict full-scale behavior." Nearly all design codes pertaining to bridge columns during earthquakes, except for those in New Zealand and Japan, are



NBS researchers are constructing a computerized facility to test how full-scale bridge and building components perform during earthquakes. The reinforced concrete wall (in background) is being built to resist the force which will be applied to the side of bridge columns. The wall stands 45 feet high and weighs 2 million pounds.



NBS Large-Scale Seismic Test Facility.

based on the research done on building columns.

"This project will give us benchmark data, something we didn't have before, a point of reference to compare other data. It should help us develop improved criteria for designing bridges and buildings to better resist earthquake damage," says Culver.

In a smaller-scale facility at NBS, researchers also will run tests on columns one-third and one-sixth the size of the full 30-foot columns. After testing the large columns they will compare the results of both sets of tests to see whether the behavior of the small-scale bridge columns can be used to predict that of full-scale columns. This information will be used by the NBS scientists to evaluate and refine computer models which predict how structures fail during earthquakes. Such models will help the building community design safer buildings and bridges without conducting expensive failure tests.

Also as part of the project, one of the three large columns will be repaired and then retested to see how well the repair work withstands further seismic stresses.

The NBS large-scale seismic test facility is the largest facility of its kind in the United States. The Bureau's existing universal testing machine, which is capable of exerting up to l2 million pounds of force, will be used to press down on the bridge columns to simulate the superstructure of the bridge. A specially designed hydraulic jack, called a bi-directional actuator, will be used to simulate the lateral forces of an earthquake by pushing and pulling the base of the 250-ton bridge columns.

All of the movement will be controlled by a computer which also will feed back information to the researchers. Says NBS structural engineer William Stone, designer of the facility, "Each column will be fully instrumented both inside and out so we know what kind of stress and strain it is taking."

Because of their size and weight, the columns will be cast in the facility and rolled into the testing machine on four steel railroad tracks.

The facility is now undergoing shakedown tests and full-scale column testing is scheduled to begin this spring. This unique facility will be available in the coming years for cooperative research with industry, government, and universities. J. K.

Welcome to the New Computer Age: The Era of Networks

Surely you have heard by now. Computer technology is taking yet another "new" direction, but this direction is actually as old as civilization itself. The computer industries are acquiring the measurement base and adopting the standards necessary to "match parts" with ease—to make one system or piece of equipment work with another system or piece of equipment regardless of who manufactures the individual pieces.

Where does the expertise in measurement and standards come from to support such a broad, diffuse effort? In large part from the measurement and standards-making community, which is international in scope and of which the National Bureau of Standards is a member. But more about that later.

Who Cares?

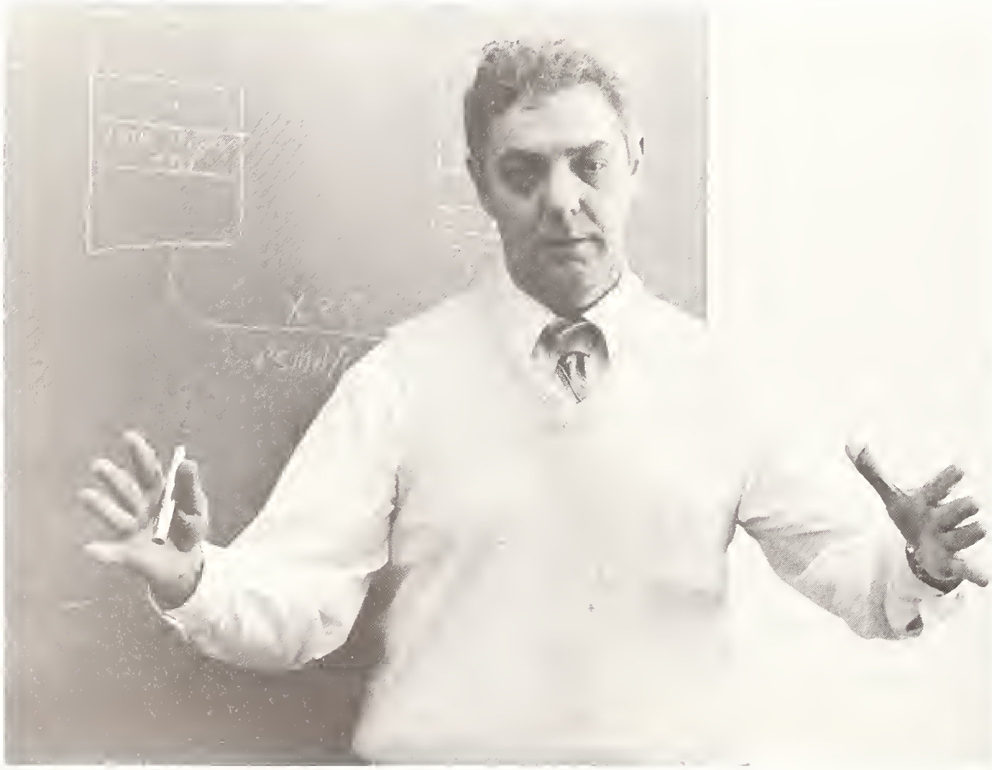
First, to the heart of the matter: Why standards? Who needs them? Who cares?

Edward Deenihan, supervisor of development engineering of General Motors (GM), sums it up succinctly: "We cannot buy from different computer vendors and expect their products to be compatible. This slows down computer integration in manufacturing, and it limits our options. We find if we have a particular vendor in one of our facilities, we tend to reuse that vendor instead of looking for the best technical solution to a problem. If we don't do that, if we go after the best solution, we can end up rewriting software—a big, expensive headache.

"We want communications standards that are implemented in off-the-shelf products," he emphasizes. "We want to get GM people out of the communications software business. We want to make our decisions based on the best solution, not on whether this machine can talk to the one next to it."

General Motors is committed to getting what it wants, and that means the company is dedicating money and staff to develop a Manufacturing Automation Protocol (MAP)—a set of standards, based on an international model (see box), which will become GM's and others' basis for buying computer equipment. The company's prominent presence in the standards community has accelerated a networking standards effort that was already under way, an effort to which many computer vendors, such as Digital Equipment Corporation, have subscribed since its beginning in the late 1970's.

Digital's Tony Lauck, head of networks and communication architecture and advanced development, says, "In December of 1982 we [computer companies] were still sitting in standards committees wondering whether multivendor networks were ever really going to happen—or whether we were just going to continue going to standards meetings. Six of us got together and asked NBS to work with us and others to make something happen."



John Heafner, chief, NBS Systems and Network Architecture Division.

NBS Role

Although it is not a regulatory agency, the NBS Institute for Computer Sciences and Technology (ICST) is the hub of the networking standards effort in the United States. ICST is, in fact, one of a handful of laboratories worldwide—and the only one in this country—equipped in terms of staff, technical resources, and basic mission to do the research required for international networking standards. The institute's staff have helped develop the International Organization for Standardization's (ISO) model for networking, called Open Systems Interconnection (OSI), and they are carrying out work related to that model.

"It's a matter of research first," says Stephen Nightingale, NBS' resident expert on one area of computer network testing. Nightingale is one of several dozen NBS staff members directly involved in the laboratory work associated with network standards. He says, "ICST staff members belong to computer-related committees of voluntary standards organizations—like ANSI [American National Standards Institute]. ANSI represents the United States in ISO, and through ANSI, we also participate in ISO.

"We help write voluntary standards because NBS can then adopt them as FIPS.* But before anybody can write standards, somebody has to do the technical spade work—developing the data, testing the theories, making sure something can work. ANSI doesn't have a lab. ISO doesn't have a lab. None of them do. But NBS does, and the work we do is not proprietary. If private companies want to send their people to work with us, so much the better. It helps ICST do its most important job—get the standards out of the lab, out of the

* FIPS, short for Federal Information Processing Standards, are standards and guidelines developed by ICST to aid federal agencies in procuring, using, and testing computer systems and equipment.

NBS Contributions to Networking Standards

Through participation in domestic and international voluntary standards organizations, or through the programs of its Center for Computer Systems Engineering, the Institute for Computer Sciences and Technology has:

□ Helped develop the seven-layer ISO conceptual framework for computer networks—known formally as the Basic Reference Model of Open Systems Interconnection, and then helped write ISO standards (known as protocols) that, when completed, will define how each function of each layer is to be carried out.

□ Translated several ISO protocols, which are written in prose, into a formal notation developed by ICST for the express purpose of specifying protocols.

□ Derived, from the protocol specifications, machine-readable computer programs (known as implementations) for use by computer vendors in developing prototype implementations.

□ Developed test methods for determining whether a computer vendor's implementation of a specific protocol is "correct." (That is, will the program work and is it in accord with the international standard?)

□ Developed test methods for monitoring the performance of prototype implementations so they can be modified for maximum economy of operation. (Get the job done at the least expense.)

□ Worked with IEEE and CCITT (the United Nations Consultative Committee on Telephone and Telegraph) on communications technology standards (for local area and wide area networks, respectively) related to the physical, data-link, and network layers of the ISO model.

□ Conducted workshops for private companies and government agencies to transfer NBS networking standards and testing expertise to the ultimate users.

□ Worked directly with 14 computer vendors to help them develop, test, and refine prototype implementations of the ISO Class 4 Transport Protocol in preparation for the world's first two demonstrations of computer networking through ISO standards.

□ Cosponsored, with Boeing Computer Services, one of the two demonstrations alluded to above at the 1984 National Computer Conference in July. (Boeing/NBS coordinated an office communications networking demonstration; GM sponsored a factory automation network display.)

□ Expanded interactions with private companies and federal agencies since the 1984 National Computer Conference by initiating a new series of workshops and planning a global "standard" network on which companies, with NBS assistance, can test their equipment.

Also, ICST is adopting standards compatible with the ISO model as Federal Information Processing Standards. A local area network standard has been approved by the Secretary of Commerce. It incorporates IEEE standards 802.2 and 802.3 and will be published as FIPS PUB 107 for *Local Area Networks: Baseband Carrier Sense Multiple Access with Collision Detection and Physical Layer Specifications and Link Layer Protocol.* (Order from the National Technical Information Service.) The NBS-developed transport protocol has been proposed to the Secretary. Other standards will be proposed when they are developed in voluntary standards groups.

standards-writing organizations, and into use."

The computer institute has been part of the international effort to bring about networking standards since that effort began in 1979. The main function of the Bureau in general, as well as the computer institute in particular, is to develop the measurement science and standards base for American science and industry.

This has been the case in the area of computer networking standards. The computer institute has developed the technology, the standards, and the test methods that industry needs and wants.

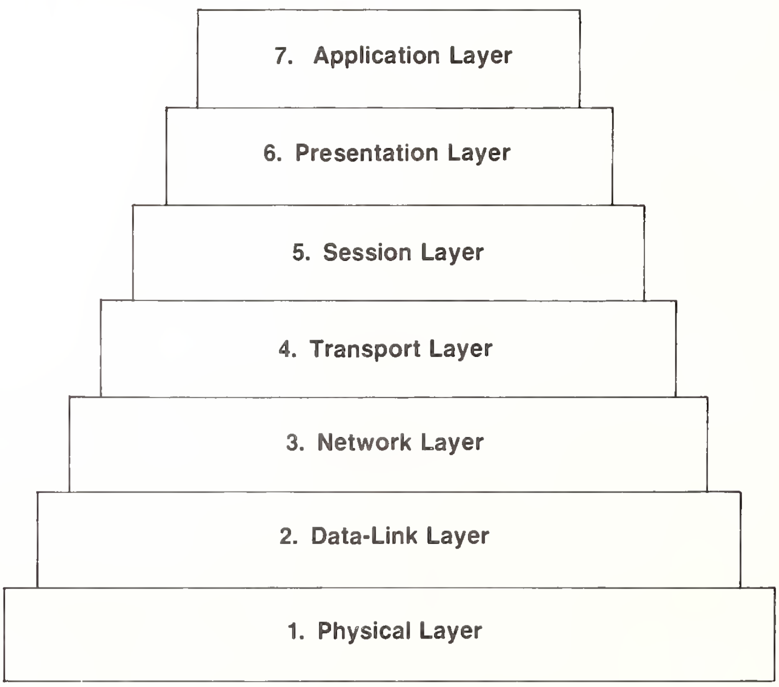
"But before anybody can write standards, somebody has to do the technical spade work—developing the data, testing the theories, making sure something can work."

"Standards aren't useful unless they are implemented," says Robert Blanc, director of the NBS Center for Computer Systems Engineering. "So today, most of our resources go into helping industry develop and test their implementations for international standards."

The help Blanc's center provides is critical to the success of networking standardization, as GM's Deenihan points out. "We would not be where we are now with our MAP program if it weren't for NBS," he says. "The strategy of the project is not to develop GM-specific communications standards but to support national and international standards."

The close interaction between NBS and computer vendors and users began at the request of industry in 1983. Prior to that time,

Open Systems Interconnection Reference Model



The Open Systems Interconnection (OSI) Reference Model is a standard of the International Organization for Standardization. It is a blueprint for achieving off-the-shelf compatibility of computer systems and equipment.

The model consists of seven abstract "layers" to which standard protocols—procedures—are assigned. A protocol stipulates how to carry out a set of network functions (commonly called layer services). The functions required of a layer may vary depending on many factors, such as the underlying technology (whether coaxial cable, satellite, or so on). Thus each layer contains alternative protocols. (The transport layer, for example, subsumes five classes of protocols, numbered 0 through 4).

An OSI protocol starts out as a document written in prose. Unless the protocol is an engineering specification concerned with the hardware of the physical network, it will be translated into formal notation (a programming language developed for the purpose of specifying protocols). It can then be transformed by a combination of manual and automated procedures into a machine-readable

NBS had been working informally with, as John Heafner, head of the Systems and Network Architecture Division, puts it, "many organizations interested in computer networking standards, from IBM to the city government of Baltimore." In 1982, however, several companies asked NBS to hold workshops on the Institute of Electrical and Electronics Engineers' (IEEE) 802 series of standards for local area network technologies (these standards relate to the physical and data-link layers of the ISO model) and on working standards for the transport layer. NBS agreed.

Workshops

The workshop series convened in February 1983, and the participants decided to conduct two public demonstrations of local area networks based on international standards. Over the next year and a half, in preparation for the demonstrations: NBS developed a prototype working standard for the transport layer of the ISO model and related test methods (this standard is a software program which "implements" the OSI transport-layer Class 4 protocol); participating computer vendors derived their own working implementations from the NBS standard; IEEE 802 standards were selected for the physical and data-link layers, thus eliminating the need for a network layer; also, no session- or presentation-layer functions were used; and a draft ISO file-transfer protocol served for the application layer.

Once development was finished, testing began. NBS set up two testbeds, one for testing transport protocol implementations (the Bureau tested all such implementations) and one for testing the entire office communications network. Using the NBS network testbed as a model,

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program—a software "protocol implementation" in correct terminology.

7. Application Layer
Functions: Gives the computer operator or application program access to the network and provides a context in which an individual can use the network for specific purposes, such as querying a database in another system, transferring a file to or from another system, making an airline reservation, transferring money from one account to another, and so on.

6. Presentation Layer
Functions: Transforms data codes and structure received from the application layer into a "common denominator" language for sending and transforms incoming data from the common-denominator language into the codes and structure of the receiving system.

5. Session Layer
Functions: Enables management and synchronization of streams of data that are being exchanged between communicating application programs. For example, data streams are marked and resynchronized to ensure that sessions of dialogue are completed and not terminated prematurely. This layer also permits two-way alternating (half duplex) or two-way simultaneous (full duplex) communication, depending on the requirements of the application.

4. Transport Layer
Functions: Provides end-to-end data reliability. Specifically, this layer makes sure data are not lost, duplicated, or corrupted in transit and that they get to their destination in the right order. The transport layer must, therefore, append transportation information (such as the address of the sending machine and the address of the receiving machine) to outgoing data and strip it off incoming data, perform mathematical operations that reveal data errors, signal a sending machine to resend garbled data, and, in the absence of a network protocol, control the rate at which data are received and disassemble/reassemble session messages. (Session messages might be too long to transmit on the network in one transport data unit; the outgoing message would be segmented by the sending transport layer and reassembled by the receiving transport layer.)

3. Network Layer
Functions: Routes information—along possibly multiple paths—to get it to its physical destination. The internetwork sublayer routes data to addresses on different networks. If all the communicating units on a network are directly connected to a physical link (such as a coaxial cable), and the network does not communicate with another network, the internetwork protocol is unnecessary.

2. Data-Link Layer
Functions: Flags data packets so that the receiving data-link layer can distinguish beginnings and ends of messages, signals the physical layer to begin transmission, or, in the case of baseband and broadband coaxial cable technology, handles access to the cable channels.

1. Physical Layer
Functions: Constitutes the physical medium of transmission, with all associated hardware, and carries out the logical function of encoding data in the transmission signals, such as electrical pulses or waves.

The network protocol laboratory shown here is one of several NBS facilities used for OSI-related standards work. Standing, from left, are NBS researchers Jerry Linn, Ken Diamond, Wayne McCoy, and Fran Nielson and sitting, from left, Dan Rorrer and Stephen Nightingale.

GM installed its own network-testing system and tested the factory automation network.

Fourteen computer manufacturers and communications companies, divided into two groups—one group led by GM and one by NBS and Boeing Computer Services—were ready to demonstrate Open Systems Interconnection to the public in July 1984. They chose the 1984 National Computer Conference in Las Vegas as the appropriate forum.

Networking Demonstrations: The Future is Now

Coming and going, all visitors to the computer conference passed both networking demonstrations. On one side of the lobby of the Las Vegas Convention Center, toy car chassis rolled along a miniature GM assembly line, each one passing a robot arm and getting fitted with a brightly colored body. At the end of the line, the cars were automatically sorted by color, with blue cars shunted to one slot, red ones to another, and so on.

On the other side of the lobby, Boeing and NBS were providing an information service, operating from some 10 pieces of computer equipment with 13 video screens, any or all of which might be working at a given moment, giving information on Las Vegas hotels, exchanging files, showing color graphics, or monitoring (in the form of a real-time visual display) the otherwise invisible interconnections taking place among the various computer systems.

Participating Organizations

Following is a list—current as of press time, December 21, 1984—of companies and agencies involved in NBS-sponsored Open Systems Interconnection workshops and related activities. Asterisks denote the companies that participated in the first OSI demonstration, held at the July 1984 National Computer Conference.

Able Computer
ACC (Advanced Computer Communications)*
Allen-Bradley Company*
American Robot Corporation
ASEA Robotics Corporation
AT&T Communications, Inc.
AT&T Information Systems, Inc.
Bell Communications Research, Inc.
Bell Northern Research
Bell Telephone Laboratories
Boeing Company*
Bolt, Beranek & Newmann, Inc.
Burroughs Corporation
Charles River Data Systems*
Cincinnati Milacron Corporation
Codex Corporation
Communications Satellite Corporation (Comsat)
CompuCorp
Compuvision Corporation
Concord Data Systems*
Data General Corporation
Defense Communications Agency, Department of Defense
Digital Equipment Corporation*
E.I. Du Pont de Nemours
E-Systems
Florida State Legislature
Foxboro Company
General Electric Corporation
General Motors Corporation*
Gould, Inc.*
Gould S.E.L. Computer Systems, Inc.
Hewlett-Packard Company*
Honeywell, Inc.*
Interlan, Inc.
International Business Machines*
International Computers Limited*
Intel Corporation*
ITT Dialcom
Korea Institute of Electronics Technology
Library of Congress
Motorola, Inc.
National Telecommunications and Information Administration, Department of Commerce
NBI, Inc.
NCR Corporation*
Network Solutions, Inc.
Northern Telecom Ltd.
Ing. C. Olivetti Company, S.P.A.
Prime Computer, Inc.
Reliance Electric Company
Rolm
Siemens A.G. (two divisions)
Sperry Corporation
Square D Company
System Development Corporation
Tandem Computers
Tektronic, Inc.
Texas Instruments, Inc.
Verdix Corporation
Wang Laboratories, Inc.
Westinghouse Electric Corporation
The World Bank
Ungermann-Bass (Industrial Networking, Inc.)
Xerox Corporation
Ztel

For the first time in history, 14 computer vendors cooperated in implementing international networking standards so their systems could easily communicate with each other.

These demonstrations probably spoke more for the future of computer technology than did any of the other exhibitions at the computer conference. They signalled to the computer community that a new opportunity is at hand today, not 5 or 10 years from today—the opportunity to greatly expand the use of networks and to open new markets for network equipment.

The Next Step

The workshops were a success; the demonstrations were a success. So where are the products, and what's next? Those are questions asked by observers at the National Computer Conference.

Several companies have products on the market, and they will soon be joined by many others. But the basic work is not yet finished. NBS is conducting a new series of workshops for further standards development, and, if industry agrees to support it, the Bureau will sponsor a global network on which companies can test their prototype implementations.

As NBS' Heafner points out, however, "NBS will not provide protocol-testing as a service. We are doing this as a cooperative research effort in test method development. We will continue to be the central source for testing methods, but how those methods are applied is up to the vendors and their customers."

In the meantime, all companies and agencies interested in computer networking are invited to use NBS to their own advantage—as some 50 companies are already doing. J.C.

NBS Perspective on Open Systems Interconnection

Robert Blanc, head of the NBS Center for Computer Systems Engineering, recently discussed issues related to computer compatibility and the NBS role in international computer standards development. The following questions and answers are taken from that discussion.

Question: The objective of Open Systems Interconnection [OSI] is to make it easier for computers to communicate. From what we hear and read in the media, unscrupulous individuals already find it easy to gain access to other people's computers. Will OSI increase the threat to computer security?

Blanc: Coupled with the program to make it easier to access computers, we have a program to limit access to people authorized to use the system. We've worked closely with the Department of Defense, the Treasury Department, and the banking community to develop effective safeguards that will protect computer systems. Of course, the safeguards have to be used and used correctly.

Question: The NBS Institute for Computer Sciences and Technology is obviously deeply involved in the work of the International Organization for Standardization [ISO] and other voluntary standards-making groups, both domestic and international. What is the basis for this involvement?

Blanc: Our charter is to develop standards* to increase the effectiveness of the government's use of computers. We think the best way to do that is to develop standards in such a way that they are implemented in commercial products rather than in products developed especially for government. When industry invests resources to develop sophisticated products, they expect to be able to sell them to a worldwide market, not just to the U.S. government.

By developing our standards through the commercial worldwide standards process, we aggregate the market for products that implement our standards. It's to the advantage of industry then to develop those products that respond not only to the requirements of government agencies but to worldwide requirements as well.

Question: Open Systems Interconnection is the answer of the international standards community to computer incompatibility. Are the individual companies really paying attention to it, or are they going to give it lip service and hope that it goes away?

Blanc: OSI standards are being implemented by quite a large number of companies. We are working with over 50 companies

"Coupled with the program to make it easier to access computers, we have a program to limit access to people authorized to use the system."

in a new series of workshops. They decide, as a group, which standards to concentrate on—and which features to implement. This way, all their systems will be compatible, which is the main objective of OSI.

A precondition of fairly rapid implementation of the standards is the availability of test methods

"By developing our standards through the commercial worldwide standards process, we aggregate the market for products that implement our standards."

which can be used by companies to assist them in developing good, correct [by OSI standards], compatible implementations. At NBS we have the responsibility of developing those test methods, and we use the government/industry workshops to help us set our priorities on what tests to develop first.

Question: What about equipment tied into computer networks in factories and offices right now? Won't that equipment be incompatible with new equipment implementing OSI protocols?

Blanc: Certainly we're going to have that kind of compatibility problem. We recommend, if an organization plans to develop a network with equipment from different manufacturers, they become aware of OSI—and more importantly with protocol specifications that have been developed to support OSI. It might be a mistake now to be designing your own network protocols. The OSI protocols are sophisticated enough in most cases to support computer-to-computer requirements in office, factory, and laboratory environments.

User groups can help companies keep up with OSI developments. Industrial computer users can get involved with a factory-floor communications users group. Over 100 corporations belong, and General Motors is playing a lead role. Boeing Corporation started a network users

* The standards referred to here are Federal Information Processing Standards, called FIPS for short. They are not regulatory standards, but standards and guidelines developed by NBS' Institute for Computer Sciences and Technology to aid federal agencies in procuring, using, and testing computer systems and equipment. NBS is not a regulatory agency.

association that is concerned with OSI for many networking applications, particularly in office environments. I think it now has about 85 companies as members.

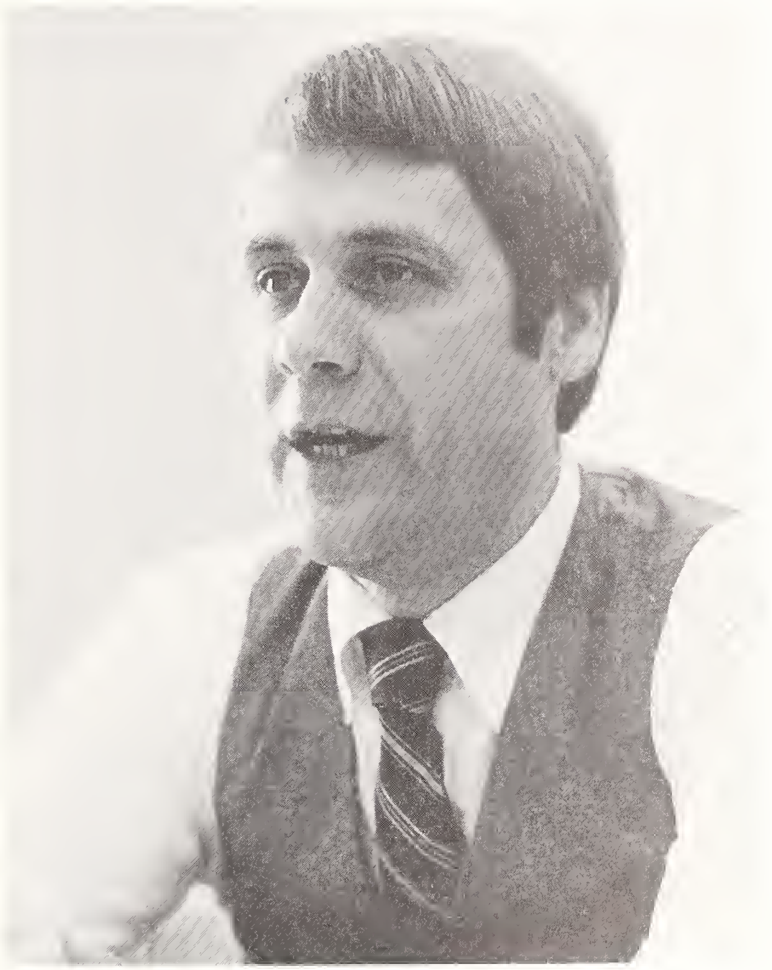
Question: Do you have any points you think deserve particular emphasis?

Blanc: First, I want to stress that our interactions with industry and the standards-making community are aimed ultimately at satisfying the needs of federal agencies. We have an interagency research agreement with DoD [Department of Defense] to help make sure that their requirements are met by standards developed nationally and internationally by ISO and other voluntary standards organizations. We have an agreement with FAA [Federal Aviation Administration] to assist them in the use of OSI protocols.

"The OSI protocols are sophisticated enough in most cases to support computer-to-computer requirements in office, factory, and laboratory environments."

We think it's important to get information to the government agencies as well as industry to tell them what OSI is all about and how to make use of standards that have been developed. We're working jointly with the Computer and Business Equipment Manufacturers Association to organize a major seminar on OSI, to be held here at NBS in October.

I also want to emphasize that we have an NBS Research Associate Program where people from industry and other agencies come and work in our laboratories on programs of mutual interest. We have research associates here now working on protocol development and test methods, and we would welcome more. It's the quickest way we know to transfer our technology.



Robert Blanc, director, NBS Center for Computer Systems Engineering.

Question: You have said several times that the aim of NBS' OSI-related programs is "portable technology"—prototype protocols and test methods that companies will use themselves to develop and test their OSI standards. You do not intend to offer long-term testing or direct assistance. As the OSI work gradually phases out, what will replace it as a research priority?

Blanc: We have already initiated research efforts in high-performance computing. We think this is an area of growing importance, and we think we can play a leading role in measurement and test method development. There is a need for methodologies to measure the performance of novel computer architecture to support design decisions. We think we can work cooperatively with industry to meet this need, just as we have in networking.

NBS Adds Credibility to Energy-Related Inventions

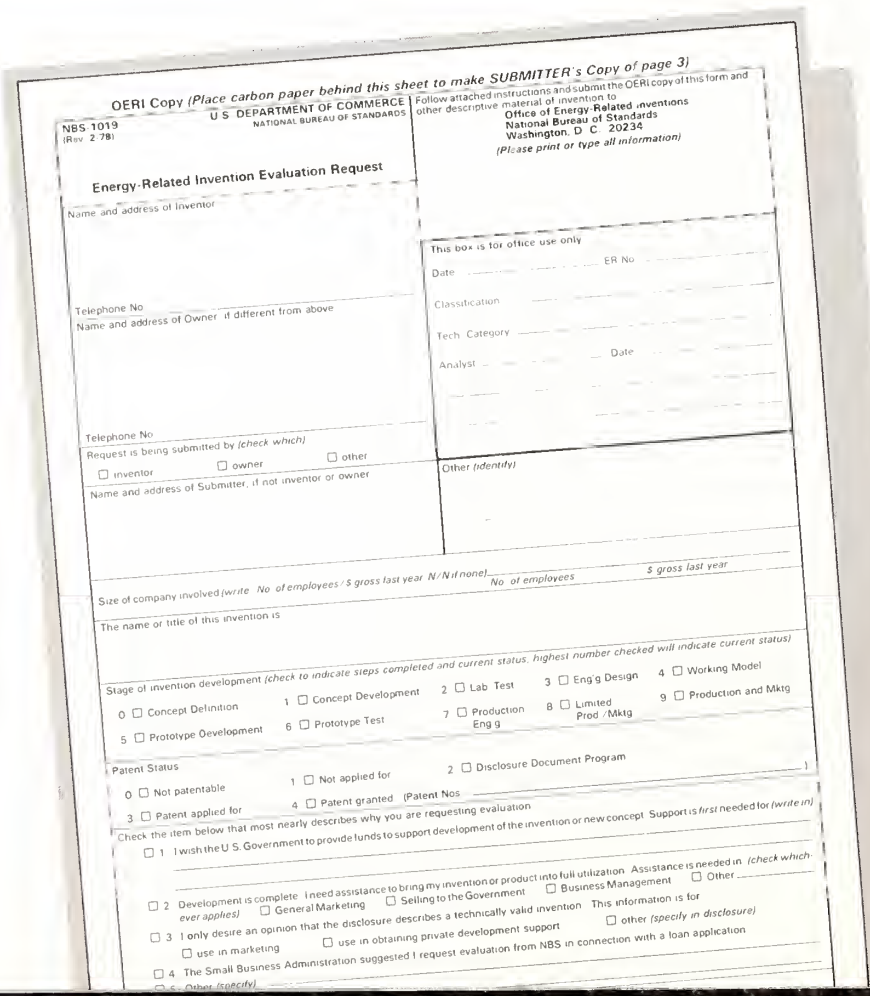
A small program conducted jointly by the National Bureau of Standards and the Department of Energy (DoE) is helping inventors get their ideas from the workshop to the marketplace. NBS provides, at no cost to the inventor, evaluations of energy-related inventions and recommends those it considers promising to DoE. In turn, DoE provides financial and/or marketing support.

The Energy-Related Inventions Program also gives inventors what many of them need most—credibility. "Without credibility it's likely the individual inventor will find it very difficult to find financial support for an idea," says George Lewett, chief of the NBS Office of Energy-Related Inventions.

"Financial institutions like to know who they are dealing with. If they don't, chances are the inventor's request for funding will be rejected," says Lewett. "But with a favorable NBS review, an inventor often can take an idea to the bank and turn it into funds or other support."

California inventor Norman Fawley agrees. "While I would like to think that the world would recognize an inventor, this simply is not a fact. The NBS recommendation was critical to me because it added that necessary ingredient of 'scientific credibility.' "

After several years of knocking on doors and being told, "That's a great idea, come back and see us again," Fawley submitted his idea to NBS in June 1981, for review. The following June, after a detailed evaluation, NBS gave Fawley's idea a favorable recommendation.


OERI Copy *(Place carbon paper behind this sheet to make SUBMITTER's Copy of page 3)*

NBS-1019 (Rev 2-78)
U S DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Follow attached instructions and submit the OERI copy of this form and other descriptive material of invention to
Office of Energy-Related Inventions
National Bureau of Standards
Washington, D C 20234
(Please print or type all information)

Energy-Related Invention Evaluation Request

Name and address of Inventor

Telephone No

Name and address of Owner if different from above

Telephone No

Request is being submitted by *(check which)*
☐ inventor ☐ owner ☐ other

Name and address of Submitter, if not inventor or owner

This box is for office use only
Date ____ ER No ____
Classification ____
Tech Category ____
Analyst ____ Date ____

Other *(identify)*

Size of company involved *(write No of employees / $ gross last year N/N if none)* ____ *No of employees* ____ *$ gross last year*

The name or title of this invention is

Stage of invention development *(check to indicate steps completed and current status, highest number checked will indicate current status)*
0 ☐ Concept Definition 1 ☐ Concept Development 2 ☐ Lab Test 3 ☐ Eng'g Design 4 ☐ Working Model
5 ☐ Prototype Development 6 ☐ Prototype Test 7 ☐ Production Eng g 8 ☐ Limited Prod /Mktg 9 ☐ Production and Mktg

Patent Status
0 ☐ Not patentable 1 ☐ Not applied for 2 ☐ Disclosure Document Program
3 ☐ Patent applied for 4 ☐ Patent granted (Patent Nos ____)

Check the item below that most nearly describes why you are requesting evaluation
☐ 1 I wish the U S. Government to provide funds to support development of the invention or new concept Support is *first* needed for *(write in)*
☐ 2 Development is complete I need assistance to bring my invention or product into full utilization Assistance is needed in *(check whichever applies)* ☐ General Marketing ☐ Selling to the Government ☐ Business Management ☐ Other ____
☐ 3 I only desire an opinion that the disclosure describes a technically valid invention This information is for ☐ use in marketing ☐ use in obtaining private development support ☐ other *(specify in disclosure)*
☐ 4 The Small Business Administration suggested I request evaluation from NBS in connection with a loan application
☐ 5 Other *(specify)*

Fawley's invention is a lightweight aluminum cylinder reinforced with resin-impregnated glass filaments. This doubles the cylinder's ability to withstand pressure. The cylinder makes it practical to use natural gas as a vehicle fuel. The primary drawbacks to using natural gas have been the low capacity and heavy weight of high-pressure steel tanks. But, because of the light weight and greater pressure capacity of Fawley's aluminum cylinders, a greater amount of natural gas can be stored at less than half the weight of steel tanks.

Says Fawley, "With abundant North American natural gas supplies, a distribution system that's already in place, and a cost about half that of gasoline, many energy experts believe that compressed natural gas will emerge as a major vehicle fuel in the near future."

The cylinders being produced by Fawley's company, now a subsidiary of the Aluminum Company of America (ALCOA), have been installed in fleet vehicles of 20 companies in the United States and Canada. Fawley estimates an annual demand of 500,000 cylinders by 1990.

Another Fawley invention, which was also evaluated favorably by NBS, is based on the same technology of reinforcing metal with a composite. This invention could help make gas pipelines safer. A puncture in a conventional gas pipeline can cause a several-thousand-foot crack to develop in a matter of seconds, creating a potentially explosive situation. But testing has shown that a crack will not propagate in a pipeline made using Fawley's idea of reinforced composite metal. The invention is expected to be on the market in the near future.

Other NBS/DoE-assisted inventions which have been successful include a direct-fired gas heating system invented by Harry Wood of New Orleans. The highly efficient industrial system heats water by bringing a natural gas flame into direct contact with the water and recovering the latent heat of the water vapor produced during combustion. Wood licensed his invention to another corporation which has sold over 65 units and has orders for more. He has adapted the technology as a stack waste heat reclaimer for industry that uses hot flue gas in lieu of a gas burner to heat water. This year, Wood plans to manufacture $3 million worth of the units.

The "Heat Extractor," which can be used by both industry and the homeowner, was invented by Daniel Ben-Shmuel. The St. Johnsville, N.Y., inventor used his DoE grant to install, operate, and test the Heat Extractor in an operating paper mill. The device removes and recycles heat from the furnace flue gas. So far, Ben-Shmuel has achieved the greatest commercial success of inventors supported by the program with sales currently running about $25 million a year.

Inventors getting a favorable NBS review are a relatively select group—those with very promising, new ideas. Of the 21,000 inventions submitted to NBS since the program started in 1975, NBS has recommended 275 for DoE assistance.

An invention that passes initial NBS review undergoes a rigorous evaluation by one of six evaluators on the NBS Office of Energy-Related Inventions staff. In the evaluation process, NBS draws upon a national network of hundreds of expert consultants from government, industry, and universities. Typically NBS evaluators obtain written opinions from at least two consultants on each invention evaluated.

"The NBS recommendation was critical to me because it added that necessary ingredient of 'scientific credibility.' "

The NBS evaluators ask three key questions: Is the invention technically feasible? Will it save a significant amount of energy or increase supplies from nonnuclear sources? Does it have a reasonable chance of becoming a commercial success?

Even rejected inventions get a bonus: a free evaluation by NBS. If an invention does not warrant further review, the key reasons for rejection are identified and sent to the inventor, who is welcome to try again. "We're always willing to reconsider our position if the inventor can provide further details or new information," says Lewett.

If the invention is considered promising, NBS forwards it to DoE for financial support and/or help with marketing the invention. Before 1982, the primary form of DoE support was a one-time grant to the inventor for research and development. Grants typically have ranged between $50,000 and $200,000, with an average of $70,000.

During 1982 and 1983 grant funds were not available. In that period, DoE began helping inventors to obtain private-sector financial support and develop marketing plans. Though DoE is once again able to provide grants, this help will continue.

So far, DoE has awarded grants totaling nearly $14 million for 175 of the 275 inventions recommended by NBS. Forty-six inventors have been able to acquire a total of $45,855,000 in follow-on financing, mostly from private, non-federal sources. Some $3 million is available for grants in fiscal year 1985.

Statistics on total energy savings from the program are just now starting to accumulate. According to DoE, four of the inventions which have made it to the marketplace saved about 2 trillion Btu's in 1983—the equivalent of about $10 million in oil. In 5 years the savings attributable to 35 of the inventions now on the market are expected to be $100 million per year. Federal funding for the Energy-Related Inventions Program at NBS and DoE has averaged about $5 million a year.

The assistance the program gives to inventors does not stop at evaluations and financial and marketing support. For the past 4 years the program has been bringing together inventors through a series of nationwide National Innovation Workshops. The 2-day workshops give practical guidance and information to inventors and prospective inventors through lectures and panel discussions. Advice is given on turning ideas into inventions, patenting, licensing and selling, starting new businesses, and getting help from both public and private sources. Over 4,500 inventors and would-be inventors have attended these 25 workshops.

NBS' Lewett feels very strongly that America's future lies in innovation and in the creativity of the individual inventor. "Our future technological and economic growth will depend in no small part on inventions and innovations by individuals and small companies. We should make a special effort to make sure these inventions are recognized and to help establish credibility for the individual inventor."

If you think this program can help commercialize your energy-saving idea, write to: Office of Energy-Related Inventions, ER Division, Room 209 Engineering Mechanics Building, National Bureau of Standards, Gaithersburg, MD 20899. J.K.

TABLES OF THERMAL CONDUCTIVITY OF FLUIDS

Roder, H. M., ***Experimental Thermal Conductivity Values for Hydrogen, Methane, Ethane, and Propane,*** *Natl. Bur. Stand. (U.S.), NBSIR 84-3006, 58 pages (May 1984). Order by stock no. PB 84-235332 from NTIS, $10 prepaid.*

New experimental measurements of the thermal conductivity of fluids, which are absolute and which were made using a very accurate apparatus called the transient hot-wire device, are given in this publication. It contains data in the temperature range from about 77 K to 325 K, and over the pressure range of near zero to 70 MPa. The thermal conductivity surfaces are delineated by measurements along isotherms (about 20 K intervals) at 400 to 1,600 separate points for each fluid.

SPECIMEN GEOMETRY EFFECTS IN FRACTURE TOUGHNESS TESTING

Anderson, T. L., ***Effect of Crack-Tip Region Constraint on Fracture in the Ductile-To-Brittle Transition,*** *Natl. Bur. Stand. (U.S.), NBSIR 84-3001, 199 pages (May 1984). Order from NTIS by stock no. PB 84-237395, $19 prepaid.*

Since full-scale fracture toughness tests of structures are expensive and sometimes wholly impractical, it is necessary to conduct tests using reduced-scale specimens. However, specimen geometry has a significant effect on the measured toughness, so test results often do not scale up directly to allow accurate performance predictions. This NBS publication examines this problem and presents a theoretical model to account for the discrepancy. An approach to a solution of the problem, based on critical crack-tip opening displacement and J-integral measurements as a function of temperature in ABS grace EH36 steel, also is presented.

TRAINING MATERIAL ON COST-EFFECTIVE BUILDING DECISIONS

Ruegg, R. T. and Marshall, H. E., ***Economic Evaluation of Building Design, Construction, Operation and Maintenance,*** *Natl. Bur. Stand. (U.S.), instructor's manual—NBS Tech. Note 1194, 317 pages (June 1984). Order from GPO by stock no. 003-003-02596-8, $8 prepaid; workbook—NBS Tech. Note 1195, 183 pages (June 1984). Order from GPO by stock no. 003-003-02597-6, $4.50 prepaid.*

NBS researchers have put together a printed version of a short course on economic evaluation procedures. It was designed to help those in the building community who are faced with tight construction and operating budgets make cost-effective building decisions. The material covers the fundamentals of economic evaluation methods, modeling building economics problems, and data compilation. NBS has published the materials for the course as an instructor's manual and a seminar workbook.

DIRECTORY OF U.S. STANDARDS ACTIVITIES

Toth, R. B., editor, ***Standards Activities of Organizations in the United States,*** *Natl. Bur. Stand, (U.S.), NBS Spec. Pub. 681, 592 pages (August 1984). Order by stock no. 003-003-02602-6 from GPO, $13 prepaid.*

Manufacturers, exporters and importers, and others concerned with the standards developed by trade associations, technical and professional societies, federal agencies, and state governments will be interested in a new directory of mandatory and voluntary standards activities in the United States. This directory was prepared by the NBS Office of Product Standards Policy, which serves as the national focal point for domestic and international standards and certification information. The directory summarizes the standardization activities of more than 750 organizations in the United States, including federal and state agencies and approximately 420 private sector groups that develop standards.

NEW GUIDES FOR MOBILE AND PERSONAL RADIOS

Scott, Jr., W. W., ***Mobile Radio Guide,*** *Natl. Inst. of Justice (U.S.), 202-83, 45 pages (November 1983) and Shafer, J. F.,* ***Personal Radio Guide,*** *Natl. Inst. of Justice (U.S.), 203-83, 27 pages (August 1984). Order from the National Institute of Justice, National Criminal Justice Reference Service, Washington, DC 20531.*

Working for the National Institute of Justice, NBS has developed guidelines for the selection and procurement of two-way mobile and personal radios. Although written specifically for the law enforcement community, these two user guides will be helpful to anyone who plans to purchase and use two-way radios. The guides cover such diverse topics as operational considerations, radio coverage, regulatory aspects, design and construction, cost, maintenance, safety, and purchasing hints.

THERMAL CONDUCTIVITY OF METALS

Hust, J. G. and Lankford, A. B., ***Thermal Conductivity of Aluminum, Copper, Iron, and Tungsten for Temperatures From 1K to the Melting Point,*** *Natl. Bur. Stand. (U.S.), NBSIR 84-3007, 255 pages (June 1984). Order from NTIS by stock no. PB 84-235878, $22 prepaid.*

NBS has critically analyzed published data on the thermal conductivity of commercially pure aluminum, copper, iron, and tungsten. The results of this analysis are presented in this publication which includes an extensive bibliography of the sources of the data, an explanation of the methods used in the analysis, and discussions of the effects on thermal conductivity of chemical impurities, physical defects, specimen size, and magnetic fields. "Smoothed values" for conductivity are calculated from the best data and listed for various temperatures and residual resistivity ratios.

NEW NBS/NRC STEAM TABLES

Haar, L., Gallagher, J. S., and Kell, G. S., ***NBS/NRC Steam Tables,*** *Hemisphere Publishing Corp., (New York), 320 pages (1984). Order from Hemisphere Publishing Corp., 79 Madison Avenue, New York, NY 10016, $34.50 prepaid.*

Eight of the world's leading industrial nations recently endorsed new steam tables for scientific and general use. The tables, which were developed by NBS and the National Research Council of Canada, were endorsed through the International Association for the Properties of Steam (IAPS). They are based on an equation that establishes a formulation which provides scientists and engineers with thermodynamically consistent data on the properties and density of water from the triple point (the state of equilibrium between the solid, liquid, and vapor phase) to 2500 °C and from zero pressure of an ideal gas to more than 20 kilobars. This equation makes it possible to obtain pressure data 10 times higher than the previous IAPS formulation. The tables will help scientists and engineers in designing industrial and chemical processes; exploring for petroleum and minerals; designing heat transfer systems, boilers, and turbines; and harnessing geothermal energy.

IMPROVED GUIDE FOR INSPECTING PACKAGED GOODS

Brickenkamp, C. S., Hasko, S., and Natrella, M. G., ***NBS Handbook 133—Second Edition: Checking The Net Contents of Packaged Goods,*** *Natl. Bur. Stand. (U.S.), NBS Hdbk. 133, 314 pages (October 1984). Order by stock no. 003-003-02616-6 from GPO, $9 prepaid.*

Quality control specialists in packaged goods industries, such as foods, chemicals, pharmaceuticals, and other consumer products, will be interested in this new, second edition guide. Adopted by the National Conference on Weights and Measures, the handbook is an easy guide for testing packaged goods to determine that net contents conform to packaging label requirements. Procedures are provided for statistical sampling techniques to test individual lots of packages which include anything that is put into a container, wrapped, or banded and labeled as to quantity. While developed primarily for weights and measures officials in the states, counties, and cities, the handbook also is helpful for establishing content compliance by commercial and industrial firms involved in the packaging, distribution, and sale of packaged commodities.

INDUSTRIAL GUIDE TO ACCURATE MASS MEASUREMENT

Jaeger, K. B. and Davis, R. S., ***A Primer for Mass Metrology,*** *Natl. Bur. Stand. (U.S.), NBS Spec. Pub. 700-1, 81 pages (November 1984). Order by stock no. 003-003-02621-2 from GPO, $3.25 prepaid.*

Researchers from NBS and the Lockheed Missiles and Space Company, Inc., have collaborated on this guide which outlines fundamental concepts and equations and good metrology practice for the measurement of mass. The text also serves as a bibliography of more detailed NBS publications on mass measurement. It is the first of the new NBS Industrial Measurement Series, which will feature treatises on topics of special interest to industrial metrologists, prepared jointly by NBS and industrial specialists.

ULTRASONIC THICK-WELD INSPECTIONS AUTOMATED

Fortunko, C. M., Schramm, R. E., Moulder, J. C., and McColskey, J. D., ***Electromagnetic-Acoustic-Transducer/Synthetic-Aperture System For Thick-Weld Inspection,*** *Natl. Bur. Stand. (U.S.), NBS Tech. Note 1075, 117 pages (May 1984). Order from GPO by stock no. 003-003-02578-0, $4.75 prepaid.*

A thick-weld inspection system recently developed by NBS for the U.S. Navy uses ultrasonic shear waves, polarized parallel to the surface of a plate, to detect flaws in butt welds and determine their size. Non-contacting electromagnetic-acoustic transducers (EMAT's) generate ultrasonic probe signals and detect waves scattered from defects in the welds. EMAT's, unlike conventional transducers, do not require fluid couplants or special surface preparation, so they can be used on virtually any surface: rough or smooth, hot or cold, rusty or painted. The system automatically scans the inspection site under computer control, and processes the reflected waves to aid in determining flaw size. The computer uses synthetic-aperture waveform reconstruction techniques to reduce interference in the noisy welding environment. This publication describes the concept, design, and operation of the system.

BIBLIOGRAPHY ON ELECTROMAGNETIC TECHNOLOGY

Kamper, R. A. and Kline, K. E., editors, ***Metrology for Electromagnetic Technology: A Bibliography of NBS Publications,*** *Natl. Bur. Stand. (U.S.), NBSIR 84-3014, 66 pages (July 1984). Order by stock no. PB 84-112985 from NTIS, $10 prepaid.*

Researchers in the NBS Electromagnetic Technology Division have published their work in a wide variety of journals, texts, and NBS publications, covering research in the fields of cryoelectronics, lasers, microwaves, optical fibers, superconductors, and other areas connected with the measurement methods and standards developed by NBS. This work provides measurement support for a broad range of industries and applications including telecommunications, lasers, radar, instrumentation, electrical power generation and transmission, and optical fibers. This publication lists these papers for the period 1970 through 1983.

ORDERING INFORMATION

To order publications from NTIS, send request with payment to: National Technical Information Service, Springfield, VA 22161. Publications can be ordered from GPO by mailing order with payment to: Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. ■

1985 Trends and Applications Conference: Utilizing Computer Graphics, Sheraton N.W. Washington, Silver Spring, MD

May 21-22, 1985

Techniques for using computer graphics for greater productivity will be discussed at the 1985 Trends and Applications Conference. Presentations will address current systems and applications as well as ongoing research into advanced concepts. The conference should provide needed background for data processing professionals in both government and commercial sectors in the evolving areas of new graphics technology, applications, standards, management and controls, user interfaces, and overcoming barriers to utilizing graphics. Sponsored by the Institute of Electrical and Electronics Engineers Computer Society and NBS. Contact: Joseph C. Collica, A245 Technology Building, NBS, Gaithersburg, MD 20899, 301/921-2431.

Mechanisms of DNA Damage and Repair, NBS, Gaithersburg, MD

June 3-7, 1985

Although damage to DNA is believed to play a critical role in carcinogenesis, mutation, and numerous genetic disorders, we still have no mechanistic understanding of how the majority of DNA-damaging agents work.

This conference will examine mechanisms of DNA damage, including strand breaks (single and double), base alteration or loss, crosslinks within DNA and between DNA and proteins, and covalent and non-covalent binding. Other topics will include the localization of damage in the genome, the relationships of DNA damage to oncogene activation, and DNA repair mechanisms.

The conference will also consider how an understanding of the mechanisms of DNA damage and repair might be used for accurate "dosimetry" of hazardous exposure to chemicals, drugs, and ionizing radiation. Sponsored by NBS, the National Cancer Institute, and the Radiation Research Society. Contact: Dr. Michael G. Simic, C216 Radiation Physics Building, NBS, Gaithersburg, MD 20899, 301/921-2374.

Workshop on Robot Standards, Pontchartrain Hotel, Detroit, MI

June 6-7, 1985

This workshop will provide a forum where researchers, vendors, and users from government, academia, and industry can learn what is happening in robot standards. Requirements and opportunities for robot standards will be presented and discussed. Topics include: control system interfaces to robots, sensors, databases, and high-level control systems; mechanical interfaces to grippers; programming languages and environments; performance measures; and human interfaces. Sponsored by NBS and the Navy/NAVCIM Program; cosponsored by the Robotic Industries of America, ASTM, the Institute of Electrical and Electronics Engineers, the American National Standards Institute, and the Electronic Industries Association. Contact: Leonard S. Haynes, A123 Metrology Building, NBS, Gaithersburg, MD 20899, 301/921-2181.

International Conference on Biologically Induced Corrosion, NBS, Gaithersburg, MD

June 10-12, 1985

This conference will focus on mechanisms, case histories, and experimental methods of and remedial measures for biologically induced corrosion in both natural and artificial environments. Special emphasis will be placed on corrosion mechanisms and on establishing the causative links between the simultaneous observations of corrosion and the presence of microorganisms. Sponsored by the National Association of Corrosion Engineers and NBS. Contact: Dr. Warren P. Iverson, A331 Materials Building, NBS, Gaithersburg, MD 20899, 301/921-2953.

International Conference on Chemical Kinetics, NBS, Gaithersburg, MD

June 17-19, 1985

The progress and problems of current interest in theoretical and experimental chemical kinetics will be reviewed by leading scientists from universities, research laboratories, and industrial organizations. A major goal will be to bridge the gap between theoretical and experimental gas- and condensed-phase phenomena and ionic and neutral species chemistry. The occasion will also be used to honor Professor Sidney W. Benson for the very important role he has played over the past 30 years in focusing attention on the themes of this conference. Six nonparallel sessions are planned, consisting of invited lectures, contributed poster sessions, and general discussions. Each session will focus on one fundamental aspect of chemical kinetics. Sponsored by NBS and the National Aeronautics and Space Administration. Contact: Dr. John T. Herron, A147 Chemistry Building, NBS, Gaithersburg, MD 20899, 301/921-2792 or Dr. Wing Tsang, A147 Chemistry Building, NBS, Gaithersburg, MD 20899, 301/921-2775.

VLSI Chip Packaging Workshop, Gaithersburg Marriott, Gaithersburg, MD

September 9-11, 1985

This workshop has become a premier forum for technical professionals in the field of package development and analysis for VLSI integrated circuits. The topics covered will include large chips, high-lead-count packages, conventional and pin-grid-array chip carriers, TAB and wire bonding, and electrical and thermal performance packages. Sponsored by the Institute of Electrical and Electronics Engineers, the Component Hybrids and Manufacturing Technology Society, and NBS. Contact: George G. Harman, B344 Technology Building, NBS, Gaithersburg, MD 20899, 301/921-3541. ■

The National Bureau of Standards was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, the Institute for Computer Sciences and Technology, and the Center for Materials Science.

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- Chemical Physics
- Analytical Chemistry

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- Manufacturing Engineering
- Building Technology
- Fire Research
- Chemical Engineering

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Conducts research and provides measurements, data, standards, reference materials, quantitative understanding, and other technical information fundamental to the processing, structure, properties, and performance of materials; addresses the scientific basis for new advanced materials technologies; plans research around cross-country scientific themes such as nondestructive evaluation and phase diagram development; oversees Bureau-wide technical programs in nuclear reactor radiation research and nondestructive evaluation; and broadly disseminates generic technical information resulting from its programs. The center consists of the following divisions:

- Nondestructive Evaluation
- Inorganic Materials
- Fracture and Deformation
- Polymers
- Metallurgy
- Reactor Radiation

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