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NIST Research Reports

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On the cover: NIST chemist Marlon L. Walker (left) and physicist William L. McLaughlin developed a rugged, optical system to monitor radiation dosage for quality control of a variety of industrial processes. The system is one of the advances in instrumentation and measurement technology for which NIST received seven R&D 100 awards. See article on page 10.

NIST Research Reports

U.S. DEPARTMENT OF COMMERCE
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Examiners Needed for 1991 National Quality Award

The Malcolm Baldrige National Quality Award Office is seeking applications from individuals who can qualify as examiners. The award is offered annually to American companies that demonstrate the highest levels of total quality management. Examiners are responsible for reviewing and evaluating applications submitted for the award. Information on the award program and applications to serve as an examiner are available from the Baldrige Quality Award Office, A537 Administration Bldg., NIST, Gaithersburg, Md. 20899. Application requests also can be made by fax, 301/948-3716; telephone, 301/975-2036; or electronic message on the Quality Award BBS, 301/948-5635 with parameters 300/1200/2400-8-N-1. Examiner applications are due November 21, 1990. The Malcolm Baldrige National Quality Award, established by law in 1987, was launched in 1988.

NIST Seeks Proposals for Measurement Grants

NIST is seeking project proposals for its FY 1992 Precision Measurement Grants. The grants are for $30,000 for 1 year and may be renewed for up to 2 additional years. Prospective candidates must submit summaries of their proposed projects and biographical information to NIST by Feb. 1, 1991, to be considered for the current grants, which will run from October 1991 through September 1992. The Precision Measurement Grants are awarded each year to scientists in academic institutions for work in determining values for fundamental constants, investigating related physical phenomena, or developing new, fundamental measurement methods. For information, contact Barry N. Taylor, Chairman, NIST Precision Measurement Grants Committee, B160 Physics Bldg., NIST, Gaithersburg, Md. 20899, 301/975-4220.

NIST, APL Study Automated Electronics Assembly

NIST and the Applied Physics Laboratory (APL) of the Johns Hopkins University have established a 1-year cooperative research program. The goal is to achieve productivity and quality improvements in computer-integrated manufacturing systems used for electronics assembly. Surface-mount printed-circuit boards would be a typical product. The project will include the specification of process and quality-control techniques and strategies, computer hardware and software, data requirements, and interface and support standards, such as STEP (STandard for the Exchange of Product model data) and the Defense Department's CALS (Computer-aided Acquisition and Logistic Support) standards. New concepts for process control sensors will be tested. The project draws on NIST skill in process control sensors, automation, and standards technology, and APL expertise in applications and electronics manufacture.

New Plumbing Program Announced for Testing Labs

NIST has established a laboratory accreditation program for labs that test plumbing products and devices. Labs can seek accreditation to test plumbing fixtures under ANSI Z124 standard series for plumbing plastics and to test fixture fittings and fixtures under ASME/ANSI 112 standards 18.1 and 19.2. The new program is part of the National Voluntary Laboratory Accreditation Program (NVLAP) for commercial products, which was established at the request of the International Coalition for Procurement Standards to provide buyers with a list of accredited labs that can test products to conform to contract specifications. The program also meets the needs of public authorities for energy and water conservation programs nationwide. Labs seeking accreditation for one or more of the test methods must meet all NVLAP criteria and renew their status annually to maintain accreditation. For information, contact Lawrence S. Galowin, NVLAP, A124 Bldg. 411, NIST, Gaithersburg, Md. 20899, 301/975-4022, fax: 301/975-3839.

Aristech Chemical To Consult with NIST on Polymers

Aristech Chemical Corporation, Monroeville, Pa., has established a Research Associate Program at NIST to consult with Institute scientists on nonproprietary polymer blends of polycarbonate and poly (methyl methacrylate) (PMMA) materials. Scientists from Aristech's Research Laboratory will use the NIST time-resolved light-scattering instrument and small-angle neutron scattering techniques at NIST's research reactor to measure the kinetics and thermodynamics of polymer blend phase behavior. Blends of PMMA with polycarbonates or other polymers are used widely in manufacturing transparent window panels or molded into large-scale plumbing fixtures such as bathtub enclosures and shower stalls.

The NIST Research Associate Program provides an opportunity for engineers and scientists from industry, universities, technical societies, and other

organizations to conduct cooperative research at NIST on projects of mutual interest, with salaries paid by the sponsor.

Materials Can Help Evaluate Industrial Atmosphere

Regulatory agencies and others studying the toxic metal concentration of industrial environments now have a new tool from NIST to help them achieve the most accurate measurements possible. It is a series of cellulose filters—similar to the ones used to sample atmospheric specimens—each containing certified concentrations of nine metals known to be toxic at certain levels. The filters that make up this Standard Reference Material (SRM) can be dissolved easily in acid and diluted with distilled water to the desired volume and concentration level. In solution form, the SRM can be used in atomic absorption, optical emission (plasma), spectrometry, spectrophotometry, or any other analytical techniques that require aqueous standard solutions for calibrating instruments.

Metals represented on each of the filters are barium carbonate, cadmium, chromium, iron, magnesium, nickel, lead, selenium, and zinc. Each SRM consists of six filters containing the metals and five "blank" filters that allow chemists to assess the ambient levels of the metals being measured. SRM 3087, Metals on Filter Media, sells for $155 and is available from the Standard Reference Materials Program, Rm. 215 Bldg. 202, NIST, Gaithersburg, Md. 20899, 301/975-6776.

Security Bulletin Board Expanded

The NIST Computer Security Bulletin Board has been expanded, making it easier to access the information stored in the system. Since October 1989 this electronic bulletin board has provided information dealing with computer security, including bibliographies of relevant publications and listings of security-related seminars and conferences. In addition, the system contains information issued by NIST and others concerning computer security incidents, such as computer virus attacks. NIST also will use the bulletin board to disseminate information about future incidents.

A standard ASCII terminal or a personal computer with serial communications capability is needed to access the bulletin board. The terminal should be set up for these communications parameters: 2400, 1200, or 300 modem baud rate; 8 data bits with no parity (or 7 with even parity); and 1 stop bit. Dial 301/948-5717 to connect with the board. The system is available 24 hours a day. For further information, call NCSL Security BBS assistance at 301/975-3359 or use the message subsystem of the bulletin board.

PHIGS Conformance Test Available

The Programmer's Hierarchical Interactive Graphics System (PHIGS) provides a standard library of routines for use in programming three-dimensional graphics. PHIGS is a Federal Information Processing Standard (FIPS 153) that adopts a voluntary industry standard (ANSI X3.144-1988). NIST has developed a test system to help users and vendors determine whether the complex data structures used to generate the graphics displays conform to FIPS 153. A future version will include interactive tests to determine if the visual output is correct.

The test suite consists of a set of FORTRAN programs that can be easily adapted for most computer system operating environments. The PHIGS validation test costs $1,000 for the first operating environment, $1,500 for two different environments, and $2,000 for three. Four or more will cost $2,500. A user guide is included in the package, which describes test suite installation and operation and gives guidance on interpreting the test results. To order the test suite, contact John Cugini, A266 Technology Bldg., NIST, Gaithersburg, Md. 20899, 301/975-3248.

New Video Can Help Save Energy and Dollars

Energy-efficient buildings make dollars and sense. But tight operating and construction budgets often force tough decisions to be made on energy-conservation projects. A new video training program developed by NIST gives building professionals the basic tools needed to evaluate the cost effectiveness of these decisions.

The 1-hour video is the first in a series NIST is producing for the U.S. Department of Energy (DOE). NIST economists and a DOE engineer explain basic concepts of life-cycle cost analysis and demonstrate problem-solving techniques and computer programs that can be used to calculate a building's energy consumption and the life-cycle costs of alternative designs and systems. By the end of the video, the viewer should be able to solve simple, but realistic, problems. A workbook accompanies the video. The videotape, titled "Least-Cost Energy Decisions: An Introduction to Life-Cycle Cost Analysis," is available from Video Transfer Inc., 5709-B Arundel Ave., Rockville, Md. 20852, 301/881-0270. VHS format is $19. Contact Video Transfer Inc. for prices on other formats.

1999 Deadline Set for Uniform Gas Pump Pricing

Weights and measures officials adopted Jan. 1, 1999, as the deadline by which all retail motor fuel dispensers used in multitier pricing must compute at all prices at which the product is offered for sale through the device. The deadline was set at the 75th Diamond Anniversary of the National Conference on Weights and Measures (NCWM), July 8-13, 1990. The decision will affect gasoline service station pumps and other motor fuel dispensers that use different prices for the fuel depending on whether it is paid for in cash or by credit card. The 1999 date was supported by the major oil companies and industry associations representing independent service station owners. NCWM, an organization of state, county, and city weights and measures enforcement officials, receives technical support from NIST, a non-regulatory agency, through the Institute's Office of Weights and Measures.

Study To Help Understand Bone Demineralization

One of the major problems potentially limiting the long-term habitability of outer space is the "demineralization" of human bone that occurs in a microgravity environment. To help understand this loss of calcium and breakdown of bone tissue, scientists need enriched calcium isotopes that can act as "markers" to study the calcium metabolism process in the body. Three researchers from Eastern Analytical Inc. are teaming with NIST scientists to develop and evaluate processes aimed at producing large quantities of a marker isotope—calcium-48—inexpensively. Because calcium-48 is not abundant in nature, the isotope must be produced in the laboratory to acquire the needed amounts. Researchers hope that by using laser light to excite calcium-48 at its resonance frequency, they will be able to extract the isotope from samples. The research will be used by the National Aeronautics and Space Administration in its ongoing investigation of space effects on bone tissue.

Radioscopic Image Quality Indicator Designed

A long-established way to test the quality of a weld is to x ray it and analyze the film for flaws and imperfections. More recently, this process has been computerized and digitized so that film can be replaced by an electronic system that projects the image on a video screen. This permits real-time examination of the weld and improves productivity by allowing the object to be rotated during inspection. But the procedure has been inhibited by lack of an indicator that evaluates image quality as the specimen and its associated image quality indicator (IQI) are rotated. NIST scientists have developed a design for an indicator that has spherical symmetry and provides the same image quality information independent of rotation. For a copy of paper no. 24-90, which describes the design, contact Jo Emery, Div. 104, NIST, Boulder, Colo. 80303, 303/497-3237.

NIST Method Allows Quicker, Cheaper Analyses

Preparing samples of contaminated soils, sediments, and sludges for analysis of environmentally hazardous trace elements can be time consuming. Typically such preparations take 8 to 24 hours to complete. Now NIST and the Environmental Protection Agency (EPA) have produced a method that uses a heating device similar to a kitchen microwave oven to cut the sample preparation time. By using microwave energy to heat a sample in acid within a closed vessel, the processing time can be shaved to 10 minutes. Because so much time is saved, the NIST/EPA method substantially lowers the cost of each analysis. Recent tests also indicate that the new technique will allow trace elements to be detected at lower levels. The method was accepted by EPA after a successful demonstration involving 15 laboratories and will be added to EPA's procedures for its Resource Conservation and Recovery Program and its Superfund Program.

Inexpensive Frequency Calibration Service Available

The NIST Automated Computer Time Service (ACTS), a dial-up service begun in 1988, can also act as an inexpensive frequency calibration service. NIST researchers have found that a frequency calibration accuracy of better than one part in a billion is readily available from a single long telephone call or from a sequence of short calls averaged over a few days. The cost of hardware and software for ACTS is only about $100 versus up to several thousand dollars for most other frequency dissemination services with this level of accuracy. Access ACTS by dialing 303/497-4774. Software can be obtained for $36 from the Standard Reference Materials Program, Rm. 204 Bldg. 202, NIST, Gaithersburg, Md. 20899, 301/975-6776. Ask for Automated Computer Time Service, RM 8101. Paper no. 44-90 describes the service and is available from Jo Emery, Div. 104, NIST, Boulder, Colo. 80303, 303/497-3237.

Four Companies Win Baldrige Quality Award

Commerce Secretary Robert A. Mosbacher announced the four winners of the 1990 Malcolm Baldrige National Quality Award for excellence in quality management on October 10. The winners are the Cadillac Motor Car Division (Detroit, Mich.) and IBM Rochester (Rochester, Minn.) in the manufacturing category; Federal Express Corp. (Memphis, Tenn.) in service; and Wallace Co., Inc. (Houston, Texas) in small business.

The award, named for the late Commerce Secretary Malcolm Baldrige, was established by legislation in August 1987. It promotes national awareness about the importance of improving total quality management and recognizes quality achievements of U.S. companies. Firms applying for the award must undergo a rigorous evaluation by an independent board of examiners composed of private and public sector experts in quality. The examination includes on-site visits for those passing the initial scoring.

Announcing the 1990 award winners, Mosbacher noted, "When President Bush said in this year's State of the Union address, 'Made in the U.S.A. is recognized around the world as the symbol of quality,' he made clear the importance of quality to our economy. Quality is the key to increasing our exports around the world and to a strong economy that assures job growth.

"The winners of this award have made quality improvement a way of life. Quality is their bottom line, and that kind of can-do attitude makes for world-class products and services."

Cadillac Motor Car Company

The Cadillac Motor Car Division, headquartered in Detroit, Mich., is the flagship division of the General Motors North American Automotive Operations. In 1990, sales of nine models are projected to total over 305,000 units and generate $7 billion. The company employs about 10,000 workers at its headquarters, at four Michigan-based manufacturing plants, and at 10 sales and service zone offices in the United States. In the domestic market, which accounts for nearly 99 percent of Cadillac sales, cars are sold through a network of 1,600 franchised dealerships, which are full partners in the division's quality improvement efforts.

During the 1980s, foreign and domestic competitors gained market share at Cadillac's expense. But over the last several years, Cadillac has improved its cars markedly in quality, reliability, durability, and performance. Cadillac's turnaround began in 1985 when top management started implementing simultaneous engineering (SE), the first of several major changes designed to ensure that the division's products and services would be first to meet or exceed the expectations of potential buyers. SE contrasts sharply with the traditional serial approach to automobile development and manufacturing in which individual departments functioned largely in isolation from the others.

The Malcolm Baldrige National Quality Award.

Product design and development now begin with integrated knowledge of all essential elements, including performance targets, product features, systems and parts, processes, and maintenance requirements. Thus, SE anticipates how changes in one functional area will affect the others, making it easier to prevent problems and bottlenecks, to determine in advance how to monitor and control production processes, and to identify opportunities for quality improvement.

The effectiveness of SE, however, hinges critically on carefully orchestrated teamwork. More than 700 employees and supplier representatives now participate on SE teams that are responsible for defining, engineering, marketing, and continuously improving all Cadillac products. Their coordinated efforts on three recent major styling changes, involving, on average, more than 650 part changes, trimmed between 50 and 85 weeks from what typically had been a 175-week process.

In step with service and product quality, customer satisfaction has risen, as measured through extensive surveys and analyses of complaints handled by its 24-hour Customer Relations Center, for instance. On three key measures—satisfaction with cars, service, and total ownership experience—1985 customers rated Cadillac at about 70 percent. In 1989, Cadillac's scores in all three categories were 86 percent or better.

IBM Rochester

IBM Rochester, located in Rochester, Minn., provides employment to more than 8,100 people and is responsible for product development and U.S. manufacturing of both intermediate computer systems and hard disk storage devices for intermediate and personal computers. In addition, its processes are used in plants located in Japan, Mexico, the United Kingdom, and Italy. Rochester is the primary location of Application Business Systems, one of seven business units in IBM U.S.

The concept of quality at IBM Rochester is linked directly to the customer. Detailed features are crafted from the analysis of the needs and expectations of existing and potential owners of the computer hardware and software. At every step, customers are directly involved in every aspect of the product from design to delivery—through advisory councils, global information systems, trials of prototypes, and numerous other feedback mechanisms.

And quality has owners: managers and non-managers alike. Trained in quality concepts and methods, supported by advanced technology, and assisted by decision-making tools, employees have clearly defined quality improvement goals. Often working in teams that erase boundaries between departments, they are given the authority to

determine how best to accomplish those goals.

The IBM Rochester quality culture has been transformed from reliance on technology-driven processes delivering products to market-driven processes directly involving suppliers, business partners, and customers, delivering solutions. A 30-percent improvement in productivity occurred between 1986 and 1989. Product-development time for new mid-range computer systems has been reduced by more than half, while the manufacturing cycle has been trimmed 60 percent since 1983. Customers have benefited from a threefold increase in product reliability; an increase in the product warranty period, from 3 months to 12; and a cost of ownership that is among the lowest in the industry. IBM's share of the world market for intermediate computers increased one full percentage point in both 1988 and 1989, and revenue growth in 1989 was more than double the rate for the industry.

IBM Rochester recently strengthened its strategic quality initiatives by formulating improvement plans based on six critical success factors: improved product and service requirements definition, an enhanced product strategy, a six-sigma defect elimination strategy, further cycle time reductions, improved education, and increased employee involvement and ownership. Each senior manager "owns" one of the six factors and assumes responsibility for plans and implementation. Progress toward achieving improvement goals is closely monitored. Support processes are a part of this network.

Federal Express Corporation

The Federal Express Corporation, the Baldrige Award's first winner in the service category, employs approximately 90,000 people at more than 1,650 facilities worldwide. Headquartered in Memphis, Tenn., the company started the air express delivery service business in 1973. It now enjoys about 40 percent of the market and handles over 1.5 million shipments daily.

"The winners of this award have made quality improvement a way of life. . . ."

Since its founding in 1973, Federal Express has followed a management philosophy that emphasizes people, service, and profit, in that order. By constantly adhering to this philosophy, the company has achieved high levels of customer satisfaction and experienced rapid sales growth. Through a quality improvement program that focuses on 12 Service Quality Indicators (SQIs), all tied to customer expectations and articulated at all levels of its international business, the Memphis-based firm continues to set higher standards for service and customer satisfaction. Measuring themselves against a 100-percent service standard, managers and employees strive to improve all aspects of the way Federal Express does business.

Federal Express's "People-Service-Profit" philosophy guides management policies and actions. The company has a well-developed and thoroughly deployed management evaluation system called SFA (survey/feedback/action), which involves a survey of employees, analysis of each work group's results by the work group's manager, and a discussion between the manager and the work group to develop written action plans for the manager to improve and become more effective. Data from the SFA process are aggregated at all levels of the organization for use in policymaking.

Performance data are gathered with the company's advanced computer and tracking systems, including the Super-Tracker, a hand-held computer used for scanning a shipment's bar code every time a package changes hands between pick-up and delivery. Rapid analysis of data from the firm's far-flung operations yields daily SQI reports that are transmitted to workers at all Federal Express sites.

Since 1987, overall customer satisfaction with Federal Express's domestic service has averaged better than 95 percent, and its international service has rated a satisfaction score of about 94 percent. In an independently conducted survey of air-express industry customers,

53 percent gave Federal Express a perfect score, as compared with 39 percent for the next-best competitor.

Wallace Co., Inc.

The Wallace Co., Inc., based in Houston, Texas, is the small business winner of the Baldrige Quality Award. Founded in 1942 and still family owned and operated, the company distributes pipe, valves, and fittings as well as value-added specialty products, such as actuated valves and plastic-lined pipe. It employs 280 people through its headquarters and 9 branch offices in Texas, Louisiana, and Alabama.

Firms applying for the award must undergo a rigorous evaluation by an independent board of examiners composed of private and public sector experts in quality.

Wallace Co., Inc., has pursued a long-term strategy of Continuous Quality Improvement. In only a few years, Wallace has distinguished itself from its competitors by setting new standards for service. Now entering the final stage of the three-phase quality program it initiated in 1985, Wallace has effectively merged business and quality goals, built new partnerships with customers and suppliers, and instilled associates with a commitment to one overriding aim: total customer satisfaction.

In tandem with its move to Continuous Quality Improvement, Wallace shifted its marketing focus from engineering and construction activities to maintenance and repair operations, now the source of 70 percent of its sales. In 1989 sales totaled $79 million.

Not only does Wallace comprehensively monitor its activity—it has identified and now measures 72 discrete processes that contribute to on-time delivery and accurate invoicing—but it invites the scrutiny of customers. Customers receive computer-generated reports that document how well the company has been servicing its accounts. Customer feedback is ensured through four types of surveys, "partnering" meetings, frequent contacts by sales representatives, and a Total Customer Response Network.

Wallace holds suppliers to its same high standards, requiring firms to provide statistical evidence of the quality of their shipments and to guarantee their products for a minimum of 12 months.

Since 1987, Wallace's market share has increased from 10.4 percent to 18 percent. Its record of on-time deliveries has jumped from 75 percent in 1987 to 92 percent in 1990. The distributor has committed to guarantee all customers an on-time delivery rate of 98 percent as of July 1991. Its customer base has grown, while existing clients have increased their business. As a result, sales volume has grown 69 percent and, because of greater efficiency, operating profits through 1989 have increased 7.4 times.

1991 Applications Available Soon

Application guidelines for the 1991 Malcolm Baldrige National Quality Award will be available in early December. A maximum of two awards may be given annually in each of three categories: large manufacturers, large service companies, and small businesses.

The winners in 1988 were Motorola, Inc., the Commercial Nuclear Fuel Division of Westinghouse Electric Corp., and Globe Metallurgical, Inc. In 1989, the award recipients were Milliken & Company and Xerox Business Products and Systems.

The booklet containing the applications includes a description of the award, an application form, detailed instructions for completing the form, and specifics about the scoring criteria and examination. Free copies will be available from the Malcolm Baldrige National Quality Award Office, A537 Administration Bldg., NIST, Gaithersburg, Md. 20899, 301/975-2036, fax: 301/948-3716. The Malcolm Baldrige National Quality Award is managed by NIST with the active involvement of the private sector.

NIST, Industry Work Together for Automated Quality

Six industrial firms have joined forces with the National Institute of Standards and Technology in a cooperative research program to develop an automated inspection system for manufactured parts. The effort is part of NIST's "Quality in Automation" project to help U.S. industry in developing quality assurance techniques vital to global competitiveness. CADKEY Inc., Automation Software, Sheffield Measurement, Renishaw Inc., CMX Systems Inc., and ICAMP Inc. are contributing resources to the automated inspection project. NIST researchers plan to incorporate software and hardware products loaned by these firms into one of the first fully integrated part design and inspection systems to use the ANSI Dimensional Measuring Interface Specification (DMIS) standard. The entire software system will run on a single low-cost personal computer.

Steven D. Phillips, director of NIST's automated inspection project, says that the research should yield significant industrial results. He says, "The DMIS standard, which is the focal point of our integration efforts, allows two important industries—that of computer-aided design and of coordinate measuring machines—to communicate with each other. These markets alone are estimated to have a combined 1990 sales volume of half a billion dollars. The result of this integration, in increased productivity and in quality assurance, can play a dramatic role in improving manufactured parts, an especially important issue in today's world market. Thousands of machine shops in the United States can benefit from this technology."

NIST engineers working in the prototype effort use CADKEY's software for three-dimensional, computer-aided design of parts. Automation Software programs allow engineers to create inspection paths and procedures on graphical images displayed on the personal computer. The inspection instructions are automatically converted into the DMIS format, which provides a common language between computers and inspection equipment.

Sheffield Measurement software translates the DMIS instructions into a computer language used by a coordinate measuring machine, another Sheffield product. The machine measures and inspects the manufactured parts using a probing system from Renishaw Inc. and laser interferometers from CMX Systems Inc. The data are translated back into DMIS code, and, using ICAMP's QUALSTAR analysis software, engineers can compare the manufactured product as-built, with the original computer-aided design model.

NIST shares research results with the cooperating firms and provides suggestions for improvements, compatibility, and expansion of the products contributed to the cooperative effort.

NIST's "Quality in Automation" project is funded by the U.S. Navy's Manufacturing Technology program. Project findings are published annually in open literature.

by John G. Blair
NIST Public Affairs Specialist

Seven R&D 100 Awards Go to NIST

The National Institute of Standards and Technology received seven R&D 100 Awards for advances in instrumentation and measurement technology September 26 at ceremonies in Chicago. R&D 100 Awards are presented annually by *Research & Development* magazine to highlight the 100 "significant new technical products" of the preceding year. NIST has now received 71 of these awards since first entering the competition in 1973.

Information Retrieval System

Computer scientist Donna Harman and mathematician Gerald Candela, of the NIST National Computer Systems Laboratory, have developed a fast, easy-to-use system for retrieving information from databases containing large amounts of text such as reference books, bibliographies, and directories.

Gerald Candela (left) and Donna Harman demonstrate their information retrieval system.

The system uses a simple sentence or phrase, such as "human factors in information retrieval systems," to query the database and return a list of records within 1 or 2 seconds. Other systems can take up to a minute.

Even more important than being fast, the system can be used with little or no training. More than 90 percent of the keyword retrieval systems now on the market are based on a deductive logical system known as boolean algebra and can require extensive training. Also, unlike many other systems, this one arranges the retrieved records so the ones at the top are more likely to be relevant to the search, an important factor in a long list of records.

Scanning Scattering Microscope

Physicist Joseph Fine, of the NIST Center for Atomic, Molecular, and Optical Physics, and Denes Marton, a visiting scientist from the Technical University of Budapest at the time of the invention, have devised an optical technique for imaging the surface microstructure of materials. The scanning scattering microscope (SSM) combines the sensitivity of the integrated scattered light measurement concept with a microfocused scanned-light beam to produce three-dimensional-like micrographs of surface features at the nanometer level.

Industrial applications could include measuring and imaging the surface roughness of polished semiconductor wafers and detecting defects; measuring and imaging the surface topography of vapor- and sputter-deposited thin films; and monitoring the effect of surface abrasion processes on highly polished metals.

The SSM has a relatively long working distance of many centimeters from surfaces. As a noncontacting probe, it can be used with other instruments to monitor and control the fabrication of surfaces during processing.

Stochastic Analyzer for Pulsating Phenomena

Physicist Richard J. Van Brunt, of the NIST Center for Electronics and Electrical Engineering, and visiting Indian scientist Sanjay V. Kulkarni have created an instrument that makes real-time measurements of the rapid pulses that can occur when insulating materials in electrical systems are subjected to stress. These partial discharge pulses, seemingly random (stochastic) in nature, can induce material degradation that leads to eventual failure of the insulation, causing electrical breakdown in the system.

Gauging and understanding these pulses is more critical than ever for the $266 billion U.S. electrical power industry. Electrical breakdown in insulating materials could mean the loss of electricity in large geographic areas.

The NIST device, called a stochastic analyzer for pulsating phenomena (SAPP), provides a "signature" of the pulse memory effects that can be used to study the underlying physics and to develop better diagnostics for insulation performance. It also allows scientists to determine, from these signatures, the degree of order in what might seem a series of unrelated, random events.

The device is an improvement over earlier instruments that provided only limited information about the pulses and failed to indicate the stochastic nature of the pulse phenomenon.

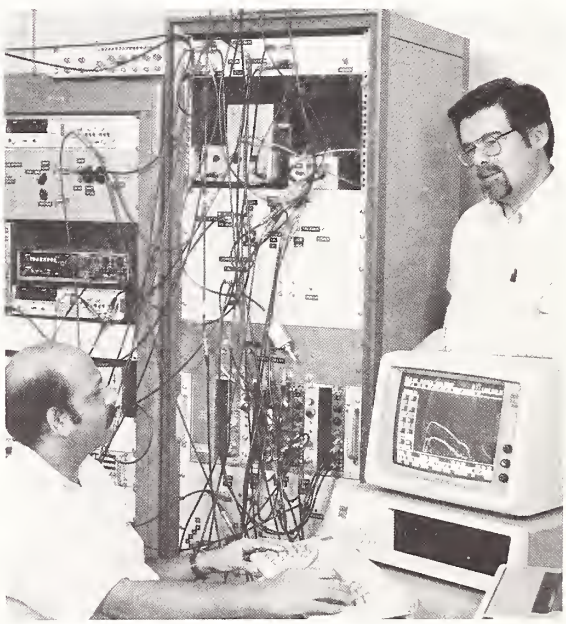
Denes Marton (left) and Joseph Fine with their scanning scattering microscope.

In addition, the SAPP can be used to investigate any pulsating phenomena such as the human heartbeat or pulsating fluids.

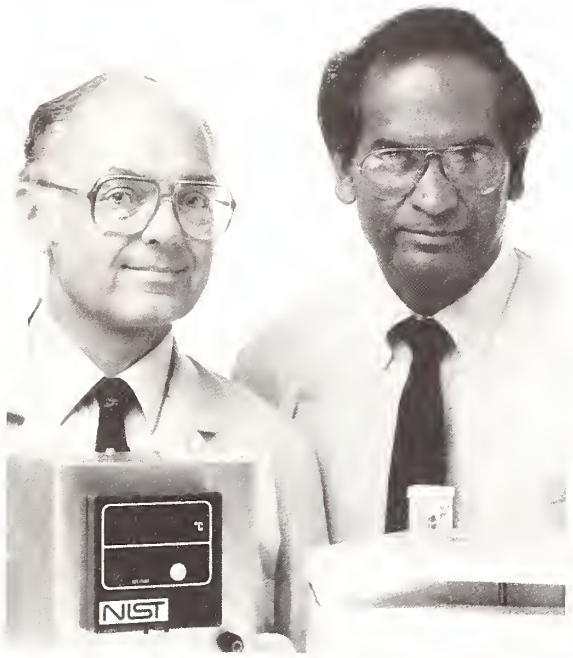
Crystal Growth

Researchers Subhas K. Sikdar and Paul W. Todd, of the NIST Center for Chemical Technology, (assisted by Cheryl Walker) have created a novel method for growing single crystals of proteins and other substances by the process of osmotic dewatering.

This advancement is significant because rapid advances in molecular manipulation—including drug design and protein engineering—are awaiting improved, reliable methods for protein crystal growth. The osmotic dewatering system provides a versatile way of growing defect-free single crystals in a controlled environment.



The stochastic analyzer for pulsating phenomena operated by Sanjay V. Kulkarni (seated) and Richard J. Van Brunt.



Paul W. Todd (left) and Subhas K. Sikdar with their osmotic dewatering apparatus for growing crystals.

Osmotic dewatering occurs when two aqueous (water-based) salt solutions are separated by a semipermeable membrane through which only water can pass. The osmotic pressure difference causes slow transport of water from the dilute solution containing a protein to a concentrated salt solution. The process removes water, and only water, from the mother liquid in which crystals are grown.

Using this method, the NIST researchers have grown crystals of lysozyme, a protein, to about 1 millimeter in size and of high quality for x-ray crystallography.

Dosimetry System

Chemist Marlon L. Walker and physicist William L. McLaughlin, of the NIST Center for Radiation Research, have developed a real-time measurement system to monitor radiation dosage for quality control of a number of widely used industrial processes—including polymer curing, sterilization of medical instruments, or semiconductor hardening tests.

A radiochromic sensor, which changes color with absorbed x-ray and gamma-ray radiation, is placed on the item to be irradiated. A laser is directed on the sensor, and the transmitted light is returned by a retroreflector to a detector adjacent to the laser. Any changes in the retroreflected signals are evaluated by a data analyzing system.

The NIST measurement system is insensitive to microwave, infrared, and electromagnetic impulses. It is ideal for industrial and field work because the system does not require ionization chambers and delicate laboratory instruments. On the assembly line or in the field, personnel and equipment can make continuous measurements remote from a hazardous radiation source.

Two Jointly Shared Awards

NIST also shared two R&D 100 Awards with other organizations.

One joint award honored a class of high-efficiency silicon photodiodes developed for use in the ultraviolet and soft x-ray (xuv) spectral range. The devices may be used as high-sensitivity radiometric standards, compact xuv photometers for space and defense applications, detector array elements for xuv imaging applications, and inexpensive remote sensors for monitoring industrial processes (x-ray lithography, for example). The quantum efficiency of the xuv photodiode is very high, about 300 times the quantum efficiency of the best laboratory-made photoemissive diode. NIST physicists L. Randall Canfield and Jonathan Kerner shared the award with Raj Korde of UKDT Sensors Inc.

The other joint award cited the "Coolahoop" project, a venture of NIST and Los Alamos National Laboratory. Coolahoop is a cryogenic refrigerator that, unlike similar devices, has no moving parts. While mechanical cryocoolers on the market require periodic maintenance due to wear on moving parts, Coolahoop has no apparent feature that would limit its lifetime. Potential applications include uses as a cooling medium for high-temperature superconducting devices and for satellite-based infrared detectors, such as those used for climate monitoring and Earth-resource surveying. Coolahoop may also be used for the remote production of small quantities of liquid nitrogen for use in medicine and in the livestock breeding industry. Researchers Ray Radebaugh of NIST and Gregory W. Swift and Richard A. Martin of Los Alamos are the joint award winners.

Teaching Machines Their ABCs

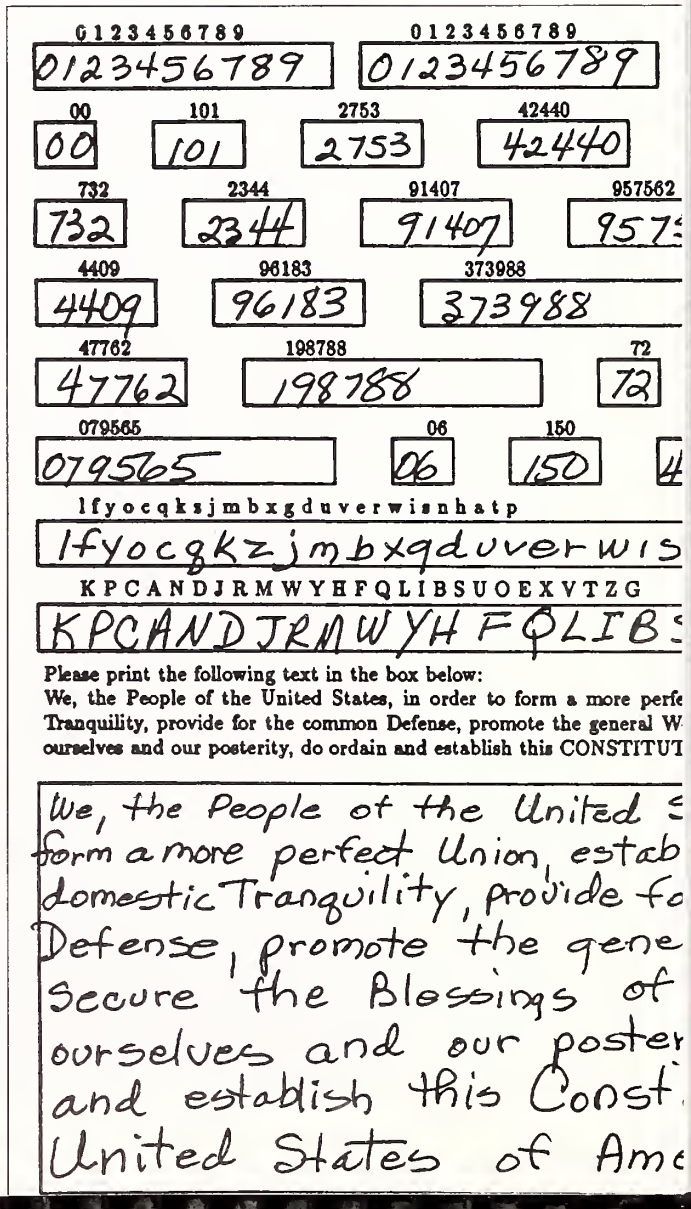
A first-of-its-kind database containing over 1,000,000 handprinted characters has been developed by the National Institute of Standards and Technology to help measure the performance of systems designed to recognize handprinted numbers and letters. Banks, insurance companies, and other form-processing organizations represent an enormous market for systems that can automatically read and process handwritten characters on forms. Machines are available to identify characters that have been printed by other machines, such as numbers on a bank check, and then enter the information into a data processing system. A few devices can recognize handprinted letters and numbers, but only if the writer carefully forms each character. A machine that can accurately read unconstrained handwritten script is still only a tantalizing prospect, largely because of the wide variations in writing style.

Finding a standardized way to measure performance of character recognition systems is an important link in developing the technology. According to a recent issue of *Neural Technology Update,* ". . . it is very hard to objectively and rigorously compare these character recognition products . . . because there is not yet any standard set of characters or numbers by which to test recognition software."

"This database is a big step in that direction," says supervisory mathematician Charles Wilson, who managed the program. "It will be a key in evaluating a system under development or comparing systems to see which performs best. Both uses are needed to advance the technology," explains Wilson.

To efficiently process handwriting, a machine must be able to locate text on a page, separate text into characters, and identify specific characters. The database can be useful in all three areas, says Wilson.

He and his team worked with the U.S. Bureau of the Census to collect samples of handwriting. "There is a theory that handwriting, like speech, has local variations in different parts of the country. This database will



To collect samples of handwriting, NIST asked 2,000 employees from the U.S. Department of the Census to fill out sample forms like this one.

help determine whether the theory is valid," says Wilson.

The database consists of 2,100 pages containing 294,000 numbers and 728,700 alphabetic characters. Each page contains 33 boxes for numbers and letters and one for printing the preamble to the U.S. Constitution.

In addition the NIST researchers are working with the U.S. Internal Revenue Service to develop more sophisticated tests as well as a model recognition system. Says Wilson, "The best way to understand how these systems work and to develop generic, standard tests is to build one."

So far, Wilson and his team have developed software to account for some of the factors that a recognition system would encounter in the real world. These include poor quality photocopies, missing data, letters where numbers should be, and letters and numbers written outside of the

More Standard Reference Databases

Reliable, well-documented data are invaluable to scientists and engineers for research as well as development of new products such as character recognition machines. With the proliferation of personal computers, standard reference data can be more accessible and play a more critical role. Other NIST databases include:

■ **NIST/CARB Biological Macromolecular Crystallization Database.** This new computerized database for biochemists in industrial laboratories and universities brings together for the first time all of the published information on the successful crystallization of proteins and nucleic acids. Pharmaceutical manufacturers use protein structures in rational drug design, and chemical companies use protein structures as well to understand and alter the action of enzymes. Information on the three-dimensional atomic structure of a protein is an invaluable aid in understanding the protein's function.

The database, Standard Reference Database 21, is designed for personal computers (PCs) and contains crystal data and the crystallization conditions for more than 1,000 crystal forms of over 600 biological macromolecules. For each crystal entry there is a complete description of crystallization conditions and related crystallographic data. The database also provides researchers with evaluated critical data on the physical characteristics of known crystals, including unit cell parameters, space group, crystal density, and diffraction limit.

Available for $300, the database can be stored on a hard disk of an AT- or XT-Class PC where it occupies 2.8 megabytes.

■ **Thermophysical Properties of Hydrocarbon Mixtures (Supertrapp).** This database, Standard Reference Database 4, is used to calculate density, viscosity, and other important engineering properties of hydrocarbon mixtures—petroleum, natural gas, and organic materials.

Supertrapp is designed to provide rapid access to vital information on the storage and transportation of fluids, and for the design of new chemical processes. The interactive program allows users to calculate quickly various thermodynamic and transport properties for pure fluids or for mixtures of up to 20 components that can be selected from a database of 116 components.

Isothermal flash calculations can be performed to give an estimate of what fractions of a bulk mixture, at a specified temperature and pressure, are in the vapor and liquid phases and the compositions and properties of those phases. The properties that are calculated include density, enthalpy, entropy, heat capacity, sound velocity, viscosity, and thermal conductivity.

The Supertrapp program is available for $490. It can be stored on a hard disk of any AT-, XT-, or PS/2-Class PC where it occupies 256 kilobytes of storage space.

box on the form. The team has developed algorithms based on neural network technology that can be used on a parallel computer to recognize characters. A neural network approach uses the same principles as a human brain would for functions such as seeing, learning language, or manipulating objects.

According to Wilson this method allows characters to be recognized in 4 milliseconds per image, with greater than 99-percent accuracy on machine print and 80-percent accuracy on unconstrained handprinted characters.

NIST Special Database 1—Binary Images of Printed Digits, Alphas and Text is available on an ISO 9660 format CD-ROM disk for $895. For ordering information, contact the Standard Reference Data Program, A323 Physics Bldg., NIST, Gaithersburg, Md. 20899, 301/975-2208.

by Jan Kosko
NIST Public Affairs Specialist

■ **NIST/EPA/MSDC Mass Spectral Database.** More than 4,500 new analytical mass spectra have been added to this database, which now contains complete spectra for approximately 54,000 chemical compounds—the only such collection of its kind. The database, used by analytical chemists and environmental scientists to identify unknown substances, comprises evaluated electron ionization mass spectra on organic and inorganic substances and related data on the molecular structures of compounds. Instrument manufacturers incorporate the spectral collection into the data systems of thousands of mass spectrometers where the data are used as comparison standards.

Stephen E. Stein, technical director of the Mass Spectrometry Data Center, displays masses of peaks in the NIST/EPA/MSDC Mass Spectral Database.

The database is available on standard diskettes for PCs or in a magnetic-tape format. PC Version 3.0 of the database is available for $1,050 and is designed to be stored on a hard disk of any AT- or PS/2-Class PC.

■ **NIST Thermodynamic Properties of Refrigerants and Refrigerant Mixtures (REFPROP).** This PC software package, Standard Reference Database 23, gives researchers who use chlorofluorocarbons (CFCs) a tool for evaluating the performance of refrigerants and refrigerant mixtures.

Users can assess several environmentally acceptable refrigerants and mixtures as possible replacements for currently used materials. The tables also can be used to help determine the efficiency and capacity of a wide range of equipment that will operate with alternative refrigerants.

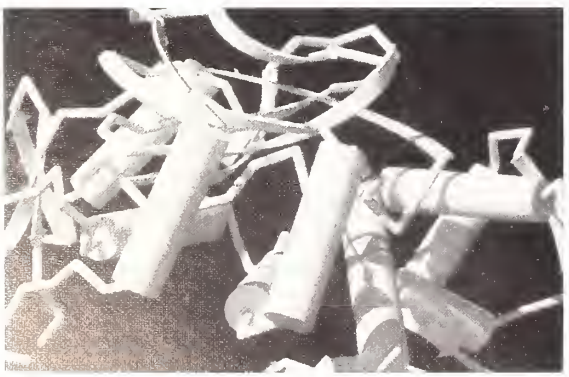
Users can produce tables of thermodynamic properties for 15 partially and fully halogenated CFC refrigerants and 20 of their mixtures. Users of REFPROP also can calculate other mixtures of the 15 refrigerants by using their own data.

The REFPROP database is available for $225 and is designed to be stored on a hard disk of any AT- or XT-Class PC where it occupies 250 kilobytes.

■ **Ordering information** for these and other databases is available in the *NIST Standard Reference Data Products 1990 Catalog* (NIST SP 782). To obtain a copy, send a self-addressed mailing label to the Standard Reference Data Program, A323 Physics Bldg., NIST, Gaithersburg, Md. 20899, 301/975-2208.

Technologies of the Future Identified

The Commerce Department has identified 12 "emerging technologies" that will create markets for an estimated $1 trillion in sales by the year 2000 and listed actions that might be taken by both industry and government to spur their commercial development in this country. The outlook is contained in a report, *Emerging Technologies: A Survey of Technical and Economic Opportunities,* compiled by Commerce's Technology Administration. "The intent is to continue our dialogue with industry, not prescribe a remedy," Commerce Secretary Robert A. Mosbacher said of the report's findings. "It's up to industry to take a lead on which technologies to pursue. Government's role will be to remove impediments."



In consultation with private industry, the Technology Administration concluded that the 12 "emerging technologies" are among those most applicable to commercial opportunities and lie in four areas:

- Advanced materials such as ceramics, polymer composites, metal alloys, and superconductors.
- Electronics and information systems, including advanced semiconductor devices, digital imaging technology, high-density data storage, high-performance computing, and optoelectronics.
- Manufacturing systems, including artificial intelligence, flexible computer-integrated manufacturing, and sensor technology.
- Life sciences applications, including biotechnology and medical devices and diagnostics.

For the report, an emerging technology was defined as one in which research has progressed far enough to indicate a high probability of technical success for new products and applications that might have substantial markets within approximately 10 years.

"These technologies offer tremendous market potential," said Mosbacher. "But the United States will benefit only if American business shakes out some cobwebs and takes some decisive actions. At the same time, government should remove obstacles to competition."

To improve U.S. competitiveness, the report makes a number of recommendations, among them:

- Lowering the cost of research and development (R&D) capital by a permanent tax credit.
- Improving engineering training and education, particularly in manufacturing engineering.
- Integrating R&D, design, and manufacturing through such concepts as concurrent design, total quality control, and just-in-time production.

■ Improving quality of products and services using, for example the quality control principles embodied in the Malcolm Baldrige National Quality Award.

■ Encouraging U.S. companies to focus on world markets instead of solely domestic ones, including more aggressive pursuit of technologies developed overseas that are crucial to American exploitation of emerging technologies.

■ Increasing private-sector cooperation in technology development by encouraging joint production ventures and lowering antitrust barriers.

■ Reforming the product liability system.

■ Opposing restrictive trade practices by other countries.

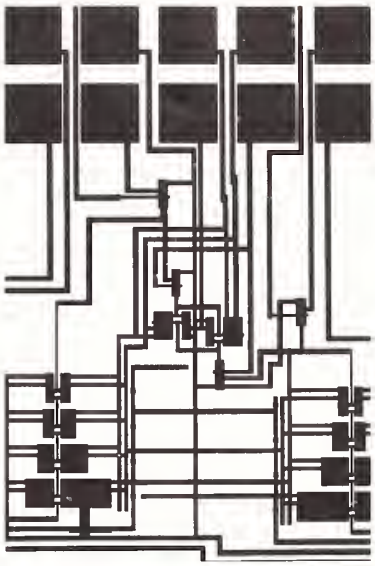
The report expands and brings up to date a similar Commerce study issued in 1987. It includes an assessment of the positions of the United States, Japan, and the European Community in developing and commercializing the technologies, as well as the driving forces that have created the new competitive realities. While the world market for the emerging technologies is predicted to be $1 trillion by the end of the century, the U.S. market would represent roughly one-third of that total, or approximately $356 billion.

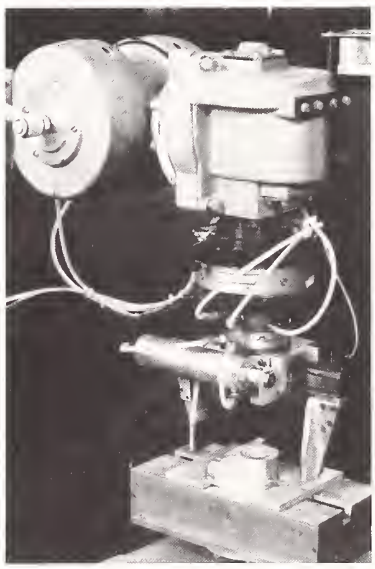
Detailed descriptions of the 12 emerging technologies, taken from the report, can be found on pages 18 through 21. The descriptions include information in eight areas. "Major Technology Elements" lists specific technology areas that describe the emerging technology. "What It Is" is a brief non-technical description of the emerging technology and its importance. "Underlying Sciences" gives the specific scientific or engineering competencies of critical importance for the development and marketing of products based on the emerging technology.

Under "Engineering Barriers" are technical impediments that must be eliminated or circumvented before products based on the emerging technology can be marketed. Specific improvements in processes, procedures, devices, or products that could result from the introduction of the emerging technology are listed as "What Is New or Better." "Impact on What Products or Processes" gives the products and/or manufacturing areas that will benefit directly from the emerging technology.

The major markets that could profit from the emerging technology are listed in "Likely Markets or Industries." Estimates of the total U.S. and world market sizes expected to result directly from the emerging technology are given under "Annual Sales by Year 2000."

Copies of the report, *Emerging Technologies: A Survey of Technical and Economic Opportunities,* are available from the National Technical Information Service, Springfield, Va. 22161 for $17. Order by PB #90-216557.





Advanced Materials

Major Technology Elements: Structural and functional ceramics, ceramic and metal matrix composites, intermetallic and lightweight alloys, advanced polymers, surface-modified materials, diamond thin films, membranes, biomaterials.
What It Is: Advanced metals and alloys, ceramic and polymeric materials, and composites of these constituents used to produce devices and structures having improved performance characteristics and special functional attributes.
Underlying Science: Solid-state physics and chemistry, interface and surface science, mechanics, fluid dynamics.
Engineering Barriers: Rapid and reliable processing methods are needed. Complex failure mechanisms need to be understood and related to processing and service-produced microstructures.
What Is New or Better: Improved functional and structural properties like high-temperature strength, creep resistance, and corrosion resistance for ceramics and intermetallic alloys; composites offer high strength and stiffness combined with low weight, corrosion resistance, high dimensional stability; technology for controlling composition and processing that allows "designed in" properties.
Impact on What Products or Processes: Devices and structures used at very high temperatures or special service applications, aircraft, aerospace, transportation, electronics, construction, wear resistant items.
Likely Markets and Industries: Aerospace, construction, engines, electronics, manufacturing, energy.
Annual Sales by Year 2000: U.S.: $150 billion; World: $400 billion.

Advanced Semiconductor Devices

Major Technology Elements: Silicon, compound semiconductors (gallium arsenide), ultra-large-scale integration, memory chips, x-ray lithography.
What It Is: Improved materials, fabrication techniques, and advanced components and devices for use in electronic equipment of all kinds.
Underlying Science: Solid-state physics and chemistry; surface and separation science; electrical and electronics engineering; electrical properties of materials; optical, x-ray, ion-beam fabrication methods.
Engineering Barriers: Difficulties in manufacturing at high volume, yield, and quality but low cost. Must control contaminants and prepare high-purity gases and liquids.
What Is New or Better: Improved speed, higher operating frequencies, reduced size, higher density, multiple functions, lower cost, heat dissipation.
Impact on What Products or Processes: Integrated circuits, smart power transistors, semiconductor materials, micromachines, solar cells, memory chips, microprocessors.
Likely Markets and Industries: Electronics, television manufacturing, communications, computers, recording devices, medical and manufacturing equipment, toys and tools, aerospace—any area that requires significant use of electronics.
Annual Sales by Year 2000: U.S.: $75 billion; World: $200 billion.

Artificial Intelligence

Major Technology Elements: Intelligent machines, intelligent processing of materials and chemicals, expert systems.
What It Is: Electronic and electromechanical systems incorporating knowledge-based control systems.
Underlying Science: Data structures, data management systems, software engineering, servo engineering, biological and cognitive sciences and engineering, numerical analysis, statistical physics.
Engineering Barriers: Size of databases, computational speed, lack of formal tools for knowledge representation.
What Is New or Better: Improved performance over current systems, which are, at most, capable of a limited number of responses to events fully anticipated in advance; improved graphical representation of results.
Impact on What Products or Processes: Manufacturing of machine tools, robots, construction equipment; materials and chemical processing; computer-aided design; signal and image processing; analysis of medical tests or symptoms.
Likely Markets and Industries: Manufacturing, mining, security, health care, construction, materials processing, communication and financial services.
Annual Sales by Year 2000: U.S.: $5 billion; World: $12 billion.

Biotechnology

Major Technology Elements: Bioprocessing, drug design, genetic engineering, bioelectronics.
What It Is: Production of high value-added biological products on a commercial scale; modification of the genetic machinery of living cells to produce useful biochemicals.
Underlying Science: Genetic engineering, molecular biology, chemical engineering, biochemistry, biophysics.
Engineering Barriers: Difficulty in controlling processes in large-scale bioreactors and making economical large-scale separations; lack of measurement tools, data, and knowledge to control cellular processes and to elucidate protein structure/function relationships for intelligent product and process design.
What Is New or Better: Biosensors for on-line, real-time control; new and efficient separation and purification methods; new or better techniques to produce natural and/or new biochemicals; more efficient bioprocesses.
Impact on What Products or Processes: Production of high value-added chemical products and new engineered chemicals.
Likely Markets and Industries: Pharmaceutical and related products; foods, flavors, and fragrances; agrichemicals; commodities and fuels; pollution abatement.
Annual Sales by Year 2000: U.S.: $15-40 billion; World: $40 billion.

Digital Imaging Technology

Major Technology Elements: High-definition systems, high-definition television, large displays, data compression, image processing.
What It Is: Use of digital technology to store, display, process, analyze, and transmit images.
Underlying Science: Electronics, artificial intelligence, communications engineering, surface science, solid-state physics, chemistry.
Engineering Barriers: Large, high-resolution (flat) displays, storage requirements for digital information, effective utilization of bandwidth, computer speed and memory, ability to recognize characteristic features in complex images.
What Is New or Better: Advances in digital cameras, high-volume information storage and retrieval, high-speed computing (including parallel processing), higher resolution video display.
Impact on What Products or Processes: Industrial processes in which the human eye or other detectors are used for inspection and monitoring, photography, printing, television, computer manufacture, process control systems, telecommunications.
Likely Markets and Industries: Electronics, computers, process control and inspection, medical diagnostics, consumer electronics, telecommunications, broadcast television, satellite broadcast, data storage, defense industries, nondestructive inspection and evaluation.
Annual Sales by Year 2000: U.S.: $3.3-4.3 billion; World: $5 billion.

Flexible CIM

Major Technology Elements: Computer-integrated manufacturing (CIM); computer-aided design, engineering, manufacturing, and logistics support; flexible manufacturing systems; product data exchange specification; control architectures; adaptive-process control.
What It Is: A new approach to manufacturing and construction requiring not only technology but management and engineering adjustments; use of computers, robots, and intelligent machines in the total manufacturing and construction enterprise; integration of both the materials handling and processing systems as well as the planning, logistics, and business systems.
Underlying Science: Control theory; operations research; electrical, mechanical, manufacturing, and industrial engineering; business and management science.
Engineering Barriers: Need for data structures to describe product and process, concurrent engineering to integrate design and manufacture, more reliable machines, automated process planning, "smarter" robots, more accurate and inexpensive sensors.
What Is New or Better: Reduced cost and time to manufacture, improved quality; competition by scope and variety of product line; reduced inventory, manufacturing to order rather than to plan.
Impact on What Products or Processes: Manufacturing discrete and batch parts, economical small lot manufacture, continuous and adaptive processes, chemicals, pharmaceuticals, steel, paper, textiles, residential and commercial construction, public works.
Likely Markets and Industries: High-tech manufacturing, automotive, construction, home appli-

ance, computers, office machines, machine tools, aerospace.
Annual Sales by Year 2000: U.S.: $10-20 billion; World: $20-40 billion.

High-Density Data Storage

Major Technology Elements: High-density magnetic storage (including perpendicular recording), magneto-optical storage.
What It Is: Erasable (read/write) data storage offering several orders of magnitude improvement in information storage density.
Underlying Science: Optical physics, surface science, magnetics, solid-state physics, mechanical engineering, fluid dynamics (aerodynamics).
Engineering Barriers: Magnetic disk and tape: interaction between read-write head and magnetic media surface; crosstalk; size of information cells (domains); flatness (of disks); error detection. Magneto-optical disk: mass of read head that slows access time; relaxation effects; spacing of tracks; tracking; size of information cells.
What Is New or Better: Magnetic disks with thin-layer technology: steady increases in information density (doubles about every 3 years); reduced access time (mean time to get to data from random location on disk or tape). Magneto-optical disks: very high information densities; reduced danger of contact with storage media and lower cleanliness requirement offer potential of high reliability and provide removable media.
Impact on What Products or Processes: Data storage devices, home and studio audio and video, computers, communications, television, consumer cameras, office information storage systems.
Likely Markets and Industries: Computers, office equipment, recording systems, cameras.
Annual Sales by Year 2000: U.S.: $15-100 billion; World: $30 billion.

High-Performance Computing

Major Technology Elements: Modular/transportable software, numerical simulation, neural networks.
What It Is: Design and development of architectures for rapid and efficient processing, development of ways to program large systems to perform complex tasks.
Underlying Science: Software engineering, microelectronics, optoelectronics, data structures and algorithms, numeric and symbolic methods, computational science and technology.
Engineering Barriers: Reliability, accuracy, and automated development deficient; difficulty in specifying and designing software; costly and time consuming development; difficulty in testing for failures that might occur during use.
What Is New or Better: Can address large problems of numerical and scientific computing such as weather forecasting, hydrodynamics, aerodynamics, weapons research, prototyping of products and facilities, high-energy physics.
Impact on What Products or Processes: Computer and communication systems of all sizes; networking; word processing; information retrieval and distribution; database management; manufacturing processes; engineering design; science, research, and development in all fields.
Likely Markets and Industries: Manufacturing, business, service industries, research organizations, product, process, plant prototyping.
Annual Sales by Year 2000: U.S.: $50-100 billion; World: $100 billion.

Medical Devices and Diagnostics

Major Technology Elements: Cellular-level sensors, medical imaging, in-vitro and in-vivo analysis, targeted pharmaceuticals, fiber optic probes.
What It Is: Health-care diagnosis and treatment equipment and supplies based on new sensors, biotechnology processes, and imaging devices.
Underlying Science: Immunology, microbiology, biology, electronics engineering.
Engineering Barriers: Need to design instruments with little or no invasion of the human body; cellular level devices and diagnostics require miniaturization.
What Is New or Better: Capability to detect and understand defects at cellular level; opportunity to harness biomolecules as sensitive probes; minimized trauma during treatment and diagnoses; improved diagnostic and therapeutic systems.
Impact on What Products or Processes: Diagnostics and treatment equipment; health-care products, including diagnostic instrumentation such as magnetic resonance imaging and computer-aided tomography scanning; clinical analyzers; radiation treatment.
Likely Markets and Industries: Health care, instrumentation, pharmaceutical, medicine.
Annual Sales by Year 2000: U.S.: $8 billion; World: $16 billion.

Optoelectronics

Major Technology Elements: Integrated optical circuitry, optical fibers, optical computing, solid-state lasers, optical sensors.
What It Is: The use of light (visible, infrared, ultraviolet radiation) as the means to transmit, process, and store information.
Underlying Science: Optical physics and engineering, solid-state physics, surface science, electronic engineering.
Engineering Barriers: Device speed; integration of components with electronic devices; laser performance; materials limitations.
What Is New or Better: Improved information handling capacity and signal quality, reduced sensitivity to interference, increased processing speed and data storage capacity.
Impact on What Products or Processes: Long-distance and local fiber optic systems; electrical, mechanical, and thermal sensors; computers; chemical and mechanical manufacturing processes.
Likely Markets and Industries: Telephone, television, teleconferencing, on-demand audio and video programming, telecommunications, electric power, computers, manufacturing, medical diagnostics and therapy.
Annual Sales by Year 2000: U.S.: $4.6 billion; World: $10.8 billion. (Optical fiber communication components only—optical sensors alone add $1 billion worldwide.)

Sensor Technology

Major Technology Elements: Active/passive sensors, feedback and process control, nondestructive evaluation, industrial and atmospheric environmental monitoring and control.
What It Is: Devices that provide a signal (generally optical, electrical, or acoustical) that accurately reflects process parameters in real time.
Underlying Science: Electronics, nondestructive evaluation, control theory, mechanical and industrial engineering.
Engineering Barriers: Lack of one or more of the following characteristics: range, stability, precision, resistance to harsh environment, selectivity, sensitivity, poor integration of sensors and signal processing.
What Is New or Better: More accurate measurement of parameters in real-time under a wider range of conditions due to better materials, fabrication techniques, and more complex electronics and data processing.
Impact on What Products or Processes: Continuous process industries like materials, food and beverage, pharmaceutical, chemical, biochemical, smelting and refining, waste management, construction, manufacturing.
Likely Markets and Industries: Chemical smelting and refining, pharmaceutical, food and beverage, electric power, materials.
Annual Sales by Year 2000: U.S.: $5 billion; World: $12 billion.

Superconductors

Major Technology Elements: High-temperature ceramic conductors, advanced low-temperature conductors.
What It Is: Superconducting materials having critical transition temperatures (T_c) above 77 K (boiling point of liquid nitrogen); low-temperature superconductors with improved performance characteristics and materials properties.
Underlying Science: Solid-state physics, ceramic processing science, electronic engineering, surface science.
Engineering Barriers: Low-current densities and strengths in bulk forms; composition and environmental stability; integrated circuit fabrication technology; economical refrigeration techniques.
What Is New or Better: Reduced cost by eliminating liquid helium as coolant; low-temperature superconductors yielding sophisticated integrated devices, even first microprocessors; powerful magnets for research and medical diagnostics; magnetically levitated trains.
Impact on What Products or Processes: Electronics; electrical transmission, switching, motors, and controls; electric power generators; medical diagnostic equipment; rail and ship transportation; computers; particle accelerators.
Likely Markets and Industries: Electronics and data processing, electric power equipment, medical diagnostics, transportation equipment, high-energy physics.
Annual Sales by Year 2000: U.S.: $3-5 billion; World: $8-12 billion.

To Measure a Molecule

In the past, we saw them only in the mind's eye, as little balls and springs we used to visualize chemical reactions and physical laws. Now atoms and molecules are taking on real substance as we invade their realm. We peer at them through powerful microscopes and build devices with dimensions just a few atoms across. We explore and build on a scale in which atoms and molecules exert their individual identities, the way a small enough pinch of the finest dust acts like a collection of boulders.

But scientists easily lose their way while exploring this uncharted world. They lack the tools to measure or track positions accurately. To help them get their bearings, National Institute of Standards and Technology physicist Clayton Teague conceived of a machine to survey positions in the atomic-scale world. Teague and his colleagues aim for a "molecular measuring machine" or M cubed for short, with the power to measure the spacing of individual atoms separated by as much as 5 centimeters. If it works, it will provide measurements that are of increasing importance to people in the electronics and optics industries.

"The hard part will be discerning things so far apart," says Teague. "The separating distance spans a billion times the diameter of the objects measured." Measuring that much relative distance is a feat equivalent to measuring the distance between two short needles in a haystack the size of the Earth.

The machine will build on the technology that gave us our first glimpse of atoms in the early 1980s with the scanning tunneling microscope (STM). But the tunneling microscope gave a sort of tunnel vision view, limited to a field only a few hundred or thousand atoms across. The M cubed will use the same sharp-eyed probe the STM uses to find atoms but will then expand on the STM's range. With excruciatingly fine-tuned carriages and carefully aimed lasers, it will measure the vast distances between individual atoms separated by billions of atoms.

Measuring that much relative distance is a feat equivalent to measuring the distance between two short needles in a haystack the size of the Earth.

The U.S. semiconductor industry has a growing need for exactly this sort of measurement. For semiconductor makers to create more powerful computer chips, they need to squeeze more intricate electronic circuitry patterns onto these chips. The individual "devices" that channel current and store information on these chips get tinier and tinier.

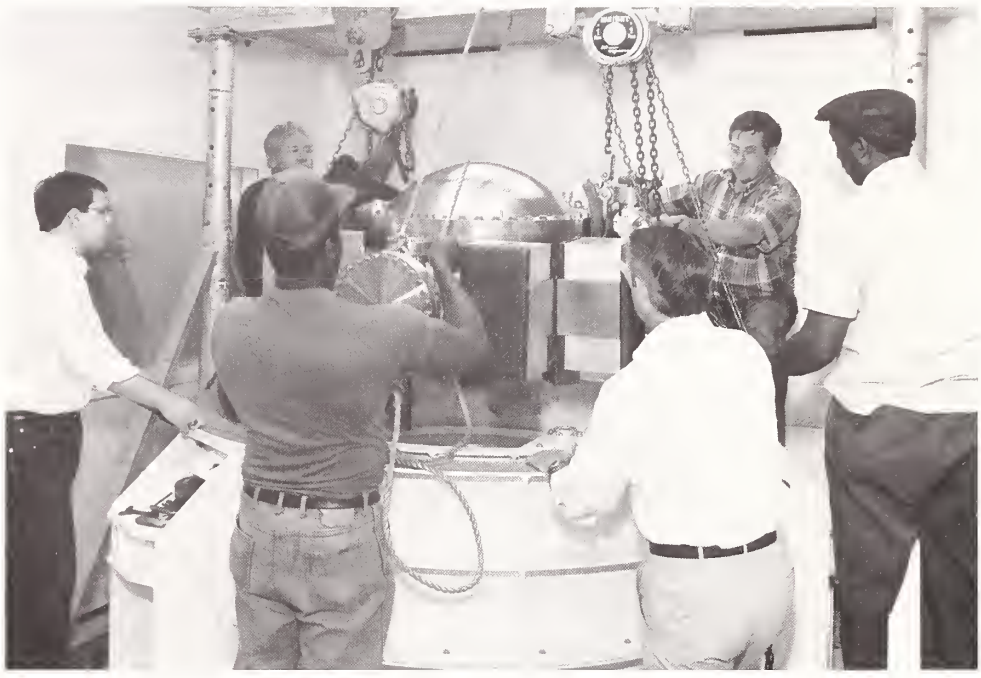
Manufacturers go through many painstaking steps to etch delicate networks of devices onto silicon chip surfaces. They repeatedly shine light through stencil-like "photomasks" to expose light-sensitive chemicals on the chips in just the right patterns and then etch out the exposed, or sometimes the unexposed areas. Chipmakers need to position these masks with ultra-high precision to avoid misaligning the circuit patterns, producing worthless devices.

To make the next generations of powerful memory and processing chips, manufacturers will need to align masks much better than our present measuring and positioning ability allows. Even with current dimensional tolerances, often only about 1 in 5 or 10 of the new and more complicated chips work properly. Many factors contribute to such low yields, but if M-cubed brings its hoped-for capability, it will provide the nation's electronic industries with an essential measurement reference for characterizing mask geometry and feature critical dimensions.

Teague shows how the outer workings of the machine will fill his whole lab, surrounding the machine's heart like a series of shells. The heart of the M cubed fits into a copper sphere the size of a basketball.

The laser beams work as virtual tape measures, graduated in increments about 1 atomic diameter apart. . . .

This copper sphere houses the sample and the scanning tunneling microscope probe, which finds specific atoms. The probe has a very sharp tip (it ends in a single atom), which scans the sample like a record-player needle. It doesn't actually touch the surface but hovers only about 10 atom-diameters above it.



M cubed team members work with rigging contractors to install the vacuum system into an environmental enclosure, which will shield the device and its sample from outside disturbances.

At this distance, the electrons belonging to the STM probe overlap with electrons from the sample's atoms. As the scientists apply an electric field to the tip, a few of these overlapping electrons travel or "tunnel" from the tip to the sample. The rate of this tunneling depends greatly upon the distance between the tip and sample. An atom-sized bump shortens this distance enough to make the tunneling rate soar and plummet, allowing the instrument to trace the contours of atoms over a surface of metal or silicon.

Thanks to the STM, finding atoms is relatively easy. To measure the distance between two objects, the instrument must be able to fix the position of atoms relative to some stable reference point. The machine will position the probe over the sample with carriages that move in precise increments. In the current design, the carriages glide on sapphire-coated "pads" over surfaces of very smooth metal. Teague doesn't expect to move these carriages with atomic-scale precision, but he and the team members have taken extreme care in their attempts to make the motion repeat with such precision, using calculations to correct for any inaccuracies.

To read the horizontal distance from his probe to some reference point, he will bounce lasers between them. The laser beams work as virtual tape measures, says Teague, graduated in increments about 1 atomic diameter apart—if all goes well.

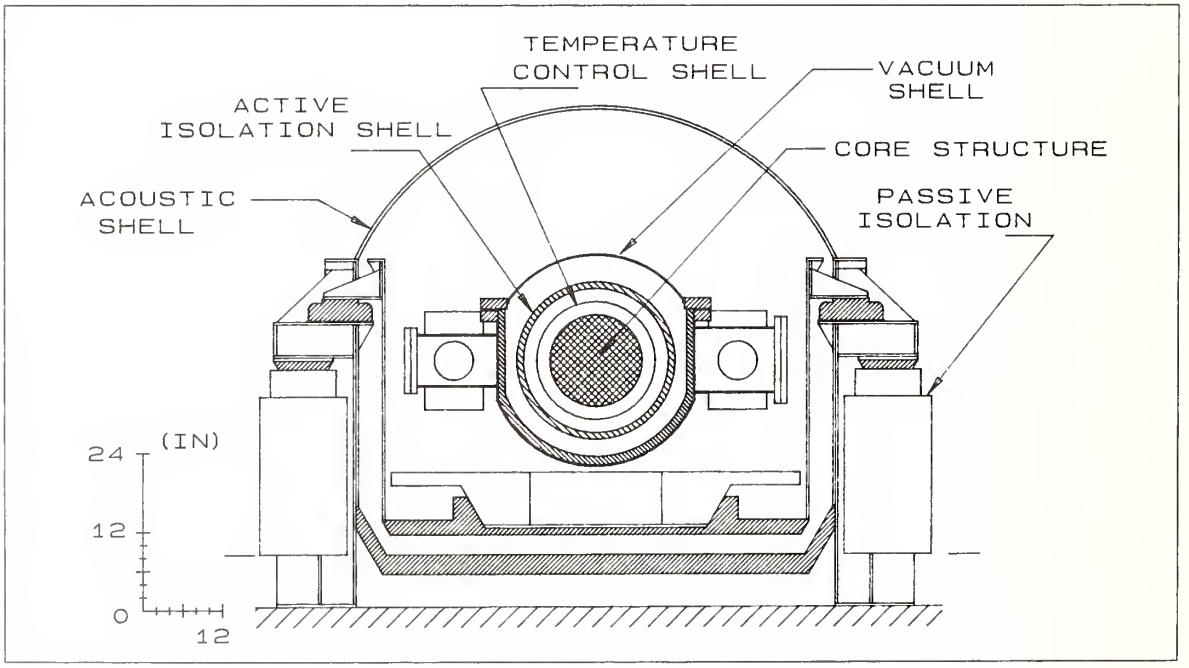
But in the real world, the distance between a probe and a test specimen can vary wildly. The softest voice, remote vibrations, or distant footsteps can jostle the probe around by distances many times larger than the atoms being measured.

To create the M cubed with its promised ability, Teague is fighting a war against vibrations with vacuum chambers, isolators, and temperature regulators that will enshroud the instrument in the layers filling the whole room. Two vibrational and acoustical isolation shells shield the machine and sample from any disturbance. Also, a temperature-controlled chamber keeps the temperature constant to within one-thousandth of a degree. Knowing the exact temperature is critical because positions depend on the temperature. Carrying a carefully measured sample into a warmer room will expand the material, increasing the distances between points and invalidating measurements made in the cooler room. Only by knowing the exact temperature upon measurements can scientists adjust these values as the temperature changes.

If it succeeds, the M cubed will hold one of the keys to an ever shrinking world of useful gadgets. Today, the microscopic devices that channel current and store information on computer chips approach the "critical dimension" beyond which a material stops behaving like a uniform mass and starts acting like handfuls of discrete atoms. And yet, many in the electronics industry predict that we can soon expect 1,000 times the memory storage packed in PC-sized computers. Can it be done?

Physicist Richard Feynman answered a definite yes to that question back in 1959 in a paper entitled "There's plenty of room at the bottom." In this paper he described the idea of storing information on devices like computer chips (invented many years later) and shows that there is far more room in small spaces than we have begun to exploit 30 years later. It is within the laws of physics, and probably the ability of man, he said, to fit all of the pages of all the books ever written into a space the size of a dust speck. But before we can start to utilize all this space, we need to learn to work—and measure—within the scale of atoms and molecules.

by Faye Flam
Washington, D.C.-area
science writer



This diagram is a cross section of the molecular measuring machine's mechanical structure.

Key Industries Invest To Boost Quality

Semiconductor and optical fiber firms in the United States have dramatically increased investments in quality practices over the past decade. Many are now funneling as much as a third of their operating budgets into total-organization approaches that aim to assure quality of both products and related services. This is a key conclusion of a report prepared by Quick, Finan & Associates (QFA) for the National Institute of Standards and Technology.

The study, covering the 1980-89 period, surveyed managers of prominent companies in the semiconductor and optical fiber industries. The study was commissioned to help NIST shape its own research programs, which assist and leverage measurement and quality aspects of industrial research and development.

"This study likely marks the first attempt to obtain detailed quantitative information on industrial investment outlays for quality," says Gregory Tassey, a senior economist at NIST who coordinated the study.

Semiconductors, integral parts of most electronic systems, and optical fibers, glass strands that are revolutionizing the telecommunications industry, were chosen for the QFA study because they offer excellent examples of U.S. high-technology industries today. Both industries were found to be investing in quality—though at different rates—in the face of international competition. Also, because the two industries have few organizational similarities, the study was able to address the influence of industry structure on the level and kind of quality investments.

"This study likely marks the first attempt to obtain detailed quantitative information on industrial investment outlays for quality."

In the case of semiconductors, U.S. companies are facing fierce foreign competition, and their survival is intimately tied to how well they implement quality programs. Thus, the QFA report says, the semiconductor industry has embraced closely the total quality philosophy of its Japanese competitors, which seeks continuous improvement not only in product value, but also in service levels, delivery, and production capability. This approach to quality pervades virtually all aspects of a firm's operations, from research and development, to manufacturing, to customer and vendor interactions.

Domestic customers of U.S. semiconductor firms, expecting the same level of quality they get from Japanese suppliers, have pushed U.S. manufacturers to rethink their quality philosophy. "Because of competition and pressure from major customers, the U.S. semiconductor industry has moved at least as far as any other domestic industry in quality improvements," Tassey says. "In some respects it now serves as a model of quality assurance practices for U.S. industry as a whole."

The U.S. optical fiber industry, still dominant in global markets, has been somewhat slower to implement a comprehensive quality program. This industry has set some quality improvement in motion in recent years, but the QFA study found

that fiber manufacturers define quality more in the traditional sense: ensuring that a product conforms to specifications and is well fit for its intended use. This relatively slower pace of change may be due to the fact that competition is an important but not yet overwhelming factor in determining corporate quality strategy, as is the case for semiconductors. Still, the industry spends as much as one-fifth of its operating budget on quality, much higher than its foreign competition.

One goal of the QFA study was to determine what percentage of quality resources is allocated for measurement needs in each industry. Because technology is increasingly complex, measurement is more important than ever to manufacturers. Bad measurement can mean wasted time and defective products. Technology-intensive industries typically apply generic measurement technology at some or most phases of the research and development, manufacturing, and marketing chain. The two industries were chosen for this study on the expectation that measurement technology investments would be an important component of total quality-related investment outlays.

One goal of the QFA study was to determine what percentage of quality resources is allocated for measurement needs in each industry.

The study found that the semiconductor industry, which spends between 20 and 35 percent of its total operating budget on quality, allotted 15 to 40 percent of this investment in quality to measurement. Optical fiber companies, estimated to spend 17.5 percent of their total budget on quality-related programs, used 27.5 percent of their quality funds for measurement. "These sizable sums are not surprising," Tassey says, "due to the increased awareness of measurement importance." As for NIST measurement programs, all semiconductor industry respondents to the study and most of those from the optical fiber industry indicated that they use NIST services.

The QFA study also found that both industries were in various stages of implementing a quality manufacturing concept called concurrent engineering, which merges efforts to speed and improve not only a product's design but also its ease of manufacturability. Tassey explains: "There was a time not too long ago when design departments and production departments were separate entities in companies. A product design was literally handed over the wall to the manufacturing department, which was left to its own devices to come up with a cost-effective method for manufacturing the product. Now, companies are increasingly merging these two departments allowing designers to create a product that not only does the job but also is easy to manufacture. It's a much more efficient way to do business."

Bad measurement can mean wasted time and defective products.

Tassey says lessons learned from the QFA study can be applied to the larger picture of how U.S. high-technology industries are implementing strategies for quality. He emphasizes, however, that other studies need to be done to definitively evaluate the quality programs of industries such as chemicals and electronics. But experience from the QFA study indicates that information on quality programs won't come easily. In the case of semiconductors and optical fibers, the study found that specific quality strategies are so new to both industries that responses to queries on quality were not readily available through internal accounting.

Copies of the 244-page QFA report, *U.S. Investment Strategies for Quality Assurance,* are available free of charge. To obtain a copy, send a self-addressed mailing label to Quality Report, c/o Gregory Tassey, Program Office, A1002 Administration Bldg., NIST, Gaithersburg, Md. 20899. The report also will be available from the National Technical Information Service.

by John Henkel
NIST Public Affairs Specialist

No Evidence for Fifth Force Found

The most sensitive gravity experiment of its kind ever conducted has failed to find evidence for a suggested "fifth force" in nature, according to researchers at the Joint Institute for Laboratory Astrophysics (JILA) in Boulder, Colo. The results, which appear in the October 15 issue of *Physical Review Letters*, rule out the existence of any such force at the magnitudes previously suggested.

The experiment was carried out by a team of scientists working with James E. Faller of JILA, a cooperative venture between the University of Colorado at Boulder and the National Institute of Standards and Technology.

"Gravity, which glues the universe together, is thought to be understood on the scale of planetary distances," Faller said. "However, the possibility of a fifth force, as first suggested in 1986, raised the intriguing and fundamental question of the existence of a small and heretofore undetected short-range component to gravity that would act over distances of up to a few miles."

The experiment measured gravity at various heights on a 1,000-foot meteorological tower located 15 miles east of Boulder in Erie, Colo. These measurements were then compared with the values that were predicted from surface gravity measurements and Newton's inverse-square law.

"We found superb agreement between the measured values and the Newtonian predicted values," Faller said. "Newton has been vindicated on the plains of Colorado."

Gravity decreases the further away something is from the center of the Earth, and also from location to location depending on whether there is a mineral deposit or other variation in density. In order to determine gravity accurately in the vicinity of the Erie tower, the scientists combined 30,000 existing surface gravity measurements, covering a region roughly the size of Colorado, with 265 team-made measurements within a 5-mile radius of the tower.

Gravity measurements were made at eight different heights on the tower on about 10 occasions over a 2-month period. Tower measurements had to be made between 10 p.m. and 6 a.m. to avoid interference by wind and the thermal heating of the tower by the sun, Faller said.

Great care and attention to a myriad of details were required to obtain the achieved measurement accuracy. The experiment took slightly less than a year to conduct and cost $1,000 for rental of the tower, Faller said. All other equipment was borrowed.

The four known forces of nature are gravity, electromagnetism, the strong force that binds atomic nuclei, and the weak force that causes radioactive decay.

Faller's co-authors were Clive Speake (now at the University of Birmingham, England), Tim Niebauer (now at the Max Planck Institute for Quantum Optics, Munich), Martin McHugh and Paul Keyser of JILA, Jamie Cruz and Chris Harrison of the Geodynamics Corp. of Santa Barbara, Calif., Jaako Makinen of the Finnish Geodetic Institute in Helsinki, and Raul Beruff of the Cheyenne, Wyo., office of the U.S. Defense Mapping Agency.

by Peter Caughey
University of Colorado science writer and
Collier Smith
NIST Public Affairs Specialist

Tech Transfer Awards Announced

The Commerce Department's Technology Administration (TA) has announced the award of nine grants totaling $910,845 to state governments to support programs that transfer federal government technology to private industry. "One of the most exciting developments of the last few years in the area of technology transfer has been the appearance of an impressive array of imaginative, aggressive programs sponsored by state and local governments," said Under Secretary Robert M. White, who heads the Technology Administration. "We're pleased to be able to make this contribution to that important effort."

The State Technology Extension Program was established under the 1988 Technology Competitiveness Act and is administered by the National Institute of Standards and Technology, a part of the Technology Administration. The grants are available for projects which either demonstrate cooperative programs with federal laboratories that can increase the use of government-developed technology by industry, or help businesses take advantage of services and information available from NIST or the NIST Regional Centers for the Transfer of Manufacturing Technology. This is the first year that funding has been available for such grants.

"We see these grants as an experiment in technology transfer," says NIST Director John Lyons. "Each was selected for some new, innovative approach to our goal, making the fruits of federal research and development more accessible to U.S. industry."

NIST officials said the winning projects, which must provide matching funds, were selected based on technical merit and innovation from among 43 proposals.

Brief descriptions of the winning projects are given below.

Arkansas ($125,000). The Arkansas Science and Technology Authority will sponsor a statewide initiative linking existing business assistance providers with newly formed technical assistance providers. These teams will work with Arkansas businesses to solicit, evaluate, and fund specific federal technology transfer projects.

For more information, contact the Arkansas Science and Technology Authority at 501/371-3554.

Georgia ($65,719). The Industrial Extension Service at the Georgia Institute of Technology plans to demonstrate a variety of methods for technology transfer in its different operating regions of the state. The transfer methods to be demonstrated include: conferences, videos, mass mailings of literature on federally developed technology, and feasibility audits.

For more information, contact the Industrial Extension Service, Georgia Institute of Technology at 404/894-6100.

Maryland ($49,797). The University of Maryland Technology Extension Service will create and promote the Maryland Technology Commercialization Coalition. This coalition will include federal laboratory technology transfer agents, consultants from the University of Maryland's Technology Extension Service, a representative from the university's Technology Liaison (patent licensing) Office, invited industry principals, Maryland Department of Economic and Employment Development liaison, and a

separate technical and business team with the mission of investigating suggested new technologies for viability in the commercial marketplace.

For more information, contact the Technology Extension Service, University of Maryland at 301/405-3883.

Massachusetts ($129,068). The Massachusetts Center for Applied Technology, a project of the Massachusetts Centers of Excellence Corporation (a quasi-public agency), will join with the Technologies for Effective Cooperation Network and two programs of the state-funded Industrial Services Program to help businesses in Massachusetts take advantage of the services and information offered by the NIST Northeast Manufacturing Technology Center (NEMTC).

For more information, contact the Center for Applied Technology at 617/727-7430.

Michigan ($165,089). The approach of the Michigan Department of Commerce to technology transfer is to develop specific plans for key industries in the state's economy. This includes: identifying potential companies that are good candidates for technology transfer; matching them with potential federal providers of the technologies; and providing assistance in the development of an "Action Plan" of specific steps and requirements to bring the appropriate technology to use or commercial application.

The demonstration project will focus on up to four key industries (plastics, tooling, capital equipment producers, aluminum casting) to maximize the potential return on investment.

For more information, contact the Michigan Modernization Service, Michigan Department of Commerce at 517/373-7411.

Minnesota ($60,000). Minnesota Project Innovation Inc., in cooperation with the Department of Trade and Economic Development, the Greater Minnesota Corporation, and other public and private organizations, plans to recruit between 200 and 300 Minnesota high-technology firms, educate them on the status of relevant federal technologies, and acquaint them with the federal laboratory process through a series of technical workshops.

For more information, contact the Minnesota Project Innovation Inc. at 612/338-3280.

New York ($75,000). The New York State Science and Technology Foundation project is to assist businesses in gaining access to the services and information offered by NEMTC at Rensselaer Polytechnic Institute.

The strategy is to ensure maximum cooperation and coordination between the New York Industrial Technology Extension Service (ITES) and the NEMTC, ultimately integrating ITES with the center for the training of technology extension agents.

For more information, contact the New York State Science and Technology Foundation at 518/474-4349.

Pennsylvania ($150,000). The Pennsylvania Office of Technology Development plans to strengthen the competitive performance of a critical segment of Pennsylvania's manufacturing base: the 2,100 metalworking and precision machining firms that constitute more than 10 percent of Pennsylvania's industrial economy. The grant-supported program will establish links between the Pennsylvania Industrial Resource Network and the two NIST regional Manufacturing Technology Centers that border Pennsylvania (the Northeast Manufacturing Technology Center at Rensselaer Polytechnic Institute and the Great Lakes Manufacturing Technology Center at Cuyahoga Community College in Ohio).

For more information, contact the Pennsylvania Office of Technology Development at 717/787-4147.

Tennessee ($91,172). The Tennessee Department of Economic and Community Development will contract with the University of Tennessee's Center for Industrial Services to establish a Tennessee Technology Extension Program that will network the capabilities of various organizations in the state to provide manufacturing technology transfer to businesses in the state.

For more information, contact the Tennessee Department of Economic and Community Development at 615/741-1888.

by Michael Baum
NIST Public Affairs Specialist

New Publications

Government's Role in Standards-Related Activities: Analysis of Comments

Leight, W.G., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 4367, 36 pages (July 1990). Order by stock no. PB #90-215534FAH from NTIS, $15 prepaid (plus $3 handling).

A thorough analysis of the record and comments from the April 3-5, 1990, hearing on the federal role in international standardization indicates that the private sector opposes significant changes to the current standards development system. In this publication, NIST reports that the private sector recognizes a need for a strong government role in conformity assessment to ensure foreign acceptance of products tested in the United States. Proposed improvements relate to the private sector instituting its own oversight mechanisms, increased informational and educational programs, intensified government efforts for greater participation by agency experts, wider use of international standards, and financial support by the private sector for small and medium-sized company participation in international standards activities. Proposals for conformity assessment include a call for the government to intensify its efforts to ensure foreign acceptance of products tested and certified within the United States.

U.S. Department of Energy Risk Assessment Methodology

Roback, E., NIST coordinator, Natl. Inst. Stand. & Tech. (U.S.), NISTIR 4325, 194 pages (May 1990). Order by stock no. PB #90-244484FAH from NTIS, $23 prepaid.

An important part of developing a computer security program is weighing the costs of controls against the risk of loss. Controls more expensive than the information they protect are not cost effective. To achieve a balance, NIST is investigating ways to identify risks and select appropriate cost-effective computer security measures. This includes making available information on methods developed by other federal agencies. This publication describes the risk assessment method used by the U.S. Department of Energy (DOE). Their approach specifies six steps, including defining the system, software, and data; identifying threats; selecting countermeasures; and obtaining management review, participation, and accountability. Worksheets and tables needed for each step are included.

GATT Standards Code Activities of the National Institute of Standards and Technology 1989

Overman, J.R., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 4314, 49 pages (April 1990). Order by sending a self-addressed mailing label to Standards Code and Information Program, A629 Administration Bldg., NIST, Gaithersburg, Md. 20899.

This annual report describes the role of the NIST Standards Code and Information Program (SCI) in support of the GATT Agreement on Technical Barriers to Trade (GATT Standards Code). Also given are statistics on 10 years of the codes's implementation in the United States. SCI staff operate the U.S. GATT inquiry point for information on standards and certification activities that might affect U.S. trade. SCI also coordinates comments on foreign regulations, arranges for translations of foreign texts, and maintains the GATT "hotline" (301/975-4041) for the latest information on notifications of proposed foreign regulations issued by the GATT Secretariat in Geneva.

High-Technology Office Evaluation Survey—A Pilot Study

Rubin, A., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 4354, 68 pages (June 1990). Order by stock no. PB #90-244427FAH, $17 prepaid.

What is the most important feature in an office? How important are design and furnishings? These are questions NIST researchers recently asked office space designers and facility managers from 22 major corporations and government agencies. The survey was conducted to provide insights about how offices and workstations are planned and designed. Included were the effects of technology on design, space allocations, and systems furnishings. Respondents rated functionality, privacy, storage, and aesthetics as the top features needed for a high-quality workplace. In comparing today's offices with those of 5 years ago, they said that design and furnishings are more important now and that more space for support activities is needed.

Center for Electronics and Electrical Engineering Technical Progress Bulletin

Natl. Inst. Stand. & Tech. (U.S.), NISTIR 4323, 46 pages (June 1990). Order by sending a self-addressed mailing label to Center for Electronics and Electrical Engineering, B358 Metrology Bldg., NIST, Gaithersburg, Md. 20899.

NIST measurement programs in semiconductor technology, signals and systems, electrical power, and electromagnetic interference are described in this bulletin. NIST's Center for Electronics and Electrical Engineering provides national reference standards, measurement methods, supporting theory and data, and traceability to national standards. The publication includes abstracts of papers and

published works arranged by topic (with phone numbers of contacts). Semiconductor subjects covered include silicon materials, dimensional metrology, photodetectors, and device physics and modeling. Also included are sections on waveform, antenna, cryoelectronic, electro-optic, optical fiber, and power systems metrology.

State Weights and Measures Laboratories: State Standards Program Description and Directory

Harris, G.L., Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 791, 68 pages (June 1990). Order by stock no. 003-003-03024-4 from GPO, $3.75 prepaid.

This directory is designed to help manufacturers and others in commerce and industry locate and obtain needed measurement services. The publication is a guide to state and other labs certified by NIST that are capable of performing reliable measurements with staff trained in proper procedures. To be certified in a particular area, each state must have a trained metrologist and an adequate facility, and must demonstrate on a continuing basis that it is capable of providing valid measurements. NIST certification indicates the laboratory is capable of providing a measurement service, but each state is responsible for verifying its measurement traceability. The directory contains the following information for each lab: the certification period, if certified by NIST; lab staff members, addresses, and telephone or fax numbers; services available; and fees, if any, for services.

Guidelines for Pressure Vessel Safety Assessment

Yakawa, S., Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 780, 75 pages (April 1990). Order by stock no. 003-003-03003-1 from GPO, $4.25 prepaid.

Deterioration of certain kinds of pressure and storage vessels in the United States could result in the loss of dozens of lives and millions of dollars. A NIST study, sponsored by the Occupational Safety and Health Administration, gives an overview of stationary, unfired carbon steel and low-alloy steel pressure vessels for liquids and gases, and low-pressure storage tanks used at temperatures between –75 and 315 °C. These vessels are used in the process, pulp and paper, petroleum refining, and petroleum chemical industries, and for water treatment systems for boilers and steam generators. Included are causes of failure and nondestructive inspection standards, practices, and methods.

Trade Implications of Processes and Production Methods (PPMs)

Cooke, P.W., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 90-4265, 23 pages (March 1990). Order by sending a self-addressed mailing label to Patrick W. Cooke, A629 Administration Bldg., NIST, Gaithersburg, Md. 20899.

This report provides background information on processes and production methods that prescribe how to produce a product rather than describe the performance or other characteristics of an end-item. When specified in technical standards and regulations, PPMs may become a trade barrier. The GATT Standards Code is based on the concept that standards should not act as technical barriers to trade, but the European Community (EC) and some other signatories to the Standards Code have interpreted the article on PPMs so narrowly that it has been nearly impossible to resolve a PPM case. NIST recommendations include resolving PPM issues between the United States and the EC in GATT based on technical considerations and equivalency, conducting a test program of GATT notifications for proposed PPM regulations, and making exporters more aware of PPM issues and urging them to report difficulties.

Characterization of Clocks and Oscillators

Sullivan, D.B., Allan, D.W., Howe, D.A., and Walls, F.L., editors, Natl. Inst. Stand. & Tech. (U.S.), NIST Tech. Note 1337, 352 pages (March 1990). Order by stock no. 003-003-03019-8 from GPO, $17 prepaid.

This collection of published papers is designed as a reference for those involved in characterizing and specifying high-performance clocks and oscillators. It includes tutorial papers, papers on standards and definitions, and papers detailing specific measurement and analysis techniques (with corrections and notes indicating current recommended IEEE notation). Topics covered include properties of signal sources, phase noise measurements, standard terminology, stability measurement, and biases and variances.

Ordering Information

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

Conference Calendar

Experiment Design for Scientists and Engineers

NIST, Gaithersburg, Md.

This 5-day workshop will help scientists and engineers in research and development or manufacturing improve quality and productivity. Familiarity with the concepts of elementary statistics will be useful but not required. The workshop will de-emphasize mathematical development and replace it with an experimentalist-based evolution of concepts and techniques with reinforcement via practical applications. The workshop covers specific designs that have proven best for three very important classes of problems: (1) how to ferret out systematically the most important factors from a large number of potential factors, (2) how to converge to an optimal operating condition starting from a best guess, and (3) how to identify settings of controllable factors that reduce variability caused by unavoidable sources of variation (Taguchi's quality engineering approach). Sponsored by NIST. Contact: Eric Lagergren, A337 Administration Bldg., NIST, Gaithersburg, Md. 20899, 301/975-3245.

Workshop on Fundamentals of Carbon/Carbon

NIST, Gaithersburg, Md.

The objective of this workshop is to encourage fundamental research, interdisciplinary cooperation, and technology transfer to increase the understanding of mechanisms and processes relevant to new concepts for high-temperature carbon/carbon composites. Scientific issues to be covered at the workshop include mechanisms and materials for high-temperature oxidation inhibition, protective coatings, and fundamental modeling of microstructure and mechanical properties. Approximately 12 invited speakers will review the current state of the art. Poster papers are encouraged. Sponsored by the Air Force Office of Scientific Research and NIST. Contact: David C. Cranmer, A329 Materials Bldg., NIST, Gaithersburg, Md. 20899, 301/975-5753.

International Workshop on Reliability of Offshore Operations

NIST, Gaithersburg, Md.

Participants will discuss current practice, progress, and future directions in the fields of risk management and safety/reliability analysis of offshore oil and gas operations. Recent experience and case studies will be emphasized. Representatives of the petroleum industry, consulting firms, government agencies, and academic and research institutions will attend. Sponsored by the Minerals Management Service, U.S. Department of the Interior; Canada Oil and Gas Lands Administration; Petroleum Division, Department of Energy, United Kingdom; the American Society of Civil Engineers; and NIST. Contact: Emil Simiu, B158 Building Research Bldg., NIST, Gaithersburg, Md. 20899, 301/975-6076.

Applications of Cold Neutron Spectroscopy in Chemistry, Biology, and Physics

NIST, Gaithersburg, Md.

This workshop will acquaint the research community with new capabilities in high-resolution neutron spectroscopy soon to be available at the NIST Cold Neutron Research Facility. Several instruments at NIST's research reactor will be brought into operation from 1991 to 1993, permitting the observation of chemical, physical, and biological processes with energies across a very wide energy range, from 10^3 to 10^{-4} cm^{-1}. This will extend the lower limit of accessible energy transfers by several orders of magnitude. Plenary and invited speakers will describe the instruments and give examples of the scientific results that can be expected from them. Workshop participants will be encouraged to comment on user policies, the disposition of instruments, and unrecognized scientific applications. Sponsored by NIST. Contact: Carol O'Connor, E151 Reactor Bldg., NIST, Gaithersburg, Md. 20899, 301/975-6240.

Third International Symposium on ESR Dosimetry and Applications

NIST, Gaithersburg, Md.

This symposium will focus on current applications of electron spin resonance (ESR) spectroscopy in the general areas of ionizing radiation dosimetry, archaeological dating, and instrumentation, including imaging and measurements for solid-state, biological, and medical applications. The topics of discussion include solid-state effects, reference dosimetry, transfer dosimetry, dating, and geology. Also, presentations of new, innovative developments in the ESR field are encouraged. Sponsored by NIST, the China University of Science and Technology, and the International Atomic Energy Agency. Contact: Marc F. Desrosiers, C214 Radiation Physics Bldg., NIST, Gaithersburg, Md. 20899, 301/975-5639.

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