NBS Moves to Gaithersburg

Although some retire at age 65, the National Bureau of Standards is more active than ever. At its new home, being dedicated this month, some 2700 people will be working. Most of the equipment and staff have already left the crowded, obsolete Washington site and occupy 15 of the buildings planned.

by Gloria B. Lubkin

THIS MONTH the world's largest physical science laboratory, the National Bureau of Standards, is dedicating its new facility at Gaithersburg, Maryland. We recently visited the 565-acre site, to which most of the activities formerly housed on Van Ness Street in northwest Washington have been moved. In addition three major new facilities for which the old site was unsuited have been completed in Gaithersburg. These are a high-intensity 100-MeV electron linear accelerator (linac), a 10-megawatt heavy-water-moderated reactor for materials research and a collection of highly accurate deadweight machines to calibrate force-measuring devices.

Why move the bureau?

The old 68-acre site in northwest Washington, occupied by NBS since 1903, had become overcrowded with obsolete facilities. Some buildings were more than 50 years old. Others, still in use, had never been intended for more than temporary housing. New facilities, such as a research reactor, could not fit on the old site at all.

In 1955 the Government proposed that NBS move to a new site, with two limitations: it must be at least 20 miles from the center of Washington, to remove it from a prime target area, and not in the "Washington-Baltimore corridor."

Over 100 sites were screened; the final selection, in Gaithersburg, met the criteria so well that the site is actually traversed by the 20-mile limit.

Congress appropriated funds for the fiscal year 1957 for site acquisition and planning. Both the architects and bureau staff members visited many new laboratories to benefit from their mistakes and successes.

The final plan, which is by now mostly reality, was to build a central administration building, seven general purpose laboratory buildings and 13 special purpose buildings.

The facility has 1.2 million square feet of assignable space which, when the move is finished, will be occupied by 2700 of the bureau staff.

The administration building, towering 11 stories high over the campus structures, contains the director's office, most administrative support employees, meeting and dining rooms, a library, a small museum and the standards vault.

Four of the special buildings are now in use: Radiation Physics Laboratory, Nuclear Reactor, Engineering Mechanics Laboratory and Boiler Plant. Four are being built now: Hazards Laboratory (where experiments with a relatively high accident probability will be done), Industrial Building, Sound Laboratory and Concreting Materials Building. Being planned are the Fluid Mechanics Laboratory and Non-Magnetic Laboratory. The remaining two have been indefinitely postponed: Fire Research Facility and High Voltage Laboratory (and these laboratories will stay in Washington for a while, although the fire-research *section* is moving to Gaithersburg).

The general-purpose laboratories, which are connected to each other and to the administration building by glass-enclosed corridor bridges, contain more than half the Gaithersburg floor space, and will be occupied by about 1500 scientists, engineers and their staffs. Most of the laboratory areas are expected to convert easily from one research activity to another, say from chemistry to electronics. The buildings house Metrology, Physics, Chemistry, Materials, Polymer, Instrumentation and Building Research.

Missions for NBS

NBS was established in 1901 by an act of Congress that stated: "The functions of the bureau shall

consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce and educational institutions with the standards adopted or recognized by the Government; the construction when necessary of standards, their multiples and subdivisions; the testing and calibration of standard-measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants, and the properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere."

Although the bureau is best known for its measurements, it has, over the years, taken on many additional programs for government agencies and industry. Among its recent new responsibilities, the bureau will:

- Serve as the focus within the federal government for stimulating application of science and technology to the economy;
- Establish and operate the National Standard Reference Data System;
- Set up a clearinghouse for federal scientific and technical information, and thus organize the distribution of all unclassified documents produced by government agencies;
- Conduct cost-benefit studies for Department of Commerce bureaus and other agencies;
- Provide a technical base for standardization in computers, develop ways of using computers for new tasks and use them more efficiently on old tasks.

Meanwhile the bureau has lost its responsibility for the Central Radio Propagation Laboratory in Boulder, Colorado, which is now part of the new Environmental Science Services Administration.

In 1964 the bureau was reorganized into three institutes:

- Institute for Basic Standards is the national center for a complete, consistent system of physical measurement. Divisions of the institute represent classical subjects in science and engineering: electricity, metrology, heat, radiation physics, mechanics, applied mathematics, atomic physics, physical chemistry, astrophysics, radio standards physics and radio standards engineering.
- Institute for Materials Research assists and stimulates industry through research in basic properties of materials. Within the institute, divisions are organized primarily by technical field and include: analytical chemistry, polymers, metallurgy, inorganic materials, reactor radiation and cryogenics.
- Institute for Applied Technology looks for applications of technology to problems in government and industry. Within the institute there are industry divisions (such as building research and electronic instrumentation) and specialized centers (such as the center for computer sciences and technology, office of weights and measures, clearinghouse for federal scientific and technical information).

Radiation research

When we visited Gaithersburg, our first stop was the new electron linac, where James Leiss, who is chief of the accelerator branch, was busy adjusting the magnet system that will extract the beam into any of three measuring rooms. The traveling-wave linac, which produced its first beam last year, can generate 150-MeV electrons at low beam power and 80 MeV at 80 kW peak power.

Electrons are energized in nine 10-ft sections of waveguide; in the first three sections, 10 MW of peak power at L-band (20 kW average) are

ENTRANCE adjoining administration building.

supplied; the remaining six sections receive 5 MW peak power (10 kW average). Pulse lengths between 0.1 and 6 microsecond and can be repeated as often as 720 pulses per second. Eventually NBS expects to produce pulse lengths as short as 1 nanosecond.

The linac is one of many NBS tools for doing radiation physics, we were told by H. William Koch, director of the Radiation Physics Division (and soon to be director of the American Institute of Physics. See page 9). His division specializes in using photons and electrons to explore nuclei, and in a way fills the gap left by AEC-funded research, which emphasizes neutron and positive-ion bombardment.

For nuclear physics research, there are only about a dozen electron accelerators in the US, Koch says. The number of positive-ion accelerators, on the other hand, is 160. One reason for the electron's lack of popularity, is the low photonuclear cross section. Now that NBS has such a well resolved, intense beam of electrons, Koch expects to obtain data whose quality compares favorably with positive beams.

In the 20–100 MeV range available to the linac, one expects the electron to cause quite different nuclear behavior than a proton of the same energy. Because the electron wavelength, at a given energy, is much longer than the proton's, the electron will interact with the entire nuclear volume, whereas the proton will usually affect a single particle, Koch points out. Electrons excite predominantly those few nuclear states with strong transition probabilities to the ground state. Protons, however, excite many energy levels. Electrons carry few units of angular momentum; protons carry many.

Koch notes that energies and beam intensities now available from electron linacs can cause a wide variety of photodisintegrations. Some preliminary experiments at NBS by James Wyckoff have produced all reactions from γ, 3n to γ, 9n, with a ^{209}Bi target. Such reactions require 100-MeV x-ray energies with lots of x-ray beam power.

The three measurement rooms adjoin each other; by dint of 3.7-meter thick concrete shields they can be occupied simultaneously. In fact, one can safely enter a room while the beam is on, provided the electrons are not also entering.

The linac will also be used as a neutron source. A uranium target is expected to yield 10^{14} neutrons per second, which will then follow a 40-meter path for time-of-flight measurements. Much longer flight paths are also being planned. A magnet system, currently being designed, will bring the linac beam from its habitat 9.2 meters underground, to a spot somewhat above grade, where the beam will strike a target. Neutrons produced will then travel in time-of-flight tubes that could be extended as far as 800 meters.

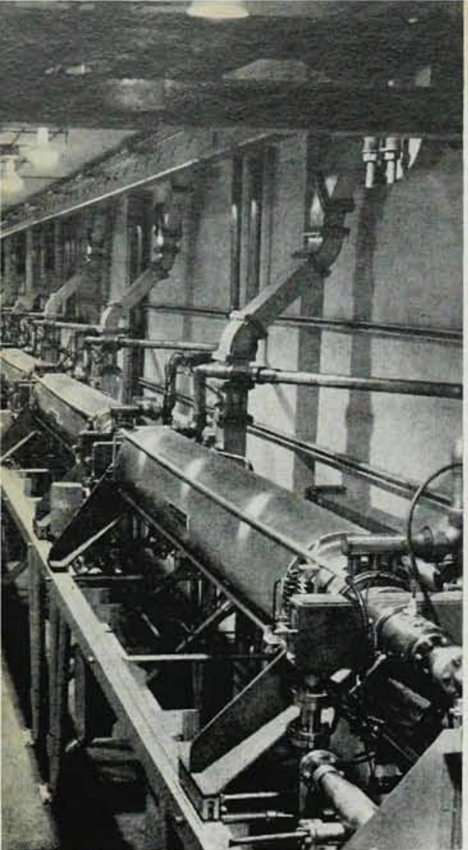
The Radiation Physics building houses two other high-intensity electron accelerators—a 4-MeV Van de Graaff and a new 1.5-MeV dynamitron, a 2-MeV positive-ion Van de Graaff (primarily for making neutrons) and a 0.5-MeV electrostatic electron accelerator. A 180-MeV electron synchrotron (PHYSICS TODAY, September, page 76) is still doing atomic physics experiments on the old Washington site.

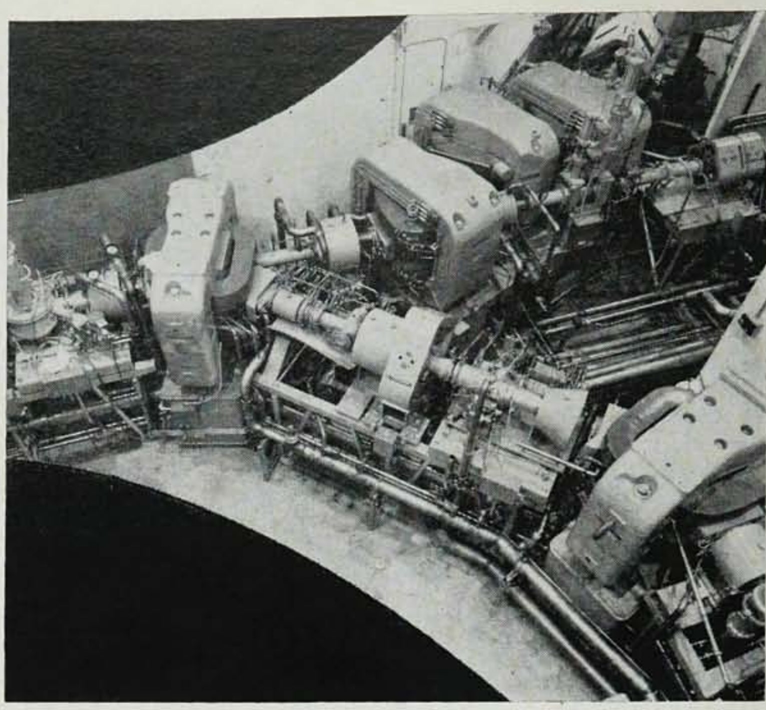
Reactor for materials study

The new 10-MW heavy-water-moderated reactor will be used primarily for materials research, according to Carl O. Muehlhause, who heads the Reactor Radiation Division, Institute for Materials Reseach. As soon as AEC grants permission, the reactor will go critical. Although initial operation will be at 10 MW, the shielding and piping are heavy enough for 20 MW.

At 10 MW the reactor core is expected to produce about 10^{14} neutrons/cm^2-sec of thermal neutrons and of fast neutrons, although the ratio will vary from position to position. Beams outside the reactor will contain about 10^{10} neutrons/cm^2-sec.

Muehlhause is especially proud of the reactor's two cold-neutron beams, produced inside the moderator, where a block of frozen heavy water is kept at 25°K by a large cryogenic system. Neutrons from the core enter the block and lose most of their energy through multiple collisions with D_2O molecules. These subthermal neutrons, with wavelengths of about 0.4 nanometer (three times the size of thermal-neutron wavelengths), can then





100-MEV LINAC. (l) The nine 10-ft sections of waveguide accelerate electrons. (r) Magnet system will extract beam into any of three measuring rooms.

be used to study lattice dynamics. The huge cryogenic system, designed by NBS engineers at Boulder, is a turbo-expansion machine. It can extract 1 kW of heat, and cost $200 000, including design.

To irradiate samples with neutrons in the core, sample-holding tubes pass into or close to the lattice of fuel elements. If one wants very short irradiation times, such as in chemical-activation studies, a system of pneumatic "rabbit tubes" can be used; then the sample can be rapidly (a few seconds) inserted, withdrawn and zipped over to a laboratory for study. Two other beam tubes go completely through the reactor along lines tangential to the core.

Nine special ports in the shielding, directed radially outward from the core, will be used for out-pile thermal-neutron analytical work in nuclear, solid-state or chemical physics.

Samples can be inserted in the thermal column, located in the reactor shielding. Thermal neutrons of well-defined energy are produced by allowing the reactor flux to pass successively through a tank of heavy water, a bismuth shield for gamma rays and a cavity filled with graphite.

Muehlhause expects that about 85% of research will be on material. With the intense thermal-neutron beams one can analyze structure of solids and liquids; for example, one can locate hydrogen atoms in crystals, find intermolecular force constants and chemical bond strengths.

Radiation effects on materials will be studied, not only for solid-state and chemical research, but also for radiation processing and the alteration of structural properties. Some nuclear physics experiments using neutrons are planned, including some in fission physics.

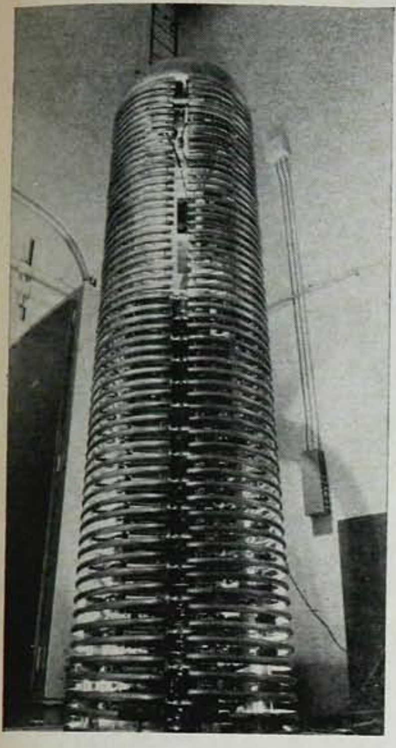
Electrostatics not static

"Standards is a dynamic business. You don't just keep things locked up in a vault," says Chester Page, head of the Electricity Division, Institute for Basic Standards.

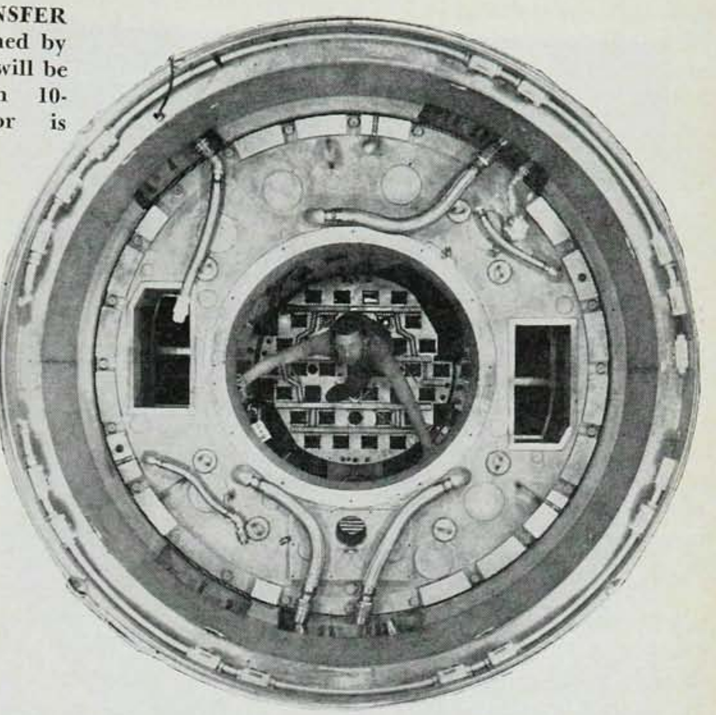
The standard cells, for example, must be checked regularly to see if they have changed. Techniques developed by Raymond Driscoll and Peter Bender for measuring the gyromagnetic ratio of the proton in a weak field were immediately applied to a scheme for checking constancy of standard cells.

Even a field as classical as electrostatics had an exciting new development a few years ago that has revolutionized electrical standards. Two Australians, A. M. Thompson and D. G. Lampard, discovered a new theorem in electrostatics—they found the capacitance of a "computable cross capacitor" can be obtained by a single length measurement, thus enormously increasing the accuracy of capacitance and resistance measurements.

A cross capacitor is a cylindrical arrangement of four electrodes; the cylinder cross section can be an arbitrary simply connected curve, divided into four segments; these electrodes are separated from each other by very small insulating gaps. Thompson and Lampard, by topological arguments, showed that if C_1/L is direct capacitance per unit length (perpendicular to the cross section) between electrodes 1 and 3 with electrodes 2 and 4 grounded, and C_2/L is direct capacitance

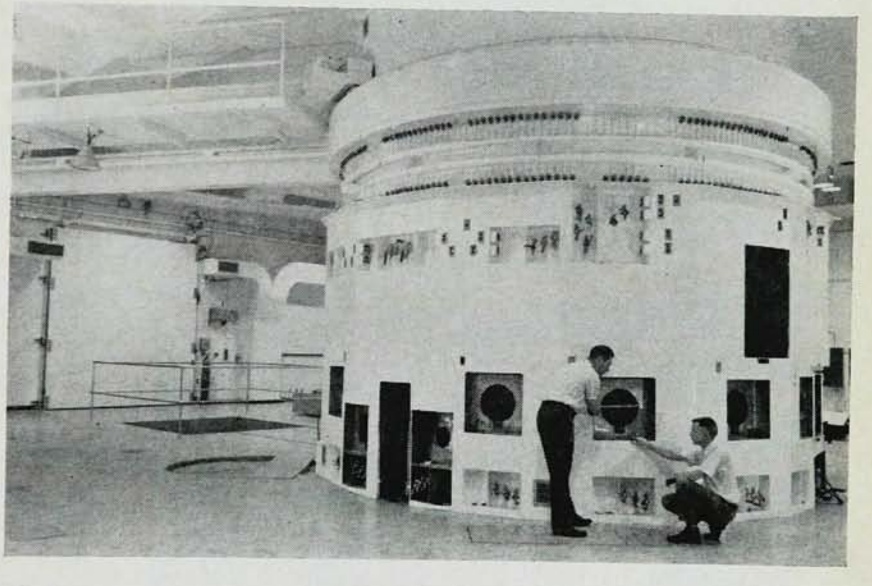


FUEL TRANSFER AREA, spanned by man's arms, will be sealed when 10-MW reactor is operated.

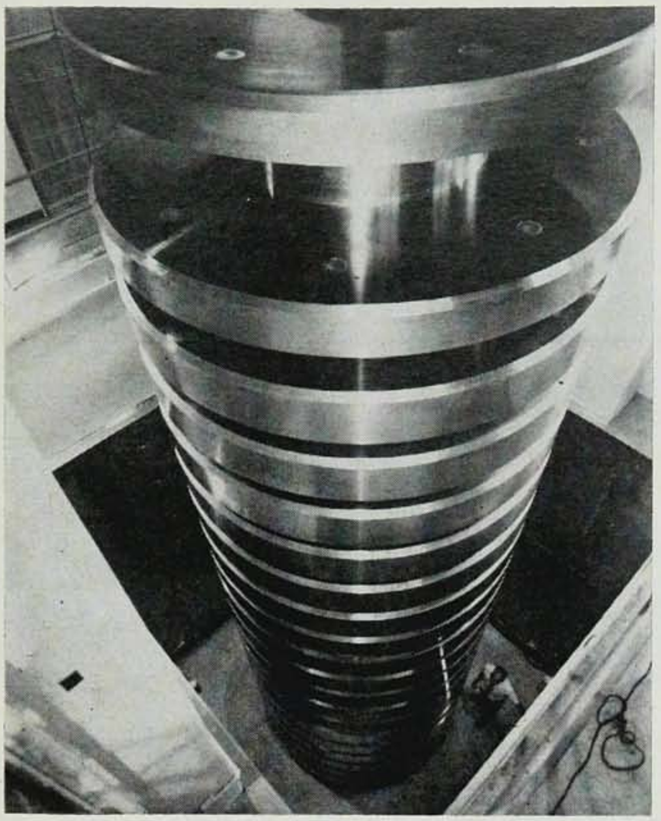


1.5-MEV DYNAMITRON, 7 meters high, mounted vertically.

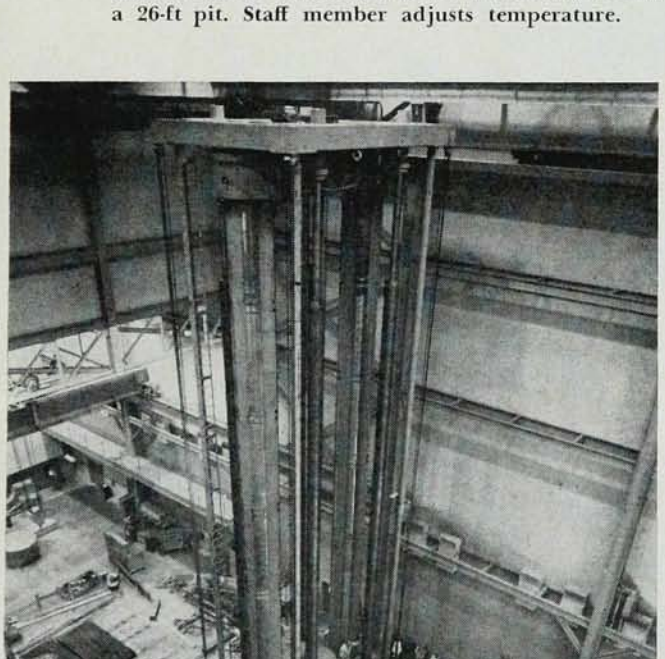
ONE OF 13 beam ports is examined by NBS technicians. Reactor will specialize in materials study.



MOVING DAY. A. G. McNish, chief of metrology, carries old standard meter bar to vault at new administration building.



DEADWEIGHT STACK has maximum capacity of 1 million lb. Each 50 000-lb weight is 10 ft in diameter. Most of stack is below first-floor level in a 26-ft pit. Staff member adjusts temperature.



12-MILLION LB capacity hydraulic testing machine nearing completion will be nation's largest machine for calibrating force-measuring devices.

per unit length between electrodes 2 and 4 with electrodes 1 and 3 grounded,

$$\exp\left(-4\pi^2 C_1/L\right) + \exp\left(-4\pi^2 C_2/L\right) = 1 \quad \text{(CGS units)}$$

By a Taylor expansion (in MKS units),

$$\overline{C} = (C_1 + C_2)\ /2 = \epsilon_0 L[\ln 2/\pi]\ [1 + 0.087\ (\triangle C/\overline{C}^2] + O\left[(\triangle C/C)^4\right] \text{ farads}$$

Following the lead of the Australian National Standards Laboratory, R. Cutkosky and his group built a capacitor (with C_1 almost equal to C_2, making $\triangle C/\overline{C}$ negligible) whose absolute capacitance could be determined just by measuring cylinder length. The accuracy was about 1 part in 10^6; Cutkosky hopes that a new version being finished will yield 1 or 2 parts in 10^8. Cutkosky has also developed a special quadrature bridge and some ratio techniques for intercomparing resistance and capacitance (taking advantage of the accuracy of the Thompson-Lampard capacitor) to calibrate the NBS standard resistor.

Measures for industry

Measurements of fundamental quantities such as length, mass, volume, light, radiation and color are done by the Metrology Division, Institute for Basic Standards. Alvin McNish, metrology chief, told us that his division specializes in service to industry. In addition to his $1.2 million budget, $0.5 million is supplied by industry for bureau testing. NBS now has a pilot program on do-it-yourself standards, McNish says, in which the bureau develops measurement techniques and then teaches industry standards laboratories how to use them.

The length of the standard meter was directly measured with an interferometer two years ago, by bureau scientists (K. D. Mielenz, H.D. Cook, K.E. Gillilland and R.B. Stephens). Before, using conventional krypton or mercury lamps, one could not make direct interferometric length measurements over more than a few decimeters. But with a helium-neon laser and an automatic fringe-counting interferometer, the group counted fringes over the entire length. The value obtained agreed with the assigned length of the line standard to 18 parts in 10^8.

For sheer size there is nothing else in Gaithersburg to compare with the seven large force-application machines in the Engineering Mechanics Laboratory. The largest deadweight machines have capacities of 1 000 000 lb, 300 000 lb and 112 000 lb. Loads can be applied in tension or compression with an uncertainly of 0.002% (PHYSICS TODAY, November 1965, page 86). Nearing completion is a 12 000 000-lb universal testing machine, which will be the largest in the US. □