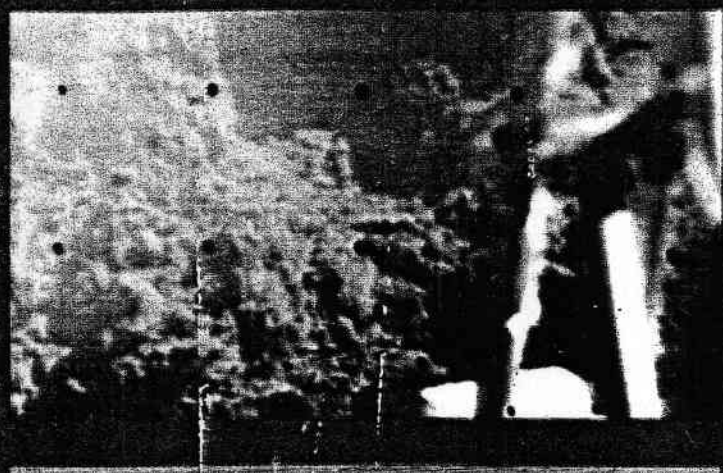
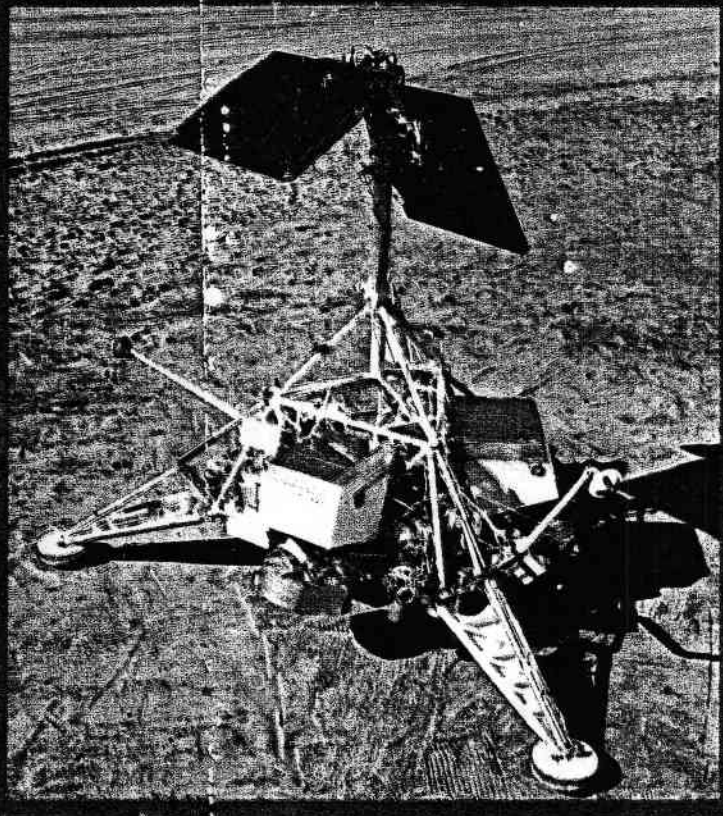
INDUSTRIAL RESEARCH

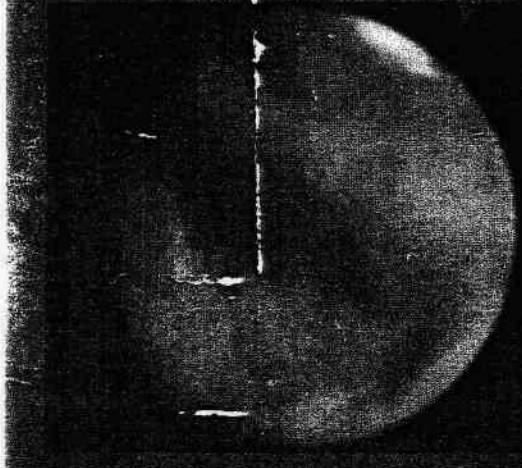
JANUARY 1968

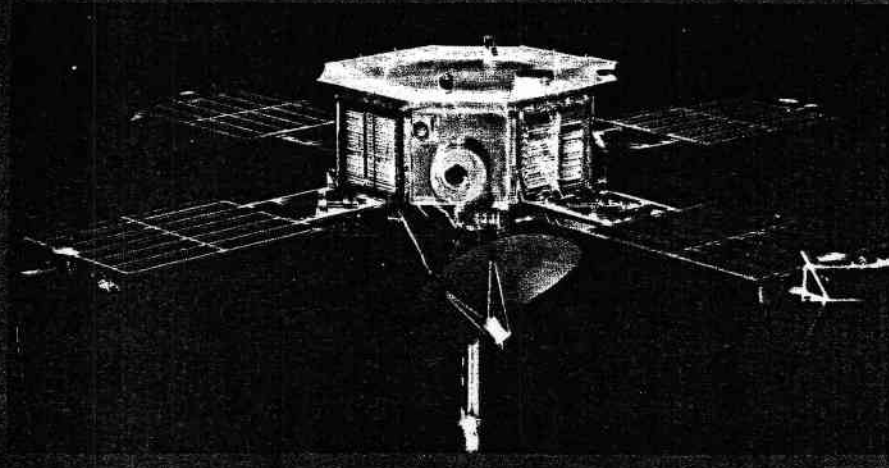




1963

I·R man of the year





AN INDUSTRIAL RESEARCH INC. MAGAZINE

INDUSTRIAL RESEARCH

THE COVER shows several spacecraft that are forerunners in the exploration of the solar system, as well as the man chiefly responsible for their development—Dr. William H. Pickering, director of the Jet Propulsion Laboratory in Pasadena, Cal. Pickering was selected the "I·R Man of the Year" by the editors and Editorial Advisory Board of Industrial Research. ■ At top left is a photographic reconstruction of the trench carved out of the lunar surface by *Surveyor 3's* surface sampler. A close-up view of *Surveyor* is shown at the center left, next to a portrait of Pickering. Along the bottom of the cover (left to right) is a composite photograph of Mars and the *Mariner 5* Venus probe. ■ Under Pickering's guidance, JPL helped compile many of the nation's deep-space "firsts." They include the first American artificial satellite, *Explorer 1;* the first successful flyby of Venus by *Mariner 2;* and of Mars by *Mariner 4.* ■ For the second consecutive year, *Industrial Research* is honoring an outstanding researcher and technical administrator who has made a notable recent contribution to the advancement of science and industry. Recipients of the annual award are presented an inscribed plaque and $1,000 at the National Conference on Industrial Research. ■ This year's conference, having "Research Decision-Making in New Product Development," as the theme cosponsored by *Industrial Research* and IIT Research Institute, will be held on the IIT campus in Chicago on Jan. 22-23. ■ The January issue also features the annual I·R forecast of research expenditures, advances, and trends. ■

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NEWS OF THE $25-BILLION RESEARCH INDUSTRY

FORECAST ARTICLES

EDITORIAL

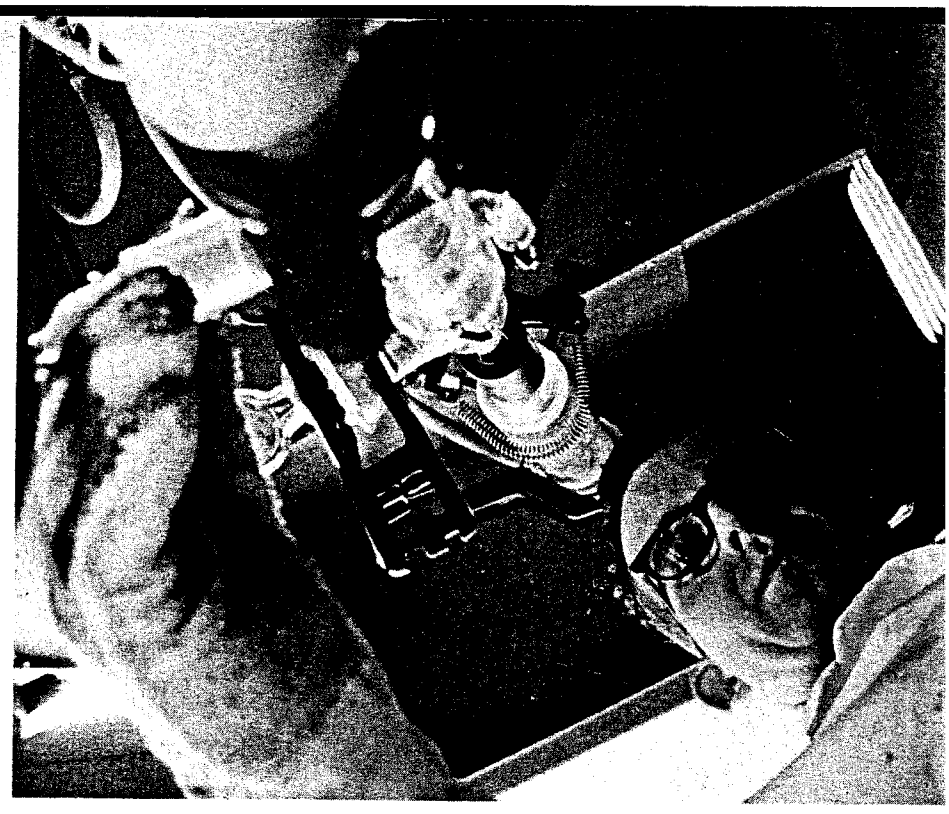
ADVANCE CONFERENCE REPORT

MATERIALS APPLICATIONS

DEPARTMENTS

The study of naturally occurring **POLYMERS** *has led to the synthesis of many products.*

by **Dr. Julio Natta,**
professor and director, Industrial Chemistry Dept., Institute of Milan, and 1963 Nobel laureate in chemistry



***THERMOGRAVIMETRIC** analysis measures and records changes in weight as a function of temperature of polymers at Martin Marietta Corp.*

ALTHOUGH macromolecular compounds have been used widely in the course of the ages as building materials (for example, cellulose, natural rubber, etc.), and they constitute the basis of all living organisms, both animal and vegetable (starch, proteins, etc.), macromolecular chemistry rose to the dignity of science only about 30 years ago.

At that time, Herman Staudinger, 1953 Nobel laureate in chemistry, in his fundamental research, laid the foundations of the study and knowledge of that science.

Since then, macromolecular science has developed not only due to the better knowledge of macromolecular natural products, but because several new products have been synthesized that exhibit different properties based on the specific conformation of their molecules.

The new methods of stereospecific polymerization recently have acquired great importance. They allow the synthetic production of macromolecular substances identical with the natural ones, such as *cis*-1,4 polyisoprene (identical with natural rubber), and of new types of stereoregular macromolecules.

New methods of polymerization also allow us to obtain a *trans*-1,4 polymer of isoprene, which exhibits an identical structure with that of gutta-percha rubber.

Amorphous polymers, and, in particular, the copolymers with ethylene, exhibit properties of elastic rubbers and are used largely as synthetic rubbers.

Stereospecific polymerization has considerably increased the spectrum of synthetic macromolecular chemistry, especially because new, as well as previously known, monomers may be used for the production of new polymers having particular physical properties.

Some polymers of alpha-olefins and butadiene, copolymers of ethylene and propylene, polyesters, and polyamides have spawned new applications in the fields of plastics, textiles, and synthetic rubbers.

The stereospecific polymerization of diolefins also is of great interest. It yields products that present different properties, depending on the structure and configuration of the monomer units.

Crystalline polymers

It is possible to obtain polymerization products from the same starting material that have different physical properties. This, of course, depends on their molecular weight and especially on the structure of the macromolecules constituting them.

A regular succession of single monomer units generally is accompanied by a crystallinity that produces polymers with high melting temperatures, good mechanical properties, and an orientability of the molecules of the stretched products, which generally allows the production of valuable crystalline textiles.

The isotactic polymer of propylene, with macromolecules characterized by the presence of monomer units with the same configuration, actually exhibits a high crystallinity below melting temperature (about 170 to 180 C). Valuable plastics, textiles, and films obtained from polypropylene are produced commercially all over the world.

The isotactic polymers of α-olefins can crystallize. The stereoregularity of isotactic poly-α-olefins often is high. Crystallinity decreases with increasing steric irregularities. Generally 30% of randomly distributed non-isomorphous monomer units is enough to obtain a completely amorphous polymer.

If monomer units with the same configuration are combined in chain segments, block polymers form; they still exhibit some crystallinity, but their x-ray diffraction spectra reveal the presence of bands that are broader and less intense than those characteristic of highly isotactic and well-crystallized polymers.

Also, syndiotactic polypropylene, which was prepared in our institute, is crystalline. However, having a lower melting temperature than the isotactic polymer, it is of less practical interest than the latter.

Isotactic polymers may be obtained only in the presence of heterogeneous catalysts generally consisting of a transition metal halide (with a valence lower than the maximum), insoluble in the reaction medium, and of an alkyl organometallic compound.

Both steric purity and homogeneity of the polymers depend on the catalyst constitution. Actually, a catalyst prepared from pure and microcrystalline violet $TiCl_3$ yields a polymer predominantly consisting of isotactic mole-

cules. However, a catalyst also containing $TiCl_3$ — but obtained by cold reduction of $TiCl_4$ with organometallic compounds—consists of a heterogeneous mixture of titanium chlorides with a different degree of oxidation and of crystallinity. The resulting compound is less stereospecific from a catalytic point of view.

On the other hand, high yields of syndiotactic polymer are obtained in the presence of some homogeneous catalysts. For example, the catalysts obtained by reaction of a solution of vanadium tetrachloride with aluminum diethyl monochlorine exhibit a high stereospecificity for the low temperature production of syndiotactic polymers.

Major butadienes

Among the synthetic products obtained by the polymerization of diolefins, I mention the four fundamental polymers of butadiene. Among them, the *cis*-1,4 polybutadiene is of practical interest, as it is a synthetic rubber that will crystallize spontaneously only below 2 C. At higher temperatures, it can crystallize under stretching like natural rubber; it has an excellent tensile strength and elongation at break. *Trans*-1,4 polybutadiene exhibits high crystallinity also in the unstretched state and a high melting temperature (about 145 C).

Polybutadiene-1,2 was obtained in two stereoisomeric forms — isotactic and syndiotactic respectively. Both are crystalline. However, these polymers are of little practical interest, unlike 1,4 polymers, due to the relatively low flexibility of the chain.

From a scientific point of view the synthesis of stereoregular, optically active alkyl polysorbates is of considerable interest. Because they are obtained from monomers having no optical activity, the corresponding macromolecules consist of monomer units with the same configuration.

The above reveals the importance of both chemical and steric regularities on the physical and technological properties of linear high polymers.

My earlier remarks about the synthesis and properties of polypropylenes with different steric structures obviously may be extended to all polymers (hydrocarbon or not) of asymmetric vinyl monomers.

Therefore, stereospecific polymerization allows one to obtain valuable products from monomers that otherwise would have no practical interest.

In fact, by the old processes of polymerization, they mostly yielded low-molecular-weight polymers with an irregular structure due to the irregularity in the succession of monomer units of different configuration. ■

Asexual reproduction of humans may be the next major advancement in **GENETICS.** *But controversies could hamper progress in this area.*

by **Dr. Joshua Lederberg,**
professor of genetics, School of Medicine, Stanford University, and 1958 Nobel laureate in physiology and medicine

RECENT DISCUSSIONS of controlled human evolution focus on two techniques — selective breeding (eugenics) and genetic alchemy (algeny).

Algeny presupposes a number of scientific advances that have yet to be perfected, and their immediate application to human biology is, probably unrealistically, discounted as purely speculative.

Paradoxically, the issue of "subhuman" hybrids may arise first, just because of the touchiness of experimentation on obviously human material. Tissue and organ cultures and transplants already are in wide experimental or therapeutic use, but there would be widespread inhibitions about risky experiments leading to an object that could be labelled as a human or parahuman infant.

There is enormous scientific interest in organisms augmented by fragments of the human chromosome set, especially as we know so little of man's biological and genetic homology with other primates. This is being and will be pushed in steps as far as biology will allow, to larger and larger proportions of human genome in intact animals, and to organ combinations and chimeras with varying proportions of human, subhuman, and hybrid tissue.

Note that there have been efforts to transplant primate organs to man. The hybridization is likely to be somatic, and the elaboration of these steps will make full use of nuclear transplantation to test how well and to what extent these assorted genotypes will support the full development of a zygote.

The sharpest challenges to our pretensions about human nature already are in view, yet they may be overlooked as a result of too farsighted focusing on possibilities such as the "chemical control of genotype."

Man is, indeed, on the brink of a major evolutionary perturbation—vegetative propagation.

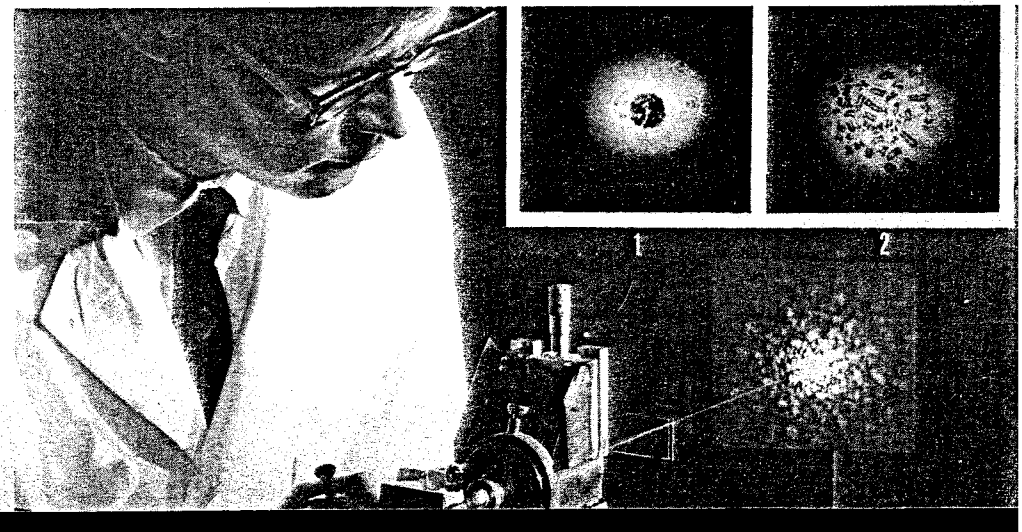
Experimentally, we know of successful nuclear transplantation from various adult tissue cells into amphibian eggs whose own nuclei have been removed. There is nothing to suggest any particular difficulty about accomplishing this in mammals or man, although it rightly will be admired as a technical *tour-de-force* when it is first implemented.

A biological accident?

I am more puzzled by the rigor with which asexual reproduction has been excluded from the vertebrate as compared to the plant world, where its advantages are widely exploited. Many plants spread almost entirely by asexual growth and reproduction.

A colony of organisms derived from

***LASER** beams are used by Perkin-Elmer scientists to find blood cells in the process of dividing (mitosis). Cut 1 is a normal blood cell image; cut 2 is a mitotic cell image showing the chromosomes.*



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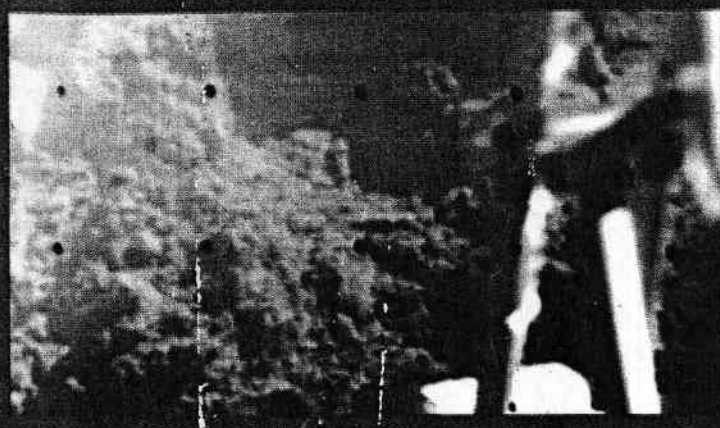
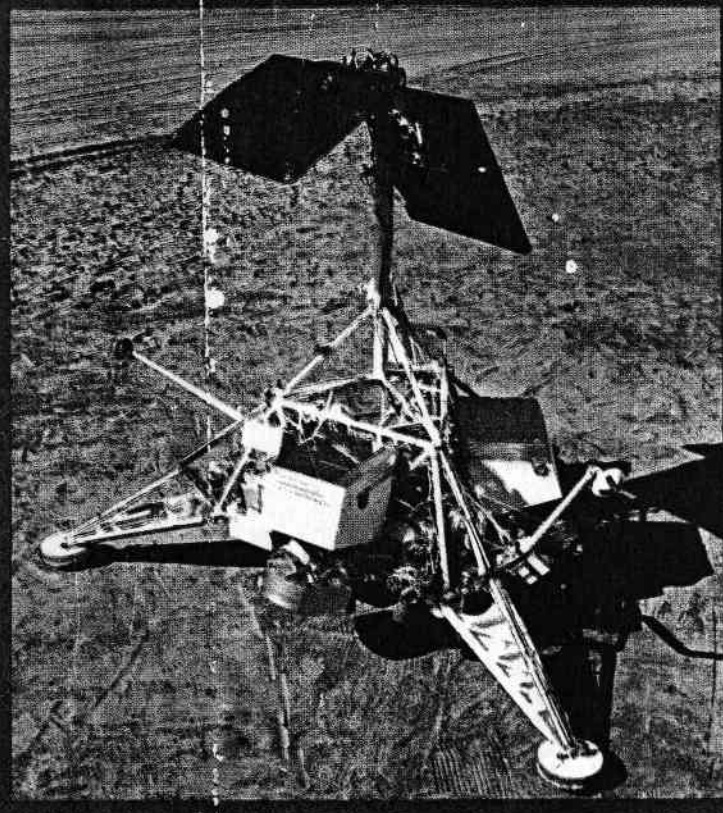
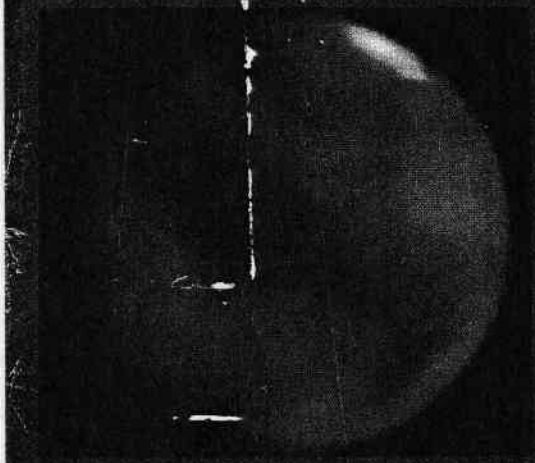
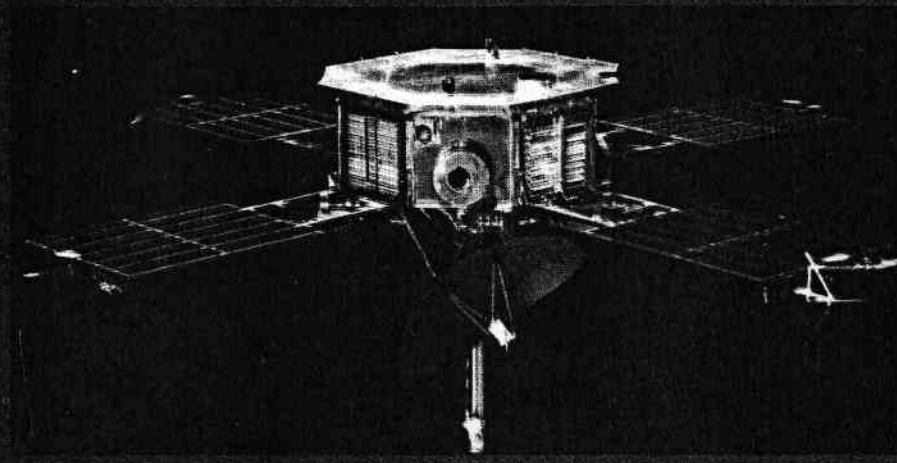




I·R man of the year





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Spokesman for the $25-billion research industry

INDUSTRIAL RESEARCH, Vol. 10, No. 1, January 1968, published 13 times a year, with the annual Buyers' Guide in the fall, by Industrial Research Inc., Industrial Research Bldg., Beverly Shores, Ind. 46301. The telephone number is 219/872-8685. Regional editorial offices are: Eastern: 9 E. 41st St., New York 10017 (212/682-5332); Washington: 1000 Tracy Dr., Silver Spring, Md. (301/622-0366); Midwest: Beverly Shores, Ind. 46301 (219/872-8685); and Western: 1250 Wilshire Blvd., Los Angeles 90017 (213/482-3521). Industrial Research Inc. also publishes Oceanology International magazine.

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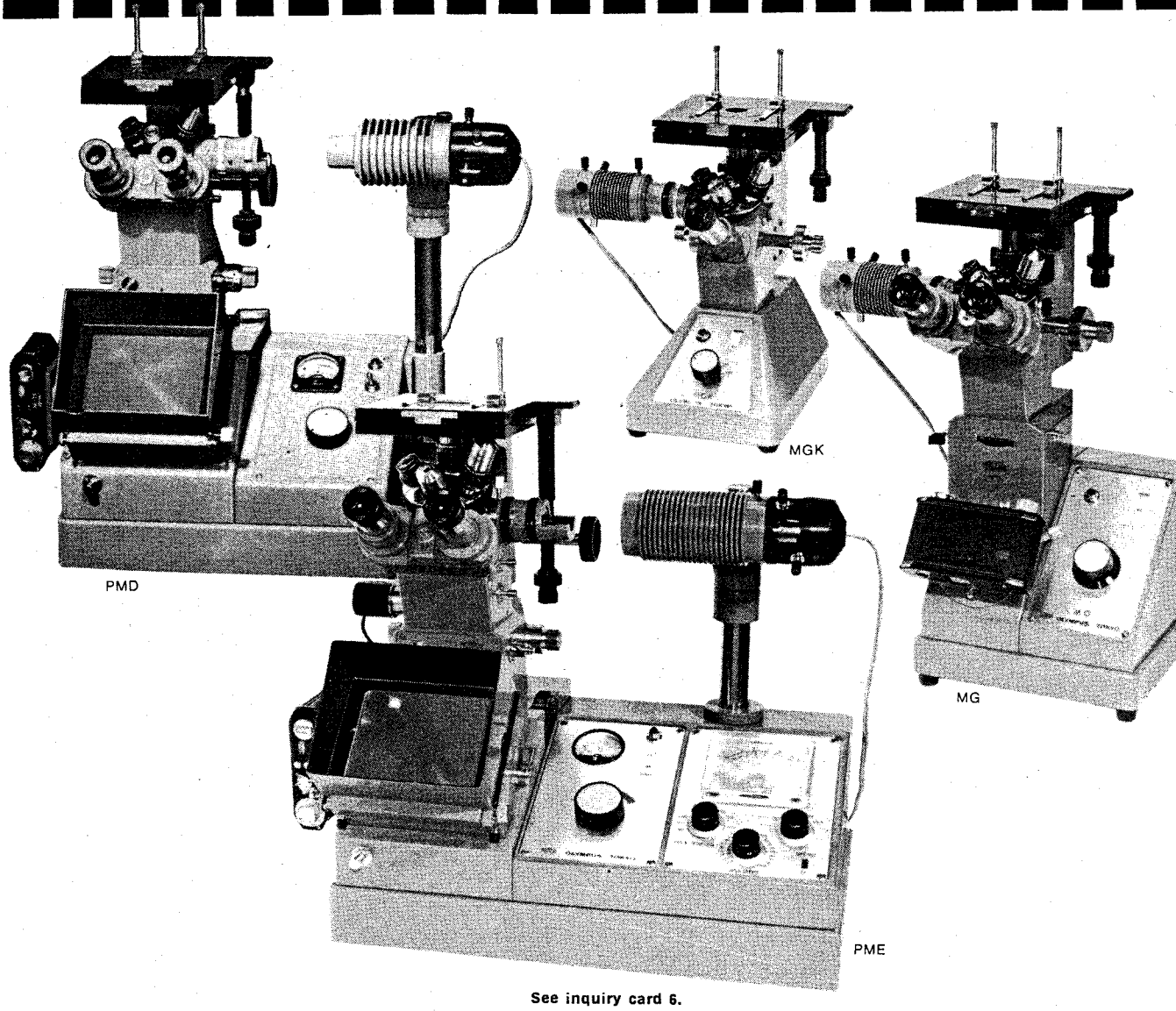
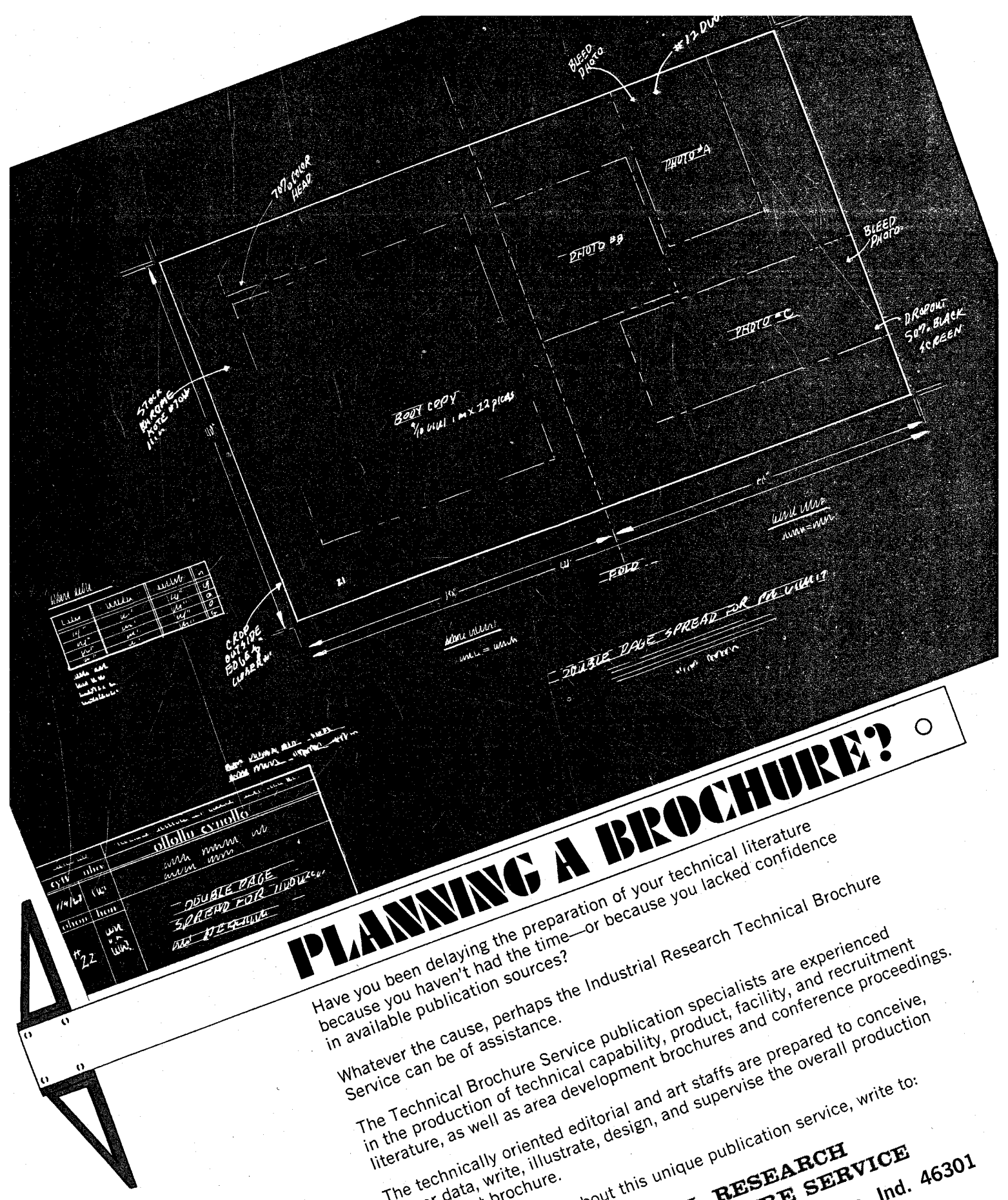


See inquiry card 6.



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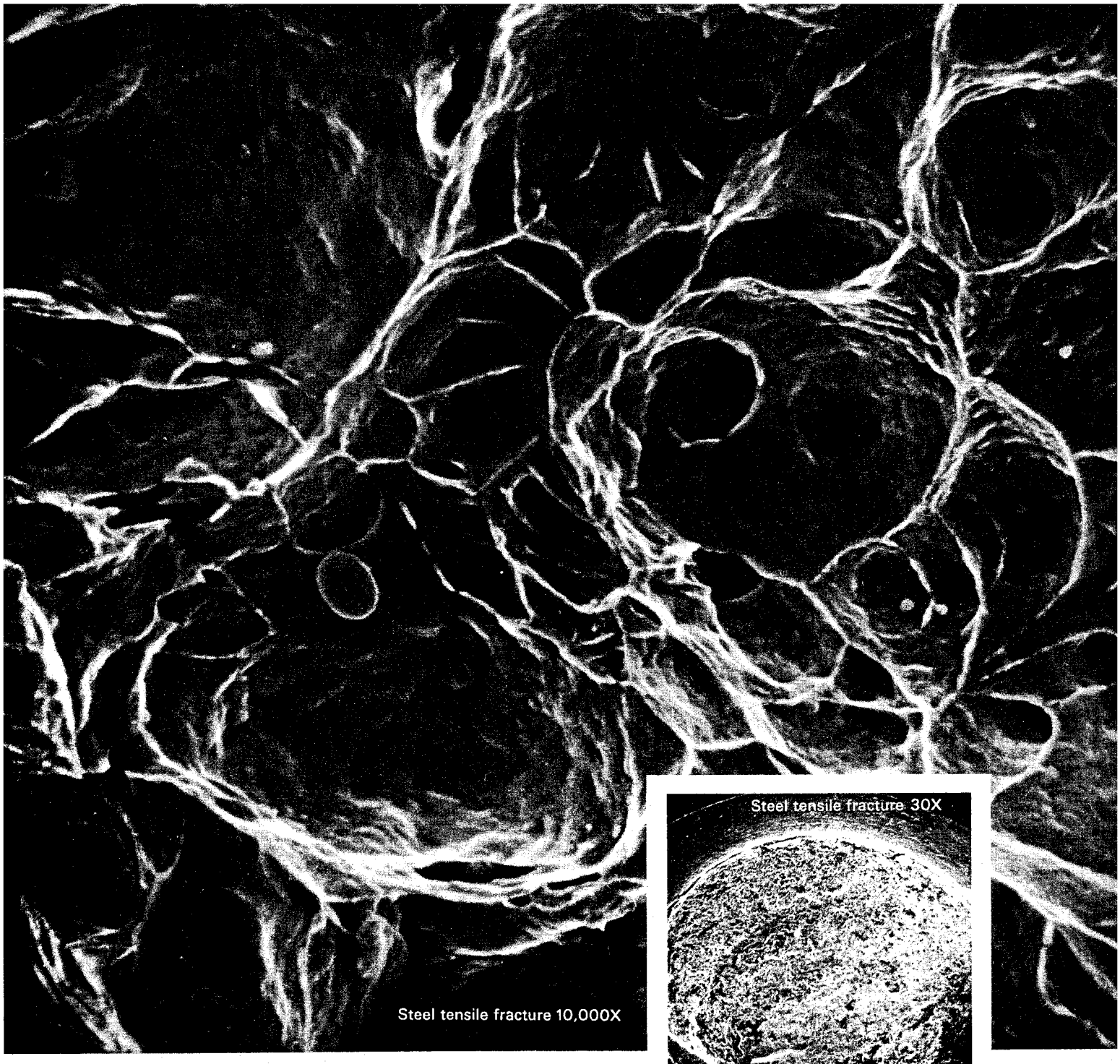

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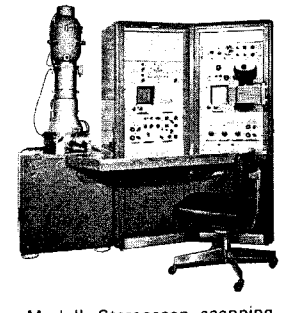

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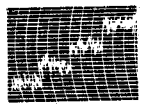
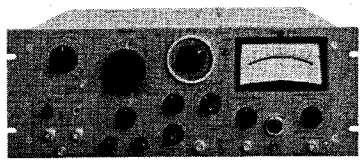
See inquiry card 9.

When information buried in noise is periodic, transient, or random, there is a *PAR*[T.M.] instrument to recover it

PAR manufactures a complete line of signal processing equipment to measure signals of various types buried in noise. The choice of the most appropriate instrument depends upon the characteristics of the signals. The equipment falls into three general classes:



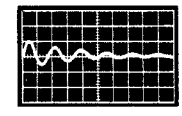
LOCK-IN AMPLIFIERS

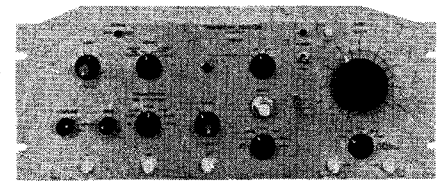


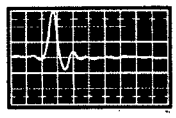
Lock-In Amplifiers have application where the signal of interest is or can be made to appear at a single frequency and where a reference voltage related in frequency and phase to the signal can be obtained. These instruments employ phase-sensitive detection and narrow-band filtering techniques to provide a DC output signal proportional to the amplitude of the fundamental component of the signal being measured. The Lock-In Amplifier can be described as a tuned voltmeter, the response of which is "locked" to that particular frequency and phase at which the signal information has been made to appear. They operate typically in the frequency range of 1.5 Hz to 150 kHz with full scale sensitivities down to 10^{-9} volts.

Waveform Averagers are useful when, after processing, the actual waveform of the signal of interest must be maintained and the signals are repetitive waveforms or transients whose onset can be related to a trigger pulse. The application of a synchronized, repetitive waveform will result in an output that corresponds to the average value at each of the segments of the waveform being studied, whereas any non-repetitive (or un-synchronized) signals such as noise will be suppressed since their average after many occurrences will approach zero. PAR makes two instruments that perform this function; the Boxcar Integrator and the Waveform Eductor.[T.M.] The Boxcar Integrator is a single point averager in which a single slice, as narrow as 1 microsecond, of the input waveform is averaged while the position of the slice is slowly scanned through the waveform. The Waveform Eductor simultaneously averages one hundred points of the waveform which can be distributed over periods varying from 100 microseconds to 10 seconds.

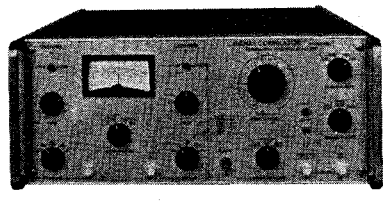
WAVEFORM AVERAGERS







CORRELATION FUNCTION COMPUTERS



Correlation Function Computers are the most general form of signal processing equipment that can be constructed (Lock-In Amplifiers and Waveform Averagers are actually special cases of correlation equipment). Whereas a reference or synchronization signal is required in the other equipment discussed, autocorrelation analysis allows periodic and random signals to be defined without this restriction. An even more powerful technique is crosscorrelation which has the ability to describe the degree of conformity between two different signals as a function of their mutual delay. The PAR Signal Correlator simultaneously computes in real time 100 points of either the auto- or crosscorrelation function over total delay spans of 100 microseconds to 10 seconds.

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P A R **PRINCETON APPLIED RESEARCH CORP.**

See inquiry card 10.

EDITORIAL

a shortsighted R&D policy

THE RESEARCH AND DEVELOPMENT OUTLOOK is discouraging. As indicated in the annual forecast in this issue, the nation's R&D expenditures probably will increase less than 4% to about $25-billion during the coming year.

In an effort to reduce the budget deficit, the federal government has adopted a hold-the-line policy which has curtailed existing R&D programs and delayed or killed many proposed projects.

Congress has insisted on drastic cuts in space, defense, nuclear, health, and other research and development programs. Although resisting a 10% across-the-board cutback, President Johnson has agreed to some reductions and to keeping R&D increases to a minimum.

Industry has adopted a wait-and-see attitude. As a result, only nominal increases are being made in industrial R&D expenditures until the impact of the government holding action can be determined.

Unless there is a dramatic change in the government and industrial positions, it is possible that R&D spending will rise to only $24.5-billion, or about a 2% increase over the estimated $24-billion for 1967. This hardly will cover the inflationary increases to maintain the same level as last year.

The editors of *Industrial Research* believe such an R&D approach is a shortsighted policy that could have unfortunate repercussions for the nation and industry.

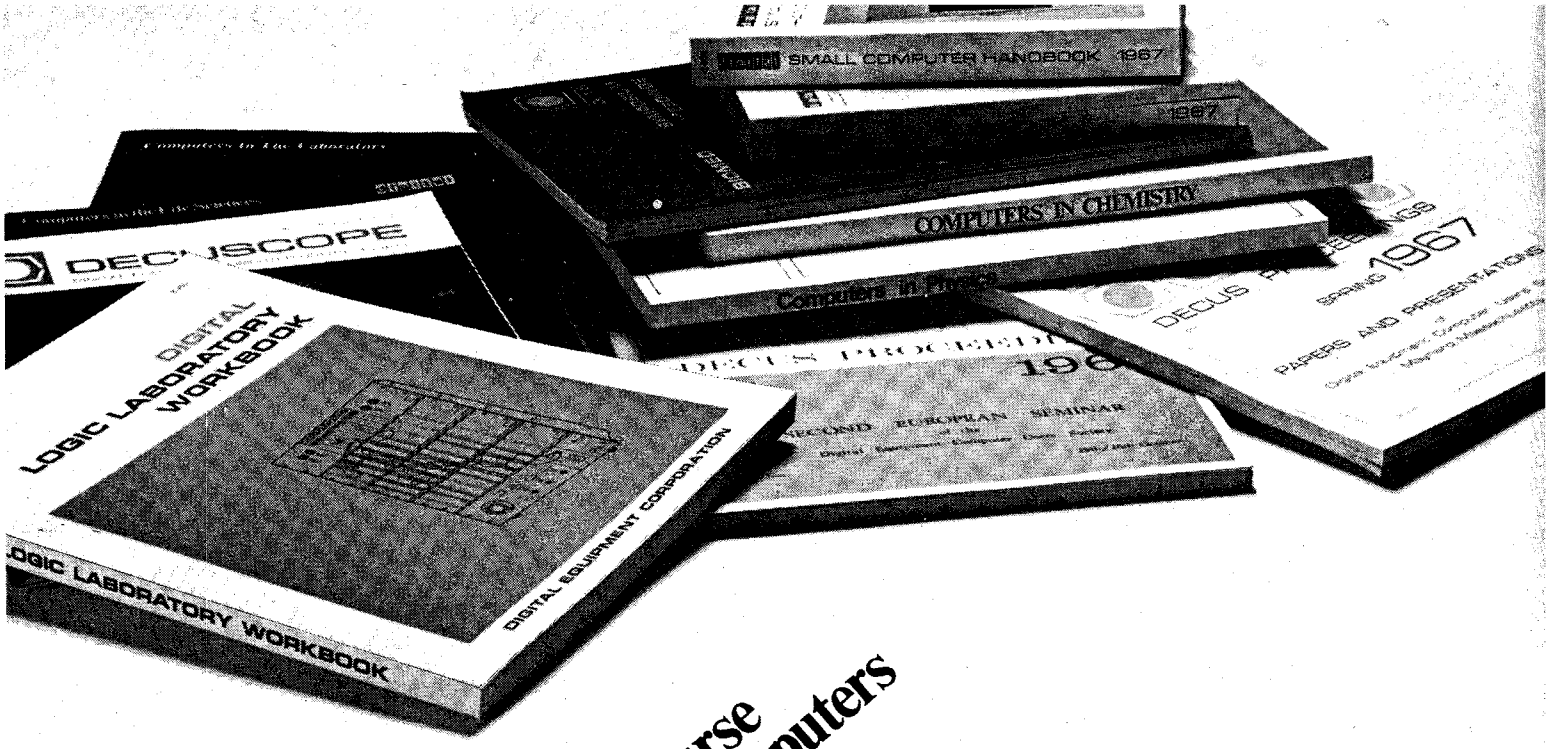
We realize, of course, that it is not possible to fund every worthwhile project. And we recognize the value of objective reevaluation and the pruning of less promising programs. However, we are opposed to indiscriminate budget surgery, the shelving of projects with great potential, and a government or industrial attitude that fails to grasp the significance of the R&D investment.

Instead of leveling off R&D expenditures, it is time to accelerate the discovery and application of scientific and technological knowledge. Both the nation and industry are faced with many needs that can be resolved only through more and better research and development.

It is primarily through increased federal R&D support, for example, that we will obtain cleaner air and water, better health, faster transportation, efficient nuclear power, economical desalination, improved weaponry, full exploitation of the sea's resources, and a greater understanding of matter and the universe.

At the same time, industry cannot hope to keep pace with the demands of the market and the offerings of competitors without continuing R&D programs aimed at new and improved products and services.

We believe that a nation as large, prosperous, and strong as the United States—and companies as profitable as those in this country—should be able to support a much higher level of research and development than is planned for 1968. The failure of the President, Congress, and industrial leaders to recognize the value of R&D could be disastrous. ■



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See inquiry card 12.

Pickering selected 'man of the year' in research

BETWEEN 10:34 AND 11 A.M. last Oct. 19, the *Mariner 5* spacecraft completed an almost perfect flyby mission to Venus. As the 245-kg craft passed within 4,000 km of the cloud-covered surface of our nearest planetary neighbor, it returned new data about the planet's temperature, atmospheric structure, and solar wind shock wave pattern.

Less than a month later, on Nov. 9, *Surveyor 6* touched down on the rugged lunar surface only 5 km from the target launching spot. *Surveyor 6* has relayed back pictures and chemical data. Eight days after landing, the craft, in response to Earth command, rose 3 m above the lunar surface under rocket power and moved 2.4 m laterally.

The flawless completion of these complicated missions was an amazing scientific feat in more ways than one. No one had planned to have such a *Mariner* flight until barely a year before it began, and few people thought it would be possible to effect the *Surveyor* leap at this stage of the space program.

Basically, *Mariner 5* was a stopgap, low-cost program. Its aim was to keep America's planetary program in motion after budget and other restrictions had delayed more ambitious spacecraft designs until sometime in the mid or late 1970s. *Mariner 5* was hurriedly started using the backup spacecraft from the earlier *Mariner* Mars flyby program.

The seeming ease with which the new mission was accomplished and the accuracy of its operation were an impressive tribute to the capability of the Jet Propulsion Laboratory of Pasadena, Cal., and its longtime director, Dr. William H. Pickering.

Because of the major contributions of this space probe and earlier *Mariner, Surveyor,* and *Ranger* flights to man's understanding of the universe, Pickering was selected the "I·R Man of the Year" by the editors and the distinguished 30-man Editorial Advisory Board of *Industrial Research.*

He will be presented $1,000 and a beautifully inscribed plaque by Industrial Research Inc., publisher of *Industrial Research* and other technical publications, at the third annual National Conference on Industrial Research in Chicago on Jan 22-23.

The conference, which will have "Research Decision-Making in New Product Development" as its theme, is being cosponsored by *Industrial Research* and IIT Research Institute.

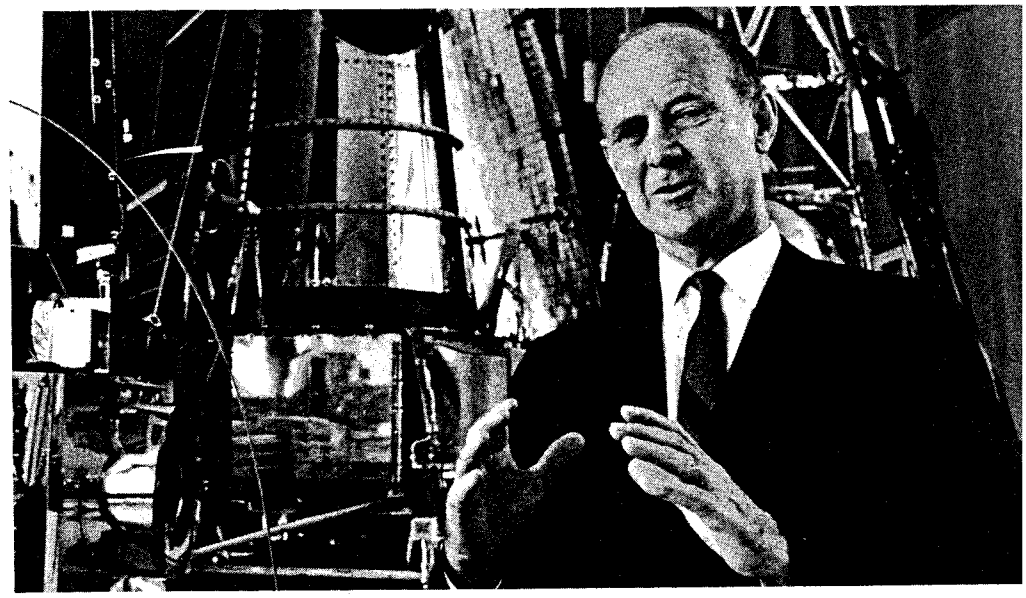
Under Pickering's guidance, JPL helped compile most of the nation's deep space "firsts." These included the first American artificial satellite, *Explorer 1* (1958); first successful cislunar space probe, *Pioneer 4* (1958); first successful flyby of Venus by *Mariner 2* (1962); and world's first successful flyby of Mars by *Mariner 4* (1965). Added to this list is the continuing series of missions onto the lunar surface by the JPL-administered *Surveyor* spacecraft program.

The Jet Propulsion Laboratory is operated by the California Institute of Technology under contract to NASA.

The well-modulated voice of the erudite Pickering betrays a trace of an English accent. This reflects his birthplace, Wellington, New Zealand, from which he emigrated as a young man to attend Caltech. There he gained a BS and MS in electrical engineering and a PhD in physics.

After receiving his doctorate, he remained to teach electrical engineering, eventually attaining the rank of professor in 1946. His interest in space phenomena was a strong one, however, that was stimulated by association with Caltech's renowned president, Dr. Robert A. Millikan.

In the years before World War II, Pickering joined the group under Nobel laureate Millikan conducting a worldwide program of high-altitude cosmic-ray research.



CITED FOR DIRECTION OF SPACE PROBES
Dr. William H. Pickering of Caltech's Jet Propulsion Laboratory

Pickering traveled to many parts of the U.S., as well as to India and Mexico, to help the launch of instrumented high-altitude balloons. These probes telemetered back some of the first data about the variation of cosmic ray intensity with changing altitude and latitude due to the Earth's magnetic field.

Pickering turned towards applied research during World War II. He conducted work in the field of microwaves at Caltech, Massachusetts Institute of Technology, and other laboratories. With growing Army interest in guided missilery, he was given the task of organizing the electronics effort for the first operational U.S. missile at JPL in 1944. This led to his appoint-

ment as project manager for the *Corporal* missile program at the laboratory in the late 1940s.

For several years, Pickering divided his time between teaching and supervising graduate work at Caltech and directing studies at JPL. Gradually, the laboratory took more and more of his time, culminating in his appointment as director in 1954.

Under his direction, the laboratory continued working on Army missile and space projects until 1958. At this time, the newly organized National Aeronautics & Space Administration appointed JPL as its major contractor responsible for unmanned lunar and planetary flight projects and the supporting technology.

The laboratory continued to grow in size—from 1,500 employes in 1954 to about 4,400 today—and prestige under Pickering's guidance. The fruits of his labors brought recognition in many forms, including NASA's Distinguished Civilian Service Award, British Interplanetary Society's Special Award, Columbus Gold Medal of Italy, Galabert Award of France, James Wyld Memorial of the American Rocket Society, and Robert H. Goddard Memorial Trophy of the National Space Club.

Besides directing the laboratory's R&D, Pickering found time to serve the nation and the scientific community in other ways as well. This included service on the Army Scientific Advisory Panel, charter membership on the Air Force Scientific Advisory Board, and election as first president of the American Institute of Aeronautics & Astronautics.

Pickering is an ardent supporter of research, basic and applied. "Without basic research, there would be no space program nor, for that matter, the major advances in technology of today," he states.

As he points out, the success of today's planetary programs is due to basic theories developed in many disciplines 10 or 20 years ago. "We might take deep-space communication as an example. The systems of *Mariners 4* and *5* are examples of developments based on the quantum physics principles involved in invention of the maser and the mathematical precepts that permitted development of optimum coding and modulation.

"Our people at JPL, of course, took the basic research results in these areas and built on them with their own applied research. The result has been an amazingly efficient system with performance close to the maximum theoretical possibility."

The results from all the NASA-JPL space projects have been impressive, but some stand out particularly in

TRACKING MARINER 5
JPL 'dish' looks past the Moon

Pickering's view of things. The knowledge gained from the 22 television pictures of Mars returned by *Mariner 4* in July 1965, he stresses, should not be overlooked.

"They showed that the Martian surface is cratered to look more like the surface of the Moon than of Earth. Although it had been recognized that probably all planets in their early history had been bombarded with meteoric particles, most people felt that a planet the size of Mars would have had enough tectonic (*i.e.*, mountain building processes) and erosive activity to erode the basic surface as has been the case on Earth.

"On Earth, it is difficult to find traces of craters. The fact that Mars still shows these indicates little dynamic evolution of the surface in the periods since cratering occurred. This implies very little tectonic activity, no free water in quantity, and an extremely thin atmosphere. Therefore, if life forms have developed on Mars, they must have developed within an environment similar to what exists there now.

"The evolution of our atmosphere to its present oxidizing state probably is related to the presence of life as we know it on Earth. An understanding of how life developed on Mars, if it has developed, could contribute highly important information about the rise of life forms on our planet."

The *Mariner 2* and *5* flights to Venus have indicated the planet is too hot to support life as we know it on the surface. This does not rule out life in the dense atmosphere, however. As Pickering points out, "Just as we find that life floats in Earth's oceans, we also could find floating forms in Venus' atmosphere."

The four successful *Surveyor* flights to the Moon have provided basic data for the future manned landing of the Apollo program. "Analysis of the lunar surface," Pickering stated, "shows it to be made of a powdered material that will support a reasonable load, at least in the *Surveyor* landing sites to date. Also important to our understanding of Earth's natural satellite is the *Surveyor* data on chemical composition showing it to be similar to basalt in at least one region."

Pickering is certain that continued expansion of space research will bring important new advances for mankind in the future. But he also believes some of the fallout from space research to date is of greater importance than many people realize.

Development of the concept of systems engineering, he believes, is of major significance. "This might prove to be one of the most useful things to come out of the program. It provides a major tool to solve problems in many other areas. We already can see this application starting in such things as transportation research and resource planning.

"The development of project teams covering a wide spectrum of technological disciplines is another part of this picture. In planetary missions, for example, we have biologists working with structural engineers, communications engineers with solar physicists, and so on. This has important connotations for the approach to research both today and tomorrow."

Industrial Research believes the selection of Pickering as I·R Man of the Year is particularly significant in the light of the completion of man's first decade of space exploration.

Reviewing the decade's accomplishment, Pickering said, "We, and I mean everyone at JPL and NASA, have contributed heavily to man's knowledge of the planets and have paved the way for future work of even greater importance. We look forward to playing a part in what we hope will be a continuing program of planetary research."

Last year, the I·R Man of the Year award went to Emmett N. Leith, associate professor of electrical engineering and head of the Radar & Optics Laboratory at the University of Michigan, for his pioneering efforts in laser holography.

The *Industrial Research* award program was started in 1966 to honor outstanding scientists, engineers, and technical administrators who have made significant recent contributions to the advancement of applied science and technology. — IRWIN STAMBLER, WESTERN EDITOR □

tax relief for small businesses

UNDER THE PRESENT TAX STRUCTURE, a large corporation engaged in R&D can pursue many ventures that never pay off. Such losses are written off against profits in other divisions of the company. In many cases, the government bears nearly 50% of the cost for these misadventures.

However, a small company cannot do this since it generally lacks a profitable segment of its operation. It must rely on carrying forward its losses against profits for the succeeding five years. Thus, the government doesn't contribute its 50% until the five years have passed.

And if the company doesn't become profitable until after five years, the first year tax writeoff is lost.

Sen. Gaylord Nelson (D-Wis.), a member of the Select Committee on Small Business, has introduced a bill to extend the period of loss carryforward to 10 years. He limits its application to companies:

- Engaged in producing products or services that can be sold, leased, or licensed.
- In which at least 25% of the employes perform "technological or skilled technical functions."
- With at least 25% of the gross income attributed to the company's product.
- Having less than 500 employes, or gross sales less than $1-million, or net worth less than $2.5-million, or total assets less than $5-million.
- That are independently owned.

Nelson limits his proposal to small businesses on the grounds that they require the incentive, and have the greatest potential.

"It is almost axiomatic," he says, "that small independent innovative companies exert the most leverage per dollar spent and hour consumed in the whole process of innovation." □

clinical lab standards

CLINICAL LABORATORIES engaged in interstate commerce will be required to meet standards set by the Dept. of Health, Education & Welfare in the future.

The action was a result of hearings that revealed significant shortcomings in the quality of the tests performed by some laboratories.

The department will set standards in quality control, records, equipment, facilities, qualifications of supervisory personnel, and will establish a proficiency-testing program.

However, laboratories certified by professional accreditation bodies with standards as good as those set by HEW will be exempt. This provision apparently is intended to keep the federal government free of licensing details.

The accreditation bodies plan to make their services available to all laboratories without requiring membership in the associations.

Three groups specifically identified as providing the necessary accreditation are the Joint Commission on Accreditation of Hospitals, the American Osteopathic Assn., and the College of American Pathologists. □

another metric plan

WHEN SWEDEN finally decided to drive on the right side of the road (to conform with the rest of Continental Europe), it was not with the intent of promoting a switchover to the metric system in the United States.

Yet, Sen. Frank E. Moss (D-Utah) drew a parallel between the choice that faced Sweden and that which confronts this country.

Bills pending before the Senate Commerce Committee (and consigned to oblivion in the House Rules Committee) call only for a study of the advantages and disadvantages of joining most other countries in the world in their adoption of metric measures.

The proposed study obviously has been prejudged by most proponents of the bills. Conversion is inevitable in their view.

Thus, opponents are fighting to insure that the study, if authorized, does not overlook those aspects that might put the switch in an unfavorable light.

REVISES METRIC PLAN
Sen. Robert P. Griffin at hearing

IR STAFF PHOTO

Their vehicle is a bill introduced by Sen. Robert P. Griffin (R-Mich.). It differs from the earlier Sen. Claiborne Pell (D-R.I.) version in three respects:

- It preserves, "more clearly," the option of recommending retention of the existing system.
- It requires specific recommendations for meeting the difficulties and costs of conversion in those areas of the economy where change is advocated.
- It calls for a comparison of metric and nonmetric standards and their use in fields subject to conversion.

This last requirement, according to the Industrial Fasteners Institute, is "the most important." This group sees conversion as "redesign and change in physical size, shape, and form," and it requires revision of technical standards.

The industry group points out that the locknut industry, for example, would have to scrap 20 years of technical standards development and start from scratch to prepare metric versions because "there is no comparable documentation in any metric country in the world."

But Pell and other backers of the earlier bill were not visibly swayed by such reasoning. Included in his arguments were the results of an *Industrial Research* "Opinion Poll" in which 93% of the 3,800 respondents supported the switch. □

election by computer?

CAN COMPUTER VOTE PROJECTIONS broadcast by the television and radio networks affect the outcome of the November Presidential election? In close elections, it is a possibility.

A switch of only 11,874 votes in five states would have reversed the outcome of the 1960 Presidential election.

Three of those states—Hawaii, New Mexico, and Nevada — are in time zones potentially susceptible to influence by computer projections based on Eastern returns, had such methods been in significant use at that time.

All of the networks will be using projections extensively during the November elections. But although Congress is pondering the effect of these projections, it is unlikely to take any specific action.

Last summer, the Senate Commerce Committee held hearings to consider the possibility of voter influence or fraud in connection with the projections. It also examined the accuracy of past results and considered four possible ways of minimizing problems:

- Several studies offered no evidence to indicate that voters could be influenced by early returns.
- Consideration of the elaborate

procedures used by the networks suggested that the possibility of fraud was remote.

■ Where projection errors did occur, they were in close races, particularly the three-way Georgia governor's contest, and could be attributed to human error.

■ Four potential solutions were to require a uniform time for release of results, a uniform poll-closing time, prohibit predictions prior to poll closings, or ask the broadcasters to voluntarily withhold predictions until after all polls had closed.

But this year's Presidential race may be a three-way battle. The studies that found no voter influence were made during the 1964 election.

The impact of the computer-aided projections is an open question. □

the patent debate

CRITICS of the Administration's patent reform bill have a new rallying point.

Sen. Everett M. Dirksen (R-Ill.) has introduced a substitute measure that preserves the present "first-to-invent" principle and the one-year grace period prior to filing.

The Dirksen proposal was drafted in cooperation with the American Bar Assn.'s Section on Patent, Trademark & Copyright Law.

The Administration bill, introduced earlier in 1967, is based on a Presidential study commission report that favors a package overhaul of the patent system.

The report recommended making the American system more compatible with international procedures by adopting a "first-to-file" policy and dropping the grace period.

In introducing his bill, Dirksen said, "It modernizes our patent laws without destroying the proven principles upon which the U.S. patent system is based solely for the sake of international standardization of inferior patent systems used in other countries."

Retention of the two controversial features permits an inventor to explore the potential interest in his idea before committing funds to obtain the patent. And the actual inventor would receive the patent, rather than the first individual to submit an application.

But those backing the commission approach see "first-to-file" as a clean-cut mechanism for handling priority disputes. They would substitute a preliminary application for the grace period mechanism, thus offering the same interest-measuring capability in the period between preliminary and final application.

Chances for passage of either measure this session are slim in view of the diversions which accompany a Presidential election year. □

I+R STAFF PHOTOS

DISCUSS KENNEDY REORGANIZATION PLAN
NSF Director Leland J. Haworth (left) and Sen. Edward M. Kennedy

support for stronger NSF role

SOMETIME during the second session of the 90th Congress, the long-discussed National Science Foundation reorganization may materialize.

Contemplated and debated for several years now, a bill which cleared the House last April is intended to convert a "passive" organization into one which might more actively guide the science effort in channels appropriate to the national interest.

But some of the details of the House bill are not viewed enthusiastically by the NSF and the President's Office of Science & Technology. Thus, a new bill was introduced into the Senate recently by Sen. Edward M. Kennedy (D-Mass.). In hearings held before a special science subcommittee of the Senate Labor & Public Welfare Committee, the differences were spelled out.

While the House measure seems intended to strengthen the role of the foundation's board, the Senate version favors the NSF director. In the first case, the board "shall establish and be responsible for the policies of the NSF and be denied a separate staff.

In the Senate view, the board will merely "establish policies to guide" the foundation and be denied a separate staff.

The House bill requires the director to obtain board approval for large expenditures, while the Senate would leave the approval request to the director's discretion.

In essence, the Senate version would recognize the director as an official of the Administration, rather than an official of the board.

It is unlikely that these differences will go unresolved in view of the many areas of agreement which call for substantial change in the NSF role.

Thus, in view of its importance and Kennedy's recent interest in NSF affairs (perhaps spurred by his Cambridge constituents), the bill could find its way to the Senate floor and eventually clear Congress. □

declassified research

IN A MOVE TO PACIFY academic critics, the Dept. of Defense has announced plans to declassify a portion of the research sponsored at universities.

In the future, all basic research sponsored by the DOD at universities will be unclassified, according to Dr. John S. Foster Jr., director of defense research and engineering.

The Pentagon currently has about 5,500 university research contracts, with only 420, or less than 10%, of a classified nature.

Of the total, 4,152 can be considered basic research projects. Only 138, or 3.3%, are classified. It is not known whether existing projects will be declassified under the new policy.

The DOD move came after faculty members at a number of universities objected to the performance of "secret" research on the campus. In some instances, these protests have been spearheaded by anti-war elements.

It is doubtful if the new policy will have much impact on the volume or nature of DOD-funded research.

Although fewer projects will have the "classified" label, the DOD is likely to make greater use of contracts with individual professors for the same investigations.

In those instances where the work must be conducted through the institutions, the DOD always can shift "basic research" into the classified "exploratory development" category. □

funding based on social value?

WILLIAM D. CAREY of the Bureau of the Budget speculated on research budgeting problems of the future at a recent Johns Hopkins Applied Physics Laboratory colloquium.

Conceding that the science community was unhappy with recent budget-cutting, the assistant director of the budget bureau suggested that "weeping off in a corner isn't going to melt any hearts."

It must be recognized that R&D is in competition with other programs, ranging from educational proposals to income-maintenance schemes, he asserted.

Carey said he was not aware of any post-Vietnam planning on the part of the research community. If this is the case, he said R&D people will end up reacting, rather than leading in the future.

As he sees it, a concept of "social value" could emerge as the criteria for federal support of civilian R&D.

Carey said he had been studying the problem for some time, and that he has developed a unique approach—called "Social Merit Matrix" — for comparing competing research programs.

Carey emphasized the matrix is not an evaluation approach employed by the Bureau of the Budget. He said it was being presented only as "a beginning to stimulate reaction and discussion as to whether it is possible and useful" to develop such an analytical tool.

To start, Carey suggests that social merit might be measured in terms of the contribution of research to three different types of values:

- ECONOMIC. Does it contribute to health and welfare, technical advance, conservation of resources, and/or return on investment?
- CULTURAL. Does it contribute to exploration, understanding man's environment, enrichment of education, and/or improvement of human relations?
- POLITICAL. Does it contribute to national prestige, international understanding, problem-solving in underdeveloped countries, and/or cold war advantage?

Carey then assumes that each of the three types of values is equally rated at 25 points and splits the total within each category according to his merit assessment. Next, a matrix is constructed to depict the relative worth of several research programs.

While Carey describes the matrix as a superficial examination of a complex problem, others will see it as a legitimate initial analytical attempt to grasp some slippery issues.

The real controversy would surround assigning relative social values to research projects. This is the old problem of establishing national goals. Such an obstacle also lies at the end of the technology assessment question now under study in Congress. Yet this political task appears to be the most promising area for progress if approached in an unemotional fashion.

But the task of foretelling the unknown results of research projects, particularly in basic research, is formidable.

There is evidence that Congress tends to object to the newer analytical tools, such as cost-benefit analysis, because it does not participate in setting the assumptions that determine the final choices. The question at issue in evaluating approaches such as Carey's may not be where it *should* be employed, but how it can be utilized.

Can an analytical approach be developed that would permit the policy-making, political inputs to be supplied from the Congress, rather than from the analysts?

Thus, in Carey's matrix, perhaps Congress could be polled to obtain an average set of weighting numbers. The weighting role could be split with the Administration.

The research community seems certain to encounter more concepts like the "Social Merit Matrix" in the future.—ALFRED J. COTE JR., WASHINGTON EDITOR. □

the Carey 'Social Merit Matrix'

		RESEARCH PROGRAM				
Value Category	Weight	Desalination	Population Control	Weather Modification	Oceanography	Lunar Exploration
ECONOMIC						
Health and welfare	3	x	x	x		
Technological gain, business expansion, full employment	10			x	x	x
Conservation of resources	10	x	x	x	x	
Return on investment (cost-benefit)	2	x		x	x	
CULTURAL						
Exploration	5				x	x
Understand environment	5			x	x	x
Enrich education	10					
Improve human relations	5		x			
POLITICAL						
National prestige	2	x				x
International understanding	5				x	
Problem-solving in underdeveloped countries	3	x	x	x		
Cold war advantage	15			x	x	x
Relative Program Values		20	21	48	52	37

I•R CHART

FDA lab search

IN 1948, the Food & Drug Administration decided that it needed more laboratory space. Seven years later, a construction request was submitted to the General Services Administration. Within a mere 12 months, appropriate Congressional committees gave the project their blessing.

But, by the time construction appropriations cleared Congress in 1961, this initial facility (HL-O) was deemed inadequate and work began on a headquarters laboratory (HL-1). The new facility was not located near HL-O in downtown Washington, but at nearby Beltsville, Md.

In 1965, the FDA set out to create a third laboratory (HL-2), deciding that Beltsville was an appropriate site. Unfortunately, the House Appropriations Committee was captivated by a decentralization philosophy and tossed out the planning funds. The Senate Appropriations Committee restored the money and then lost the conference fight.

One year later, the House reversed its position and okayed the Beltsville site. But the Senate group also had changed its mind, vetoed the funds, and this time it won the conference fight.

This year, the Food & Drug Administration showed up at appropriations hearings with an alternate site to Beltsville. It offered Madison, Wis., and this time the planning funds cleared Congress.

Beltsville was not rejected by name. A rider was inserted prohibiting considering any site within 80 kilometers of Washington.

However, the FDA is not yet clear of the woods, for now the House Intergovernmental Relations Subcommittee has published a 15-page report on

"FDA Procedures for Selection of Laboratory Sites." It concludes that:

- Laboratory HL-O really should have been considered for location outside Washington.
- FDA failed to advise Congress of the shortcomings of a Midwest location and exhibited a "completely inconsistent" attitude.
- Selection methods were "of poor quality and doubtful validity" since it was noted that an original estimate of $5.4-million extra cost for a Madison choice dropped to $1-million when the options were restudied.
- Site selection regulations were ignored.
- There was "an almost total absence of documentary support for the selection made."

Two questions emerge from the miasma surrounding FDA's laboratory development efforts: Was decentralization of federal installations or uniform distribution of R&D spending the motivation behind the Madison selection? If an agency can wait that long for facilities, does it really need them in the first place? □

UFO report delayed

ANXIOUS SCIENTISTS and laymen awaiting solution of the flying saucer riddle will have to wait a little longer.

Results of the prestigious scientific inquiry have been moved back another six months, according to the project's scientific director, Dr. Edward U. Condon, professor of physics and astrophysics at the University of Colorado and former director of the National Bureau of Standards.

In late 1966, the Air Force Office of Scientific Research named the university and Condon to study the phenomenon of unidentified flying objects (UFOs) under a $300,000 contract.

The investigation was expected to be completed by the end of 1967. Now, Condon told *Industrial Research*, the report will be submitted for review near the end of September to a special committee of the National Academy of Sciences.

"We have a free hand to do most anything we want. The contract just calls for a scientific study. In fact, I think the Air Force hoped we would come up with some new ideas," he said.

New ideas or no, Condon asserted that the "messy, complicated" task is a difficult one because of "wild-eyed interest" and too much energy is being dissipated in running down a large number of false leads.

But some critics are not so lenient with Air Force motives for establishing the research panel.

Dr. James E. MacDonald, senior physicist at the Institute of Atmospheric Physics, University of Arizona, has hinted that Condon's panel was convened merely to improve the Air Force's public relations. In addition, he fears the panel may be inadvertently glossing over the whole problem by spending too much time with "crackpots."

MacDonald also is convinced that at least some UFOs are extraterrestial in origin—an admitted guess based on 10 years of personal research.

The original champion of the scientific UFO investigation, Dr. J. Allen Hynek, seems less inclined to criticize what is undoubtedly attributable to his efforts. Hynek is director of Northwestern University's Dearborn Observatory and long-time sole scientific consultant to Project *Bluebook*, the small Air Force team assigned to look into flying saucer reports.

Regardless of the outcome or of whatever "surprises" Condon's committee releases this fall, it now is obvious that UFOs and their possible origins are admissable as topics for polite conversation among more conservative scientists. □

the McNamara R&D legacy

THE DEPT. OF DEFENSE research and development program has undergone drastic changes in the last seven years.

The defense budget—once divided almost arbitrarily among the three services—now is allocated on the basis of mission.

In the R&D area, this change has resulted in greater coordination and less duplication of efforts among the Army, Navy, and Air Force.

At the same time, the control of defense R&D funds has shifted largely from military to civilian hands.

The budget and control changes have been accompanied by the introduction of new management concepts in the procurement, performance, and evaluation of research and development.

Among the innovations have been the systems analysis technique, the incentive contract, and the PPBS system (Planning, Programing, and Budgeting System).

Utilizing these and other analytical and control tools, the DOD developed a flexible response defense system based on an arsenal of nuclear missiles and a mobile striking force.

In the process, the R&D emphasis was on long-range missiles, standardized aircraft, and new ordnance. Many projects also were killed or shelved, including the B-70 manned strategic bomber, the *Skybolt* and MMRBM missiles, the nuclear aircraft engine, the *Dyna-Soar* spacecraft, and a nuclear Navy buildup.

During the seven-year period, the defense R&D budget climbed only from about $6-billion to slightly more than $7-billion, while total defense spending mushroomed from around $43-billion to almost $75-billion (largely because of the Vietnam war).

However, the increased effectiveness of DOD planning and cost-control efforts produced much greater returns for the R&D investment.

The man most responsible for these changes during the last seven years—Defense Secretary Robert S. McNamara—has announced his plans to leave the Pentagon to assume the presidency of the World Bank.

END OF AN ERA?
McNamara leaves many innovations

However, it is unlikely that there will be revolutionary changes in defense policies or practices as a result of his departure.

McNamara leaves the DOD machinery securely in the hands of civilian and military subordinates thoroughly grounded in his operational philosophy.

The defense R&D budget will remain at about the same level, the tough management techniques will continue to be utilized, and most research and development projects will follow the pattern of recent years.

But there will be increasing pressure from the military and industry to reactivate the strategic bomber program, to expand the *Nike-X* antiballistic missile system, to provide a Navy substitute for the pivot-winged F-111, and to convert the Navy to nuclear power.

The success of these efforts will depend upon who is named to replace McNamara. □

pollution creates new industry

NEW YORK—The nation seems on the verge of creating a pollution industry —one bent on cleaning up our air and water, that is.

Apparently, though, the economics of such an industry have not yet reached the point where a profit can be turned.

Two unheralded plans, one in New York and another in Texas, may prove to be a turning point in this economic race with the rising stink of cities and rivers.

New York City is experiencing a garbage crisis. The city's incinerators cannot handle the waste generated by its inhabitants. The situation has reached a point where there is serious talk about having New York declared a disaster area.

Such an unenviable status would make the city eligible for federal and state funds to help purge itself.

While the city buys more sanitation trucks (800 have been ordered) to haul garbage to nonexistent incinerators, some farsighted city officials have announced plans to build a $110-million plant to incinerate both sewage and solid refuse. As a side benefit, the plant would produce waste heat, which could be sold to a utility company.

Meanwhile, three firms in Texas are making plans for a similar plant to incinerate all types of industrial waste. Again, waste heat would be sold to make the plant economically feasible.

Consolidated Oxidation Process Enterprises Inc., Houston; Foster Wheeler Corp., Livingston, N.J.; and Nichols Engineering & Research Corp., New York, are planning a $5-million plant to be located at a Houston Ship Channel site. The plant would incinerate waste from neighboring industrial sites.

The idea to incinerate waste products and sell the heat generated is not new. What is new is that plans have been made for a major city and industrial area to put the idea to work. Should the plants be built and should they actually turn a profit, the nation's much needed pollution industry might begin to blossom. □

Northwest giants

PULLMAN, WASH.—The lion's share of industrial R&D in the Northwest is concentrated at two organizations—the Boeing Co. and Battelle Memorial Institute's Northwest Laboratories.

This fact stood out in the just-released 1964-65 report by Washington State University on regional industrial research spending.

The report showed that Boeing and Battelle employed 6,289 of the estimated 8,772 R&D personnel working in industrial and contract laboratories in Washington, Oregon, Montana, and Idaho in 1965. Dollar volumes were not given for individual organizations in the region.

From the data collected, it was estimated that only 12% of all firms in the region spent funds on R&D. Total spending was estimated at $227-million in 1964 and $245-million in 1965. Spending on in-house research accounted for 96% of the total, leaving only 4% in the form of contract research.

Distribution of 1965 industrial research funding by states was estimated to be: Washington, $212-million; Oregon, $24-million; Idaho, $5-million; and Montana, $500,000.

The instrument field, according to the report, had the highest proportion of research-performing firms.

Largest dollar volume of R&D spending was in the transportation field. It came to $182-million in 1964 and $192-million in 1965.

Heaviest concentration of funding among surveyed firms was in developmental research, increasing from 64% in 1964 to 68% in 1965. At the same time, basic research spending went down from about 7.6% to 6.4%, while applied research declined from 28.2% to 25.4%. □

academic passport

CHICAGO — In many areas — particularly sports—individual Big Ten universities are intense rivals.

On the more academic and administrative levels though, cooperation is the rule rather than the exception. One piece of evidence is the Committee on Institutional Cooperation (CIC), which conducts joint programs for member universities — Chicago, Illinois, Indiana, Iowa, Michigan, Michigan State, Minnesota, Northwestern, Ohio State, Purdue, and Wisconsin.

And what appears to be most successful venture under the CIC's jurisdiction is the unique "Traveling Scholar Program."

Starting in 1963, the program saw 41 doctoral candidates enrolled in about 20 different disciplines. By the end of 1967, more than 450 graduate students had crossed state and institutional lines with the CIC's "academic passport" to perform short-term work in highly specialized areas at neighboring campuses.

The passport cuts through the usual red tape so that the student may use special resources unavailable at his home institution, such as a specialized course offering, a unique library collection, an outstanding laboratory, or a professor who is a world authority in his field.

Dr. Stanley F. Salwak, CIC's director, told *Industrial Research* that "there really is no barrier to the number of doctoral candidates who might use the program or to the number of disciplines studied."

Theoretically, he said, a student may use the program for any subject offered in the 11 universities. The only restrictions are on time spent (usually one semester), whether the facility or course is not attainable on his home campus, and if the student is academically qualified.

Salwak also revealed that several other university groups, both in this country and abroad, are quite interested in the traveling scholar program. Among these, he said, are the University of California campuses and the Ivy League schools. □

seek science funds

CAMBRIDGE, MASS.—Teaching science and engineering is becoming a financial problem even for the regional giants in the academic community. Just how expensive is indicated by the dollar volume allotted to science and technology in many university funding drives announced this winter.

Joining the bandwagon of multimillion-dollar campaigns are California Institute of Technology, Pasadena; Harvard University and Massachusetts Institute of Technology, Cambridge, Mass.; and Yale University, New Haven, Conn.

Riding on the heels of the university announcements is Research Triangle Institute, Research Triangle Park, N.C., which revealed a plan that would double its operations within five years.

On the West Coast, Caltech kicked off a five-year, $85.4-million campaign—with most of the money to go for buildings and operating costs.

Harvard University, located at the hub of educational and scientific activities on the East Coast, is seeking nearly $50-million for "A Program for Science" at Harvard College—aimed at putting new zest into undergraduate science instruction.

Dr. Franklin L. Ford, dean of arts and sciences, explains in a report, titled "A Program for Science in Harvard College," that the construction of adequate science facilities at the university has lagged—both in comparison with earlier periods in the institution's history and in relation to nonscience fields.

Over $6-million already has been pledged to the program, which will include the construction of a $14.5-million science center and an allocation of $12.6-million for a research and teaching center in biochemistry and molecular biology.

Five endowed professorships at a total cost of $3-million will be created. Total cost of the new construction program will amount to $45,690,000.

Another educational giant in the Boston area, Massachusetts Institute of Technology, announced that a minimum of $135-million in additional private funds will be needed for capital improvements within the decade.

Among MIT's immediate plans is a $14-million electrical engineering and communications research complex. Other funding needs include $14-million for endowed professorships and faculty salaries, $6.5-million for student housing, and $2-million for student scholarships and loans.

Establishing itself as a major contender in the scientific arena, Yale University revealed its capital needs will total $388-million in 10 years.

President Kingman Brewster Jr. explains Yale, with a current endowment of $500-million, will need $241-million of the $388-million for improved faculty salaries and positions to meet competition. Another $146.5-million will finance the construction of new buildings.

Of this total, $57.4-million will be needed for expanding science facilities. Over $6.5-million will go towards a $16.5-million engineering and applied science complex now on the drawing board. Another $50.9-million will be for medical science facilities.

To achieve the projected growth of staff and revenue, George R. Herbert, president of Research Triangle Institute, forecasts a $3-million investment in new physical facilities and equipment and $1-million for working capital and program development.

The five-year expansion plan at RTI includes a professional and support staff totaling 600. Cumulative research income at RTI now tops $20-million.

The nonprofit institute was formed as a separate research corporation in 1958 by Duke University, Durham; the University of North Carolina, Chapel Hill; and North Carolina State University, Raleigh.

Heading the list of new facility requirements at RTI are two laboratory and office buildings on the institute's campus. Construction of the first building is expected to begin within the next 18 months. It will be earmarked for RTI's Chemistry & Life Sciences Laboratory, major units now located in Durham, eight miles from the research park. □

INTERNATIONAL REPORT

devaluation brings R&D cutback

LONDON—A dark cloud looms over the scientific community as Great Britain adjusts to the devaluation of the pound sterling—now pegged at $2.40 instead of $2.80.

The devaluation, ordered by the Labor Government, has resulted in a cutback of British funds for scientific research and defense programs.

A number of major research projects in Britain already have been postponed because of a lack of funds. They included the building of a national magnet laboratory, a nuclear reactor for materials research, and equipment for particle research at Rutherford and Daresbury laboratories.

The delays were revealed by Sir Harry Melville, chairman of the Science Research Council, while reporting on the council's annual expenditures.

One of Britain's first moves following the pound devaluation was the cancellation of a $28-million order for Chinook helicopters from the Boeing Co. Although the cancellation will save Britain a few dollars, it will remove a sizable order from Boeing's Vertol Div., Morton, Pa.

Another project to bite the dust is the controversial $56-million air base with the United States on Aldabra atoll in the Indian Ocean. This move is likely to cancel the order for all 50 of the F-111 fighter aircraft from General Dynamics Corp.

An unknown factor is the eventual effect of devaluation on the Anglo-French Concorde supersonic transport. Joint research and development costs still are based on the old rate at $2-billion.

Defense research and development, currently at a level of $700-million, probably will feel the brunt of the cutbacks. Refurbishing of at least two British aircraft carriers will be delayed, and the project to build a new Type 82 missile destroyer is up for review. This move, in turn, will affect the development and production of such naval missiles as the *Sea Dart*.

Although the largest item in defense equipment is for U.S. hardware, including 50 General Dynamic F-111K fighters, 80 Lockheed C-130 Hercules transports, and 170 McDonnell Phanton F-4Ks and Ms, there is little worry that the devaluation will have much effect. These contracts have been finalized.

There may be, however, some slowdown in deliveries of the hardware in an attempt to improve the balance-of-payments. □

Italian research park

NAPLES — Another American innovation is gaining in popularity in Europe. Naples is the latest Continental city to announce plans for an American-type research park.

Most likely site for the multimillion-dollar development is the government-owned site formerly occupied by the defunct "Overseas Fair," a money-losing propaganda creation of the Mussolini regime declared "superfluous" by the Italian government last year.

Backing the Naples research park project are Italy's Minister for Scientific Research, Leopoldo Rubinacci, Italy's National Research Council, the Naples city government, and Naples' two universities.

Initial occupants would be the Cianello Physics Institute, two affiliated cybernetics study centers, and the Buzzati-Traverso Biophysics & Genetics Laboratory — all presently located on or near the fair grounds.

Outside groups reportedly interested in the projected research park are the University of California at Berkeley and an American electronics company.

Italian government and industry officials consider California's Stanford Research Park a prime example of what they would like to see in Italy. The Italians also would like to emulate the European "research center-industrial parks" developed at Grenoble and Toulouse in France. □

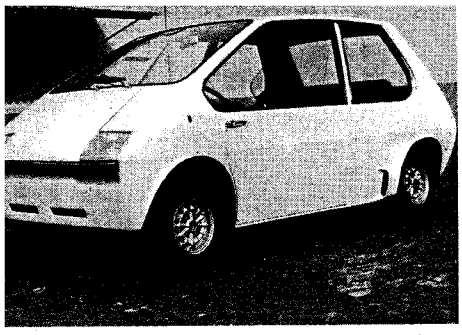
nuclear consortium

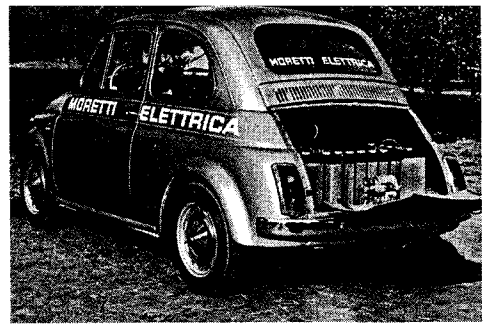
LONDON — A single British nuclear power group is suggested as a remedy for Britain's failure to hold its own against United States competition in the world market for nuclear equipment.

The proposal is for a consortium consisting of the United Kingdom Atomic Energy Authority, the big electrical equipment companies, and possibly a uranium producer.

The new organization would carry out the Atomic Energy Authority's function of developing new reactors and supplying nuclear fuel, and the job of designing and engineering nuclear power stations, which are now in the hands of three manufacturers' consortia.

The British argue that such an organization could compete on equal terms with General Electric Co. and Westinghouse Electric Corp. for the world nuclear market. □





ENTER EXPANDING ELECTRIC CAR RACE
Ghia "Rowan" (left) and "Moretti Elettrica" at Italian auto show

more electrics for Europe

TURIN, ITALY—Perhaps after the prototype electric cars unveiled over the past year in Detroit, London, and Tokyo, it was only natural that this year's Turin Auto Show also would reflect the resurgence of interest in the electric car.

There were four models on exhibit —the "Moretti Elettrica," presented by Moretti S.a.s. of Turin; the "Fiat Giannini 500 Elettrica," offered by Giannini Automobili S.p.A. of Rome; an updated version of the "Urbanina," presented by Urbanina S.p.A. of Poggio Adorno near Pisa; and the Ghia "Rowan," the sleek Italo-American prototype which was the highlight.

The major difference between the first two and the latter two was that the Moretti and the Giannini electric cars were merely standard Fiat 500s with lead acid battery-powered electric motors, while the Urbanina, which debuted at Turin two years ago, and the Rowan were examples of vehicles designed as electric cars.

The Rowan is the result of an international team venture embracing the Rowan Controller Co. of Westminster, Md., and its two recently acquired European subsidiaries, Ghia S.p.A. of Turin and De Tomaso Automobili of Modena.

The vehicle, which is roughly 3 m long, weighs 596 kg, and has a range of about 320 km at a speed of 41 to 43.5 mph. Powered by two 9 hp electric motors placed under the rear seats and connected to the control box, the Rowan has no differential, transmission system, or clutch assembly.

In the Rowan-developed Metrodyne drive system, which functions in much the same manner as a conventional automatic transmission system, the driver uses the accelerator to control acceleration, the brake to control deceleration, and a gear shift lever to change from low-speed/high-torque to high-speed/low-torque operation.

Stated in a somewhat oversimplified fashion, the secret of the Rowan is its Metrodyne electric drive system which converts the kinetic energy produced by the car's natural momentum into chemically stored battery energy via the car's braking system. That is, when the driver depresses the brake pedal, he automatically starts using the car's momentum-produced kinetic energy to recharge the batteries.

The car's electric current flows from the batteries to the control box and from the box to the two compound electric motors. Power generated by the two electric motors is conveyed to the wheels through gears connected by a cog-belt in fiberglass.

Rowan Controller has no immediate plans to produce the car in quantity, but is dickering with several anto manufacturers to evaluate the possibility of commercial production. □

new Soviet laser

Moscow—Nobel laureate Alexander M. Prokhorov said Soviet scientists have developed a powerful continuous-action laser whose coefficient of efficiency of 30% is higher than existing lasers operating at room temperature.

Using a mixture of carbon dioxide, nitrogen, and helium, the laser produces infrared radiation and can be used to generate a power of about 5 kW.

Prokhorov—who shared the 1964 physics prize for his laser discoveries —says the Soviets also have developed lasers that can emit powerful impulses with a high repetition frequency.

Encouraging experimental data have been obtained on changing the frequency of lasers in which dyestuffs are used as active media. By selecting the type of dyestuff and its concentration, it is easily possible to change the wavelength of radiation over a wide range.

By varying pressure on a lead selenide-based semiconductor laser, the frequency can be changed.

Prokhorov says Soviet industry is manufacturing various types of lasers for both research and the solution of practical problems. □

plot to steal reactor secrets?

LONDON—Anthony Wedgwood Benn, Britain's Minister of Technology, has written an open letter to Britain's atomic scientists at Dounreay in Caithness (Scotland) and at Risley (Lancashire) about an American "plot" to obtain secret information about the latest fast-breeder reactor at Dounreay.

He said Westinghouse Electric Corp. has been trying to persuade senior scientists working on the Dounreay fast-breeder reactor—the world's most advanced commercial prototype power reactor—to move to the United States.

It is understood that 24 atomic scientists working at Dounreay, where salaries range from $2,800 to $11,000 a year, have replied to an advertisement by Westinghouse offering jobs near Pittsburgh.

A Westinghouse spokesman told *Industrial Research* that active negotiations are in progress with several Dounreay scientists.

It is alleged that Westinghouse is offering salaries of between $6,800 and $15,000 for scientists, with the scale rising from $31,000 to $76,000 for the best senior staff. These latter figures were flatly denied by Westinghouse and labeled as fabrications of the London press.

The ad, which appeared in a Sunday newspaper on Oct. 29, asked for research workers with experience in liquid metal-cooled fast-breeder reactors. The only British scientists with this experience are those working on the Dounreay project.

The scientists are said to have been offered jobs without the "usual interviews," although this was called untrue by Westinghouse officials in the United States.

In his letter, Benn charged that Westinghouse tried to obtain the scientific know-how in negotiations with the United Kingdom Atomic Energy Authority, but objected to the price placed on such an exchange by the agency.

In his letter, the minister stated:

"Now, Westinghouse [officials] apparently think they can get it on the cheap by offering some of you salaries which, according to press reports, are pitched at a level that goes beyond the usual differential in income between the United States and Britain.

"This is an attempt to purchase through a few key people the knowledge and experience that the whole team has gained." More than 700 scientists and engineers are working on Britain's fast reactor projects.

"This is not just another brain drain story," Benn said. "This is not just another example of Britain having

failed to provide adequate research facilities for highly qualified men. Quite the reverse. No Westinghouse fast reactor establishment has got the facilities, scope, or resources that Britain has made available to you through the Atomic Energy Authority.

"Nor is this just another story of Britain's past failure to follow through its own pure research. The fast reactor is not just another British invention rotting in the pigeon holes of the laboratories that developed it. It is already on the verge of commercial exploitation."

The letter concludes: "The widest possible national interest is involved in this issue. I would hope that Westinghouse will get the rejection that they invite by seeking to buy the best people from a better team. If Westinghouse wants good fast reactor technology, let it develop its own, or buy a license from us on a proper commercial exploitation.

"We depend on you and so does Europe. For all these reasons, I hope you will say 'no' to Westinghouse and say it firmly and quickly."

Benn's tirade is easy to understand with Britain's best scientists slipping through her fingers like quicksilver. But American advertisements in British papers and higher salary offers are customary, and it is doubtful if such conspiracies to steal "secret" technologies exist.

A spokesman for Westinghouse is reported to have said: "The company advertises in British newspapers in a straightforward manner, identifying ourselves. We do not make personal solicitations to individuals. Salaries offered were commensurate with the going rate in America for men with these qualifications." □

U.S. leads in research support

PARIS — The United States spends three times as much on R&D as Western European countries and six times more than the Common Market nations.

The difference in the numbers of scientists, engineers, and technicians employed in R&D, however, is less marked—1.5 to 1 between the United States and Western Europe and 2.6 to 1 between the United States and the Common Market.

These findings are revealed in an Organization for Economic Cooperation & Development study of the overall level and structure of R&D efforts in OECD member countries from 1962 to 1965. The study is the first major international investigation to cover the growth of R&D in the 16 OECD member countries.

Comparing R&D efforts as a percentage of the gross national product, the survey reveals that the United States spends 3.4%, the United Kingdom 2.3%, and the Netherlands 2%. France, Germany, Japan, and Sweden spend about 1.5%; Canada, Belgium, and Norway, about 1%, and Italy 0.6%.

The United States employs a full-time equivalent of nearly 700,000 scientists, engineers, and technicians. The next highest employer among the large industrial countries is Japan with 187,000 R&D workers. The United Kingdom employs about 160,000, while Germany and France account for about 100,000 each. The figures fall steeply for other OECD countries.

The government provides from one-half to two-thirds of R&D funds in France, the United States, United Kingdom, Canada, and Norway. Between one-third and one-half of R&D funding is provided by the governments of Germany, Sweden, Austria, and the Netherlands, and one-third or less of the total in Italy, Japan, and Belgium. □

Czech plan in doubt

PRAGUE — Czechoslovakia's plans for an ambitious nuclear research program appear to be in jeopardy.

The communist-bloc nation had announced its intention to spend 20% of its R&D between now and 1980 on nuclear research and the development of nuclear power and uranium.

However, an article by a member of the presidium of the Czechoslovak Academy of Sciences, J. Backovsky, in *Rudé Pravo,* official paper of the Communist Party, suggests that it will be necessary to revise the economic analysis of the nuclear power work.

The original analysis was made, says Backovsky, on the assumption of a closed economy, when rentability and need to compete internationally were not major factors.

It also will be necessary to consider, he asserts, indirect investments for raw materials, the disposal of radioactive waste, the possible exhausting of uranium mines, and changes in the international supply of fuel and power.

In view of these additional costs, Backovsky feels that a small nation like Czechoslovakia cannot afford a national laboratory for high-energy physics, as proposed by some officials.

Czech physicists trained for this work should be diverted to other tasks, he says. Solid-state physics is a discipline which can be expanded further in Czechoslovakia at lower cost and greater benefit, he believes.

The average cost of one scientist in the Institute of Solid-State Physics of the Czechoslovak Academy of Sciences is from 1/6 to 1/10 of the cost at the Joint Institute of Nuclear Research in Dubna, Soviet Union, according to Backovsky. □

European 'comsat'

PARIS—What exists between Europe and the United States is not a "technological gap" but a "project gap."

This is the view presented by the European Aerospace Industry Assn. (Eurospace) in a 70-page report urging the creation of a European Space Authority (Eurosat) for satellite communications.

Eurospace, long a proponent of a "Comsat" system for Europe, views European capabilities in tracking telemetry, command networks, and ground stations as competitive with the United States in the world market.

The report says European industry has the technical competence to build and launch a family of communications satellites by 1971 with an initial capital investment of $100-million.

The most apparent reason behind Eurospace's cry for a European "Comsat" system is its mounting dissatisfaction with Intelsat management—particularly contracts. Intelsat, an international satellite consortium, is operated by the Communications Satellite Corp. from Washington, D.C.

The report notes that Europe subscribes to 28% of Intelsat's service, but gets back "less than 4%" of all money spent for studies and contracts.

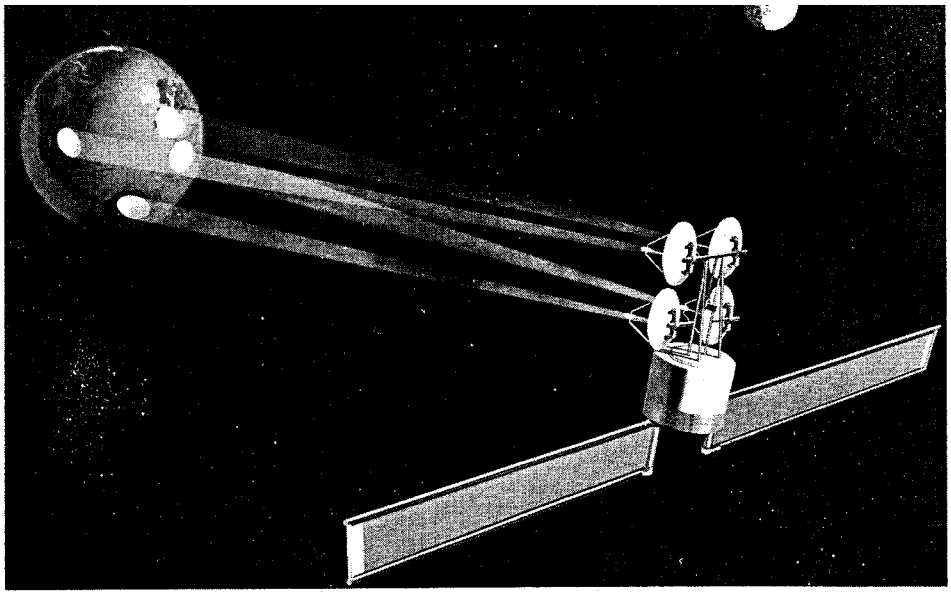
Gen. James McCormack, Comsat board chairman, however, indicates the next generation of Intelsat 3 satellites —of which six are planned at a cost of $32-million—will have about 40% of the work performed outside the United States. □

telescope threatened

LONDON—Europe's most advanced space research program—to build a satellite telescope laboratory—may be postponed because of high costs.

A report prepared for the European Space Research Organization (ESRO), the coordinating scientific agency, by an American consultant from NASA put the expected cost of the project at $112-million. The figure allowed for the production of equipment and operating costs for several years.

The decision to stop the project would come as a blow to the United Kingdom. Atomic Energy Authority's Culham Laboratory recently awarded an $8.4-million study contract for the telescope program after waiting for six years for Science Research Council action. □



NEW SATELLITE STABILIZATION CONCEPT
Hughes Aircraft's "Gyrostat" approach could bring changes

AEROSPACE

unwhirling the birds in space

SPIN-STABILIZED SATELLITES have been described as "large hat boxes," "weird insects," and the like.

Outside observers may have wondered why some of these strange shapes were necessary, but, like the crowds in "The Emperor's New Clothes," no one wanted to be caught asking foolish questions.

Now a relative youngster in the aerospace field not only posed the question, but also has provided an answer that may revolutionize future spacecraft design.

The new approach, called the "Gyrostat," was developed by Anthony J. Iorillo, spacecraft dynamicist, Hughes Aircraft Co., Culver City, Cal.

The historic reason for rotating satellite shapes, he points out, is the "major axis theorem." This theorem states that any non-rigid rotating body will end up spinning about the axis of the greatest moment of inertia. Thus, a spin-stabilized spacecraft had to be made short, squat, and spun around the major axis to prevent tumbling.

Iorillo felt there should be a way to spin the craft around its minor axis. After a two-year program, he and co-workers at Hughes developed a method of energy compensation that solved the problem: only part of the craft rotates while the rest is despun.

The new approach makes use of an eddy-current nutation damper. That is, simply, a magnet swinging like a pendulum in an induced magnetic field. The damper provides artificial energy dissipation on the despun platform to match that resulting from such things as fuel slosh and whip antenna motion in the rotating part of the craft.

Advantages of the Gyrostat method are many, Iorillo states. By freeing designers from the major axis restriction, it permits them to design larger, more powerful satellites. Because only a portion of the craft has to spin, other payloads, such as lasers and telescopes, can remain stationary or be moved easily in any direction.

One application that the new approach makes possible is genuine point-to-point satellite communications, using several antennas aimed at different areas on Earth. □

faster solid fuels

THE ACRONYM "HYCAT" (Hyer's catalyst) may be of importance to future solid rocketry. It stands for a new ingredient developed by United Technology Center, of Sunnyvale, Cal., that may permit much higher acceleration rates for solid fueled systems.

High acceleration rates have long been a prime goal for solid propellant fuels. One way of doing this, experts have long known, is to provide a catalytic additive. The problem has been to find one that did not also pose problems of stability and safety.

To be used safely, catalysts must:

- Be compatible with all other ingredients without affecting curing properties.
- Not crystallize at temperatures from −54 to +93C. When a catalyst does, it makes the propellant brittle, with degrading effects on grain structure and flame propagation.
- Have a low vaporization point.

A problem with most additives is that they partly vaporize, causing droplets to form on the lid of the propellant mixing chamber. When the oxidizer, which is in the form of a dust or powder, is mixed in, some can combine with the droplets, resulting in a dangerously explosive material.

UTC reports its Hycat material, an organo-iron compound, meets all these specifications. The material has successfully undergone many test firings with excellent predictability of properties and performance.

No propellant using Hycat presently is in production, but UTC has submitted a number of proposals to the government for future systems. □

BIOCHEMISTRY

living virius created

IN 1959, Dr. Arthur Kornberg, head of the Biochemistry Dept. at Stanford University, was awarded a Nobel Prize for his work synthesizing DNA (deoxyribonucleic acid)—a basic building block of life. But the DNA was inactive. (See page 64 for Kornberg's article on biochemistry.)

Now Kornberg and Dr. Mehran Goulain of the University of Chicago have announced they successfully manufactured a primitive form of active life in a test tube.

The material synthesized by the biochemistry team is the DNA of a simple pigmy virus that infects and destroys bacteria inhabiting the human intestinal tract.

Was the material "living" and has man in reality created life? Kornberg hedged the point, noting that viruses appear borderline cases in the molecular world of living and dead substances.

But when the artificially produced pigmy virus was mixed with bacteria, it penetrated the bacteria and reproduced itself in the same manner as the "natural" virus. Reproduction and growth are two of the basic requirements of life.

The revolutionary discovery, Kornberg explains, could lead to the creation of artificial viruses to halt the uncontrolled growth in cancer cells.

It would seem from the information available that a rudimentary form of life indeed has been created from nonliving matter. □

COMPUTERS

end in itself?

TWO ENGINEERS at Bell Telephone Laboratories published a paper in 1956 describing a design technique applicable to certain types of transistor amplifiers.

An interesting aspect of the approach was the use of a computer to carry out the complex design calculations. It was probably one of the first examples of computer-aided design.

Then, the computer was only considered a tool incidental to the main task. Today, computer-aided design seems almost an end in itself and the net effect may not be progress.

Two approaches dominated discussion of the activity at the recent Northeast Electronics Research & Engineering Meeting (NEREM) in Boston. Batch processing methods employ a remote computer and an appropriate turn-around time is inherent. On-line schemes place the designer in front of input-output equipment and let him interact with the machine.

A common aspect of most of the programs discussed is that they are analytical rather than *design* programs, and this is a significant weakness. A design program would accept as input the required performance specifications and then derive the component values and necessary interconnections. But analytical routines require that values and interconnections be supplied as inputs, from which the machine will compute the performance of the combination.

Some see the analysis method helpful because it is equivalent to going to a bench and wiring up an actual circuit. But a critic could argue that it encourages trial-and-error design rather than an understanding of the relative importance of the components in the circuit. A further disadvantage is the omission of important side effects such as stray capacity. The inaccuracy of the models employed to simulate the actual components is another problem.

However, even to those who recognize the inherent unreliability of trial-and-error methods and pursue more rational design techniques, analysis programs can prove invaluable aids *when they work.*

"One of the bad bones of the business right now is reliability," according to N. O. Sokal, president, Design Automation Inc. a consulting firm that employs computer-aided design methods. Although programs employ built-in checks, incorrect solutions sometimes slip by.

It also takes time to learn how to use a particular program for many do not perform as predicted in the manuals. The necessary effort can require one man-year and $10,000 in machine time. Couple this with a requirement for all the available programs (and more), because of the relative advantages of each, and it is not surprising that Sokal concludes the field is "not for the dabbler or casual user."

Other participants in the session seemed in agreement with Sokal's assessment. They were looking to the future when a central machine would be loaded with all programs and could service many satellite terminals. Some even saw the terminals requiring their own small computers! Even so, more sophisticated programing techniques are needed to save computer time. □

electronic chess match

THE SOVIET UNION has won the first international chess match played by electronic computers.

A computer programed by a team of Moscow mathematicians defeated a Stanford University computer in an experimental match that lasted more than a year.

Of the four games played, the Soviet computer won two and the remaining two ended in draws.

The match has been called a significant step forward in the development of computers capable of "creative decision-making" in economics, industry, and science.

Mikhail Rotvinnik, former Soviet world champion, said the experiment fell far short of developing "electronic chess players." However, he believes it is possible to devise a computer chess program that could defeat even the grand masters.

In the experiment, the computers were fed the rules of chess, the values of the pieces, and the different positions on the board. They were programed to look ahead eight moves by each computer, but to make only a limited number of moves.

The four games were played by feeding the computers with perforated cards giving information on the opponent's last move. However, the computers could have been hooked together to play without human intervention after being programed. □

ELECTRONICS

LSI circuits making inroads

THE FOURTH GENERATION of electronic circuits and systems rapidly is moving from the research laboratory into commercial applications.

In LSI circuits, from 10 to 10,000 complete circuits are built up on a single tiny chip of substrate material. It is the next step past the present third generation technology of microminiaturized integrated circuitry.

As Dr. Richard L. Petritz, division administrator, Texas Instruments Inc., Dallas, told the recent Fall Joint Computer Conference in Anaheim, Cal., there are three major LSI technologies under development—LSI chip technology, LSI hybrid, and LSI "full-slice" technology.

The first is a system of 10 to 250 circuits per chip and one to several chips per device package. Hybrid technology also involved 10 to 250 circuits per chip, but with from four to 20 chips per package. The chips are interconnected by thin film methods.

The most advanced of the three LSI types is full-slice technology. In this system, from 100 to 10,000 circuits are placed on a single chip. Full-slice technology, said Petritz, promises the greatest gains because the entire slice constitutes the packaged product.

The Air Force recently awarded Texas Instruments a contract for a complete hardware system using full-slice technology. The program calls for construction and testing of a computer for a terrain-following radar system.

Even closer to operation is an Air Force-sponsored LSI computer at Radio Corp. of America Laboratories. H. S. Miller, a member of the RCA technical staff, pointed out that the use of LSI to combine many logic gates on a single chip promises to break the speed bottleneck that hampers current computer circuitry.

He noted that 75% of the signal delays in current computers occur in interconnection wiring. By packaging many circuits on one chip, much of this interconnection wiring is eliminated. To prove out the capability of the new technology, RCA is building a large integrated monolithic array computer. □

FOOD TECHNOLOGY

recipe for oil protein

TO A GAS OIL CUT—taken directly from a refinery—add yeast micro-organisms, nutrients, oxygen, and ammonia. Allow the micro-organisms to feed on the wax content of the gas oil so that they multiply rapidly to form a yeast cream.

Pass the yeast cream through a centrifuge to separate it from the gas oil. Purify and dry the resulting protein slurry to an odorless powder.

From 91 megagrams (100 tons) of feedstock, 9 Mg of protein concentrate will result, which can be added directly to animal feeding rations. Thus goes British Petroleum's (London) recipe for helping to feed the world.

British Petroleum has been working on the process for about eight years and has now decided to build a plant at Lavera, France, to produce protein concentrate from a gas oil feedstock.

Initially, the concentrate will be produced for use in animal feedstuffs. However, tests for its use for human consumption are encouraging. □

GEOPHYSICS

earthquake alerts?

MAN HAS YET TO LEARN how to control most of nature's destructive forces. The multiple havocs of flood, hurricane, tornado, and earthquake remain as devastating as ever.

However, in the case of the first three, man has learned to take the first steps by being able to predict oncoming events.

But the occasional earthquake that destroys much of man's handiwork with impunity—witness the Good Friday earthquake in South Central Alaska nearly four years ago—thus far has defied efforts toward forecasting.

Hope may be on the way, though, according to Dr. Richard Jahns, dean of Stanford University's School of Earth Sciences.

"Within the next few years we shall have warning of a few minutes to as much as an hour in advance of strong shocks along two or three of this country's major faults," he predicts.

Recent findings seem to add considerable credibility to his hopeful statements. Scientists at the Dept. of Commerce's National Earthquake Information Center point toward small changes in the geomagnetic field as precursors to temblores.

Adding supporting information to these observations, two other Stanford geophysicists—Drs. Sheldon Greiner and Robert L. Kovach—report similar findings.

A Stanford team placed an intensified network of magnetometers around the San Andreas fault near Hollister, Cal. When four of the devices indicated a drop in field strength, the scientists then waited for an earthquake. Within two days, the area was shaken by a series of moderate shocks.

Unfortunately, most earthquake experts point out, indications are that what works in one location probably will not be effective in another. The outlook consequently is dim for now.

What worries many, especially in earthquake-prone California, is that the collective intuition predicts that the state is long overdue for a major earthquake. □

INSTRUMENTS

microscopic storage

SINCE THE INVENTION of the microscope some time ago, scientists have been trying to improve its magnification capabilities to see smaller and smaller objects.

With the latest in electron microscopes, we finally seem to be on the brink of looking at single molecules—and someday, even atoms.

But aside from the microscope's

utility for revealing the microcosmos, few other uses for the instrument have been suggested—until now.

Dr. Humberto Fernandez-Moran, professor of biophysics at the University of Chicago, says that electron microscopy and related techniques could invade the field of high resolution information storage and retrieval.

"We now can demagnify to the point which we already have achieved of reducing written pictures—at one stroke by direct imprinting—by a factor of up to 50,000," he declares.

In effect, it would be possible to print the contents of the Library of Congress on a piece of typewriter paper at that reduction.

Fernandez-Moran has contributed in quite some measure by developing the new short-focal-length lenses required for demagnification.

Other efforts by him and his coworkers have been directed toward improving electron microscope capabilities, such as better point-cathode sources that will offer more stable, coherent microbeam illumination. Goals are increased brightness, smaller spot sizes, and low energy spread of the electron beam.

But Fernandez-Moran cautions that we are still some distance away from the best possible point source.

"Someday we must find the equivalent of a laser for electrons—a highly coherent, spatially and temporally coherent source—just as we have for light," he declares. □

hydrated electrons

ALMOST SIX YEARS AGO, two research physicists working at England's Mt. Vernon Hospital in Middlesex came up with what has been hailed as one of the most significant events in modern chemistry.

They discovered a short-lived electron strongly attracted to water molecules—the hydrated electron.

Produced in water under irradiation, this intermediate chemical fraction exhibits a half-life measured in microseconds.

The researchers, Drs. J. W. Boag and Edwin J. Hart, were the first to measure the electron's optical absorption and prove its existence experimentally.

Several new avenues of scientific investigation have been opened up as a result of studies of the species' properties, reactions, and decay rates.

Hart since has returned to Argonne National Laboratory as a senior physicist. There, with another co-worker, associate physicist Dr. Klaus Schmidt, he concentrated on one of the more practical problems: the hydrated electron could only be produced with linear accelerators or expensive cobalt 60 radiation sources—each offering experimental time at a premium.

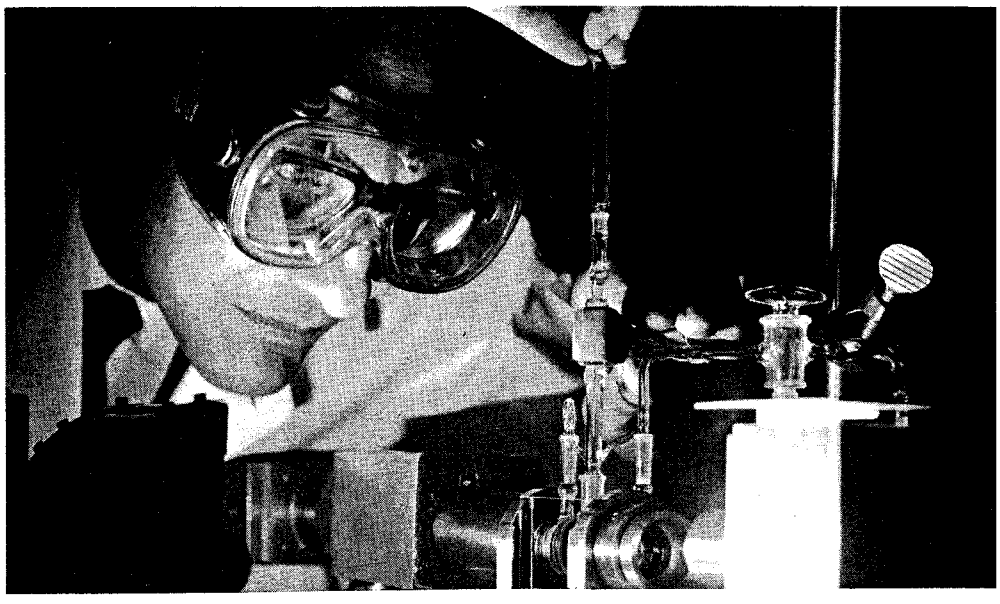
So Hart and Schmidt designed and built a low-cost device to produce hydrated electrons. It is compact, simple to operate, and can be used anywhere because there is no radiation hazard.

"The $2,500 device is well within the financial reach of small colleges and universities that do not have access to accelerators. Therefore, increasing numbers of students and researchers will be able to participate in hydrated electron investigations," Schmidt told *Industrial Research.*

The device's secret is a high-power ultraviolet light source that irradiates the solution in a small quartz cell. Pulse duration is about 30 microseconds, and the resultant hydrated electrons are sensed by the narrow light beam focused on a photomultiplier.

"Aside from the electron's value in studying reaction rates, it also can be used as an analytical tool. For example, we have been able to determine very small amounts—down to a few nanomoles—of oxygen in solution," he adds. □

MAKES POSSIBLE HYDRATED ELECTRON RESEARCH
Dr. Klaus Schmidt adding sample to new Argonne ultraviolet device



TYPICAL MICROSTRUCTURE
graphite within zirconium carbide

METALLURGY

hypereutectic carbides

THE SUCCESSFUL FABRICATION of test samples of hypereutectic tantalum and columbium carbides at Aerospace Corp., El Segundo, Cal., is the latest step in development of this promising new family of high temperature materials.

These carbides, developed in the Materials Sciences Laboratory by a group headed by Dr. Edward Kendall, are actually carbide-graphite alloys. Addition of the graphite, Kendall points out, results in materials with very high thermal shock resistance.

The first phases of the program resulted in development of hypereutectic titanium, zirconium, and hafnium carbides. These materials have melting points, respectively, of 3000, 3500, and 4000 C.

However, the melting point of the oxides that form on these carbides in high temperature use is the limiting factor. They have melting points of 1800, 2700, and 2800 C.

Rocket nozzle linings of these materials were prepared for engine tests at the Naval Ordnance Test Station, China Lake, Cal.

As Kendall told *Industrial Research,* "We can conclude that these carbide linings do not fail in thermal shock. They came through the firings without cracking—something not possible with other carbides."

Further work on properties and production scale-up needs of the titanium, zirconium, and hafnium carbides has been assigned to Battelle Memorial Institute, Columbus, Ohio.

Kendall's group recently focused its attention on the more difficult task

of making tantalum and columbium carbides with similar structure. This was achieved in mid-1967, using the same general method of arc fusion and casting. A probable next step is construction of re-entry vehicle leading edge shapes of titanium carbide for flight tests on a re-entry model.

Commercial applications may be an important byproduct of hypereutectic research. One company has fabricated test samples for use as a refractory in glass making. Other possibilities include electrodes in aluminum cells, crucibles for molten aluminum, high temperature bushings or bearings, and high temperature rings and seals in turbojet engines. □

NUCLEAR ENERGY

Project Gasbuggy

AN EVENT that could signal the start of a major breakthrough in the oil and gas industry took place Dec. 10 in a remote area of northwest New Mexico.

At 12:30 p.m., seismographic needles jumped and a slight tremor was felt 54 km southeast as a thermonuclear device detonated in a field tomb 1,272 meters below a remote site 100 km east of Farmington in northwestern New Mexico. "Project *Gasbuggy* was off to a flying start.

The shot, the first of a number of proposed tests in the use of nuclear explosions to exploit hard-to-tap sources of oil and gas, is the initial step in Project *Plowshare*—the peaceful application of nuclear explosives.

Gasbuggy is a joint project conducted by El Paso Natural Gas Co., the Atomic Energy Commission, U.S. Bureau of Mines, and Lawrence Radiation Laboratory, Livermore, Cal. It involves the use of nuclear explosions to fracture natural gas reservoirs to provide more effective drainage of the reservoir and higher sustained production rates after the initial fracture.

Expected gains from conventional stimulation would provide a gas recovery of 10% of the original gas in the test site area over a 20-year period. By comparison, AEC estimates that nuclear fracturing, using 10 kiloton explosives on 648 sq m spacing, could provide a 70% return.

In the current test, a 26-kiloton hydrogen device was placed at a depth of 1,272 m—deep enough to confine the explosion, but not so deep that emplacement costs would be too high.

Even so, the total cost of the test was about $4.7-million. Industry sources have estimated an economically feasible process requires a cost-per-shot of only $500,000.

These and other questions await not only *Gasbuggy* but many other tests

before a final assessment can be made. AEC reports there was no release of radioactivity and no damage occurred from ground shock resulting from the detonation.

Radiation and health safety experts, however, are monitoring the experimental area as drilling into the broken rock zone to collect samples for analysis proceeds.

Because of the unknowns, large scale nuclear stimulation of gas and oil lies in the 1980s or later. The time span may be affected further by delays in funding follow-up programs.

Gasbuggy itself almost was cancelled by the Bureau of Budget in late 1966. Only strong pressure from the AEC on Congress resulted in the restoration of program funds to permit the current test.

The potential return of the program could far outweigh the few million dollars involved in continued experiments. The Bureau of Mines has estimated that, if successful, nuclear fracturing could more than double the country's proven reserves of natural gas. □

deadly breeders?

MUCH OF THE PUBLIC CONCERN about nuclear reactor safety—or the prospect of a lack of it—really began on July 16, 1945.

It was on that date, at a remote testing site near Alamogordo, N.M., that man first observed the enormously destructive potential of atomic energy.

Since that time, science has attempted to match or even exceed weapons development with peaceful uses.

Unfortunately, nuclear scientists' efforts to soothe the general public's nerves were doomed to failure. No matter what was said about the differences between the bomb and a reactor or radiation-containing shielding, much of the public equated—and probably still equates—the harmless-looking reactor with the devastation of Hiroshima and Nagasaki.

More frightening to most is not the all-too-visual spectre of a cataclysmic nuclear explosion but the insidious and equally deadly effects of radiation. Unlike most other environmental dangers, radiation cannot be seen, smelled, or even felt. Worse, most of its non-lethal effects may not show up for years or even generations.

Now, however, the situation is changing somewhat.

The development that has prompted an about-face among some critics is the fast-breeder reactor. The plot also thickens considerably when it is realized that these new reactors figure heavily in plans by companies engaged in the fastest-growing segment of nuclear energy uses—the generation

of electrical power.

Unlike earlier reactors used for power generation as well as for research, which employ diluted uranium for fuel, the new breeders use plutonium—the same material used in the bomb.

Also, the utility companies are more than happy because the breeder reactor creates more plutonium than it "burns." Consequently, fuel costs will just melt away almost entirely.

It is the prospect of these mounting supplies of plutonium that frightens Dr. Edward Teller, the so-called "father" of the hydrogen bomb and a professor of nuclear physics at the University of California at Berkeley.

Teller recently stated. "For the fast-breeder to work in its steady-state breeding condition, you probably need something like half a ton of plutonium. I do not like the hazard involved."

He explained that reactors are "clean" so long as they operate as planned.

"If they malfunction in a massive manner—which can happen in principle—they can release enough fission products to kill a tremendous number of people," Teller warned.

The latter possibility brings up a point about safety factors upon which hinges much of the controversy.

Previous experience with reactors by the research community has produced a remarkably small number of fatal mishaps. Even more enviable is the record compiled by industrial users of nuclear energy—not a single injury or death since the first full-scale power plant started up a little more than 10 years ago.

Contributing in some small measure to this safety record is the fact that nuclear reactors always have been banished to sparsely populated locations to minimize the effects of an improbable release of harmful radiation to the atmosphere.

But the jitters continue to ebb and flow, hitting their high points on occasions when a power company announces plans to build a reactor closer to a population center — and when something goes awry with an existing reactor.

In the former instance, the most recent and loudest outcries occurred when a California power producer made public its intentions to build one within several miles of earthquake-prone San Francisco. After futile attempts to explain plans for elaborate additional safety features for the site, the project was dropped.

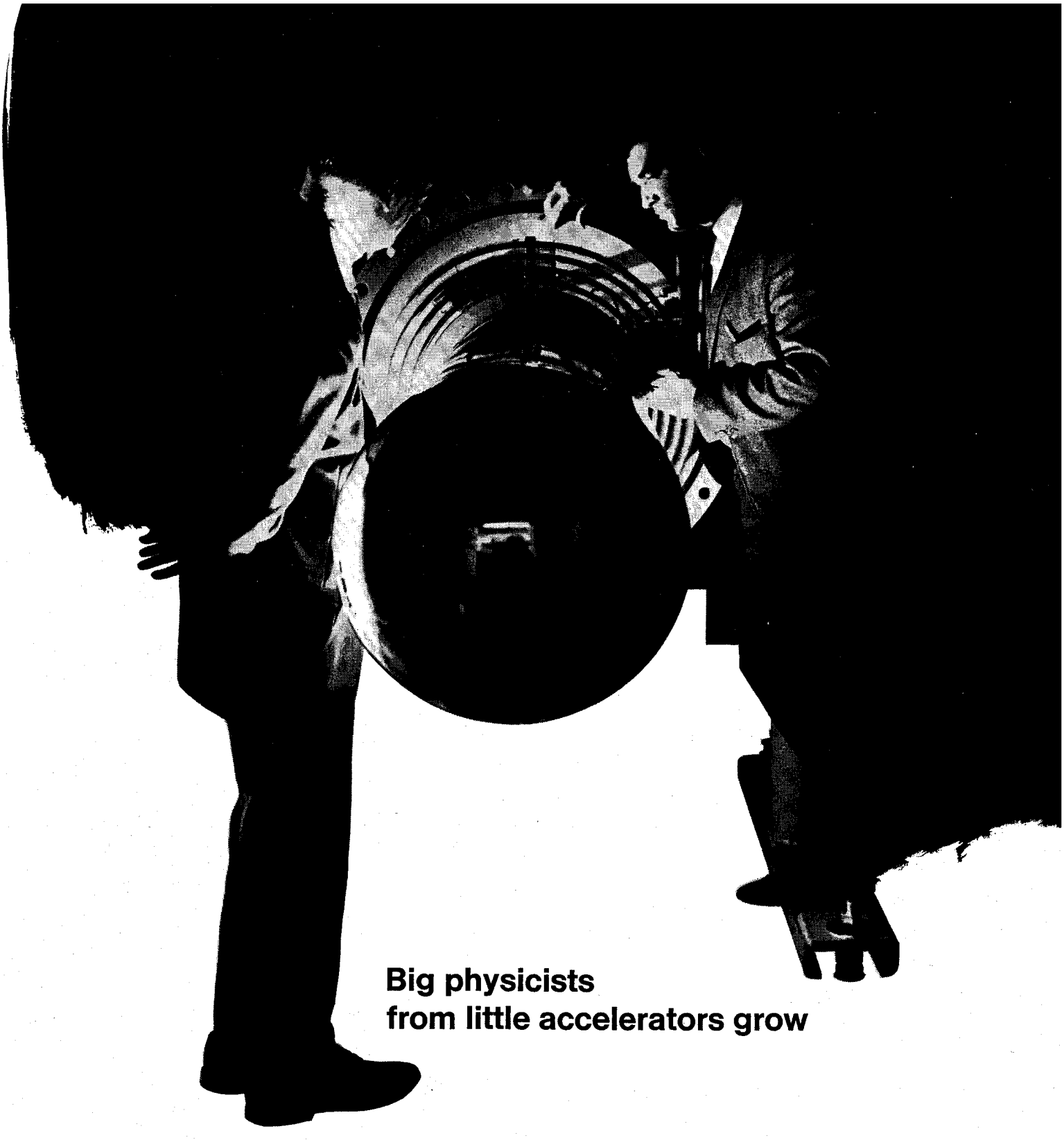
More recently, nuclear nervousness was once again stimulated by one of those "improbable" accidents. While no deaths or injuries resulted, the mishap occurred at a plant located a mere 30 miles from metropolitan Detroit.

There, at the Enrico Fermi Atomic Power Plant, a still-experimental fast-breeder reactor employing liquid sodium as a coolant shut down suddenly when a piece of sheet metal blocked the coolant flow. The accident happened more than a year ago, but it wasn't until recently that engineers found the cause and discovered some of the rather disastrous consequences.

Two of the 105 core elements had overheated and melted together — a situation that could have led to one of the few circumstances in which the reactor might blow up. The explosion certainly would not be like an atomic bomb with its resultant holocaust—but more like just enough explosive force to rupture shielding and release deadly radioactive particles for miles.

However, most scientists agree that any kind of appreciable explosion is at best a remote possibility.

One of the optimistic researchers in this field is Dr. David L. Morrison, chief of the Chemical Physics Div. at Battelle Memorial Institute's Columbus Laboratories. He also is a member of the Atomic Industrial Forum's Reactor Safety Committee.



Big physicists from little accelerators grow

What happens when a grad student closes his textbook and starts an experiment on the accelerator?

Checks the vacuum system. Then the electronic instrumentation. Pours liquid nitrogen. Reads digital printouts. Strings wires. (Oh! the wires.) Checks connectors. What has this got to do with nuclear theory?

Plenty. It's the *doing* of physics, which is essential to the knowing of physics. This graduate student will confirm for himself the basic discoveries that built modern physics. And he will earn the right to move up to larger accelerators where further original work is waiting.

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He told *Industrial Research* that the Fermi reactor is a "rather specialized machine that really isn't the type people are thinking about in the future for fast reactors."

Morrison also noted that much of the impressive safety record for commercial reactors has been gained with well-known thermal systems using pressurized water for cooling.

"Current thinking, as I interpret it, is that there is much to be learned about fast-breeder systems and liquid sodium technology. The Atomic Energy Commission has launched a substantial liquid metal, fast-breeder reactor program to find the unknowns, identify potential problems, and come up with solutions.

"I am convinced that at the end of the current development program, we will be able to say with confidence that the then-available fast systems will be as safe or safer than current water-cooled systems," he declared.

The question of reactor safety—whether absolute or only relative safety—is yet to be answered. By using past performance as a criterion, the ammunition for quieting the critics is certainly at hand.

The picture of progress also is a juggernaut only occasionally slowed or stopped. Progress in this instance means a source of electrical power that promises to become even more competitive with fossil fuel sources.

At present, plans for new nuclear generating plants are being announced at the rate of nearly three a month. Already some 1.8-billion watts of electrical power are being produced from nuclear energy sources.

This amount now represents a mere 1% of the total output, but AEC estimates have this proportion increasing rapidly to as much as 25% by 1980—up to 170-billion watts.

The expert consensus is that there is no reason to believe the trend will lose momentum. Barring discovery of an even more practical and abundant source of power, the atomic pile—including fast breeders—is here to stay.—DAVID M. GRAHAM, MIDWEST EDITOR. □

TRANSPORTATION

Aerotrain and Concorde pass test

ON PARIS'S left bank at the Gare Montparnasse, the conductor shouted a lusty "En Voiture!" And France's wheel-less Aerotrain roared along its concrete rail to claim a world record for track vehicles.

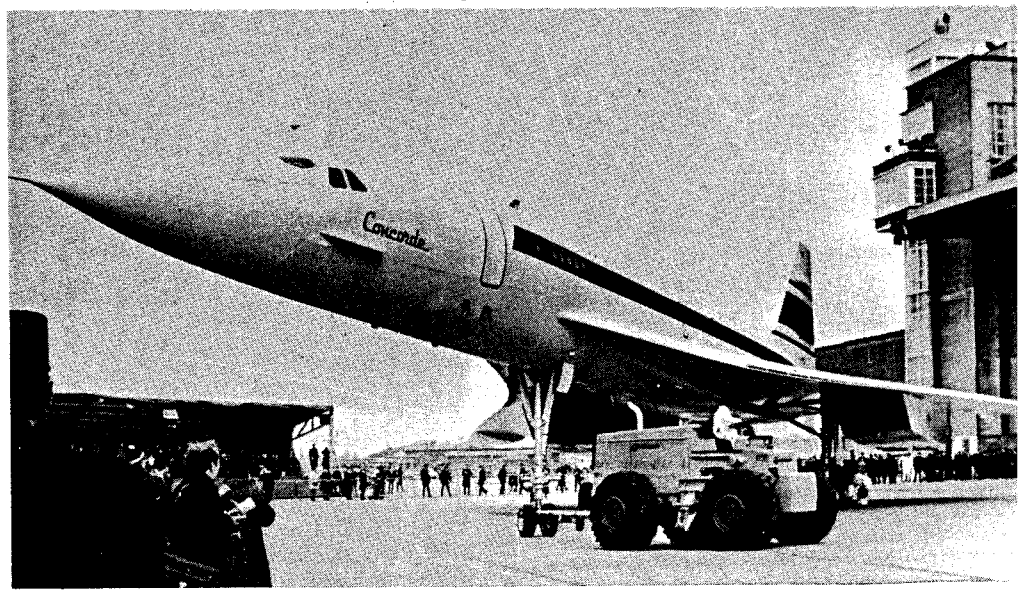
The sleek aluminum car, dubbed "Le Zinc," rushed almost noiselessly through the countryside at 215 mph—20 mph faster than the record for trains held by France for a conventional locomotive.

Le Zinc is a halfsize experimental model of the Aerotrain designed by Jean Bertin. It rides on an air cushion along a T-shaped concrete track. The full-size model, which Bertin hopes to begin building soon, will carry 80 passengers at speeds of 250 mph.

Government contracts are nearly signed that will finance not only the full-scale aerotrain but a 22-km (12.4-mile) elevated track leading north from Orleans. Eventually, promoters hope to extend the line about 126 km to Paris, which the train could make in 25 minutes.

Meanwhile, the French counterpart of the Anglo-French supersonic transport, Concorde 001, rolled out of its hangar last month at Sud Aviation's airfield in Toulouse, France. The 57-m, 1,500-mph prototype will take its maiden flight next month after ground

THE CONCORDE SUPERSONIC AIRLINER
French version unveiled as work proceeds on British counterpart



tests and engine runs are completed.

Despite political problems work at Filton, near Bristol England, is ahead of schedule and the British prototype, Concorde 002, should be flying by June or July.

In the United States, Boeing Co. announced several design changes on the 2707 supersonic transport. To smooth the ride and provide more precise control, the 1,800-mph SST will use a small, ear-like wing, called a Canard wing, far forward on its fuselage in conjunction with "direct lift control" on the main wing. Other design changes include lengthening of the fuselage from 92 m (306 ft)—longer than a football field—to 95½ m (318 ft).

The Anglo-French Concorde, however, will have one edge on the bigger and faster SST. It is slated for service in 1971, at least three years ahead of the American SST. □

new power source

AN INVESTIGATION into a new power source that may hasten the practicality of the electrically driven town car has been completed at Oxford University in Great Britain.

The Ministries of Transport, Defense, and Technology are so encouraged by the results that they are considering taking over the project to develop a prototype system.

The device is referred to as the "black box turbine." S. S. Wilson, the inventor, told *Industrial Research* he believes its development could overcome the restrictions of speed and range of electrically driven vehicles. His idea is a turbo-electric drive that eliminates the difficulties caused when rechargeable batteries are used as a source of power.

The newly developed expansion turbine operates, not with steam, but with a vapor that has a molecular weight about 20 times greater than steam. This provides a compact and efficient turbine that will produce up to 20 kW of power.

A benzene substance and a new fluorine compound have been tested in the experiments. A vapor turbine is built as a sealed box in much the same way as the compressor unit of a refrigerator is self-contained.

A paraffin or gas oil burner heats the fluid to produce the high molecular weight vapor. The vapor is directed through a nozzle onto the turbine blades and then recirculated to the boiler. The turbine motor drives an alternator to generate the electricity.

Wilson said it would be unrealistic to ignore the cost of developing units. The system's future depends on volume production, he explained. But potential uses include portable generating sets for ships and isolated dwellings, and the source of power for cars, taxis, buses, and the like.

For the small town car, speeds of 40 mph are predicted. With bigger power units, speeds of up to 70 mph are believed to be possible.

Meanwhile, an electric car with an electric motor in each rear wheel is being put into production in Britain this spring by Carter Engineering of Tamworth, Staffordshire, which has formed a subsidiary, Carter Coaster.

Initial production will be relatively low and earmarked for research bodies, public utilities, and other organizations which have expressed interest in having fleets of cars for evaluation purposes. After that stage, any necessary modifications would be made before production was stepped up and the car offered to the public at a basic price of around $840. □

ULTRASONICS

colors from sound

MOST SOUND comes to the human ear as variations in frequency. But to the biomedical engineers at Northwestern University's Technological Institute, sound is *seen* as colors—such as blue, purple, orange, or red.

In actuality, Dr. John E. Jacobs, executive director of the institute's Biomedical Engineering Center, and his coworkers developed what is probably the first ultrasonic imaging system capable of producing x-ray-like colored images of any living tissue on a color television screen.

"We can show clearly discernible blood vessels in a finger, for example, that appear as pulsating green or blue or orange lines," Jacobs told *Industrial Research.*

However, he explains, the colors do not represent real colors of the hand's internal structure. Instead, they show varying rates at which sound waves pass through the hand when it is dipped in a water tank in the path of the sound waves.

Black and white television sonic imaging systems—also developed by Jacobs—have been around for some years. The color system, however, represents an increased sensitivity of from 20 to 40 times, simply because the eye can recognize nearly 100 different shades of color at the same brightness compared to about five in black and white television.

Future uses lie both in the medical and industrial areas, he believes. The device could be quite valuable in nondestructive testing to identify defective spot welds. A good weld shows up as one color; a bad weld as a wild variation. ■

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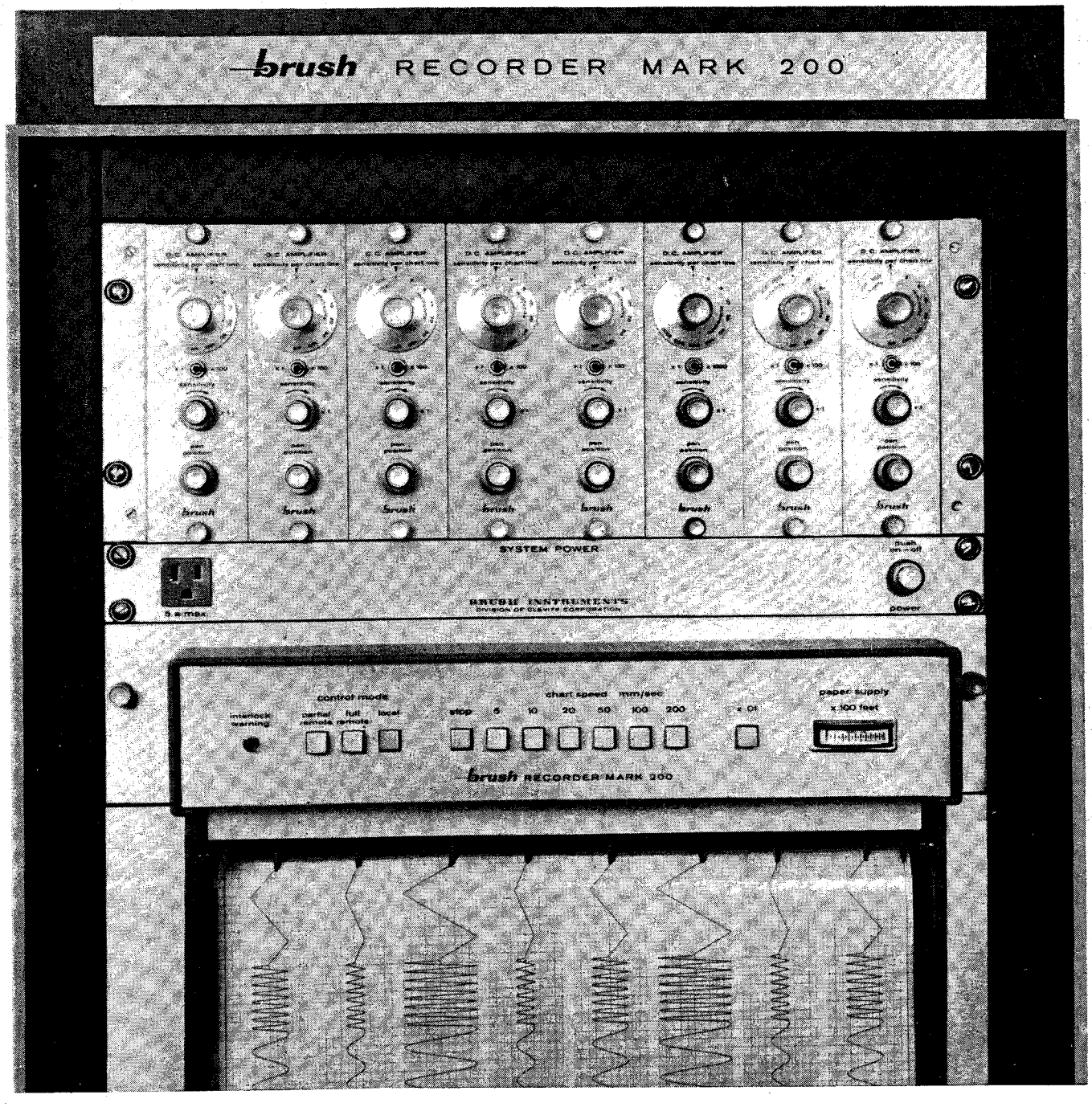

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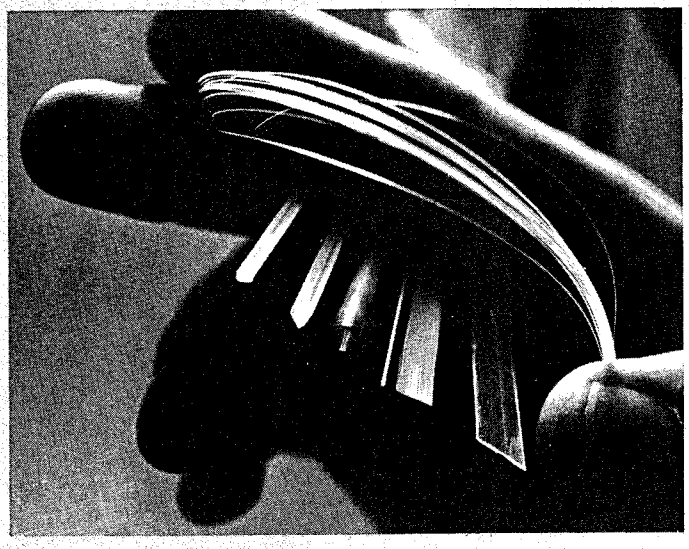
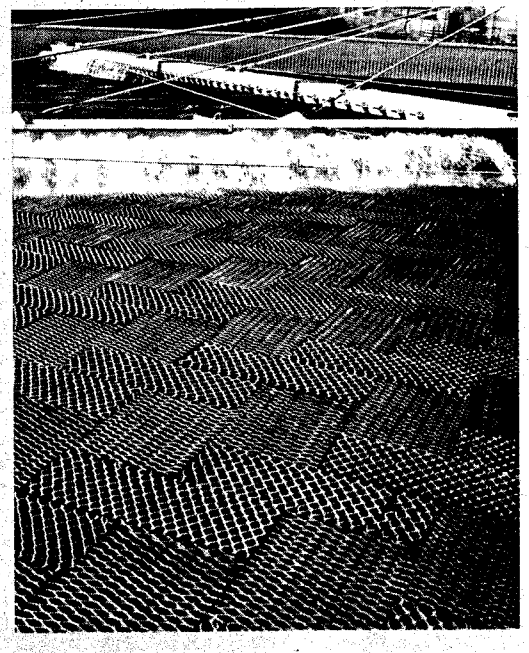
MATERIALS APPLICATIONS*

JANUARY 1968

Nature's design for purifying water is imitated by new self-supporting polyvinyl chloride honeycomb.



A VARIETY *of single-crystal sapphires is available from Tyco Laboratories Inc. Grown from a melt, the sapphires will be used as a reinforcement and insulating material. Honeycomb polyvinyl chloride (below), made by Dow Chemical Co., is used in water purification systems, allows greater surface area and ease of assembly.*



GUSHING STREAMS and fast-moving rivers are among the best systems for purifying water. Tremendous numbers of bacteria in streams digest sewage and other waste, converting it into carbon dioxide and water. Unfortunately, man's production of waste in advanced industrial societies has far exceeded the capacity of his rivers and streams.

Copying nature's excellent design, man has long used a trickling filter system to purify water. A trickling filter is nothing more than a tower containing rock or slag, through which polluted water can course. The filter allows aerobic bacteria to grow, which in turn digest waste materials.

For optimum operation, the flow of water-borne waste must be controlled so as not to exceed the purifying capabilities of the bacteria; adequate ventilation is needed to assure a supply of dissolved oxygen for the microorganisms. The efficiency of the filter unit depends on keeping a healthy bacteria colony in continuous and intimate contact with the water-borne waste.

Over the years, trickling filter systems have gone through various design changes, although the basic idea has remained the same. One of the newest variations comes from Dow Chemical Co., Midland, Mich. Dow is supplying a new biological oxidation medium to replace the rock or slag used within the filter. Called "Surfpac," the material consists of individual sheets of thermally formed polyvinyl chloride or saran plastic. Each seet is corrugated in two directions. The sheets, nested together for shipping, are quickly assembled into lightweight, structurally self-supporting modules which occupy about five times their shipping volume. They provide an open honeycomb of continuous surfaces on which bacteria can grow, and over which waste water flows, without the constant threat of stoppage.

Surfpac has a high surface area, which allows it to handle highly organic wastes. For every cubic foot of packing, Surfpac provides an area of 2.5 square meters (27 sq ft). This area is completely available for active bacterial growth and is not reduced as slimes build up. In addition, Surfpac provides 94% voids between the sheets and promotes natural draft ventilation to eliminate odors associated with trickling towers.

Surfpac is about 40 times lighter than rock or slag. Thus, self-supporting towers can be built up to 6.3 m in height. Towers up to 12 m can be built with intermediate support decks. Due to its light weight, towers packed with Surfpac can be built to much greater heights than are possible with rock or slag, greatly reducing the acreage needed for waste treatment facilities.

A domestic sewage treatment plant in Texas, built to handle 1-million gallons/day, was packed with Surfpac. Capital cost of the plant was 35% less than a rock filter plant. As an additional bonus, the plant required 55% less area than a rock filter plant.

for further information

You can obtain further information about the materials and applications discussed in the "Materials Applications" section by circling the appropriate numbers on card 35 in the inquiry card section at the back of this issue.

**Materials Applications is a trademark owned by Industrial Research Inc.*

Surfpac can be used in a number of treatments besides that for municipal water waste:

- Organic chemical plant waste.
- Phenolic petroleum refinery waste.
- Meat-packing waste.
- Petrochemical plant waste.
- Textile waste.
- Papermill waste.

More than 20 plants using Surfpac biological oxidation media are either operating or under construction. These installations include both municipal and industrial treatment plants. For details, circle "1" on inquiry card 35.

Elastic ceramic displays versatility

THE MIXTURE OF LEAD TITANATE, lead zirconate, and borosilicate glass has produced a versatile elastic ceramic material having a low dielectric constant and unusual elasticity. The material, "Composition P," can be used as an encapsulant, dielectric, and bonding cement.

Developed at International Business Machine Corp.'s Components Div., Hopewell Junction, N.Y., the composition's unusual properties permit it to be used as a hermetic encapsulant, as a dielectric substance for printed capacitors, and a metal-to-ceramic bonding cement.

A thin barrier of Composition P seals a device against air, moisture, and corrosive environments without adversely affecting its electrical properties. Microelectronic devices, such as capacitance and resistance elements, have been successfully encapsulated with Composition P.

The material overcomes one major disadvantage of many encapsulating compositions. Since many of these materials have thermal coefficients of expansion differing from those of the device to be coated—or the substrate on which the device is mounted—microfissures tend to develop in the protective coating. Devices encapsulated with Composition P have been heated as high as 700 to 900 C and cooled to room temperature without fissuring.

The material's low dielectric constant—10 to 100—has enabled its use in fabricating printed thick film capacitors. Experimental printed capacitors changed less than 5% in capacitance and dissipation factor during temperature changes of zero to 100 C or during frequency changes of 100 Hertz to 100 megaHertz.

Composition P also has been used as a bonding cement for joining metals to ceramic materials. Excellent results have been obtained when bonding two materials with substantially different thermal coefficients of expansion. For example, silver ribbon can be bonded to an alumina substrate, the respective thermal coefficients of expansion, 191 x 10^{-7} and 60 x 10^{-7}, notwithstanding. For further information, circle "2" on inquiry card 35.

Glazing material gives vandals the 'heave-ho'

VANDALISM IS A GROWING PROBLEM for school officials—and for taxpayers. Boys will be boys, but the situation has managed to get entirely out of hand. In 1965, broken windows and light fixtures cost the School Dept. of Boston more than $130,000. In school year 1964-65, broken glass cost New York schools more than $930,000; Baltimore, $128,000; Philadelphia, $222,000; and Milwaukee, $70,000.

The vandal has met his match now, in "Lexan" polycarbonate resin. Rocks just bounce off Lexan glazing, made by the General Electric Co. Chemical Materials Dept., Pittsfield, Mass.

Boston school officials, as well as those in other cities, are finding out just how effective the Lexan glazing can be. For example, before one Labor Day weekend, Boston's Paul A. Dever School exposed three types of windows to the holiday punishment provided by local hurlers: safety glass, one glazed with acrylic, and a third with Lexan. After the weekend, only the Lexan window remained unshattered.

TO PROVE A POINT, *willing helpers of General Electric Co. do their best to break glass glazed with "Lexan."*

Lexan-treated glass is 250 times more impact resistant than safety glass of the same thickness; light transmission is 82 to 89%, depending upon sheet thickness, and the Lexan glazing is weather resistant.

Lexan costs about six times as much as flat glass. However, the material is so vandal-proof that glazing with other materials in high breakage areas is false economy.

Lexan's properties have led to a number of other uses:

- Transparent guard plates for table saws.
- Various laboratory equipment.
- Decorative home lighting fixtures.

Lexan also has been used to injection-mold the first all-plastic shotgun shell cases. The material's toughness and heat resistance permit the cases to be fired and reloaded many times. One shell was actually test-fired and reloaded 60 times. To obtain more information, circle "3" on inquiry card 35.

Explosive withstands temperature extremes

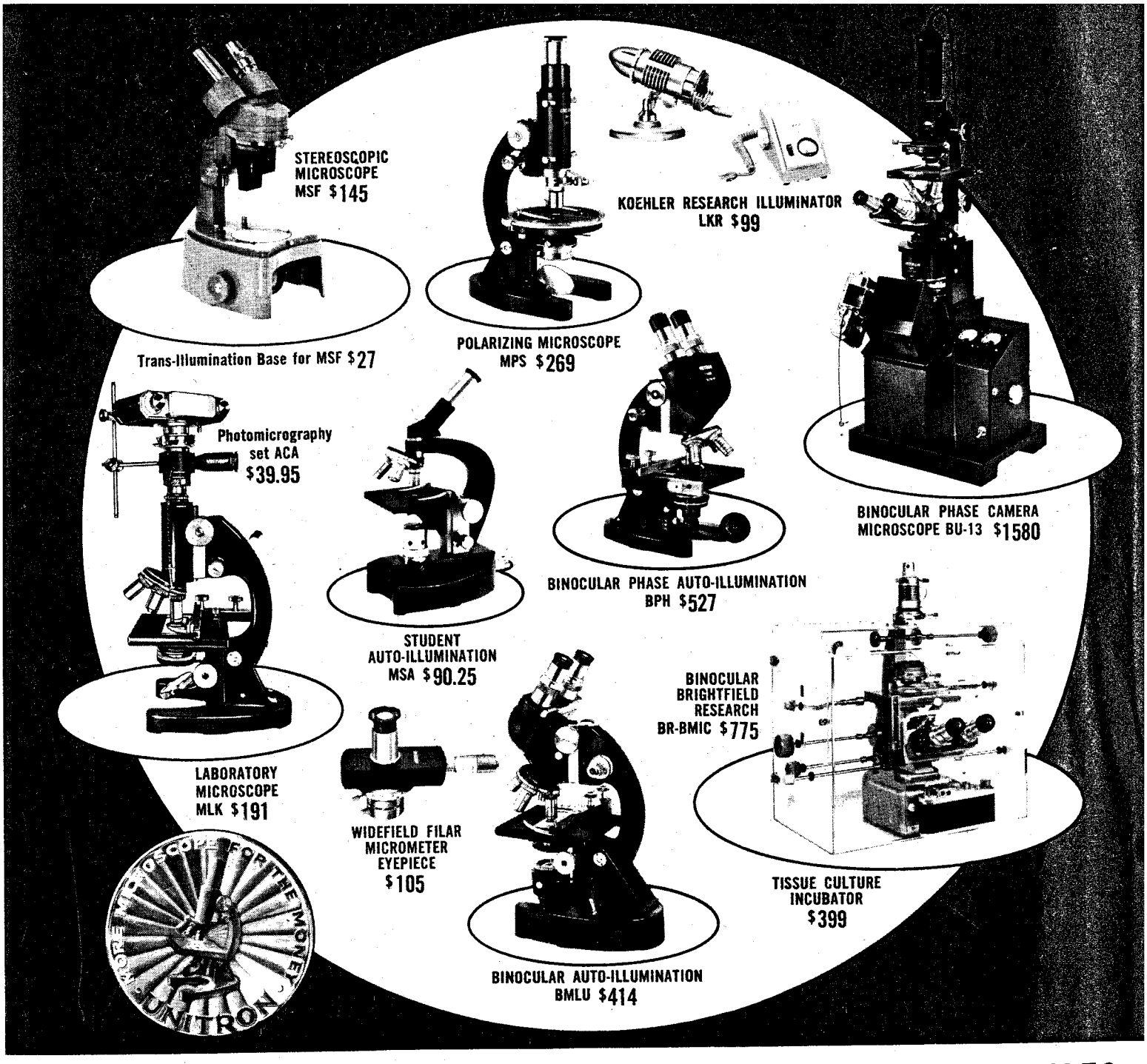
CLEANLINESS IS ESSENTIAL to success in the planetary exploration program. In the search for life on other planets, a vital requirement is that no microorganisms from Earth be carried onto the planet's surface by the spacecraft to contaminate or be mistaken for native life forms.

Complete sterilization of all flight systems is a must in such programs as the planned *Voyager* landing on Mars. The only efficient sterilization methods proposed to date call for application of high temperatures for considerable lengths of time. This poses problems for many temperature-sensitive items, but most particularly for the volatile propellants needed for in-flight maneuvers.

Pyrotechnic materials tested up to now have not met the specifications set forth by the *Voyager* project team at Jet Propulsion Laboratory, Pasadena, Cal., for NASA. JPL required that the material withstand six 92-hour cycles at 135 C without losing effectiveness. Some propellants tested suffered mechanical failure, underwent physical changes, or prematurely ignited.

Now a solution has been offered by Space Ordnance Systems, El Segundo, Cal., which developed a new material, SDX-203-HT. The compound can be sterilized at temperatures up to 454 C without degrading properties.

As Donald J. Lewis, principal scientist at Space Ordnance states, the new compound permits development of simpler spacecraft sterilization techniques. At present, several extra operations are needed to minimize damage to



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See inquiry card 37.

electro-explosive devices. Now the spacecraft conceivably could be completely sterilized in one operation. For more information, circle "4" on inquiry card 35.

Melt-grown sapphire crystals

SAPPHIRE, besides being a favorite adornment of women, has intrigued scientists with its unique optical and physical properties. It is a high-modulus, high-strength, dielectric material. To date, scientists have worked with sapphire (aluminum oxide) whiskers to take advantage of these properties.

To exploit these properties fully, a way was needed to make a continuous-length single-crystal sapphire. Tyco Laboratories Inc., Waltham, Mass., has done just that.

Tyco "grows" its continuous sapphire filament from a melt. Growth of the crystal proceeds along the c-axis (optical axis) for maximum strength and uniformity. The process can be used to grow filaments as well as other shapes and can be applied to other oxides and materials.

The most obvious use for the filament is to reinforce both plastics and metals. Sapphire is chemically inert, resistant to oxidation, and has high temperature strength. Metal composites having these properties would serve for prolonged periods at high temperatures. Both boron and graphite filaments also have high strength-to-weight ratios and are suitable for such composites. Both, however, are more reactive towards metals than sapphire.

The new continuous filament has strength properties approaching those of boron—the only filamentous, high-modulus reinforcing material available in substantial quantities. Filaments of sapphire show average tensile strength values of about 300,000 psi, going as high as 500,000 psi. Modulus of elasticity is about 50-million psi. A. I. Mlavsky, vice president of Tyco, told *Industrial Research*, "Further development of the process will lead to filaments having properties comparable to those of sapphire whiskers —namely, tensile strength in the range of 1 to 2-million psi and a modulus of about 70-million psi."

Tyco's development opens the door to a number of uses in military, industrial, and research areas:

- Sapphire's crystallography is such that it may be used as a substrate for silicon in the fabrication of an entirely new generation of integrated circuits.
- Ruby—a chromium-doped aluminum oxide—also can be made by the same process. Thus, the construction of newer, more efficient lasers is possible.
- The sapphire filament's transparency, over a wide range of wavelengths, makes it potentially suited for use in specialized fiber-optic devices, especially in high-temperature environments.
- Sapphire is an excellent insulator and can be used for making nonmetallic structural units such as radomes, which must be transparent to radio signals. Glass and silica fibers can also be used in such radomes; however, these materials have a modulus of about 10- to 12-million psi.

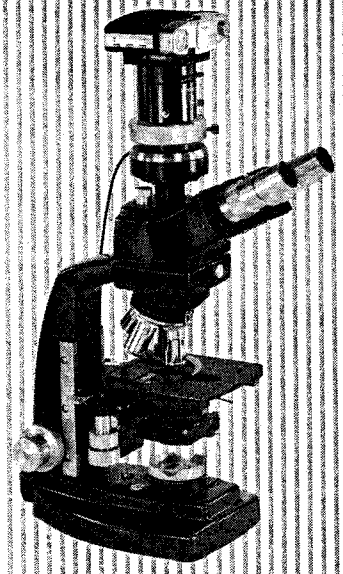
Both Tyco and the Air Force Materials Laboratory, Dayton, Ohio, are working on growing other crystals with the new process. For details, circle "5" on inquiry card 35.

Transparent-opaque storage/display ceramic

A "NOW-YOU-SEE-IT-NOW-YOU-DON'T" approach to information storage and display appears possible through the use of thin polished plates of certain ferroelectric ceramics which exhibit unique optical properties. Hot-pressed lead zirconate-lead titanate ceramics have received principal attention, although barium titanate and sodium potassium niobate also show promise.

As voltage is applied to these materials, their polarization is altered, thus affecting their ability to transmit light, which propagates faster in the direction aligned with the applied voltage. Thus, an initially isotropic material now

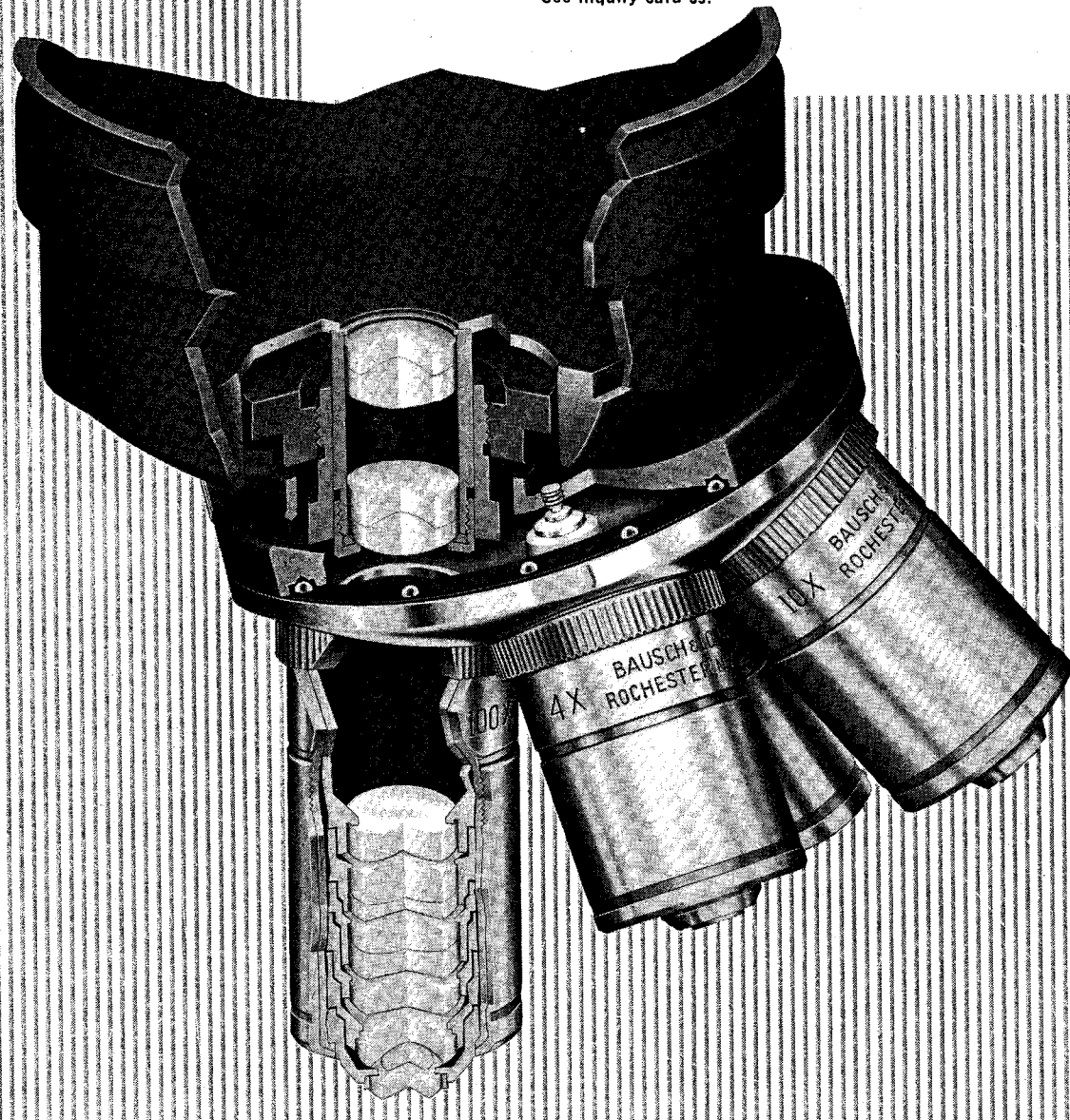
BAUSCH & LOMB



Anatomy of flat fields

Here's an "x-ray" of a sensational optical breakthrough that makes Bausch & Lomb first with truly flat fields, priced competitively with conventional, achromatic systems. Now you can afford flat, edge-to-edge images by specifying Dynazoom® of Dynoptic® Flat Field microscopes. Such performance cannot be matched for anywhere near the Bausch & Lomb price. But—let your own eyes decide. We can arrange for you to try a Dynazoom in your own laboratory. **Meanwhile, we will send you the deluxe Laboratory Microscope brochure, 31-185, and an indexed reproduction of the 21-jewel rendering. You'll want to display it in your office or use it in your classroom. Just write Bausch & Lomb, 93001 Bausch Street, Rochester, New York 14602.**

See inquiry card 39.



See inimitable quality in microvision . . . See a demonstration of Dynazoom/Flat Field

exhibits birefringent behavior; that is, the ceramic now has two refractive indices, one aligned with the voltage and the other at right angles to it.

Researchers at the Sandia Corp., Albuquerque, N.M. have been investigating two versions of these materials. In coarse-grained samples, the birefringence is hidden by scattering of the transmitted light. But if the grain dimensions approach the wavelength of light, the material's birefringent character becomes apparent when it is viewed in plane-polarized light.

If a small area of a coarse-grained sample is aligned at a right angle to its major surface, light striking the surface at the same angle is scattered in a narrow central beam, and the area appears transparent. But if the same area is switched parallel to the major surface, light transmitted in the central beam is greatly reduced and the area appears opaque.

This mechanism is the basis for a new optical memory system. Sandia has constructed a 256-bit prototype which has a storage density (5,120 bits/in.^{2}) about five times that of conventional memories.

The fine-grained memory, a ceramic which is sandwiched between two crossed polarizers, also relies on the switching of small areas between electrodes to control passage of light to a photodiode. However, it acts as a light filter, rather than as a shutter.

Transmitted light intensity depends on the angle at which voltage is applied from electrode to electrode. Thus, each bit location can be set in a number of different states.

The microscopic domains are switched parallel to the major plate surfaces and the material's state is determined at each bit location by the angular orientation of the poling direction with respect to the direction of the plane polarizer.

One version of this fine-grained memory has been designed to store any one of eight possible states.

Because the ability of the ceramic to retain its switching properties over billions of cycles is still in question, applications having limited cycling requirements will receive initial attention. For further information, circle "6" on inquiry card 35.

Thixotropic lubricant-coating

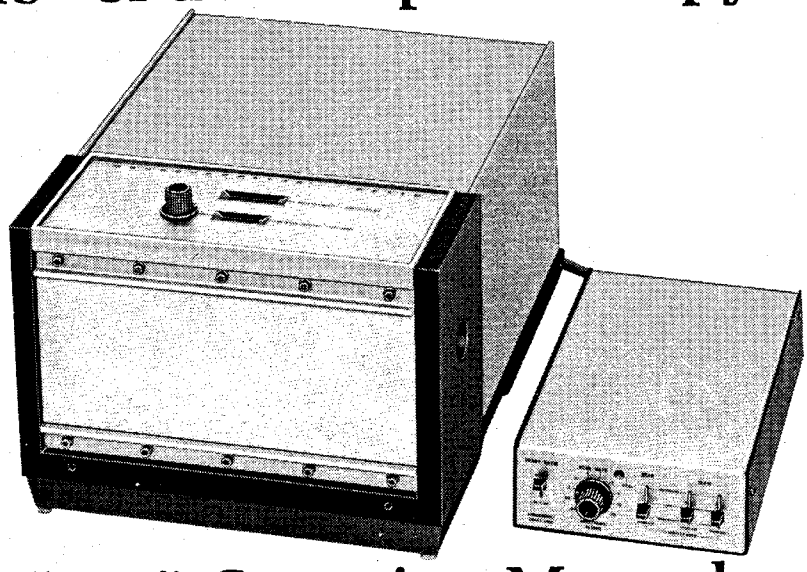
WAR IS HELL — on men and equipment. The extremes of temperature, humidity, and the abuse of combat always exact their toll on the machines of war.

The Naval Research Laboratory, Washington, set out to find a material that would protect equipment and small arms from these extremes. The need was for a material that would form a continuous, wax-like coating on metal, a material that could withstand salt- and fresh-water immersion and also be impervious to airborne moisture.

The coating also had to exhibit latent thixotropy, so that under the heat or pressure of use it would transform instantly into a fully liquid lubricant, then revert to its wax-like protective state after use. As if these requirements were not enough to make the best materials researcher blanch, the coating also was required to resist the abrasion of handling under field conditions.

Finally, NRL hit on a formulation for its preservative-lubricant. The formulation is based on tetrapropenylsuccinic anhydride, water, lubricating grade oil, n-heptane, ethanol, and an oxidation inhibitor. Added to this basic formula is "Kemamine P-190," an arachidylbehenyl primary amine, made by HumKo Products, Chemical Div., White Station Tower, Memphis, Tenn. The primary amine, 90% in the C_{20} to C_{22} range, enables the compound to undergo the transition from coating to lubricant and back to coating. For further information, circle "7" on inquiry card 35.—KENNETH A. KOVALY, EASTERN EDITOR. ■

first module* of a new spectroscopy system...



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• **Low Cost** . . . in keeping with the Heath philosophy of optimum value, you get more performance per dollar invested.

Design Features Of The Heath "700"

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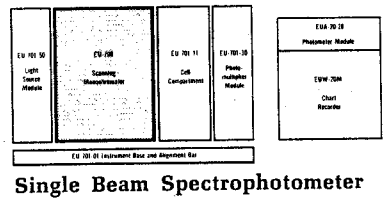
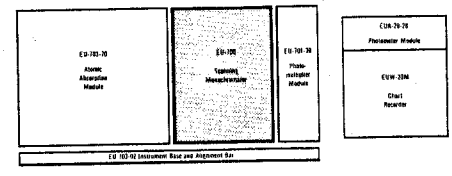
Examples Of Heath's Modular Design



Single Beam Spectrophotometer



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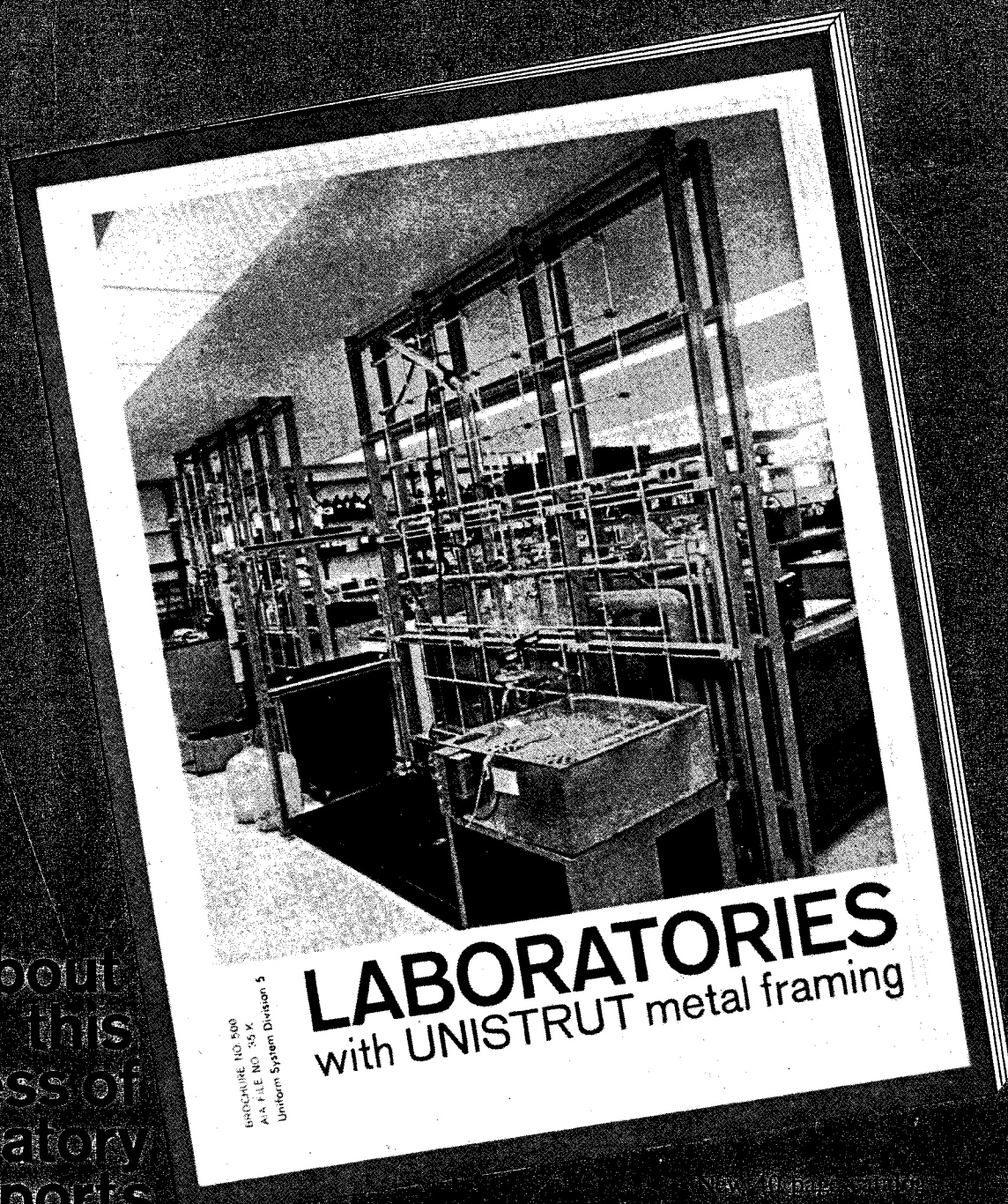
See inquiry card 41.



About this business of laboratory supports with UNISTRUT metal framing

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easy-to-handle 'paper' whiskers

WHISKER PAPER. Whiskers in an easy-to-handle paper form are available from Thermokinetic Fibers Inc., a subsidiary of General Technologies Corp., Reston, Va. The whisker paper is a felted mass of fine single-crystal fibers constructed so that whiskers are randomly oriented in the X-Y plane. A number of whisker types, including silicon carbide, sapphire, silicon nitride, and nickel-coated sapphire, is available. Circle "8" on inquiry card 35 for more details.

POLYCRYSTALLINE CERAMIC. "SPN" (sodium potassium niobate) converts electrical energy into mechanical energy—or mechanical energy into electrical energy—in advanced electronic circuits. SPN can be cut into thin sections to produce high-frequency extensional or shear mode transducers. Offered by Bausch & Lomb, Rochester, N.Y., the ceramic exhibits relatively low dielectric constants, high radial coupling coefficients, and operates over a wider range of temperatures than other piezoelectric materials. Circle "9" on inquiry card 35 for further information.

SPRAY-ON COPPER. "XP 1159" powder, a new engineering material, when melted and sprayed onto a smooth ceramic or glass, produces a highly conductive copper coating. The material is a mixture of 75% high-purity copper and 25% glass frit. The copper wires soldered to the coating withstand a pull of over 760 psi. Metco Inc., Westbury, N.Y., developed the coating. For more details, circle "10" on inquiry card 35.

SAPPHIRE ETALON. High laser peak powers, together with decreased line width and beam divergence, greater durability, and reduced scattering loss now are possible with an improved sapphire etalon available from the Crystal Products Dept. of Union Carbide Corp., New York. The material exhibits an absence of scattering sites and crystallographic misorientations of the order of minutes, compared to degrees of misorientation in conventional Verneuil sapphire. Circle "11" on inquiry card 35 for more information.

"TEFLON" PANELS. Du Pont's newly developed "Teflon-S" surface finish is now supplied on "Chemfluor" antistick panels produced by Chemplast Inc., Wayne, N.J. The panels can be used for chutes, bins, troughs, and other production equipment. The tough Teflon surface resists scratching, abra-

sion, and permits quick release of sticky materials. Circle "12" on inquiry card 35 for more details.

INTERMEDIATE RESEARCH CHEMICAL. A unique triene—bis-cyclohexenyl-ethylene—has been developed by Phillips Petroleum Co., Bartlesville, Okla. BCE is a colorless liquid, has a molecular weight of 188.3, a boiling point of 117.8 C (at 3.5 millimeters of mercury) and a specific gravity of 0.919. The product may be useful as an intermediate for plasticizers, synthetic fibers, polymers, and fungicides. For more details, circle "13" on inquiry card 35.

THORIA EXTRUSIONS. Tiny extrusions of thoria, with inner diameters of 0.02 cm, are being produced by Zirconium Corp. of America, Solon, Ohio. A full range of extruded, slip-cast, and pressed shapes is available for electrical circuit hardware subjected to high temperatures, as well as for components for high temperature fuel cells. Circle "14" on inquiry card 35 for further details.

HEXANE-HEPTANE. Signal Oil & Gas Co., Houston, has started to supply commercial quantities of 95% pure n-hexane and n-heptane. Greater specific solvency and higher average molecular weights of the solvents should make them useful in making adhesives, specialized printing inks, drugs, and rubber. Higher yields in test polymerization also are gained with the pure solvents. Both of the solvents meet the nonpollutant requirements of Los Angeles' "Rule 66." For further information, circle "15" on inquiry card 35.

METAL-DEGASSING DETERGENT. A new detergent concentrate is available from Kern Chemical Corp., Los Angeles. "DeContam" can be used for rapidly degassing metals under ultrahigh vacuum, degreasing and cleaning components, cleaning all laboratory glassware, and for decontaminating apparatus used in radioactive experiments, as well as the skin of operators. No traces of film are left after rinsing. Circle "16" on inquiry card 35 for more details.

TUNGSTEN MESH. A tungsten wire mesh is available from Richard D. Brew & Co., Concord, N.H. Originally developed and tested to provide heating elements for high-temperature vacuum furnaces, tungsten wire mesh is an excellent material where strength and the ability to withstand temperatures up to 3000 C is needed. For further information, circle "17" on inquiry card 35.

SILYLATION KIT. Thermally stable and

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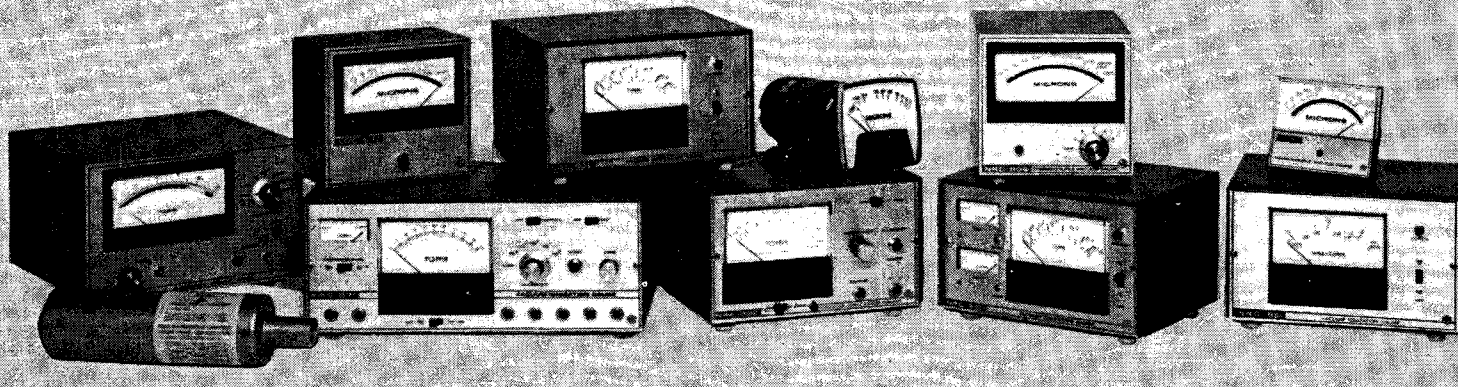

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See inquiry card 45.

volatile trimethylsilyl or dimethylsilyl derivatives of polar compounds may be produced using the new "Poly-Sil Kit." The kit is offered by Pierce Chemical Co., Rockford, Ill. Silylated derivatives have exceptional merit in gas chromatography, mass spectrometry, and in thin-layer chromatography. Circle "18" on inquiry card 35 for more information.

POURABLE SILICONE RESIN. A new, white pourable silicone resin system will cure at room or high temperatures to a flexible material, and does not lose its flexibility after prolonged exposures to temperatures of 230 C. "Eccosil 4851," made by Emerson & Cuming Inc., Canton, Mass., is useful for potting, encapsulating, and mold-making. Eccosil 4851 is made up of 100% reactive silicone resin with an inert filler that minimizes shrinkage and enhances physical strength. The system contains no solvents. Circle "19" on inquiry card 35 for data.

FIBER OPTICS. Coherent fiber optic bundles that can withstand temperatures up to 260 C are available from Bausch & Lomb, Rochester, N.Y. The fiber optics are available in connectable sections, and are fitted with standard threadings for screw-type outlets. Bundles range in length up to 1.2 m with good resolution. Circle "20" on inquiry card 35 for more details.

HIGH PURITY CHEMICALS. Barium niobate, strontium niobate, and calcium niobate are available with less than 10 ppm total impurities (with the exception of tantalum). Tantalum content is less than 100 ppm. Particle size is in the range of 4 to 12 microns. The materials have been developed by Electronic Space Products Inc., Los Angeles. For further information, circle "21" on inquiry card 35.

LIQUID FLUOROCARBON. Perfluorocyclopentene, a new cyclo olefin, is offered by Pierce Chemical Co., Rockford, Ill. The olefin, with a boiling point of 27 C (80 F), offers interesting possibilities for further synthesis of chemical compounds and polymers stemming from its double bond. It may be useful in making materials with high chemical and thermal stability. Circle "22" on inquiry card 35 for more details.

HIGH-TEMPERATURE OIL. A rugged new synthetic polyol ester lubricating oil has shown exceptional high-temperature stability. The new oil, "Nye Instrument Oil 610," is an excellent candidate for situations where continuous service above 95 C is involved. The oil is offered by William F. Nye Inc., New Bedford, Mass. For further data, circle "23" on inquiry card 35. ■

See inquiry card 47.

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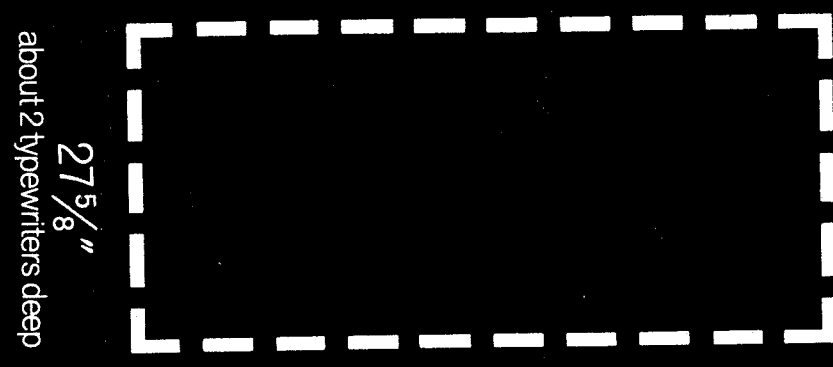

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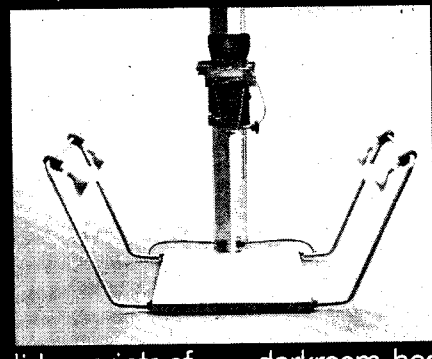

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attendees at the annual meeting of the the American Physical Society will be cast in the midst of . . .

innovation and public concern

CHICAGO—An instrument for practically every need might well be the theme of the exhibits at the annual meeting of the American Physical Society/American Association of Physics Teachers Jan. 29 to Feb. 1.

Some 9,000 physicists attending the four-day conference at the Palmer House in Chicago will see such advances as:

- A nuclear physics laboratory for student experiments at small universities.
- A modular photometric system that allows small light signals to be detected and measured in the presence of "noise."
- An image scanning instrument that can scan a photographic negative or positive print in six minutes—presenting minute changes in density and brightness as density contours.
- A new precession tool for faster data collection in x-ray crystallography.

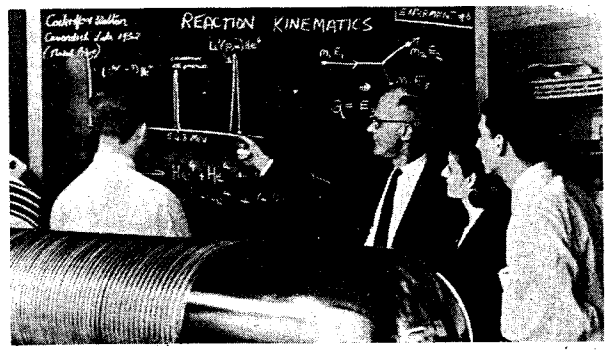
Approximately 650 papers will be delivered at the American Physical Society sessions, while 50 papers are planned by the American Association of Physics Teachers.

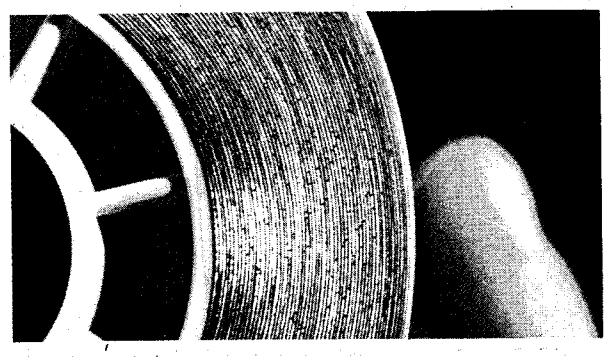
One highlight of sessions will be a separate meeting devoted to a discussion of a proposed amendment to the APS constitution.

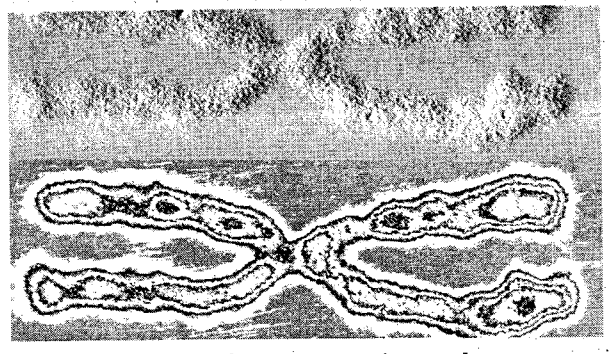
In recent months several APS members have suggested that the American Physical Society encourage discussions of public issues at its meetings and in its publications.

This proposal would allow the membership at large to vote on issues concerning the society.

A few of the more significant innovations to be displayed at the meeting appear in the following pages. *For additional information about the products, circle the appropriate number(s) on inquiry card 49.*







***VAN DE GRAAFF** accelerator, manufactured by High Voltage Engineering Corp., affords relatively inexpensive means for conducting nuclear research in the university (top). Eastman Kodak Co. will feature ultraviolet spectrography film pictured at center; beads (visible in photo) prevent the photographically active surfaces from touching while stored on reel. At bottom, "Image Quantizer," a product of Technical Operations Inc., offers 200 line/inch density profiles of photos and radiographs. A profile of a chromosome is presented (lower) along with the photomicrograph from which it was taken.*

[1] ALTHOUGH NUCLEAR PHYSICS is one of the more exciting and intellectually stimulating fields of experimental research, it has been taught with laboratory courses that probably are the most pedestrian of all modern science.

Previously only large installations with major research facilities costing millions of dollars could provide the facilities for meaningful experiments in nuclear physics.

Realizing the existing need for physics students even at small universities to experiment with the atom, High Voltage Engineering Corp., Burlington, Mass., will display its small-scale nuclear physics laboratory. The workshop, which was introduced this fall, contains classroom courses, detailed experiments, and a particle accelerator.

With the course, explains Dr. William Bygrave of High Voltage's Accelerator Div., students can extend their learning beyond textbooks. They can repeat, in a few minutes, the scattering experiment that took Sir Ernest Rutherford hundreds of hours. Or in a four-hour experiment, the lithium atom can be split.

When the course is complete, Bygrave adds, students should be prepared to undertake useful research on any accelerator.

The teaching package completed two years of experimental operation at Georgetown University where tests and course work were outlined for the laboratory handbook.

The "laboratory" consists of a 400-kV Van de Graaff accelerator, targets, radioactive sources, radiation detectors, and associated electronic gear that can be installed into a 2.7- x 6.6-meter room in about 10 days. Price, including installation, is less than $50,000.

[2] HOLOGRAPHY and laser advances will occupy an increasing number of booths at the physics show this year.

A new low-priced holographic camera system, for example, will be highlighted by Optics Technology Inc., Palo Alto, Cal. The Model 215, which has been in the development stage for the past two years, is priced at $1,995.

The system is so precisely engineered that the stability difficulties previously encountered in holographic experiments have been removed.

Stability is critical because movements of more than a fraction of a wavelength in front-illumination holograms, and smaller movements in reflection holograms, cause blurring.

To improve stability, the camera is insulated against vibration by a rigid platform, rubber foam padding, and rubber-tipped feet. A Michelson interferometer is built into the unit to measure stability.

Critical handling of the camera's reference beam is achieved without sacrificing versatility. All optical components of the system are spring-loaded for easy movement.

[3] ALUMINA CERAMIC optical flat spacers for increasing the reflectivity from laser resonant reflectors will be shown by Adolf Meller Co., Providence, R.I.

By inserting a Meller spacer between two sapphire etalons (resonant reflectors), 60 to 66% reflectivity can be achieved. An array of four etalons with three Meller spacers yields about 96% reflectivity.

The spacers, machined from Lucalox, a 99.9% pure alumina ceramic with physical properties closely matching sapphire, are lapped flat to 1/10 wavelength and parallel within one arc second. This close tolerance fabrication, the company explains, insures uniform and maximum performance. Even at 1900 C, the spacers remain stable.

[4] LASER BEAM MODULATOR, costing less than $400, will be among the several instrument innovations to be introduced at the physics show by Isomet Corp., Palisades Park, N.J.

The EOLM-400 combines Isomet's technology in crystallography with modern assembly techniques—resulting in a modulator with performance characteristics of higher priced models.

Optical bandwidth of the EOLM-400 is from 200 to 2,000 nanometers —with the capability of handling optical power approaching the same levels as the Isomet line of Q-switches.

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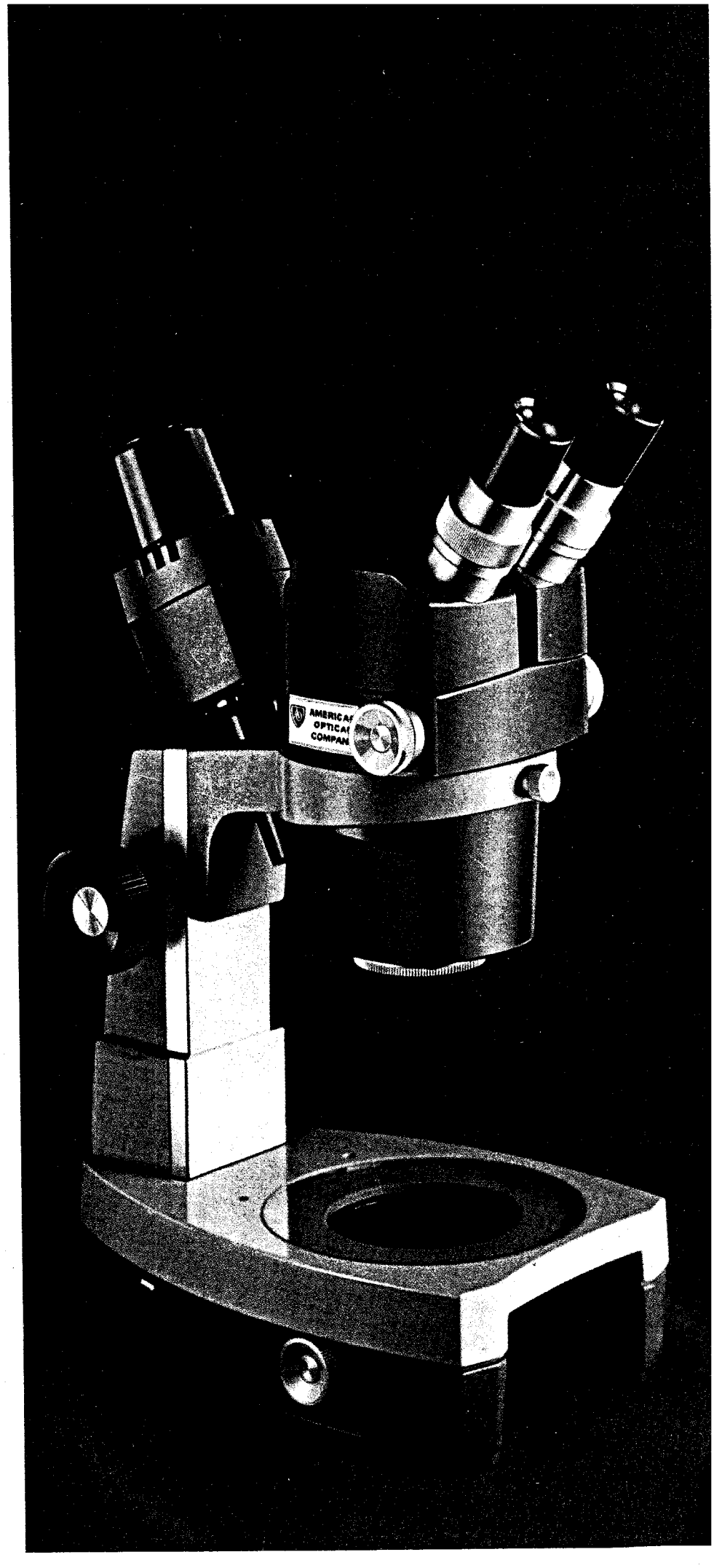


AO INSTRUMENT COMPANY

BUFFALO, NEW YORK 14215

Formerly Instrument Division of
AMERICAN OPTICAL COMPANY

See inquiry card 51.

[5] MODULAR PHOTOMETRIC system that allows small light signals to be detected and measured in the presence of "noise" will be among the new products to be shown by Princeton Applied Research Corp., Princeton, N.J.

Several new features are built into the system. The photomultiplier head has been designed to include a portion of the amplifier circuitry—thus eliminating low-level, high-impedance lines that exist in conventional arrangements.

Another unique characteristic is the photometer amplifier system. All components are housed in NIM modules that can be installed easily in standard NIM baskets.

The new design concept permits users to incorporate instruments from several manufacturers into standard racks. Modules can be interchanged with little difficulty.

[6] GATED SIGNAL AVERAGING instrument for recovering repetitive waveforms from noise will be another new product to be shown by Princeton Applied Research Corp.

The Model M160 high-resolution boxcar integrator offers improved resolution and dynamic range capabilities over conventional models by providing gate widths as small as 10 nsec — coupled with provisions for long term memory.

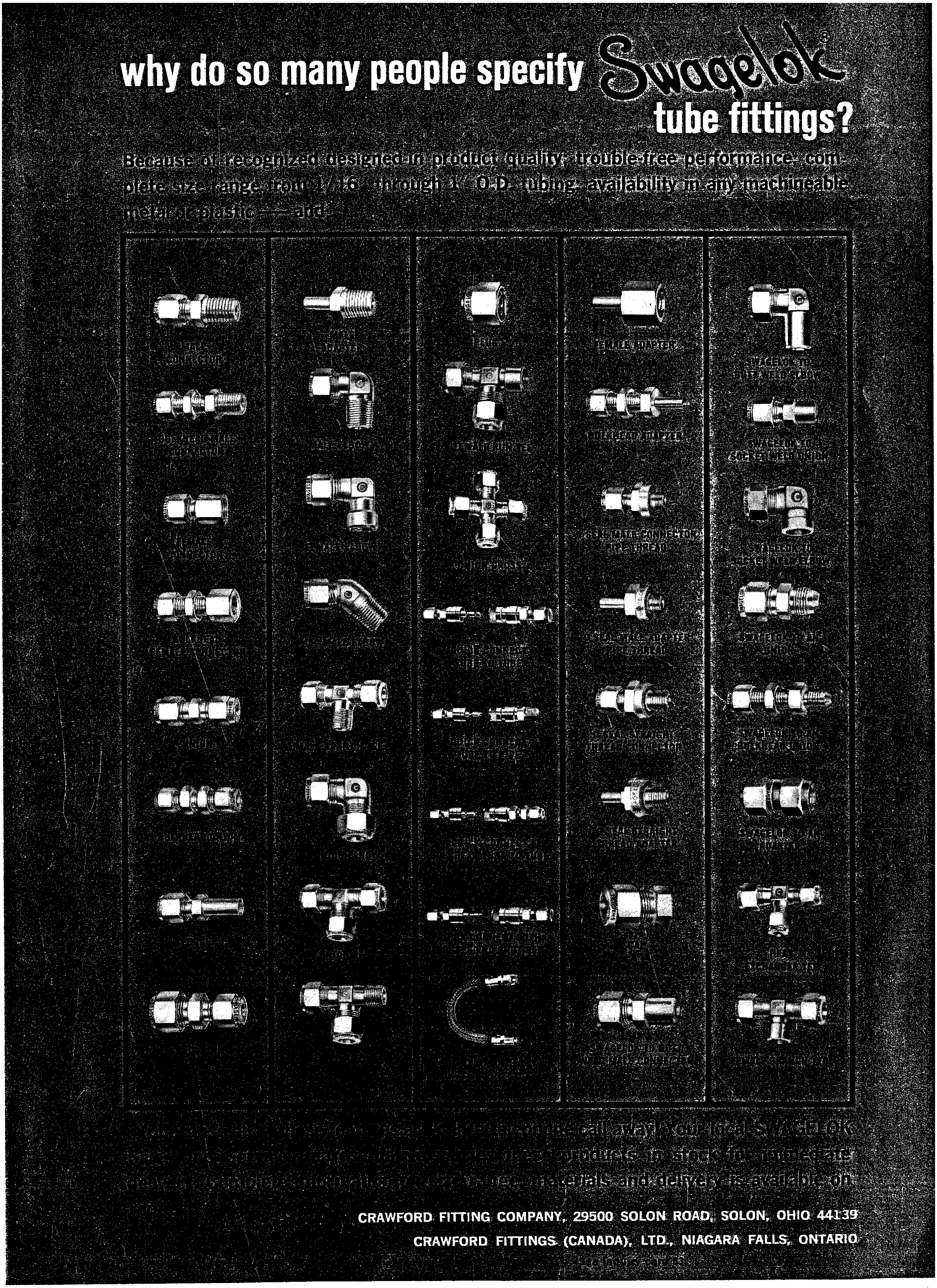
These features, the company explains, enable users to accurately observe high-time resolution responses of ultrasonic, fluorescent, laser, and pulsed nuclear magnetic resonance systems.

Nuclear-Chicago Corp., Des Plaines, Ill., will feature three new products for data handling at the physics show:

[7] COMPUTER-COMPATIBLE magnetic-tape system that permits fast recording of data collected by a multichannel analyzer system and fast return to the analyzer's memory. Flexible control of all aspects of recording with the new system allows read-in to a computer with program compatibility.

[8] PARALLEL DIGITAL stabilizer that stabilizes input energy to channel number relationship of a multichannel pulse height analyzer system. The relationship is stabilized against drifts or changes in detector sensitivity, power supply voltages, amplifier gain, analog-to-digital conversion gain, and zero calibration.

[9] AEC STANDARD MODULES for fast/slow coincidence pulse shaping and linear delay applications. Characteristic of the advances in the new research series is the capability for lead-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ing edge or crossover timing in the timing discriminator module, according to Nuclear-Chicago Corp.

[10] IMAGE SCANNING INSTRUMENT that can scan a photographic negative or positive print in six minutes and present minute changes in density and brightness as density contours will be shown by Technical Operations Inc., Radiation Products Div., Burlington, Mass.

The new "Image Quantizer," which has a printout resolution of 200 lines/in., provides a comprehensive density profile of pictorial data in an area up to 20 x 30 cm.

Prime applications for the instrument are the analysis of radiographs in biomedical research, analyzing lunar and space photographs, studying cloud densities, and the analysis of shock-test phenomena.

Three new advances will head the list of instruments to be shown by Ortec Inc., Oak Ridge, Tenn. The exhibit will feature:

[11] DIGITAL RATEMETER that serves as a scaler and ratemeter. The Model 434, contained in a standard NIM package three modules wide, is claimed to be the only unit of its type to include these two functions in a single unit. A buffer memory stores data accumulated during the printout cycle, according to Ortec.

[12] A PARTICLE IDENTIFIER, Model 423, said to be the first NIM unit to identify particle type and the sum energy of E and ΔE detectors, separating protons, deuterons, tritons, ^3He, and ^4He particles.

[13] BASELINE RESTORER that hikes count rate capabilities to 100,000 counts/sec by restoring waveform to d-c level. The Model 438 is a one-unit-wide NIM module.

Typical of the many other innovations to be included in the roster of the January meeting are:

[14] ULTRA-HIGH VACUUM gages and controls from Amperex Electronic Corp., Vacuum Products Dept., Hicksville, Long Island, N.Y. The Model VC-600 Pirani/ionization vacuum gage control unit can be used for stable pressure indication of medium, high, and ultra-high vacuums, covering the wide pressure range of 1.0 to 10^{-11} torr.

[15] PHOTOSENSITIVE MATERIALS from Eastman Kodak Co., Rochester, N.Y. One special feature will be the Kodak Special Film, Type 101-01, for vacuum-ultraviolet radiation recording. The I·R 100 award-winning product, with a sensitivity below 2,000 angstroms, makes it possible to supply ultraviolet film in rolls for extended inspace flights.

[16] PHOTON SPECTROMETER, another I·R 100 award winner, with unique capabilities for both nuclear research and applied spectroscopy. The spectrometer, available in both vertical and horizontal versions, was developed by Technical Measurement Corp., San Mateo, Cal. The instrument provides rapid analysis of characteristic x-rays of elements above argon in the periodic table.

[17] PRECESSION SYSTEM, a new crystallographic tool from Materials Research Corp., Orangeburg, N.Y. MRC explains the new system, which offers several new concepts in determining crystal structure, provides easier reading, intrinsic alignment accuracy, less operator error in adjustments, greater range in crystal studies, and faster data collection than conventional models. Temperature capabilities range from 700 C to −150 C, according to Materials Research Corp.

Next month, the *Industrial Research* Advance Conference Report will cover the 19th Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy in Pittsburgh, Mar. 3 to 8. —DOLORES A. FREDERICK, ASSISTANT EDITOR. ■

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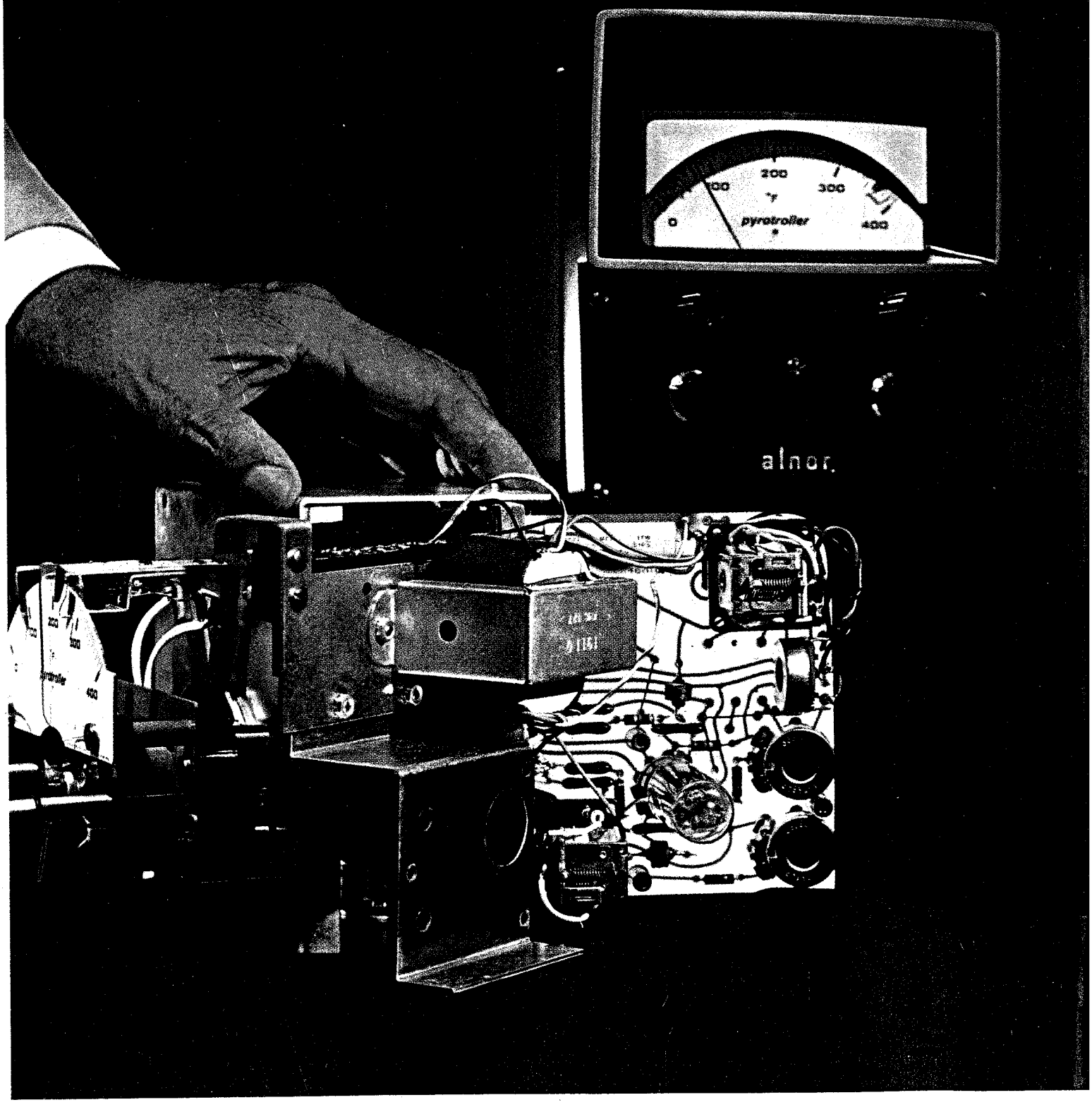

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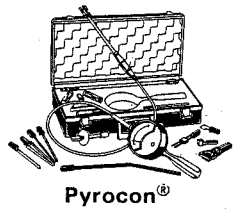

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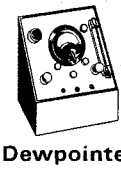
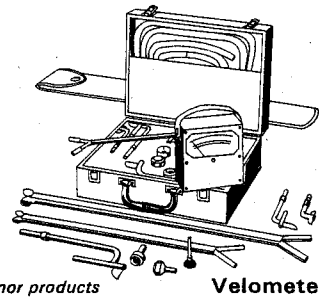


Dewpointer



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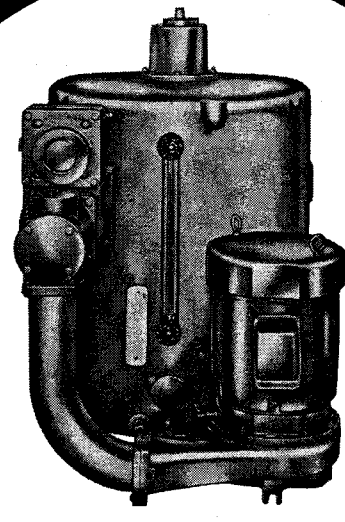

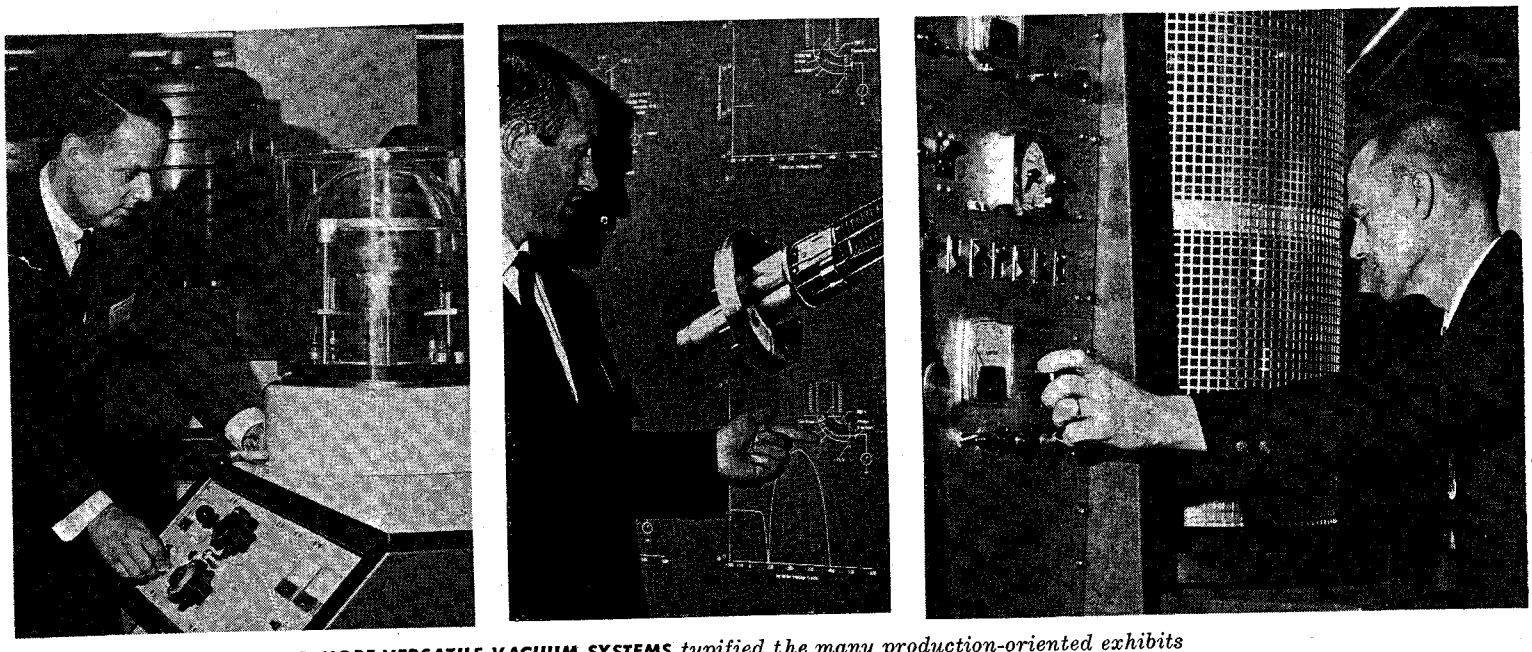

I•R STAFF PHOTOS

BIGGER PUMPS AND MORE VERSATILE VACUUM SYSTEMS *typified the many production-oriented exhibits at the AVS Vacuum Show. At the left, Edwards High Vacuum Inc.'s national sales manager, George Schmidt, demonstrates a new vacuum coating unit. Burdell Kietzmann, market research manager, Varian Vacuum Div., points out features of Helmer high vacuum gages (center). At right, General Electric's rapid cycle high vacuum system is operated by Thomas A. Pollock, product specialist.*

standard lines replace one-of-a-kind products

MORE MANUFACTURERS are stressing vacuum equipment designed for production—rather than "one-of-a-kind" pure research devices, according to indications at the 14th annual American Vacuum Society Symposium & Show in Kansas City.

Vacuum pumps are bigger and feature higher capacities; measurement systems seem to stress better accuracies; more automation (hence, more ease of operation) is evident; and there is a proclivity toward designing or improving systems for production.

Typical of the latter is Vacuum Processes Inc.'s new "Vac-u-lok" unit intended to revolutionize vacuum deposition of thin films. The Dallas firm explains that batch techniques—necessary previously because of problems with moving parts in and out of vacuum—can be eliminated. Substrates now travel through the device on a conveyor belt, are vacuum-deposited, and then unloaded—without disturbing the vacuum.

Another production-oriented device exhibited by Materials Research Corp., Orangeburg, N.Y., is a new d-c/rf sputtering module that pushes thin film deposition rates up to 1,100 angstroms per minute. MRC claims to have doubled sputtering rates for tantalum and copper—compared to those possible with standard cathode deposition methods.

The Edwards High Vacuum Inc. (Grand Island, N.Y.) Model E12E vacuum coater does lean closer to the research side. It also features a wire feed mechanism to allow prolonged coating operations without breaking vacuum. In addition, the E12E contains an electron bombardment evaporation source for difficult-to-evaporate metals.

Kinney Vacuum Div., New York Air Brake Co., Boston, introduced a positive displacement mechanical booster pump which features no blocking pressure limitations, operation at maximum efficiency over a wide range of low pressures, and a lack of sealing oil to provide a cleaner pumping action compared to conventional oil-sealed mechanical high vacuum pumps or oil ejector varieties.

High rate production is the intended goal for users of General Electric Co.'s rapid cycle high vacuum system.

Shown by GE's Vacuum Products Section, the unit can be pumped down quickly at the touch of a button. The vacuum system features a large usable sump area—about 50 centimeters in diameter by 25 cm high—and a 76-cm-high bell jar to provide adequate working space for a variety of projects. Rapid cycling is accomplished by a combination of sump, triode ion, and titanium sublimation pumps.

In other activities at the vacuum show, Paul A. Redhead, noted vacuum gage researcher, was elected president of the society. A graduate of England's Cambridge University, Redhead now leads the electron physics section of Canada's National Research Council. He succeeds Dr. Herbert W. Schleuning, who is professor of physics at Polytechnic Institute of Brooklyn.

Dr. Paul J. Bryant, associate professor of physics at the University of Missouri at Kansas City, is the new secretary-clerk for the American Vacuum Society.

Dr. Daniel G. Bills, president of Granville-Phillips Co., Boulder, Colo., was elected society treasurer. Dr. James M. Lafferty won out as president elect. He is manager, Plasma and Vacuum Physics Branch, General Electric R&D Center, Schenectady, N.Y. □

200 kilogauss goal

NEW "SURPRISES" about atomic structure are the major possible dividends from Stanford University's Linear Accelerator Center (SLAC). But just as possible are major advances in cryogenic technology.

One example is the study that may lead to large-bore, high-gauss superconductive magnets.

Basis of this possible breakthrough is a completely new design principle developed by the magnet research group at SLAC headed by Dr. Habibo Brechna.

Brechna's group designed the current 2,270-kilogram magnet that generates a 70-kilogauss field with an energy of 5-million joules in a big bore measuring 30.5 centimeters in diameter by 68.6 cm long.

The current supermagnet is cooled by circulating liquid helium around copper tubes containing thin filaments of niobium-titanium superconductor material.

The proposed new approach is to imbed the superconductor filaments in the walls of a hollow copper tube. The liquid helium coolant would flow inside the tube—with the added benefit of much higher efficiency.

SLAC calculations show the hollow tube coil provides a current density of 5,000 amp/cm². By comparison, the old design has a density of only 3,500 amp/cm².

Brechna now expects to be able to build another 70-kilogauss superconducting magnet—this time with a bore of 1.5 meters diameter by 1.8 m long. This system could increase greatly the accuracy of particle measurements at SLAC.

"Normally, we say that the diameter of the coil times the square of the field determines the bending radius of the particle," states Brechna. "The larger the bore and the higher the field, the more we can bend the path and the better the measuring accuracy. For the same field, with five times greater bore diameter, we can operate at an accuracy of at least a factor of five better."

A proposal to build the new supermagnet will be submitted to the Atomic Energy Commission next month. Approval is dubious, however, due to budget restrictions. But if AEC gives Brechna a go-ahead, the new device could be completed in about one and a half years.

Beyond this, SLAC hopes to increase field strengths by using new superconducting materials. Niobium-titanium alloy has a limit of 80 kilogauss. If niobium-tin is used instead, fields as high as 200 kilogauss may be reached. □

I•R STAFF PHOTO

IMPROVES STICKING
Stephens examines electron gun

surface effect 'gages'

AN IMPORTANT BYPRODUCT of the new double vacuum Molsink chamber just placed in operation at the Jet Propulsion Laboratory, Pasadena, Cal., is new instrumentation for measuring surface effect phenomena.

Very accurate devices were required to measure changes of materials and microorganisms in the simulated "molecular sink" of space. To meet these requirements, the JPL Space Simulators & Facility Engineering Section designed a new cryogenic quartz crystal microbalance and cryogenic quadrupole mass spectrometer.

As James B. Stephens, senior research engineer, told *Industrial Research*, the first of these basically is a much more accurate version of the quartz crystal used in thin film monitors for solid state electronic work. The JPL unit has demonstrated a sensitivity of 10^{-10} gm/cm² in measuring all gases except helium.

Even so, the unit was not quite sensitive enough for part of one Molsink study, the effect of hard vacuum on microorganism spores.

These tests are intended to find out whether undesirable microorganisms on Mars landing craft will be killed on exposure to vacuum. The spores are coated on the crystal and exposed to the vacuum. Changes in spore structure result in mass changes and, hence, frequency variations in crystal oscillations.

Initial tests have shown grossly that the spores die, but greater sensitivity is needed for more detailed analysis of the time-temperature history of the process. Thus, Stephens' group is working on a new crystal design to go to 10^{-12} gm/cm².

The second instrument, a quadrupole mass spectrometer, should provide detailed data on the bases coming from the surface under study. JPL believes the current program is the first in which such a device will be operated at 4 K.

The instrument has the great advantage of eliminating the background problem in mass spectrometry work. Unlike previous systems, JPL reports, the Molsink spectrometer data is not degraded by outgassing from the instrument's own surface. □

hydrogen mystery solved

SCIENCE HAS KNOWN for some time that crystal forms of solid hydrogen —and its heavier isotope, deuterium— sometimes were cubic rather than normally occurring hexagonal.

But until just recently, nobody knew why.

Hoping to add to man's fundamental understanding of the basic structure of matter, Drs. Adam Schuch and Robert Mills delved into the strange supercold world of cryogenics to solve this mystery. Both are chemists at the Los Alamos Scientific Laboratory, Los Alamos, N.M.

While studying x-ray photographs, the two scientists noted that hydrogen and deuterium of the hexagonal type change to the cubic if cooled to almost 2 K. The exact temperature at which the change takes place seems to depend on certain properties of the hydrogen and deuterium molecules.

To pinpoint the cause, Schuch and Mills studied diffracted x-rays with a Geiger counter—giving them a continuous picture of the nature and progress of the change. They found that crystal structure change is caused by a shift of certain layers of molecules relative to other layers.

Specifically, the Los Alamos scientists say, it is the nuclear spin of the hydrogen molecule that affects the hexagonal-to-cubic transition temperature. When the atomic nuclei of the molecule spin in one direction, one type of structure forms. Should the two nuclei spin in the same direction, another structure results.

When hydrogen or deuterium are made up of molecules with similar nuclear spin, the cubic building blocks

See inquiry card V3. ▸

New Veeco "776" Thin Film Evaporator is manual!

Now the ultra-clean Veeco 7¾" evaporator is available in an improved, manual version. The new VE-776M includes several improvements in the design of the vacuum system, including a new reliable butterfly-type high vacuum valve. More important, however, the design is offered in a very straightforward configuration, with minimum accessory controls and devices. It offers only what is absolutely necessary for you to do a quality job—which includes the Veeco double baffle and *all* stainless steel high vacuum system. The VE-776M is useful for every thin-film job. It is especially valuable to installations that require the very best, but must have it with maximum economy. Write for more information now.

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form at a higher temperature than they do when some of the opposed-spin molecules are present.

In addition, if more than about 40% of the molecules are opposite spinners, the crystal remains hexagonal—probably right down to absolute zero. On the other hand, the cubic structure will not go hexagonal unless the temperature is raised considerably higher than that at which it first forms.

Finally, the more opposed-spin molecules there are present, the more reluctance there is for the molecule to turn back to hexagonal. □

Europe's new simulator

EUROPE'S LARGEST space simulator has been commissioned at the European Space Technology Center, Noordwijk, Holland.

Any space probe, experiment, or satellite to 3 meters in diameter can be tested in the stainless steel chamber. Three vacuum pumps, each with a pumping speed of 50,000 liters/second, produce a vacuum of 10^{-7} torr within 2½ hours—ensuring only radiative heat loss as in space.

The internal surface of the simulator is shrouded with an aluminum liner containing 1,200 m of piping through which liquid nitrogen is piped at a rate of 10,000 liters/hr to maintain the surface at a temperature of −173 C.

The liner simulates the cold blackness of space surrounding a satellite in orbit apart from the surfaces exposed to sun radiation. Solar heat is simulated by directing a beam of light, with a spectrum near to that of the sun, from a bank of 19 (6½-kilowatt) xenon lamps through a 50-cm-diameter quartz window.

Orbital movements of the satellite can be reproduced by using a special support to provide rotation in two axes.

A central console, incorporating a mimic diagram that indicates the state of all important functions, is used to control the facility. □

luminescent CdS

ELECTROLUMINESCENCE from vapor-grown cadmium sulfide (CdS) devices has been observed at 4.2 and 77 K in experiments at Massachusetts Institute of Technology's Lincoln Laboratory, Lexington, Mass.

Although luminescence has been observed before in activated CdS, the mechanism here appears to be quite different.

Emissions in the activated materials can be attributed to transitions involving deep impurity levels, notes Dr. J. F. Butler, a member of the Lincoln technical staff.

"However, the luminescence I see is essentially band-to-band. There's some indication of impurity levels, but it's at the higher energy."

The lines are very similar to those observed in electron-beam-pumped lasers, but there seems to be no adequate explanation for the excitation process. One speculation suggests that it results from ionization of electron-hole pairs by hot electrons. The average electric fields are 10^4 V-cm^{-1} when the effect is observed.

Results were obtained using high-purity vapor-grown platelets having zero-bias resistivities greater than 10^7 ohm-cm. Contacts were indium. Luminescence at the contact edges became evident at about 10 A-cm^{-2} dc, increasing rapidly with current, varying as $I^{3.6}$ over three orders of magnitude in a typical device at 77 K. □

'cooler' computers soon

SUPERCONDUCTIVITY'S IMPACT on space, high energy physics, and controlled fusion programs has been considerable — especially since the phenomenon was a laboratory curiosity but a few years ago.

On the other hand, the superconductor's invasion of the computer technology is less spectacular but equally promising. At least two papers presented at the recent Applied Superconductivity Conference at the University of Texas in Austin gave scientists and engineers a look at some aspects of the new age in computers.

Dr. Vernon L. Newhouse, physicist, and Joseph L. Mundy, electronic engineer—both from General Electric Co.'s R&D Center, Information Sciences Laboratory, Schenectady, N.Y., told of a new multi-aperture cryogenic storage cell.

Employing a recently developed cryogenic sensing technique—labeled "current stretch" — the cell allows transformation of the information into a persistent input current in a cryotron amplifier.

One result is that the signal caused by cell switching becomes proportional to magnetic flux change. Consequently, fast access current rise time, pickup noise cancellation, fast cell switching, and separate sense lines are eliminated in the new cell.

"Operating tolerance of these cells is only limited by their geometry. They have no metal-to-metal contacts, use only three metal layers including the ground plane, and can be switched arbitrarily slowly," Newhouse and Mundy explained.

Replacement of random access memories with high-speed content-addressable memories (CAMs) for some computer operations was the premise of Scott A. Keneman, technical staff

member, Radio Corp. of America Laboratories, Princeton, N.J.

He declared that large capacity, superconductive thin film CAMS would be feasible because of high information packing densities and low power dissipation.

"Some 5 x 10^5 bits of CAM storage in a cubic foot working volume at liquid helium temperatures seems to be a reasonable hardware design goal."

Keneman's theoretical refrigerator would hold approximately 200 glass substrates — each measuring approximately 10 by 15 centimeters. Each substrate would contain some 2,500 CAM cells. Such a memory should retrieve words at a repitition rate of 100 microseconds/word. □

'new breed' chamber

ANOTHER OF THE "NEW BREED" of fourth generation space simulation chambers is going up on the San Francisco peninsula.

The huge facility—featuring a 30-ft-diameter by 31-ft-high work area enclosed in a 38.5-ft-diameter stainless steel sphere—is reported to be the first of its size to employ the latest in contamination free pumping.

"Basically, we have eliminated diffusion pumping. Backstreaming from the pump adversely affects sensitive packages and optical equipment in the chamber. We circumvented this by going to so-called selective pumping," states Donald E. Richardson, project manager for the Philco-Ford Corp. chamber.

Philco-Ford's Space & Re-entry Systems Div. is building the facility at its Palo Alto, Cal., location.

Richardson told *Industrial Research* that the chamber will be able to achieve vacuum below 10^{-9} torr "clean, dry, and empty."

Leon V. Omelka, a Philco-Ford engineer and the space chamber's principal designer, stated: "We are taking the past experiences of all other space chamber builders and incorporating them into one advanced chamber. While our specification limit is 10^{-9} torr, I think this chamber will also achieve 10^{-10} torr pressures. However, the vast bulk of our testing with spacecraft and satellite systems will require only about 10^{-5} torr."

Richardson and Omelka detail the chamber's operation: Rough pumping will be done with mechanical blowers. Then a 70-watt helium refrigerator and cryopanel array takes the pressure down further. Two titanium sublimation pumps finally pull the vacuum down to near the desired pressure. In addition, ion pumps pull out noble gases if required.

In all, the desired working vacuum can be achieved in about 7 hours.

The current schedule calls for pulling the first vacuum in September of this year. In addition, studies of future needs for the $3.5-million facility will determine whether or not to add a solar simulator, which would make the chamber suitable for tests involving men in space suits.

"We already plan to supply the thermal equivalent of the sun through arrays of quartz lamps. The one big problem with adding solar simulation is the many dollars involved. We're going to have to study our needs pretty closely to justify spending what could add up to another $4-million or more. □

vacuum lab manual

LABORATORY EXPERIMENTS for students of chemistry, physics, and horticulture abound in number. In most cases, the supply exceeds the demand.

Unfortunately, however, just the opposite holds for vacuum science and technology it seems.

Consequently, the American Vacuum Society and its education committee have decided to cast about for suitable experiments among its members. Dr. John A. Dillon Jr., committee chairman and dean, Graduate

School, University of Louisville, called for experiment suggestions.

He says the experiments — geared for departments of basic science and engineering—could be in any of the various areas of pumping, gage calibration, or in physical measurements made under vacuum conditions. They will be incorporated into a laboratory manual to be prepared under supervision of Dr. V. J. Harwood, Dept. of Physics, University of British Columbia, Vancouver.

"Ideally your suggestions could be written up in exquisite detail, but if you merely have a bright idea concerning one, please feel free to submit this to Prof. Harwood. When we do decide which experiments to include, full credit will be given," Dillon adds. □

salty thermometers

CEROUS MAGNESIUM NITRATE recently has gained wide-spread popularity among cryogenic researchers. The salt has been found quite useful in obtaining and measuring temperatures below 2 K.

Previously determined temperature scales, however, exhibited a reliability that was somewhat questionable.

So, Drs. R. P. Hudson and R. S. Kaeser, research physicists, Institute for Basic Standards of the Commerce Dept.'s National Bureau of Standards, decided to find out why.

The NBS scientists obtained the necessary low temperatures by means of adiabatic demagnetization. They read the temperatures from susceptibility measurements indicated by a magnetic thermometer.

In this instance, Hudson and Kaeser employed a specimen of CMN as the core of a mutual inductance.

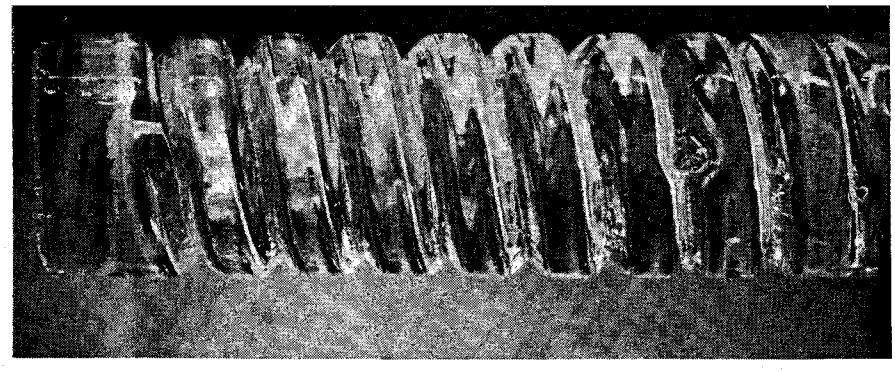
CMN already appeared ideal as a thermometer based on magnetic susceptibility because its paramagnetic susceptibility follows the Curie law down to near 0.006 K. Hudson and Kaeser's findings supported this.

In addition, their research refuted earlier work that pinpointed the region of rapid fall-off of entropy at 0.003 K. The new fall-off point was established at 0.0015 K.

One particularly intriguing property of CMN appeared when Hudson and Kaeser made cylindrical specimens of compressed CMN powder for use as a magnetic thermometer. They found strong suggestions that the powdered CMN exhibits Curie law behavior all the way down to 0.002 K.

For the latter anomoly, some of the reasons guessed included specimen shape and CMN's extreme magnetic anisotropy.

In any event, the inorganic salt is proving out as a valuable tool in the field of cryogenics. □



HELICAL 'THREAD'
shaped by electron beam in 0.5-in. silica

versatile glow discharge beams

HIGH VACUUM ELECTRON BEAM machining techniques may soon face some stiff competition from a less expensive and far more versatile innovation.

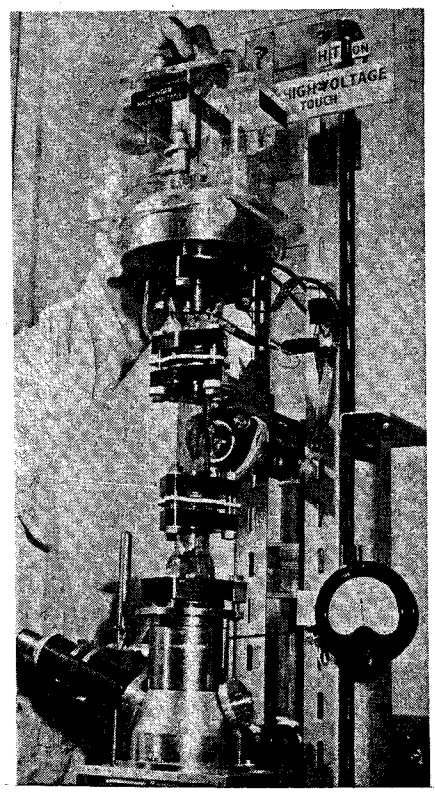
Still under development, the promising new technique—glow discharge —could become a cutting and welding tool with wide industrial application.

Research engineer R. A. Dugdale explains that glow discharge is quite similar to neon sign display lighting.

"Briefly, it offers a method of directing a beam of electrons or ions onto a workpiece. Beams of any shape can be designed—broad area, a thin sheet of particles, or very finely focused," he states.

Dugdale, working at the United Kingdom Atomic Energy Research Establishment, Harwell, England, has found that glow discharge operates in a low vacuum of about 10^{-1} torr, and it can be applied to any material—including ceramics. In contrast, conventional electron beam techniques employ vacuums approaching 10^{-6} torr and do not allow quick and easy access to the workpiece.

MILLING MACHINE
electron beams cut ceramics



The latter, conventional machining method also is restricted to metals because electron bombardment of insulating materials would set up negative charges — repelling the electron beam. On the other hand, glow discharge performs in an electrically conductive plasma that carries away any electric charge on the workpiece.

Dugdale's experiments at Harwell already have shown the glow discharge technique's utility for cutting and profiling silica and alumina.

"We focused the beam finely enough to machine a track as small as 0.025 millimeter (0.001 inch) wide and deep. This was done with a 100-watt machine that produces a power density of a megawatt/square centimeter," Dugdale says.

Other demonstrations include welding two pieces of alumina together. Existing equipment will weld materials up to ⅛ inch (3.2 millimeters) thick. Nearly 10 times the present power density will be required for inch-thick materials.

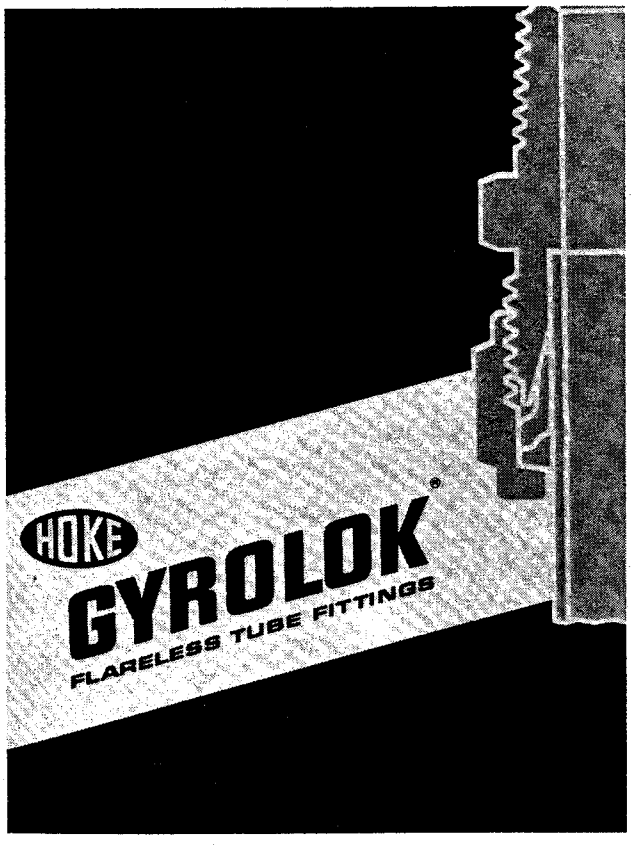
Sapphire crystals grown by the Verneuil technique employed two glow discharge electron beams, which were aimed into a liquid puddle in the top of the sapphire.

Dugdale also has deposited silica on an alumina substrate using one beam to evaporate the silica and another to preheat the alumina.

"Here is another useful quality of the glow discharge method. There is no contamination of the gun by atoms that have been evaporated off the workpiece—a frequent happening with high vacuum electron beam operations," he declares. "Instead of traveling in straight lines, free atoms are diffused by the gas and can be condensed on surfaces appropriately placed."

According to Dugdale, less than $280 will build a fine focus glow discharge electron gun with 1 kilowatt power. Vacuum systems and power supply bring the total cost to less than $580 — substantially less than comparable high vacuum electron beam equipment. Remove the fine focus requirement, he adds, and the cost

THE FIRST THREE YEARS ARE THE HARDEST!



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See inquiry card V7.

drops considerably by comparison.

As yet, glow discharge machining remains a laboratory technique. An inherent limitation is the need for even a low vacuum and manipulation of the workpiece by machine tool methods. Also out of the question for the foreseeable future is the prospect of a hand-held electron gun because of x-ray and high voltage hazards. □

ICs in cryosurgery

INTEGRATED CIRCUITRY is finding new applications in the supercold of cryosurgery.

With an exclusive amplifier design, electronics engineers at PMF Electronics Inc., Dayton, Ohio, are saying that surgeons will be able to control temperatures in cryoprobes to within 1% accuracy.

The device, which employs ordinary copper-constantan thermocouples for temperature indication, already is planned for a new cryosurgery instrument designed by Union Carbide Corp.'s Linde Div.

Surgeons merely dial the desired cryoprobe temperature—in the range from zero C to −196 C—and the PMF device controls liquid nitrogen flow to the probe.

Operations with the still relatively new surgical technique of cryosurgery in effect are matters of deep-freezing live tissue and removing it easily. Surgery that once required days of recuperation now can be completed in minutes, with the patient leaving the hospital scant hours later. □

bubble chamber bellows

BIG BUBBLE CHAMBERS promise to take high-energy physicists closer to understanding of subnuclear particles. Consequently, scientists at Argonne National Laboratory (Argonne, Ill.) are building what will be the world's largest bubble chamber.

As usual, though, planning such a large device and building it are two different tasks.

Dr. E. Gale Pewitt, manager of the chamber project, points out that one of the major hurdles has now been passed—constructing a huge steel bellows that allows flexing of a large piston designed to maintain a constant pressure of 90 psi—all at liquid hydrogen temperatures.

When particles from Argonne's Zero Gradient Synchrotron enter the bubble chamber, pressure is momentarily relieved by the piston, allowing the hydrogen to boil along the paths taken by the particles.

Pewitt explains that the 386-cm-diameter, 2,180-kilogram bellows employs type 316L stainless steel because of its excellent properties at the bubble chamber's near-absolute-zero operating temperature.

In addition, designers first predicted the bellows would operate for at least 50-million cycles. Now they say it should exceed this performance limit by a comfortable margin. □

ring of ion pumps

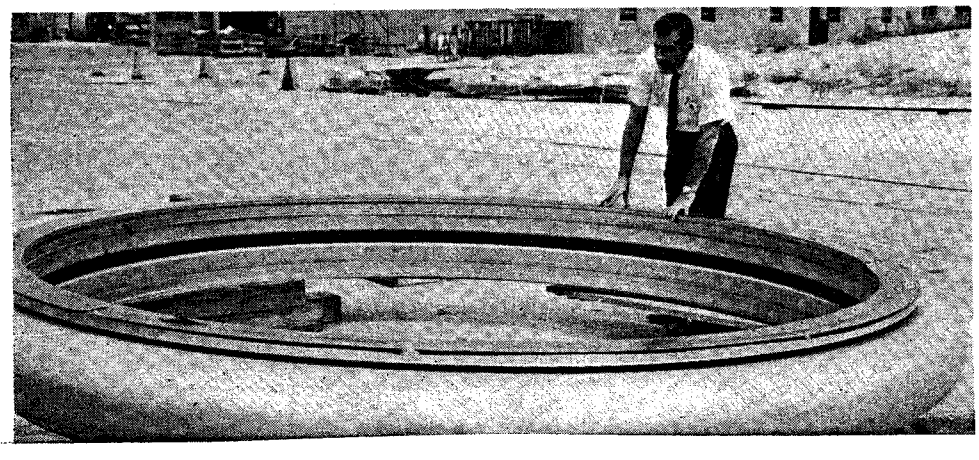
A RING OF MORE EFFICIENT ion pumps will make possible harder vacuums at Brookhaven National Laboratory's 33-billion electron volt Alternating Gradient Synchrotron.

The first 10 production pumps of a total of 240 were delivered to the Upton, N.Y., facility, last month by Hughes Aircraft Co.'s Vacuum Tube Products Div. When all 240 are installed around the rim of the 805-meter circumference of the chamber, a vacuum of 10^{-7} torr will be attained instead of the current 10^{-6}.

Hughes engineers state the pump can maintain nearly constant pumping speeds over a pressure range from 5×10^{-6} to 10^{-8} torr. Overall pressure range is 10^{-2} to 10^{-11} torr.

The pump is already in use in many other vacuum applications. A major change in the units delivered to Brookhaven is incorporation of a new demountable high voltage feedthrough. This permits replacement in case of damage. However, the new feedthrough has been ruggedized to minimize chances of breakage. ■

WORLD'S LARGEST TOROIDAL BELLOWS
destined for Argonne's 12-ft hydrogen bubble chamber



VACUUM/CRYOGENICS LITERATURE

cryogenics handling needs special rules

SAFETY WITH CRYOGENIC FLUIDS by Dr. Michael G. Zabetakis, Plenum Press, 227 W. 17th St., New York 10011, 156 pp, $11.50—provides a complete and concise exposition of safety rules, design data, first aid precautions, and hazard control procedures. The author emphasizes basic principles rather than specific applications, which should permit an individual to conduct safe operations with low temperature materials under a wide variety of conditions.

MATERIALS OF HIGH VACUUM TECHNOLOGY: METALS AND METALLOIDS, Vol. 1, by Dr. Werner Espe, Pergamon Press Inc., 122 E. 55th St., New York 10022, 912 pp, $45—offers an exhaustive treatment of metallic materials used in high vacuum technology. As the first of an intended three volumes, or more, this reference work examines closely the physical and chemical properties of metals and metalloids and outlines specifics of the materials' technical applications.

HIGH PERFORMANCE DEPOSITION SYSTEMS, 8 pp, CHA Industries, 1215 Chrysler Dr., Menlo Park, Cal. 94025. Circle "20" on Card V11.

HIGH VACUUM MODULES AND PUMPING STATIONS, 8 pp, CHA Industries, 1215 Chrysler Dr., Menlo Park, Cal. 94025. Circle "21" on card V11.

VACUUM COAXIAL SWITCHING SYSTEMS, Brochure No. 108, 8 pp, International Telephone & Telegraph Corp., ITT Jennings Div., 970 McLaughlin Av., San Jose, Cal. 95108. Circle "22" on card V11.

"AUTOMATE" CONTROL VACUUM COATERS, Bulletin No. 2-14, 4 pp, Consolidate Vacuum Corp., 1775 Mt. Read Bl., Rochester, N.Y. 14603. Circle "23" on card V11.

"AUTOMATE" CONTROL PUMPING SYSTEMS, Bulletin No. 4-6, 4 pp, Consolidated Vacuum Corp., 1775 Mt. Read Bl., Rochester, N.Y. 14603. Circle "24" on card V11.

VACUUM PRESSURE RELIEF DISKS, Bulletin No. C13-67, 2 pp, Statics-Dynamics Inc., Cryolab Div., 1155 Sunset Dr., Los Osos, Cal., 93401. Circle "25" on card V11.

SERIES SC-20 RAPID CYCLING TITANIUM PUMPED HIGH VACUUM SYSTEM, 4 pp, Andar Corp., 185 East Evelyn Av., Mt. View, Cal. 94041. Circle "26" on card V11. ■

See inquiry card V9.

Ivor Brodie appointed director of Varian Vacuum Div. research

Dr. Ivor Brodie has been appointed director of research, Vacuum Div., Varian Associates, Palo Alto, Cal. An alumnus of London University, Brodie started in microwave tube research at Varian in 1962. Recently, he directed development of a new electrostatic process graphic recorder.

Dr. William Manogue, senior research chemical engineer for E. I. du Pont de Nemours Co., Wilmington, Del., has been loaned to the University of Colorado Chemical Engineering Dept. for one year as a visiting lecturer. Manogue will continue work at the university on application of adsorption isotherms to catalytic reactions at cryogenic temperatures—between 40 K and 90 K. Consulting for the project is *Dr. Klaus D. Timmerhaus,* associate dean of the university's College of Engineering, and last year's recipient of the Samuel C. Collins award for his contributions to cryogenics.

CVI Corp., Columbus, Ohio, announced the appointment of *Douglas W. Porrey* as sales engineer. Previously he was with Airco Cryogenics in marketing and technical service for rare gases, liquid neon, and liquid helium, as well as development of cryogenic food-freezing equipment.

Robert O. Johnson has been named manager of sales for Aero Vac Corp., Troy, N.Y. He formerly was district sales manager for New York and Eastern Canada. A graduate of University of Southern California's School of Engineering, Johnson came to Aero Vac from General Electric Co.

industry notes

Leybold-Heraeus GmbH, West Germany, is the new parent firm of the U.S.-based vacuum systems manufacturer, *Heraeus-Engelhard Vacuum Inc.,* Monroeville, Pa. The new firm, which will become one of the largest vacuum equipment producers in the world, resulted from a merger between Heraeus Hockvakuum GmbH and Leybold Nachfolger KG. Combined sales were last reported as $25-million. The new firm commands 60% of Europe's high vacuum market and employs some 2,400. Because of an expected increase in sales volume resulting from the merger, Heraeus-Englehard now is doubling the size of its Monroeville facilities.

Development and manufacture of new scientific instruments and vacuum equipment are the plans of a new joint company—*Nippon Electric Varian Ltd.* in Tokyo. Varian Associates, Palo Alto, Cal., and Nippon Electric Co., Tokyo, collaborated in forming the new international venture.

Air Products & Chemicals Inc., Allentown, Pa., employs a 20,000-gal cryogenic storage tank for liquid nitrogen to supply Eastman Kodak Co. with high purity nitrogen gas. Built at Kodak's Rochester (N.Y.) facilities, the plant produces 27,000 ft³/hr with total impurities of less than 5 ppm. Kodak contracted for the GN_2 generator to assure a "highly reliable, independent" source of large quantities of nitrogen. The cryogenic liquid also can be vaporized for an uninterrupted supply of gas in case of power failure.

Medical-grade liquid oxygen and liquefied industrial gases (such as nitrogen) will be produced in another *Air Products & Chemicals Inc.* plant due to go on-stream this summer. The $6-million plant, located in Wharton, N.J., is expected to produce 500 tons/day for use in electronics, metalworking, food processing, and refrigerated transport.

Four British steel strip producers, supported by the *British Iron & Steel Research Assn.,* are pooling $100,000 to set up a test plant this month for vacuum coating steel. BISRA's technologists say the plant, which should be in production some time in February, will be located at the association's Sketty Hall, Swansea, Laboratory. The four — Steel Co. of Wales, Richard Thomas & Baldwin Ltd., Colvilles Ltd., and John Summers Ltd.—are showing high interest in depositing "duplex" finishes that are 1/5 as thick as hot-dipped galvanizing but equally corrosion-resistant.

Design and construction of new low-temperature, air separation plants is the purpose of a joint venture between *Air Reduction Co.,* and *British Oxygen Co.* The new firm, Airco-Boc Cryogenic Plants Corp., will allow Air Reduction to manufacture cryogenic plants for the first time. In addition, the British-based counterpart, Boc-Airco Cryogenic Plants Ltd., will open U.S. markets to British Oxygen. In the venture, Air Reduction will trade cryogenic processing know-how and knowledge of the U.S. market for British Oxygen's manufacturing capabilities and facilities. ■

low-cost, compact LEED device for surface structure studies

Further information about vacuum & cryogenics new products and processes in the following columns may be obtained by circling the appropriate number on inquiry card V11. The inquiry cards may be used as a convenient abstract of products offered in this issue. For fast response to inquiries, use the postage-paid I·R envelope provided.

[1] LOW ENERGY ELECTRON diffraction devices find current wide value in the study of surface structure and composition of several materials. Veeco Instruments Inc., Plainview, N.Y., recently announced availability of the Model LM-1000 LEED device that features advantages of both low cost and compactness.

The instrument can be employed for examining field-effect transistor surfaces—both MOS and MIS—to make reproducible devices, stress corrosion cracking in alloy metallurgy, catalytic surface effects, surface absorption-desorption characteristics of single crystals, and other basic physical and chemical crystal phenomena.

Continuous display of crystalline diffraction patterns is possible because of a 3¼-in.-diameter, fully hemispherical phosphor screen. In addition, a Veeco exclusive is a process allowing suppressor grids manufactured to tolerances within 0.001 in. of a perfect hemisphere.

Grids are hard-chrome-plated, type 304 nonmagnetic stainless steel. Three of them placed concentrically within the hemispherical display screen provide almost total elimination of background light. Circle "1" on card V11 for more information from Veeco.

[2] VACUUM FORMING machines incorporating a completely new concept of platen design and operation have been introduced by Osborn Mfg. Corp., Warsaw, Ind. Designed for forming thermoplastic sheets, the units fill individual manufacturers' needs for specially engineered models—but within "standard" price ranges. Platens descend to floor levels for quick installation or removal of mold assemblies, and unusually deep draws are possible without increasing the machine's height. Optional adjustable frame attachments also are available to allow use of variable dimension sheets—up to ½-in. thicknesses. Circle "2" on card V11 for more information.

[3] ROTARY FEEDTHROUGHS with intermediate and high speeds, coupled with high torque rotation, now are available from Materials Research Corp., Orangeburg, N.Y. MRC developed the low-cost units to introduce linear rotation as an answer to a growing list of applications in high vacuum space simulation chambers, linear accelerators, zone refining devices, and infrared systems. Of the four new units offered, two are magnetically coupled and two are bellows sealed. Model V4C-102M, for example, is a magnetically coupled feedthrough capable of achieving maximum operational speeds up to 15,000 rpm—compared to the nearest commercially rated speed of 750 rpm. MRC's bellows type Model V4C-103B device features a well balanced torque of 25 in./lb at a high revolution of 500 rpm. Circle "3" on card V11 for further details from MRC.

[4] VACUUM COUPLINGS designed for use at bakeout temperatures and high pressures have been introduced by Cajon Co., Solon, Ohio. The new VCR couplings are type 316 stainless steel — available in tubing diameters from 1/16th to 1 in.—that will operate to 9,000 psi. Features include socket weld ends for easy welding or brazing; no axial clearance is necessary for disassembly; special ports are provided for helium leak testing; and gaskets of aluminum, nickel, OFHC copper, and "Teflon" are available. Circle "4" on card V11 for additional technical information.

[5] PORTABLE HELIUM LEAK detector with a sensitivity to 10^{-10} atm-cc/sec is a development of Varian Associates, Vacuum Div., Palo Alto, Cal. The low-cost detector — Model LD-50 — consists of a lightweight control module connected to an analyzing tube by a 7-ft cable. Customer-specified metal-gasket flanges or standard O-rings seal the analyzer tube to any vacuum system. Filament material made of pure rhenium assures long life in the self-cleaning ion gun. All operational controls are included in the portable module—along with a standard-equipment audible alarm that signals leak rate by a change in audio frequency. The Model LD-50 indicates leaks in vacuum systems or components, furnaces, helium-pressurized components, or it can be used to upgrade the electronics of obsolete leak detectors. Circle "5" on card V11 for more information.

[6] HIGH VACUUM FEEDTHROUGHS for ultrahigh frequency applications are

the development of Ceramaseal Inc., New Lebanon Center, N.Y. The new connector-type, low-power devices simultaneously feature quick-disconnect provisions and are rated for operation to 1 kv rms. Bakeable to 450 C, each feedthrough has a high alumina ceramic insulator bonded high-vacuum-tight to a cap and flange of 42% nickel-iron alloy. This flange in turn is brazed or welded to a type 304 stainless steel vacuum flange or adaptor. Ceramaseal bonds the alumina and nickel-iron in high vacuum furnaces by the active metal process. Tightness is checked on a helium mass spectrometer sensitive to 10^{-9} cc/sec STP. Circle "6" on card V11 for information on custom designs and prices.

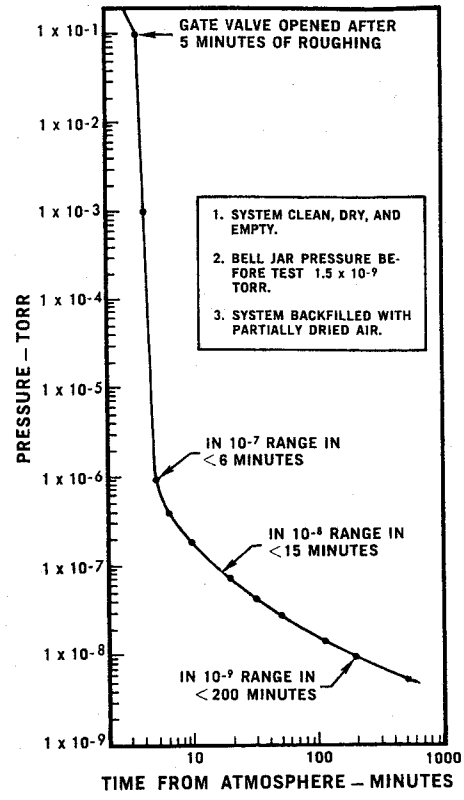
[7] ENVIRONMENTAL TESTING for power transmission cable products to meet higher standards of quality control now is available in a new chamber from Cincinnati Sub-Zero Products Inc., Cincinnati. Designated the Model HWU-100-16, this device provides specific environments for testing thermoplastic-insulated wires and cables in controlled temperature ranges from +75 to −110 F, as well as at 50% to 90% humidity conditions. The 16-ft³ stainless steel chamber is used for determining such parameters as water absorption, dielectric retention, ozone discharge, U-bend discharge, and corona levels. Circle "7" on card V11 for details.

[8] CRYOGENIC RESEARCH DEWAR that offers greater heat removal capacity, over a greater temperature range at greater efficiencies than previously available, is the product of Janis Research Co., Stoneham, Mass. In the "Super Vari-Temp," cryogens from the main dewar reservoir are bled into the sampling volume via a throttling valve — which eliminates drawbacks such as with conventional devices where varying exchange gas pressures cause an inherent low temperature limitation. Consequently, expensive liquid helium is wasted at higher temperatures. Other features of the Janis dewar are: fast turn-around time of 5 min from room temperature to below 4 K; possible temperature range from below 1.5 K to 300 K; and efficient sub-lambda operation. In the latter event, only the sample volume is pumped, which leaves the main helium reservoir at 4.2 K. Circle "8" on card V11 for more technical details about the Super Vari-Temp.

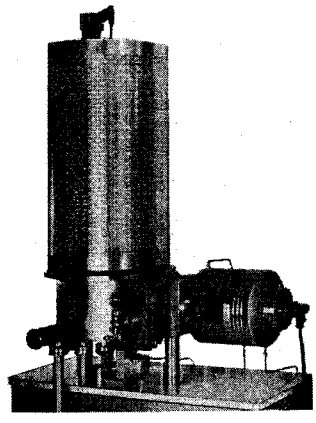
[9] CRYOGENIC ATTACHMENTS for use with x-ray diffractometers are the latest development of Andonian Associates, Waltham, Mass. This variable temperature device—designed for use with Siemens, Picker, and General

COMPARE

pumping performance per dollar



Actual pump down curve for the 18 in. x 30 in. Viton sealed bell jar system shown below. The system was filled with partially dried room air, roughed down, and the gate valve opened at 1 x 10^{-1} Torr. A standard 1600 liter/second Electro Ion pump then produced the results shown above.



Compare the performance of Granville-Phillips' *new* electrostatic getter-ion pump with any other dry vacuum pump. For nearly the same investment, the Electro Ion gives you approximately three times the pumping speed . . . the extra speed that produces results such as shown above.

Note also that it's a lightweight, compact, magnetless pump that mounts in any position; supported only on its flange. Compare its low ultimate pressure, automatic starting feature, stability in the presence of argon . . . or any other characteristic. We think you will agree the Electro Ion is a better solution to your problems in clean pumping.

Need more information to make your comparison? Write us . . . we will send complete technical information. Call us . . . we will have a field engineer at your door promptly. Visit us . . . at our plant for a demonstration.

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Advancing Vacuum Technology

See inquiry card V13.

Electric diffractometers—provides users the opportunity to study samples spectroscopically in a temperature continuum from 1.5 K to 400 K. Advantages here are significant improvement of spectral resolution, minimal background noise, and increased resolution of secondary spectral features —all as a result of lowered temperatures. Andonian's attachment allows sample changing without removing or dismantling the dewar; complete precision positioning of samples is possible, including ±30-degree rotation about a horizontal axis. Optional accessories give temperature control to ±0.001 K. Circle "9" on card V11 for more details.

[10] LIQUID NITROGEN TRAP FILLER introduced by Vacuum Industries Inc., a subsidiary of GCA Corp., Alexandria, Va., provides smooth flow of LN_2 in cold traps, shrouds, and cryogenic transfer lines in a self-contained unit. The Model MVRC 1296 features automatic venting and level control in any LN_2 system to achieve constant fluid and pressure levels as well as continuous supply in the liquid phase—even with slow or intermittent flow rates. VI's device is completely insulated, and it is a nonelectronic mechanical system requiring no flushing or purging. The float-operated trap filler excludes water vapor or other contaminants by means of an exhaust valve that closes as liquid levels rise or when gas pressure drops below 3 psig. When the pressure again rises, the exhaust valve automatically opens to protect both the valve and the system. Circle "10" on card V11 for further information.

[11] VACUUM EVAPORATOR with speed, efficiency, and time-saving advantages of fully automatic control is available from Varian Associates, Vacuum Div., Portland, Ore. The new Model VE-30 incorporates fail-safe features for protecting personnel, equipment, and processes against power failures, implosion, gross leaks, and negligence. Pumpdown to 10^{-6} torr takes only 7 min; working vacuum is in the 10^{-8} torr range. Included with the Model VE-30 are a stainless steel, 6-liter-capacity cold trap with an anticreep baffle; a 1,440 liter/sec diffusion pump; a 2-kva filament power supply; a Pirani gage; and a Bayard-Alpert ionization gage with seven linear scales covering the range between 10^{-4} and 2×10^{-10} torr. Its 18- x 30-in. work area is ideal for thin film deposition work, RF sputtering, and materials testing. Circle "11" on card V11 for more details.

[12] SOLAR PLASMA WIND SIMULATOR designed for spacecraft instrumentation calibration has been introduced by Physics Technology Laboratories, La Mesa, Cal. With the simulator, proton beams from 10- to 30-cm diameters are produced for research on materials to determine long-term exposure effects of physical properties. The continuous and parallel, large-diameter beams are space-charge neutral, are pure up to 95%, and have densities to 10^8 particles/cm^3. In addition, the device can deliver controlled proton energy for the range from 100 to 5,000 electron volts. Plasma beams of gases other than hydrogen also can be produced with controlled energies in the 2- to 10-electron-volt range. Circle "12" on card V11 for data.

[13] FREEZE ETCH APPARATUS from Denton Vacuum Inc., Cherry Hill, N.J., allows freeze etching of plant, animal, and even inorganic materials by sublimation in high vacuum. The Model DFE-2 freezes biological material—usually in aqueous suspension—for later sectioning under the high vacuum. After metal shadowing and carbon replication, electron micrographs of the material show cell structure details in depth. DFE-2 features adjustable temperature control from −190 C to ambient and can be cycled in less than 30 min. Circle "13" on card V11 for data.

[14] ION SUBLIMATION system for such research applications as environmental testing, long-term materials studies, and thin film research has been introduced by Consolidated Vacuum Corp., Rochester, N.Y. Completely portable, the table-top Model CVI-12 features a "Quick Start" ion pump and a triode element for argon pumping that is five to 25 times higher than conventional diode pumps. Helium speeds are 2½ times higher. The vacuum chamber is a nominal 12-in.-diameter by 18-in.-high bell jar with guard and is equipped with eight feedthrough ports. CVC's Quick Start pump, vertically mounted on the baseplate, starts reliably at pressures from 50 to 100 millitorr. Also, the only external service required is 115-vac, 4-amp, single-phase, 60-cps power. Circle "14" on card V11 for more information from CVC.

[15] OIL QUENCH VACUUM FURNACE of revolutionary design provides precision, versatility, economy, and safety in a single furnace—combined for the first time—used for hardening, brazing, annealing, and other heat-treating operations, according to its developers, C. I. Hayes Inc., Cranston, R.I. Designated the Model VCQ, the Hayes furnace is unusually flexible in offering both atmosphere and liquid quenching. Vacuum gives the "universal atmosphere" for coping with materials that would otherwise require several furnaces and atmospheres—endothermic or exothermic gases, dissociated ammonia, and hydrogen. Circle "15" on card V11 for more information about the Model VCQ furnace.

[16] TANTALUM ELEMENT VACUUM furnace designed for annealing reactive metals, degassing, diffusion bonding, and stress relieving has been introduced by Vacuum Industries Inc., Somerville, Mass., a subsidiary of GCA Corp. The new cold wall type high temperature furnace operates at temperatures to 2900 F at vacuums in the 10^{-6} torr range. Called the Model 2118-1600 (Series 3400), it employs tantalum strip heating elements— six of which are individually connected to water-cooled electrodes. Fast, positive pumpdown results from a high speed diffusion pump and a 50-cfm combination mechanical pump. Also, valves are pneumatically operated and sequence controlled for full automatic operation. Circle "16" on card V11 for complete details.

[17] VACUUM CAPACITANCE MANOMETER that employs solid-state logic circuits and a precision tapped binary ratio transformer has been introduced by MKS Instruments Inc., Burlington, Mass. The new low pressure device features automatic, high accuracy, a-c null balance readout from a variable capacitance sensor. The Series 100 "Baratron" displays absolute or differential pressures—to as low as 10^{-5} torr—directly on a five-place nixie tube readout. A sixth place indicates over-range readings. Parallel electrical outputs are supplied either in BCD or 18-bit straight binary form. Repeatability of the device is given as 0.2% of reading, plus one digit. Maximum resolution—including use of a residual voltage interpolator meter—is one part in 10^7. Circle "17" on card V11.

[18] TURBO-MOLECULAR PUMPING units from Welch Scientific Co., Skokie, Ill., incorporate new pumping speeds of 260 liters/sec and a guaranteed ultimate of $1\text{-}2 \times 10^{-9}$ torr. In addition, overall height has been reduced to 36¼ in.—compared to an earlier 43¼ in. The completely redesigned Model 3102D also is noncontaminating to the vacuum system, is self-cleaning, uses no pumping fluids, does not permit backstreaming of the fore pump oil or lubricating oil, will remove effectively all hydrocarbons in the system, and will pump all gases including noble gases. In addition, the device offers easy leak detection, will pump helium without danger of re-ejection, and cannot be damaged by high pressures. Circle "18" on card V11 for more data. ■

VACUUM/CRYOGENICS MEETINGS

FEB. 19-MAR. 1: Short Course—Vacuum Technology 869.1, Univ. of California at Los Angeles. (Contact Director, Engineering & Physical Sciences Extension, Univ. of California Extension, Box 24902, Los Angeles 90024.)

MAR. 7-8: Society of Vacuum Coaters Annual Conference, Fontainebleu Hotel, Miami Beach. (Contact Gene Nixon, publicity chairman, Society of Vacuum Coaters, Box 3095, Cleveland 44117.)

MAR. 18-20: Intl. Symposium on Chemistry & Cold, Nice. (Contact Societe De Chimie Industrielle, 80, Route De St. Cloud, 92 Rueil, Malmaison, France.)

MAR. 24-28: Intl. Conference on Vacuum Ultraviolet & X-Ray Spectroscopy of Laboratory & Astrophysical Plasmas, College Park, Md. (Contact Director of Institutes, University College, Univ. of Maryland, College Park, Md. 20740.)

APR. 3-5: IEEE Intl. Conference on Magnetics (Intermag), Sheraton Park Hotel, Washington, D.C. (Contact Dr. J. M. Lommel, General Electric Research & Development Center, Box 8, Schenectady, N.Y. 12301.)

APR. 3-5: Symposium on Engineering Aspects of Magnetohydrodynamics, University of Tennessee Space Institute, Tullahoma. (Contact Director, Continuing Education, University of Tennessee Space Institute, Tullahoma, Tenn. 37388.)

APR. 7-10: European Cryogenic Engineering Conference, Brighton, England. (Contact c/o Heywood & Co., Callton House, Great Queen St., London, WC 2, England.)

APR. 15-25: Short Course on Vacuum & Cryogenics Technology with Application to Space Science, University of Tennessee Space Institute, Tullahoma, Tenn. (Contact Director, Continuing Education, University of Tennessee Space Institute, Tullahoma, Tenn. 37388.)

APR. 17-19: Intl. Union for Vacuum Science General Meeting on Technique & Applications, Manchester, England. (Contact Technical Secretary, 47 Belgrave Square, London, SW 1, England.)

APR. 17-20: Intl. Vacuum Congress, Renold Bldg. of the Manchester College of Science & Technology, London, England. (Contact Secretary, Joint British Committee for Vacuum

HELIUM REFRIGERATOR
. . . from *Airco Kryosystems* mounts directly on your superconducting dewar. The "Turbo-Expander" refrigerator/liquefier operates continuously without noise or vibration. Rate it 40 watts at 4.7 K or 125 watts at 20 K. Return this card for full details from Kryosystems.
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GAS PURIFICATION SYSTEMS
. . . in standard and custom controlled inert atmosphere recirculating models for space-age R&D and production are available from *Vacuum/Atmospheres Corp.* Sensitivity is one part per million O_2 and H_2—with an optional N_2 capability. Return card for more data.
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260 LPS PUMPING
. . . of all gases, including the nobles, may be obtained with the new *Welch* 3102D low profile, turbo-molecular, ultra-high vacuum pumping unit. The caster-mounted system is just 36¼-inches high. It is equipped with a by-pass pumpdown line. Return card for full information.
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FLUID CONTROL SYSTEMS
. . . frequently use tubing in their make-up today. *Hoke Inc.* can help you keep up with this trend. A group of Hoke valves with integral "Gyrolok' tube connections have been added to the extensive line. Return this inquiry card to receive a free catalog.
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PRODUCT-PROCESS DATA
. . . on developments mentioned in "Vacuum/Cryogenics Products & Processes." Simply circle the appropriate number and return.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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'ELECTRO ION' PUMP
. . . from *Granville-Phillips Co.* is a new electrostatic getter-ion device that provides three times the speed of comparably priced pumps. Lightweight and compact, the Electro Ion features low ultimate pressure and automatic starting. Return card for details.
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GATE VALVES
. . . from *Heraeus-Engelhard Vacuum Inc.* are all stainless steel and feature wafer-thin design, over-sized openings, and bellows sealing. Valves are applicable for vacuums of up to 10^{-10} torr, and they are bakeable to 200 C. Return this card for Bulletin 22-06.
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KNOW YOUR MARKET
. . . when you plan a new venture, expand your product line, or seek reasons for lagging sales. The Research Dept. of *Industrial Research Inc.* can define your market with surveys, projects, and data-gathering. Return this card to learn about I•R's market research capability.
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Science & Technology, 47 Belgrave Square, London, SW 1, England.)

APR. 28-MAY 1: Institute of Environmental Sciences Annual Technical Meeting & Equipment Exposition, Chase-Park Plaza, St. Louis. (Contact Domenic N. Cerasuolo, Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, Ill. 60056.)

JUNE 9-12: Cryogenic Society of America/Illinois Institute of Technology Cryogenic Technology Symposia, Clinics & Exposition, Sherman House/IIT, Chicago. (Contact Dr. Harold Weinstock, Dept. of Physics, Illinois Institute of Technology, Chicago 60616, 312/225-9600.)

JUNE 10-13: American Vacuum Society Vacuum Metallurgy Conference, Beverly Hills, Cal. (Contact Larry W. Sink, arrangements chairman, Vacuum Metallurgy Div., American Vacuum Society, Pratt & Whitney Aircraft, Middletown Plant, Middletown, Conn. 06458.)

JUNE 24-27: AFSC Symposium on Bioastronautics & the Exploration of Space, San Antonio, Tex. (Contact Jack Harmon, symposium coordinator, Southwest Research Institute, Box 2296, San Antonio, Tex. 78206.)

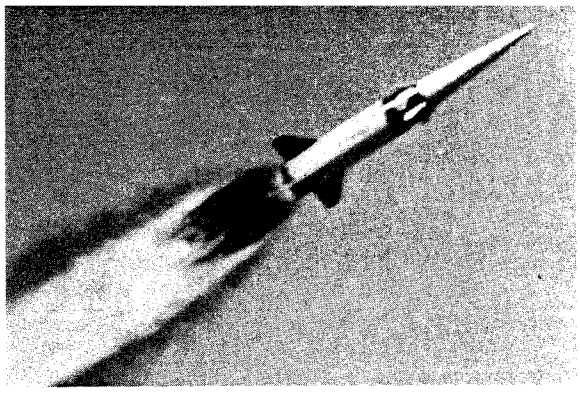
JUNE 25-28: IEEE Conference on Precision Electromagnetic Measurements, National Bureau of Standards Laboratories, Boulder, Colo. (Contact Donald D. King, Aerospace Corp., Box 95085, Los Angeles 90045.)

AUG. 19-21: National Research Council of the National Academy of Sciences & Engineering Cryogenic Engineering Conference, Case Western Reserve University, Cleveland. (Contact Dr. Richard H. Kropscnot, technical program chairman, Cryogenic Engineering Conference, Natl. Bureau of Standards, Boulder, Colo. 80302.)

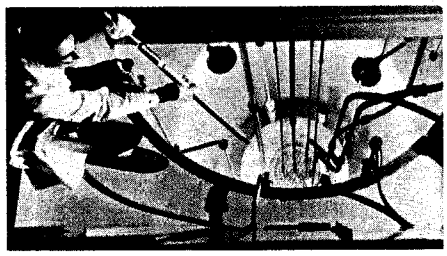
AUG. 21-28: Short Course on Low Temperature Physics, Univ. of St. Andrews, North Haugh, St. Andrews, Scotland.

OCT. 28-31: Instrument Society of America Conference & Exhibit, Statler Hilton Hotel & Coliseum, New York. (Contact Mr. O. W. Williams, Conference Program Coordinator, Instrument Society of America, 530 William Penn Place, Pittsburgh 15219.)

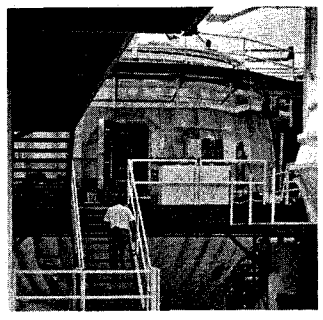
OCT. 29-Nov. 1: American Vacuum Society Annual Symposium, Hilton Hotel, Pittsburgh. (Contact W. J. Lang, Westinghouse Research Laboratory, Beulah Road, Churchill Borough, Pittsburgh 15235.) ■



"The 4% or less increase is a considerable drop from the average R&D annual growth rate of about 12% for the last 15 years. Part of this percentage decrease can be attributed to a larger dollar volume, but signs of a leveling off have been evident for several years."

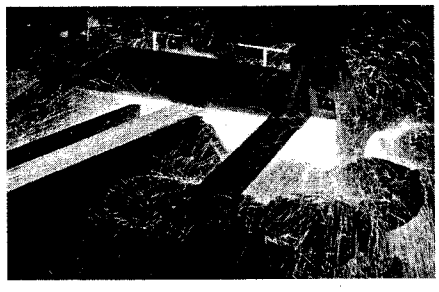


"Three federal agencies (Dept. of Defense, NASA, and Atomic Energy Commission) again will spend more than 90% of the government's $15.5-billion R&D budget, but the distribution will change with the recent cut in the space budget and growth in defense funding."

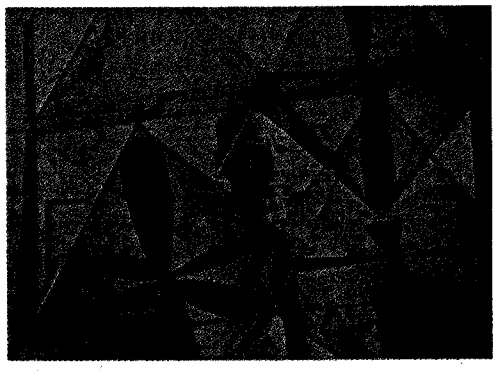


"NASA has been hardest hit by the government R&D slowdown. Nearly all of the post-Apollo planetary programs have been killed or deferred. From a peak civilian employment of 421,000 in the space program in 1966, the personnel figure is expected to drop to 260,000 during the coming year."

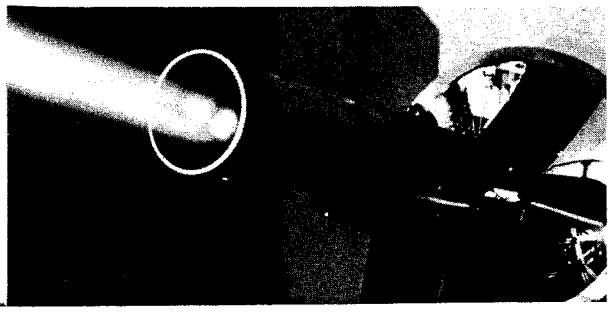
$25-BILLION FOR RESEARCH



"Industry will finance about $8.5-billion of the total R&D effort, compared to $7.8-billion in 1967 . . . Following the usual pattern, industry will perform almost $17.3-billion, or 65%, of the $25-billion R&D total."



"The research industry is passing through a transitional period that could bring about a much lower and earlier plateau in R&D support than anyone anticipated. Although R&D expenditures will continue to rise, it appears that the research industry has lost the momentum that it had during the late 1950s and the early 1960s."



"It is unlikely that there will be an upsurge or redirection of R&D unless the Vietnam war is settled—or until more government and industrial leaders recognize the full impact of science and innovation in our society and the far-reaching implications of curtailing such efforts."

Vietnam costs, 'soft' economy, and cutback-minded Congress cause slowdown in **R&D EXPENDITURES.** *The research growth will drop off to 4% as the level of spending approaches $25-billion during the coming year.*

by **Dr. Victor J. Danilov,** *executive editor, and the staff of* Industrial Research

THE COMING YEAR will be a difficult one for the nation's research industry.

Vietnam war costs, a jittery economy, the Presidential election, and an economy-minded Congress will have a serious dampening effect on research and development activities.

Although the nation's R&D spending will continue to climb, the overall increase will be the smallest since 1955.

It appears that total research and development expenditures will increase only from about $24-billion to slightly less than $25-billion, or 4%, in 1968.

If conditions should worsen, the amount of the increase could be even less—perhaps as little as $500-million instead of almost $1-billion.

The 4% or less increase is a considerable drop from the average R&D annual growth rate of about 12% for the last 15 years. Part of this percentage decrease can be attributed to a larger dollar volume, but signs of a leveling off have been evident for several years.

The average annual R&D growth rate for 1953-58 was 15.8%, but it declined to 9.5% for 1959-65. The growth slipped to about 8% in 1966 and to around 5% in 1967.

The federal government, which was responsible for the R&D funding surge in the 1950s, also has caused the recent slowdown in research support.

Federal R&D programs experienced only a nominal increase last year, and will have to struggle to avoid a decrease in 1968. All federal research administrators have been told to hold the line or to reduce spending, and not to launch any new R&D programs unless imperative to the national defense or welfare.

Only the increased cost of doing research (higher salaries, more costly equipment, etc.) will keep the federal R&D expenditures from being lower than in 1967.

As has been the case in recent years, most of the increase in R&D spending in 1968 will come from industry. But even in industry, research and development activities are being inhibited by the lack of government support, a "soft" economy, and an unclear view of the future.

The basic problem seems to be that the Johnson Administration and Congress no longer are convinced that it is necessary, or even desirable, for the nation to have a high level of R&D support.

When it became evident last fall that federal funds for nonmilitary activities were going to be scarce, Congressional leaders quickly singled out federal R&D for pruning—even suggesting a 10% across-the-board cut.

Instead of pointing out the need for increased research and development to stimulate technological progress and to improve the nation's general welfare, the Administration began to roll back R&D programs.

As a result, many companies reacted by holding up R&D plans until they could determine the extent of the government slowdown.

The government move also caused concern among universities and other nonprofit organizations, which depend heavily upon federal funds.

The R&D outlook, therefore, will continue to be muddled until President Lyndon B. Johnson clarifies the Administration's position on research and spells out the coming fiscal year budget plans.

A grim outlook

At the moment, the R&D picture appears as follows:

■ TOTAL R&D EXPENDITURES. The nation will invest between $24.5- and $25-billion in research and development in 1968, with the figure likely to be closer to the latter. This is an increase of about 4% over the nearly $24-billion spent in 1967. The totals do not include more than $1-billion for physical plant.

■ SOURCES OF FUNDS. The federal government again will provide the bulk of R&D funds, despite the "hold-the-line" policy. Of the predicted $25-billion total, about $15.5-billion, or 62%, will come from Washington. This is an increase of $300-million over last year. However, if the Administration continues to keep the lid on R&D funds, the government's share could remain closer to the $15.2-billion level for 1968.

Industry will finance about $8.5-billion of the total R&D effort, compared to $7.8-billion in 1967. But the industrial figure could fluctuate, depending upon changes in government spending and the economy. Seventy-five large research-oriented companies participating in the annual *Industrial Research* forecast survey reported they planned to increase R&D expenditures an average of 6.8%, compared to nearly 12% estimated by the same companies last year.

No major change is anticipated in the support of research and development by universities and other nonprofits, where the funding levels are approximately $800-million and $200-million, respectively.

■ PERFORMANCE OF R&D. Following the usual pattern, industry will perform almost $17.3-billion, or 65%, of the $25-billion R&D total. In 1967, industry was responsible for $16.6-billion of the dollar volume. Nearly all of the $700-million increase will come from company funds.

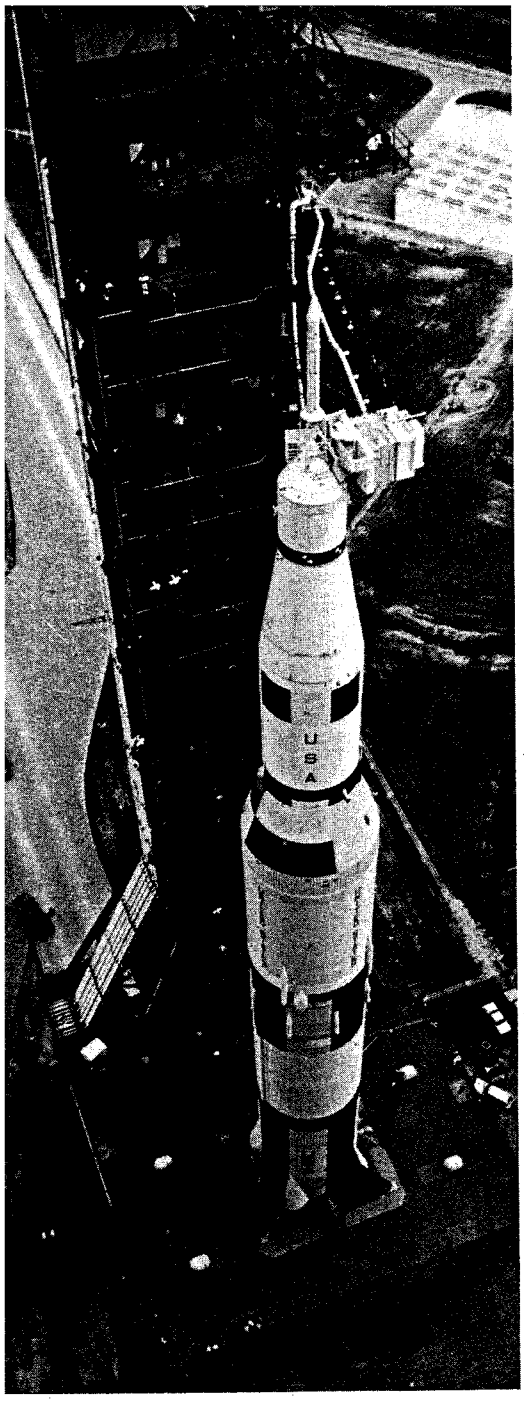
Federal laboratories will handle less than $3.5-billion of the government's $15.5-billion R&D expenditures. This is only about $100-million more than the 1967 in-house load.

The R&D volume of universities, which conducted slightly more than $3-billion in research last year, will climb to almost $3.3-billion. Of this amount, about $700-million will come from the federal government for the operation of federal contract research centers, such as NASA's Jet Propulsion Laboratory and the AEC's Argonne National Laboratory.

Nonprofit research organizations, which include the independent research institutes and the captive government-sponsored corporations, will perform slightly more than $900-million in R&D in 1968—an increase of some $100-million over last year.

■ NATURE OF R&D. Most of the R&D funds will continue to be used for applied or developmental work. About 64% will go for development and 22% for applied research. Although basic research funds have been increasing steadily, they should level off at about 14% in 1968.

Approximately 70% of the R&D support will be in the physical sci-



***LAUNCH** of 36-story* Saturn 5 *moved NASA closer to manned lunar landing. But agency's post-*Apollo *plans are curtailed by lack of funds.*

ences. The life sciences will receive about 24%, with the remaining 6% being devoted to the psychological, social, and other sciences.

In terms of defense and nondefense programs, the ratio of expenditures will stay about the same—30% for military-related R&D and 70% for nondefense programs.

■ R&D MANPOWER. More than 700,000 fulltime-equivalent scientists, engineers, and technicians will be engaged in R&D in 1968. Of this total, some 500,000 will be scientists and engineers. About 350,000 will be employed in industry, 70,000 in government, 65,000 in universities, and 15,000 in other nonprofit institutions.

The national average expenditure per R&D scientist or engineer should approach $45,000 during the coming year, as opposed to $40,600 in 1965. It is interesting to note that the lowest cost ratio in 1965 was at universities, ($34,100), while the highest average was at federal contract research centers operated by universities ($58,200).

Drop in R&D ratio

The diminishing role of research and development in the last year or so can be illustrated best by funding comparisons with the gross national product and total federal expenditures.

R&D outlays have been at least 3% of the gross national product for about a decade. This year, the ratio will drop to 2.9% if the GNP reaches the predicted $840-billion-plus.

As for federal expenditures, R&D's percentage of the budget increased every year between 1953 and 1965. Since then, when an all-time high of 15.4% was reached, R&D's share has decreased dramatically. It will decline to less than 12% of the budget in 1968.

Three federal agencies (Dept. of Defense, NASA, and Atomic Energy Commission) again will spend more than 90% of the government's $15.5-billion R&D budget, but the distribution will change with the recent cut in the space budget and growth in defense funding.

Likely expenditures for the three large research-oriented agencies for 1968 now appear to be $7.2-billion for the DOD, $4.6-billion for NASA, and $1.4-billion for the AEC.

The remainder of the federal R&D budget will be roughly as follows: Dept. of Health, Education & Welfare, $1.2-billion; National Science Foundation, $480-million; Dept. of Agriculture, $260-million; Dept. of Transportation, $180-million; Dept. of Interior, $120-million; and Dept. of Commerce, $60-million.

NASA has been hardest hit by the government R&D slowdown. Nearly all the post-*Apollo* planetary programs have been killed or deferred. From a peak civilian employment of 421,000 in the space program in 1966, the personnel figure is expected to drop to 260,000 during the coming year.

Aside from the scarcity of funds because of the Vietnam war, NASA's financial problems can be attributed to the tragic *Apollo* spacecraft fire, the failure to adopt a firm space policy for the 1970s, and the lack of strong public support for the space program.

Other federal agencies also have been having their problems. The Dept. of Defense, for instance, has been criticized for its handling of the pivot-wing F-111 program, delaying the development of antiballistic missile system, and the effectiveness of its Planning, Programing & Budgeting System (PPBS).

The Atomic Energy Commission has been under attack from Rep. John P. Saylor (R-Pa.) for its handling of the civilian nuclear program. Rep. L. H. Fountain (D-N.C.) has assailed the National Institutes of Health for "laxity, inefficiency, and irresponsibility" in the administration of research grants. The National Science Foundation has been prodded by Rep. Emilio Q. Daddario (D-Conn.) and Sen. Edward M. Kennedy (D-Mass.) to assume a more forceful role in science matters.

Members of Congress also have been critical of a wide range of R&D activities, including the uneven geographical distribution of funds, the inefficiency and waste of scientific equipment in government laboratories, the duplication and ineffectiveness of technology transfer efforts, the selection of sites for federal laboratories, the need for a technology assessment board, and the neglect of research in the social sciences.

The increasing concern of Congress with R&D is reflected in a recent report which showed that 20 House committees, 16 Senate committees, and two joint committees have jurisdiction over various aspects of federal research and development.

The industrial outlook appears more hopeful because an increasing number of companies are realizing the importance of greater R&D investments in new product development.

The annual *Industrial Research* survey of leading research-oriented companies reveals that they are planning a 6.8% average increase in R&D funding in 1968.

Of the 75 respondents, 53 intend to increase the R&D expenditures, 18 will maintain their present levels, and only four foresee decreases. The survey companies performed more than $2.8-billion in R&D last year.

Of the 55 companies that engage in federal R&D, 17 expect to perform more government work during the coming year, 29 will handle about the same volume, and nine anticipate a decrease in the federal workload.

Nearly all of the 75 survey participants intend to hire more scientists and engineers in 1968, with the average being 168 new professional staff members. About half will be replacements and half additional personnel.

Uneven funding pattern

Among the companies that expect to increase their total R&D expenditures are: EG&G Inc., 25%; Air Products & Chemicals Inc., 17%; Perkin-Elmer Corp., 13%; 3M Co.,

11%; Xerox Corp., 10% to 15%; Republic Steel Corp., 10%; Eastman Kodak Co., 8% to 10%; Dow Chemical Co., 8%; and Raytheon Co., 5%.

No substantial changes are anticipated by Allied Chemical Corp., Allis-Chalmers Mfg. Co., Bethlehem Steel Corp., Boeing Co., Control Data Corp., E. I. du Pont de Nemours & Co., Swift & Co., Union Carbide Corp., and West Virginia Paper & Pulp Co.

Among the decreases reported were the Kaman Nuclear Div. of Kaman Corp., −20%; Crucible Steel Co., −10%, and General Electric Co., −5%.

Again this year, most of the nation's industrial R&D will be financed and performed by five industries—aircraft and missiles, electrical equipment and communications, chemicals and allied products, motor vehicles and other transportation, and machinery.

The aerospace industry will have the greatest R&D expenditures ($6.435-billion), but will rank only third in company-funded research and development with $1.2-billion.

Placing second in total spending and first in industrial funding will be the electrical-electronics industry, which will perform about $3.75-billion and finance $1.5-billion.

The chemical industry will have a $1.65-billion R&D dollar volume, of which some $1.4-billion will be corporate funds.

Transportation will be fourth in both expenditures and funding. It should handle about $1.45-billion in research and development. Of the total, approximately $1.15-billion will come from company budgets.

Rounding out the "big five" will be the machinery industry, which expects to perform $1.3-billion in R&D and to support $1.05-billion of the total from its own funds.

Below the billion level

The second tier of industrial R&D consists of two industries — professional scientific instruments and petroleum refining and extraction. The instruments industry will spend $560-million (including $400-million in company funds), while the petroleum industry will have total R&D expenditures of $500-million (of which about $440-million will be financed by companies).

Two metals industries lead the third grouping of industries. Primary metals will spend $260-million ($242-million in company funds) and fabricated metal products will account for $220-million ($215-million financed internally).

They are followed by rubber products, $200-million (including $185-million in company funds); food and kindred products, $190-million ($185-million); stone, clay, and glass products, $165-million ($160-million); paper and allied products, $90-million ($89-million); and textiles and apparel, $50-million ($49-million).

All other industries will perform a total of about $480-million in research and development in 1968. Of this amount, $240-million will be supported by the companies.

In most industries, the increases will range from 5% to 10% over 1967 figures. Many companies, however, will keep their R&D budgets at the same level because of the bleak government contract outlook and the uncertain economy.

In general, the research industry is passing through a transitional period that could bring about a much lower and earlier plateau in R&D support than anyone anticipated.

During the coming year, many government and industrial programs will be re-evaluated. It is quite likely that a considerable number of projects of doubtful value will be trimmed or dropped.

Unfortunately, pressures for a cutback also will kill many worthwhile programs and cause the indefinite postponement of some key projects.

Although R&D expenditures will continue to rise, it appears that the research industry has lost the momentum that it had during the late 1950s and early 1960s.

It is unlikely that there will be an upsurge or redirection of R&D until the Vietnam war is settled—or until more government and industrial leaders recognize the full impact of science and innovation in our society and the far-reaching implications of curtailing such efforts. ■

industrial R&D outlook for 1968

Based on Industrial Research and National Science Foundation figures

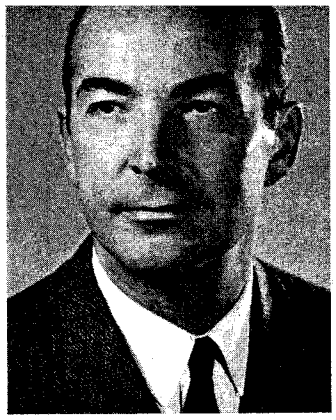
Industry	Company Funds (millions)	Total R&D (millions)
Aircraft and missiles	$1,200	$6,435
Electrical equipment and communications	1,500	3,750
Chemicals and allied products	1,400	1,650
Motor vehicles and other transportation equipment	1,150	1,450
Machinery	1,050	1,300
Professional and scientific instruments	400	560
Petroleum refining and extraction	440	500
Primary metals	242	260
Fabricated metal products	215	220
Rubber products	185	200
Food and kindred products	185	190
Stone, clay, and glass products	160	165
Paper and allied products	89	90
Textiles and apparel	49	50
Other industries	240	480
Totals	**$8,500**	**$17,300**

R&D expenditures planned for 1968

Based on annual Industrial Research forecast survey

Company	1967 Budget	Expected Increase
ACF Industries	$ 2,000,000	10%
Abbott Laboratories	20,000,000	5 to 10
Address.-Multigraph	11,000,000	7
Air Products & Chem.	4,000,000	17
Allied Chemical Corp.	30,000,000	none
Allis-Chalmers Mfg.	30,000,000	none
American Oil Co.	14,600,000	5
American Optical Co.	8,000,000	5
Armco Steel Corp.	7,500,000	none
Atlantic Res. Corp.	2,000,000	25
Atlantic Richfield	11,400,000	5
Bell Telephone Labs.	390,000,000	no answer
Bethlehem Steel Corp.	no answer	none
E. W. Bliss Co.	2,000,000	none
Boeing Co.	70,000,000	none
Borg-Warner Corp.	33,000,000	5
Carpenter Steel Co.	2,000,000	none
Colgate-Palmolive Co.	10,000,000	5
Conrac Corp.	5,000,000	20
Control Data Corp.	38,000,000	none
Crucible Steel Co.	3,250,000	−10
Dow Chemical Co.	70,000,000	8
E. I. du Pont	100,000,000	none
EG&G Inc.	2,500,000	25
ESB Inc.	3,000,000	5
Eastman Kodak Co.	100,000,000	8 to 10
Fairchild	10,000,000	none
Foxboro Co.	6,320,000	18
General Electric Co.	750,000,000	−5
General Mills Inc.	10,000,000	2
Gould Natl. Batteries	1,500,000	20
W. R. Grace & Co.	19,500,000	5
Hercules Inc.	20,684,000	some
Hooker Chem. Corp.	8,500,000	8

Company	1967 Budget	Expected Increase
Intl. Min. & Chem.	6,000,000	none
Ion Physics Corp.	2,500,000	15
Johns-Manville Corp.	7,600,000	none
Kaman Nuclear	6,000,000	−20
M. W. Kellogg Co.	3,000,000	8
Koppers Co.	6,700,000	13
Eli Lilly & Co.	40,000,000	10
3M Co.	53,000,000	11
Mead Johnson & Co.	6,466,000	12
Merck & Co.	47,000,000	10 to 15
Natl. Cash Register	no answer	10
Owens-Corning Fiber.	10,093,400	10
Owens-Illinois Inc.	30,260,000	10
PPG Industries	no answer	20
Perkin-Elmer Corp.	35,200,000	13
Pfaudler Co.	1,000,000	none
Pillsbury Co.	4,800,000	5
Radiation Inc.	15,000,000	20
Raytheon Co.	20,000,000	5
Republic Steel Corp.	7,000,000	10
St. Regis Paper Co.	3,000,000	none
Sun Oil Co.	12,200,000	13
Swift & Co.	4,000,000	none
Union Carbide Corp.	85,000,000	none
Union Oil of Cal.	9,400,000	8
U.S. Borax Res. Corp.	2,500,000	none
Universal Oil Products	10,000,000	6
Upjohn Co.	28,000,000	8
Varian Associates	18,000,000	8
Warner-Lambert Res.	21,000,000	some
West Va. Paper & Pulp	5,000,000	none
Whirlpool Corp.	8,200,000	13
Wyeth Laboratories	no answer	10
Xerox Corp.	50,000,000	10 to 15

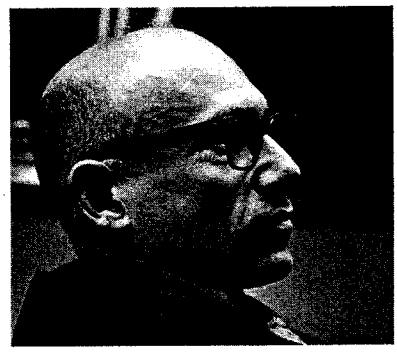


"The total synthesis of a gene is at least 10 years away. However, by using purified enzymes in his syntheses, the biochemist has succeeded in replicating lengths of DNA comprising several genes. The test-tube synthesis of a fully infectious DNA virus was announced only months ago."

—Dr. Arthur Kornberg, *professor and executive head, Dept. of Biochemistry, School of Medicine, Stanford University, and 1959 Nobel laureate in physiology and medicine, page 64.*

"The new methods of stereospecific polymerization recently have acquired great importance. They allow the synthetic production of macromolecular substances identical with natural ones, such as cis-1,4 polyisoprene (identical with natural rubber), and new types of stereoregular macromolecules."

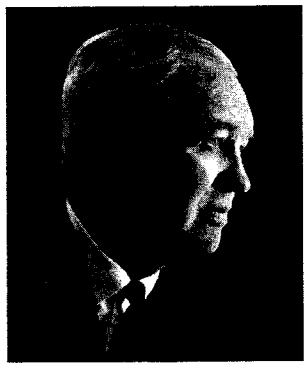
—Dr. Giulio Natta, *professor and director, Industrial Chemistry Dept., Polytechnic Institute of Milan, Italy, and 1963 Nobel laureate in chemistry, page 66.*



"Man is, indeed, on the brink of a major evolutionary perturbation—vegetative propagation. I am . . . puzzled by the rigor with which asexual reproduction has been excluded from the vertebrate as compared to the plant world, where its short-run advantages are widely exercised."

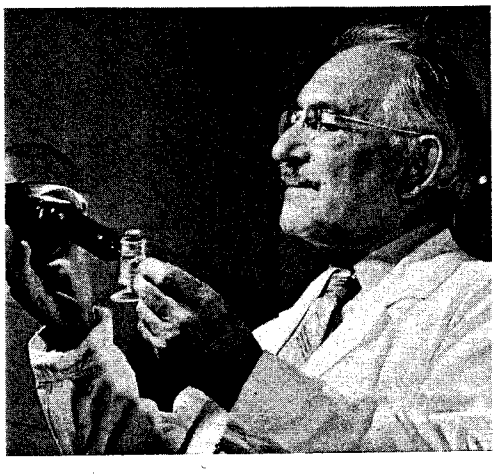
—Dr. Joshua Lederberg, *professor of genetics, School of Medicine, Stanford University, and 1958 Nobel laureate in physiology and medicine, page 67.*

OUTLOOK BY NOBEL LAUREATES



"In this new period (of organic chemistry), the scope will be enormous. As in the past, its mainspring will lie in the fascinating complexity of living matter, in the understanding of its detailed composition, its methods of synthesis, its means of adaptation, and in the essential basis of specificity."

—Lord Alexander Todd, *professor of organic chemistry, Cambridge University, England, and 1957 Nobel laureate in chemistry, page 68.*



"Can new antibiotics be expected to take up where the others have left off? Unfortunately, the introduction of new desirable chemical entities into clinical medicine has lagged somewhat in recent years, even though an increasing number of new antibiotics have been introduced every year."

—Dr. Selman A. Waksman, *professor emeritus, Institute of Microbiology. Rutgers, The State University, and 1952 Nobel laureate in physiology and medicine, page 70.*

Research in **BIOCHEMISTRY** *is showing how heredity works.*

by **Dr. Arthur Kornberg,** *professor and executive head, Dept. of Biochemistry, School of Medicine, Stanford University, and 1959 Nobel laureate physiology and medicine.*

I•R STAFF PHOTO

THE MAN SEATED NEXT TO ME in the airplane had heard of DNA, although he was not sure why, but he had never heard of ATP. These two symbols which stand for the most crucial units in the heredity and economy of living cells deserve to be as well understood as the planets, the rivers, and baseball statistics.

With even a casual grasp of the meaning of DNA and ATP, my fellow traveler could recognize that there has been a major revolution in biology in the past two decades and that this new knowledge might profoundly alter his life in the next two.

Louis Pasteur demonstrated conclusively a century ago that yeast cells were responsible for transforming the insipid juice of the grape into sparkling wine. He also persuaded everyone that the conversion of sugar to alcohol in this process required an intact, living cell.

An accidental discovery at the start of this century showed that simple juices extracted from these yeast cells also could manage this rather complicated chemistry.

The era of modern biochemistry started with this discovery.

In the period from 1900 to 1940, alcohol production from sugar in yeast juice and lactic acid production in muscle juices each were thoroughly described by a sequence of 10 well-defined chemical steps, each step catalyzed and controlled by a specific enzyme catalyst.

Since 1940 far more complicated cellular processes, such as the synthesis of hormones, have been explained in minute chemical detail—each step in the process carried out by an enzyme specially designed for the job.

Today, a high school student in biology is convinced quickly of these basic facts:

■ The cell, whether one of the several trillion that comprise a man, or the single bacterium, has a machinery made up of enzymes and a pattern of operating them that are essentially the same throughout nature.

■ The cell burns a fuel, such as sugar. But instead of producing only heat, it captures a major part of the energy and stores it in a chemical form, known as *adenosine triphosphate* or *ATP*. ATP is a chemical currency that can be used for the cell's work, such as building a complicated molecule, flexing a muscle, lighting the lantern of a firefly, or charging the battery of an electric eel. In plants, which capture the sun's energy to produce the chemical fuels which we animals consume, it is again ATP that appears as the first chemical product in the photosynthetic process.

■ The instructions on how to make each enzyme are spelled in complete encyclopedic detail in the genes. This atomic language of genes is in the form of a giant molecule called *deoxyribonucleic acid* or *DNA*.

***MODEL** of a ribonuclease molecule based on x-ray diffraction data from Yale. Scale: 200-million:1.*

The master code

A major component of the recent revolution in biology is that we know in chemical terms how heredity works and, therefore, can manipulate it. This revolution was achieved by a fusion of the disciplines of biology, chemistry, and physics into a science now called molecular biology.

A gene is a stretch of DNA spelled in four letters (nucleotides) called A, T, G, and C. The gene is on the average 1,000 letters long. The information it contains for making a particular protein (enzyme) is encoded in a unique linear sequence of these letters.

For a gene to make protein, two things must happen: the DNA must first be transcribed into a messenger form called ribonucleic acid (RNA); the latter then is translated into a protein. In the translation process, the four-letter language of DNA is converted into the 20-letter (amino acid) language of proteins.

In the master code, deciphered only very recently, a particular sequence of three nucleotides specifies a particular amino acid. The "dictionary" translating each of the nucleotide words into a certain amino acid is the same in every cell in nature. Unraveling this "language" and discovering the "dictionary" are achievements that certainly must be numbered among the most remarkable revelations in the history of science.

DNA has two major functions. One has just been described: to specify in the many thousands of genes that make up a chromosome the complete chemical detail of the many thousands of enzymes required for the machinery and fabric of a cell. The second function is to serve as a template for the production of an exact copy of itself in order that the cell may endow an offspring with the identical information that it itself contains.

Hemoglobin is the protein in blood which transports oxygen. It contains 514 amino acids. At some point in human history, Individual X had a single letter in his gene for hemoglobin replaced by another. As a consequence, the hemoglobin translation of this gene differed by a single amino acid. This hemoglobin proved defective in carrying oxygen. Mutant X

and all his offspring who inherited this altered gene suffered from a hemoglobin defect called sickle cell anemia, a disease which is disabling and sometimes fatal.

Medical researchers have identified many hundreds of human genes, each recognized as the basis of a well-defined trait or a disease resulting from a mutation affecting a trait. How does a mutation occur? We know that radiations such as x-rays, ultraviolet light, and radioactive fallout produce mutational changes in the DNA as do certain chemicals that enter our cells from the food, air, or medicinals.

The molecular biologist believes that every reaction which occurs within a living cell happens because a specific enzyme is there; and every enzyme in a cell is there because the information for its production is encoded in the cell's DNA. He thinks he will be able to write a total equation for the program of a cell and that he will understand a cell well enough to separate it into its molecular components and reconstitute them into a cell again.

Total gene synthesis

Knowledge of the composition of insulin, a protein hormone with 51 amino acids, has led to its recent successful laboratory synthesis. In the next few years, larger proteins, including active enzymes, will be synthesized.

Along with each synthesis goes the capacity to make specific alterations and substitutions, each of which will produce enzymes with altered capacities. In some instances, the laboratory product may turn out to have useful properties lacking in nature's handiwork.

Our knowledge of the chemistry of the nucleic acids—DNA and RNA—is far less advanced than that of proteins. In fact, scandalously little attention has been given by organic chemists to nucleic acids as compared to other natural products.

The total synthesis of a gene is at least 10 years away. However, by using purified enzymes in his syntheses, the biochemist has succeeded in replicating lengths of DNA comprising several genes. The test-tube synthesis of a fully infectious DNA virus was announced only two months ago.

With our developing capacity to identify, isolate, and eventually synthesize genes will come the opportunity to alter the heredity of cells. In bacteria, the removal and insertion of genes, thus creating new species at will, has been a student laboratory exercise for years. The extension of these and related techniques to alter the heredity of animal cells is likely to advance rapidly in the next few years.

Many forms of cancer, in animals at least, are caused by viruses. It seems entirely reasonable that by altering the DNA of the viruses we may destroy their capacity to induce cancer. When attempts to change the genetic makeup of a cell prove difficult or dangerous, then the administration of gene products, such as enzymes and ATP, may correct a disease.

When we know all about enzymes and what they do, we then may be able to administer compounds which will circumvent the results of aging and keep us cheerful more of the time. The timetable for maturation of these prospects will depend on greatly increased efforts by chemists to manipulate macromolecules.

We know little about the complex chromosomes of animal cells. We know even less about the composition, architecture, and properties of membranes around nuclei of cells and the membrane surfaces that define the societal arrangement of cells in tissues and organs. Rapid progress will require more biologists and medical researchers with better training.

Most important of all, the future of research in this field will require political and ethical commitments from our society to assure wise use of these efforts. ■

The study of naturally occurring **POLYMERS** *has led to the synthesis of many products.*

by **Dr. Julio Natta,**
professor and director, Industrial Chemistry Dept., Institute of Milan, and 1963 Nobel laureate in chemistry

***THERMOGRAVIMETRIC** analysis measures and records changes in weight as a function of temperature of polymers at Martin Marietta Corp.*

ALTHOUGH macromolecular compounds have been used widely in the course of the ages as building materials (for example, cellulose, natural rubber, etc.), and they constitute the basis of all living organisms, both animal and vegetable (starch, proteins, etc.), macromolecular chemistry rose to the dignity of science only about 30 years ago.

At that time, Herman Staudinger, 1953 Nobel laureate in chemistry, in his fundamental research, laid the foundations of the study and knowledge of that science.

Since then, macromolecular science has developed not only due to the better knowledge of macromolecular natural products, but because several new products have been synthesized that exhibit different properties based on the specific conformation of their molecules.

The new methods of stereospecific polymerization recently have acquired great importance. They allow the synthetic production of macromolecular substances identical with the natural ones, such as *cis*-1,4 polyisoprene (identical with natural rubber), and of new types of stereoregular macromolecules.

New methods of polymerization also allow us to obtain a *trans*-1,4 polymer of isoprene, which exhibits an identical structure with that of gutta-percha rubber.

Amorphous polymers, and, in particular, the copolymers with ethylene, exhibit properties of elastic rubbers and are used largely as synthetic rubbers.

Stereospecific polymerization has considerably increased the spectrum of synthetic macromolecular chemistry, especially because new, as well as previously known, monomers may be used for the production of new polymers having particular physical properties.

Some polymers of alpha-olefins and butadiene, copolymers of ethylene and propylene, polyesters, and polyamides have spawned new applications in the fields of plastics, textiles, and synthetic rubbers.

The stereospecific polymerization of diolefins also is of great interest. It yields products that present different properties, depending on the structure and configuration of the monomer units.

Crystalline polymers

It is possible to obtain polymerization products from the same starting material that have different physical properties. This, of course, depends on their molecular weight and especially on the structure of the macromolecules constituting them.

A regular succession of single monomer units generally is accompanied by a crystallinity that produces polymers with high melting temperatures, good mechanical properties, and an orientability of the molecules of the stretched products, which generally allows the production of valuable crystalline textiles.

The isotactic polymer of propylene, with macromolecules characterized by the presence of monomer units with the same configuration, actually exhibits a high crystallinity below melting temperature (about 170 to 180 C). Valuable plastics, textiles, and films obtained from polypropylene are produced commercially all over the world.

The isotactic polymers of α-olefins can crystallize. The stereoregularity of isotactic poly-α-olefins often is high. Crystallinity decreases with increasing steric irregularities. Generally 30% of randomly distributed non-isomorphous monomer units is enough to obtain a completely amorphous polymer.

If monomer units with the same configuration are combined in chain segments, block polymers form; they still exhibit some crystallinity, but their x-ray diffraction spectra reveal the presence of bands that are broader and less intense than those characteristic of highly isotactic and well-crystallized polymers.

Also, syndiotactic polypropylene, which was prepared in our institute, is crystalline. However, having a lower melting temperature than the isotactic polymer, it is of less practical interest than the latter.

Isotactic polymers may be obtained only in the presence of heterogeneous catalysts generally consisting of a transition metal halide (with a valence lower than the maximum), insoluble in the reaction medium, and of an alkyl organometallic compound.

Both steric purity and homogeneity of the polymers depend on the catalyst constitution. Actually, a catalyst prepared from pure and microcrystalline violet $TiCl_3$ yields a polymer predominantly consisting of isotactic mole-

cules. However, a catalyst also containing $TiCl_3$ — but obtained by cold reduction of $TiCl_4$ with organometallic compounds—consists of a heterogeneous mixture of titanium chlorides with a different degree of oxidation and of crystallinity. The resulting compound is less stereospecific from a catalytic point of view.

On the other hand, high yields of syndiotactic polymer are obtained in the presence of some homogeneous catalysts. For example, the catalysts obtained by reaction of a solution of vanadium tetrachloride with aluminum diethyl monochlorine exhibit a high stereospecificity for the low temperature production of syndiotactic polymers.

Major butadienes

Among the synthetic products obtained by the polymerization of diolefins, I mention the four fundamental polymers of butadiene. Among them, the *cis*-1,4 polybutadiene is of practical interest, as it is a synthetic rubber that will crystallize spontaneously only below 2 C. At higher temperatures, it can crystallize under stretching like natural rubber; it has an excellent tensile strength and elongation at break. *Trans*-1,4 polybutadiene exhibits high crystallinity also in the unstretched state and a high melting temperature (about 145 C).

Polybutadiene-1,2 was obtained in two stereoisomeric forms — isotactic and syndiotactic respectively. Both are crystalline. However, these polymers are of little practical interest, unlike 1,4 polymers, due to the relatively low flexibility of the chain.

From a scientific point of view the synthesis of stereoregular, optically active alkyl polysorbates is of considerable interest. Because they are obtained from monomers having no optical activity, the corresponding macromolecules consist of monomer units with the same configuration.

The above reveals the importance of both chemical and steric regularities on the physical and technological properties of linear high polymers.

My earlier remarks about the synthesis and properties of polypropylenes with different steric structures obviously may be extended to all polymers (hydrocarbon or not) of asymmetric vinyl monomers.

Therefore, stereospecific polymerization allows one to obtain valuable products from monomers that otherwise would have no practical interest.

In fact, by the old processes of polymerization, they mostly yielded low-molecular-weight polymers with an irregular structure due to the irregularity in the succession of monomer units of different configuration. ■

Asexual reproduction of humans may be the next major advancement in **GENETICS.** *But controversies could hamper progress in this area.*

by **Dr. Joshua Lederberg,**
professor of genetics, School of Medicine, Stanford University, and 1958 Nobel laureate in physiology and medicine

RECENT DISCUSSIONS of controlled human evolution focus on two techniques — selective breeding (eugenics) and genetic alchemy (algeny).

Algeny presupposes a number of scientific advances that have yet to be perfected, and their immediate application to human biology is, probably unrealistically, discounted as purely speculative.

Paradoxically, the issue of "subhuman" hybrids may arise first, just because of the touchiness of experimentation on obviously human material. Tissue and organ cultures and transplants already are in wide experimental or therapeutic use, but there would be widespread inhibitions about risky experiments leading to an object that could be labelled as a human or parahuman infant.

There is enormous scientific interest in organisms augmented by fragments of the human chromosome set, especially as we know so little of man's biological and genetic homology with other primates. This is being and will be pushed in steps as far as biology will allow, to larger and larger proportions of human genome in intact animals, and to organ combinations and chimeras with varying proportions of human, subhuman, and hybrid tissue.

Note that there have been efforts to transplant primate organs to man. The hybridization is likely to be somatic, and the elaboration of these steps will make full use of nuclear transplantation to test how well and to what extent these assorted genotypes will support the full development of a zygote.

The sharpest challenges to our pretensions about human nature already are in view, yet they may be overlooked as a result of too farsighted focusing on possibilities such as the "chemical control of genotype."

Man is, indeed, on the brink of a major evolutionary perturbation—vegetative propagation.

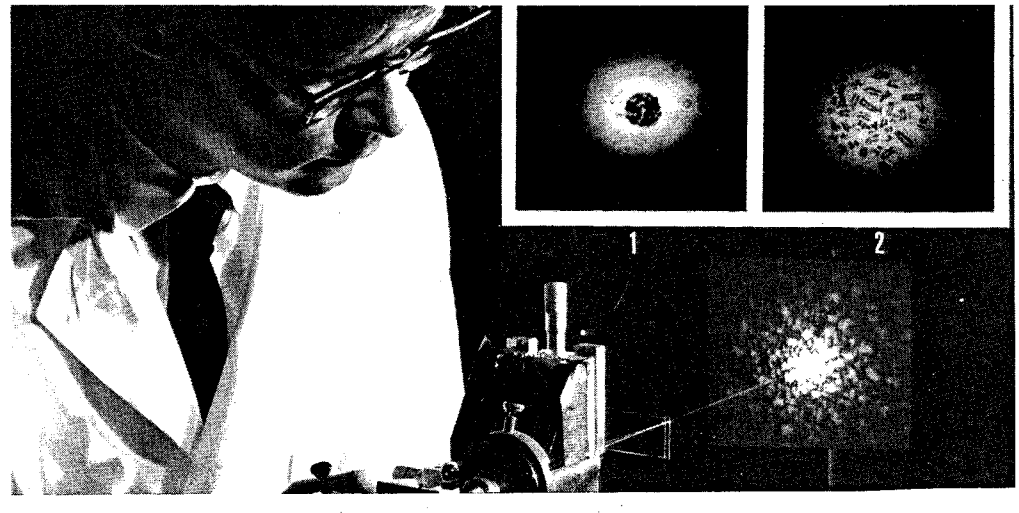
Experimentally, we know of successful nuclear transplantation from various adult tissue cells into amphibian eggs whose own nuclei have been removed. There is nothing to suggest any particular difficulty about accomplishing this in mammals or man, although it rightly will be admired as a technical *tour-de-force* when it is first implemented.

A biological accident?

I am more puzzled by the rigor with which asexual reproduction has been excluded from the vertebrate as compared to the plant world, where its advantages are widely exploited. Many plants spread almost entirely by asexual growth and reproduction.

A colony of organisms derived from

***LASER** beams are used by Perkin-Elmer scientists to find blood cells in the process of dividing (mitosis). Cut 1 is a normal blood cell image; cut 2 is a mitotic cell image showing the chromosomes.*



a single ancestor — without a sexual union or genic recombination — is called a "clone," from a Greek root, "cutting," which is related to "colony." That clonal reproduction is confined mainly to plants may be a mere accident of cell biology.

Vegetative — or clonal — reproduction outweighs other techniques of biological engineering, such as algeny, at a much earlier stage of scientific sophistication. If a superior individual, and presumably a genotype, is identified, why not copy it directly, rather than suffer all the risks, including those of sex determination, involved in the disruptions of genetic recombination?

Clonality as a way of life in the plant world is well understood as an evolutionary *cul-de-sac,* often associated with hybrid luxuriance. It can be an unexcelled means of multiplying a rigidly well-adapted genotype to fill a stationary niche.

In the human context, it is at least debatable whether sufficient latent variability to allow for any future contingency would be preserved if the population were distributed among some millions of clones. From a strictly biological standpoint, tempered clonality could allow the best of both worlds: we would at least enjoy being able to observe the experiment of discovering whether a second Einstein would outdo the first.

The duplicate man

The internal properties of the clone open up new possibilities; for example, the free exchange of organ transplants with no concern for graft rejection. However, even when nuclear transplantation has succeeded in the mouse, there would remain formidable restraints on the way to human application. One might even question the further investment of experimental effort.

But several lines are likely to become active. Animal husbandry, for prize cattle and race horses, could not ignore the opportunity, just as it bore the brunt of the enterprises of artificial insemination and oval transplantation.

My colleagues differ widely in their reaction to the idea that anyone could conscientiously risk the crucial experiment, the first attempt to clone a man. Perhaps this will not be attempted until gestation can be monitored closely to be sure the fetus meets expectations.

The mingling of individual human chromosomes with those of other mammals assures a gradualistic enlargement of the field and lowers the threshold of optimism or arrogance, particularly if cloning in other mammals gives incompletely predictable results. ■

A third major upheaval in ORGANIC CHEMISTRY *will be felt in many areas.*

by **Lord Alexander Todd,**
professor of organic chemistry, Cambridge, England, and 1957 Nobel laureate in chemistry

***HYDROGEN** bubbles provide energy for growing microorganisms at Martin Marietta Corp. Through complex chemical reactions, nutrients and oxygen are produced that may be used to sustain crews on future space missions.*

FROM TIME TO TIME all sciences pass through periods or phases of reappraisal and reorientation during which the overall pattern of progress may be in part obscured. Organic chemistry is no exception to this rule. It has experienced three such phases in the past century and a half, each spaced about 50 years apart.

The basic reasons for these disturbances have differed in each case. The first, which I would place roughly between 1855 and 1875, undoubtedly was due to the appearance of an adequate, if empirically derived, theoretical basis on which a real chemistry of the element carbon and its compounds could be developed.

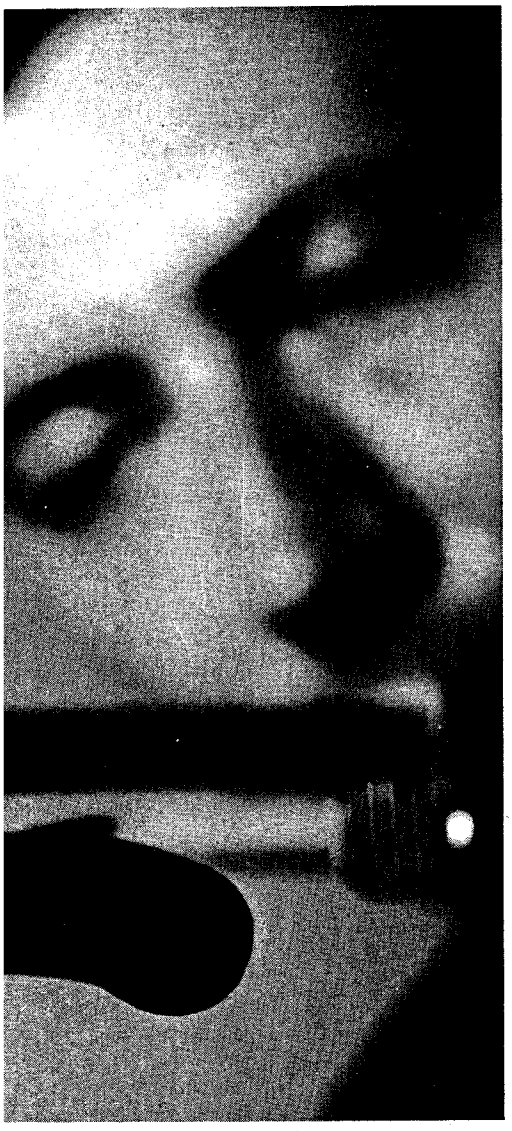
The second, which occurred within the period between the turn of the century and World War I, was of a rather different nature. It created perhaps less visible disturbance in organic chemistry at the time. But its effects were far reaching nevertheless.

This second reorientation was due to the fact that a sufficiently wide basis of carbon chemistry had been laid and experimental methods developed so that a return could be made to the study of complex substances found naturally in the biosphere.

Before discussing the current upheaval, I should make it clear that in giving approximate dates to the three phases of change I make no claim to accuracy. Contemporary events are difficult to see in true perspective. Moreover, progress in science is continuous and it is impossible to put a precise date on turning points. There always are shadows cast in advance, just as there are isolated investigators ahead of their time whose work, frequently little noticed, heralds changes ahead. Subject to these qualifications, however, I believe that the dating of major changes which I have given is at least reasonable.

The present reappraisal — and for many organic chemists it is a difficult one—is due essentially to advances in experimental technique mainly through the introduction of refined physical methods themselves stemming from progress in physics.

The organic chemist has been concerned basically with two things — molecular structure and synthesis. This is not to decry work on such subjects as reaction mechanism, but this and other sub-specialties derive from and are facets of these two main divisions or organic chemistry.



Over the past century, methods for the determination of structure by chemical degradation, usually a lengthy process occupying a period of years with complex molecules, have been brought to a high degree of perfection. The application of methods of structure determination, together with that of the equally highly developed methods of synthesis, has been the chief occupation of the organic chemist and the source of much of the attraction of the science to him. It is in the matter of structural elucidation, however, that a veritable revolution has occurred during the period of the past 20 years.

I well recall on one occasion discussing with Dr. Leopold Ruzicka of Zurich (1939 Nobel laureate in chemistry for his terpene work) the difference between the facilities and methods available to him as a young research worker early this century and those used by me at the same stage in my career a generation later.

The research "tools" were few in number. The Bunsen burner and an assortment of glassware were our principal instruments, although I had the advantage in that microanalysis, catalytic hydrogenation, and column chromatography were just beginning to appear in academic laboratories when I commenced research. What a contrast between what Dr. Ruzicka had, what was available to me, and what the young researcher today has at his disposal!

We have seen tremendous developments in methods of separating complex mixtures by chromatography in its multitudinous forms, by countercurrent distribution, and electrophoresis. Moreover, the application of spectroscopic methods—ultraviolet, infrared, Raman, nuclear magnetic resonance, electron spin resonance, and mass spectrometry has made much of the detailed work of degradative studies unnecessary.

These instruments also have permitted a much more precise understanding of reaction mechanisms and of a variety of factors influencing structure and stability of organic compounds than was dreamt of even 20 years ago.

The refinement of x-ray crystallographic techniques and the use of computers in interpreting the data obtained by them have reached a point at which it is possible in many cases to determine a complete structure without carrying out degradative experiments.

Synthesis has been less affected, although it has grown in strength and power with the introduction of new methods and reagents and with the increased ease of product identification by means of the new physical tools.

There is no doubt that the substantial replacement of the chemical degradation procedures by physical methods in structure determination has caused considerable bewilderment among some chemists. At times, one even hears the question put whether the great days of organic chemistry are past. Those who pose this question, however, completely misunderstand the situation.

From the very beginning of their science, organic chemists continually have sought and avidly accepted any tools, diagnostic or otherwise, which would ease the problem of structure elucidation.

In the chemistry of living matter, structure is not an end in itself. Structure must be considered in relation to function. Indeed, the problem of structure and function extends beyond this area into the field of industrially produced chemicals, whose function is not always concerned with living matter.

New physical instruments will be accepted by the organic chemist as he has accepted all their predecessors, and they will help him drive ever deeper into the problem of structure and function, hand in hand with the development of synthesis which is a necessary complement.

The process of reorientation in the science already is well advanced. The more baroque manifestations of the reappraisal period are diminishing, and I expect that within the next two or three years the pattern of the new period of advance—already emerging—will become clear.

The third epoch

In the new period, the scope will be enormous. As in the past, its mainspring will lie in the fascinating complexity of living matter, in the understanding of its detailed composition, its methods of synthesis, its means of adaptation, and in the essential basis of specificity.

It might be said that these are matters embraced in the popular expression "molecular biology." They are, but molecular biology is only an omnibus term for an interdisciplinary approach to the study of biological processes that embraces a number of sciences. Among them, organic chemistry must play a major role if any real progress is to be made.

With organic chemistry, I foresee not only major advances in therapy, but even planned genetic modification becoming a practical possibility with all that this would entail in man's control—not only of other forms of life, but of himself.

Stemming from work in such fields, and partly from new advances in the technique of synthesis, especially in the macromolecular field, it is certain that we will see a continuous flow of new products from the organic chemical industry. Each product will be tailored to meet a specific requirement and each will further promote man's comfort and welfare.

It is even possible to envisage organic chemistry bringing about a major change in the field of computers if a method can be found to apply the immense capacity for information storage inherent in such organic molecules as, for example, the nucleic acids.

Thanks to the sustained efforts of his predecessors, the modern organic chemist now knows enough of the nature and reactions of carbon compounds to venture into these complex fields. And the wealth of new physical tools and experimental techniques available permit him to do so with real hope of success.

Organic chemistry is just ending its third major phase of reappraisal and reorientation and is poised for a new surge forward. The outlook is bright in this, to me at least, the most fascinating of all the sciences. ■

New **ANTIBIOTICS** *are being described at the rate of 50 per year. Are they really needed?*

by **Dr. Selman A. Waksman,**
*professor emeritus, Institute of Microbiology, Rutgers, The State University, and 1952 Nobel laureate in physiology and medicine**

MODERN DEVELOPMENTS in the science and application of antibiotics date from little more than a quarter of a century ago. In 1939 and 1940, three important chemical substances, produced by different groups of microbes and possessing highly potent antibacterial properties, were discovered.

These were products of bacteria (gramicidin), of fungi (the reisolation of penicillin), and of actinomycetes (actinomycin). The introduction of shaken cultures for their growth and of deep-tank fermentation plants for the commercial production of these products greatly advanced progress in this field.

At first, only a few grams were produced; production now is measured in millions of pounds per year. The commercial production of penicillin (begun in 1942) and streptomycin (1944) served as a marked stimulus for this fantastic development. Facilities for the manufacture of antibiotics now are available in 29 countries.

Are new antibiotics needed?

Intensive screening of a wide variety of microorganisms is being carried out in many laboratories. A recent survey of antibiotics literature shows that more than 1,100 antibiotics have been reported in the past 25 years, and new antibiotics still are being described at the rate of about 50 per year.

Most of the "new" antibiotics reported from 1947 to 1960 came from laboratories in the United States. More recently, the majority of reports has been from Japan.

Any forecast of antibiotics research must address itself to two questions: Are new antibiotics needed? With 60 antibiotics now in clinical use, does the physician still need new compounds? If so, where will they come from?

Only against infections caused by gram-positive bacteria, notably staphylococci, streptococci, or pneumococci, can the physician, with any degree of confidence, use a drug that is likely to work. There always is the problem of suprainfections, especially by gram-negative bacteria. There are no sure, effective agents for many strains of such groups as *Pseudomonas* and *Proteus*. *Aerobacter* and *Salmonella* infections are imperfectly controlled.

There is great need for an antibiotic that would be definitely effective against gram-negative infections. Antifungal agents that can be used systematically and anti-protozoal agents still are insufficiently effective. There is *no* useful antibiotic that possesses antiviral properties.

Nevertheless, mortality rates from such infectious diseases as dysentery, scarlet fever, whooping cough, and syphilis have undergone a 95% decrease. A 50% to 80% drop in deaths from pneumonia, tuberculosis, and meningococcal infections has been effected since the introduction of antibiotic therapy.

Fewer new antibiotics

Can new antibiotics be expected to take up where the others have left off? Unfortunately, the introduction of new desirable chemical entities into clinical medicine has lagged somewhat in recent years, even though an increasing number of new antibiotics has been introduced every year.

This apparent inconsistency is due to the efforts of the pharmaceutical companies to continue to introduce new products, even though at the same time they are having difficulty in finding really "new" and useful entities.

In view of the tremendous testing program now required by government agencies to prove both the efficacy and safety of a new drug, it seems likely that the number of "new" compound types introduced into clinical medicine will continue to drop, though the number of new analogs of existing drugs will increase.

It is fairly easy to list the properties wanted in new antibiotics. Some of these goals include new attributes for old antibiotics, and for others—those compounds of established worth—the removal of undesired side effects inherent in their use. A great step forward would be an effective nonsensitizing penicillin, a deoxystreptamine that has no ototoxicity, and an antifungal agent much less toxic than amphotericin B. These new attributes might be found in new antibiotics, or in improvement of the old antibiotics.

'Era of the chemist'

In a sense, the period from 1940 to 1960 was the era of the microbiologist in the discovery of antibiotics. Now, with the semisynthetic penicillins, cephalosporins, modified tetracyclines and rifomycins, we are in the era of the chemist.

Chemists, working with microbiologists, have been able to change the antibiotic molecule to give broader antibiotic spectra, better absorption properties, higher blood levels, and changed excretion patterns. This chemist-microbiologist collaboration should in time result in improved, less limited antibiotics.

Although the importance of new antibiotics for use in clinical medicine is stressed in most discussions, their value in other areas should not be ignored. If we are to feed the world's increasing population, there will be a need to reduce microbial destruction leading to crop loss. Antibiotics currently used in agriculture against plant pathogens are streptomycin and tetracycline for bacteria and cycloheximide and blasticidin S for fungi. For example, the Japanese used over 12,000 tons of blasticidin S last year to combat the rice blast disease.

Current research in the field of antibiotics comprises the chemical and biological modifications of known antibiotics, their chemical synthesis, the mechanisms of their formation by the microbial cell, and the mode of their selective antimicrobial action. In addition, the broad screening programs in which bacteria, fungi, tissue cultures, and viruses are used largely as test organisms are included.

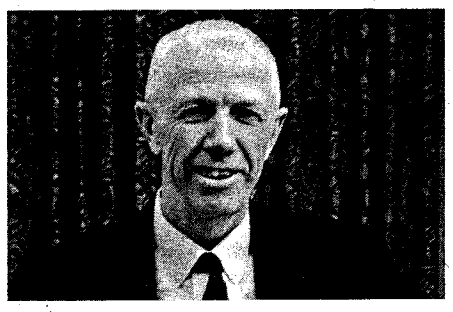
One also must mention the extensive programs carried out in laboratories throughout the world. Investigators are seeking antibiotics active against viruses and neoplasms. Although promising results are limited as yet, new approaches always suggest that some useful leads may be discovered in time.

Thus, we have many problems that can be solved with new antibiotics, and the continued search for useful compounds will give us new valuable drugs. As the antibiotic era enters its second quarter century, there is promise that the best is yet to come. ■

**Dr. Waksman was assisted with the article by Dr. David Perlman, professor of pharmaceutical chemistry, University of Wisconsin.*

"Because of the interest in nuclear-powered vehicles, further development of materials capable of withstanding intense nuclear environments will receive increased attention during the coming year."

—Elmer P. Wheaton, *vice president, research & development, Lockheed Missiles & Space Co., page 72.*



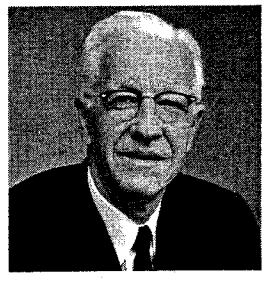
"The modern sprit of research in the (chemicals) industry is becoming that of a broadly interpreted 'materials science,' ranging from the biology of pharmaceutical materials to the physics of inorganic solids."

—Dr. David M. McQueen, *director, Central Research Dept., E. I. du Pont de Nemours & Co., page 73.*

"As we review future trends in electronics, it becomes apparent that integrated circuits will be the largest single source of improvement and change."

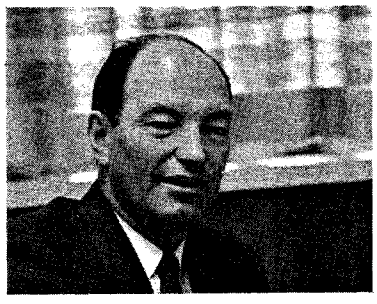
—Dr. Arthur M. Bueche, *vice president, Research & Development Center, General Electric Co., page 74.*

THE YEAR AHEAD IN INDUSTRY



"During the coming year, studies will range from new ways to use superplasticity in difficult-to-fabricate metals, computerized welding, and new composites, to 'prescription steels' and high-purity, high-strength whiskers."

—Max W. Lightner, *vice president of applied research, United States Steel Corp., page 76.*



"Simply stated, the emerging trend (in scientific instrumentation) toward data enhancement will permit analytical chemists to arrive at answers to their problems directly."

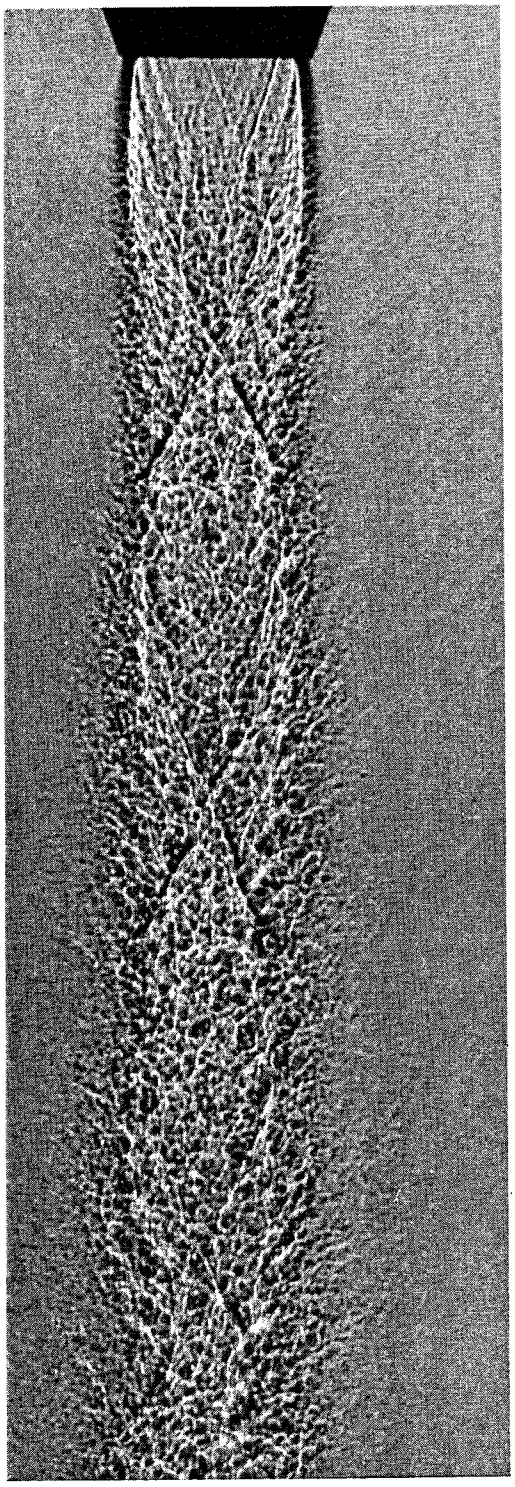
—Dr. William F. Ballhaus, *president, Beckman Instruments Inc., page 77.*

"Electric vehicles and hybrid vehicles, systems combining electric with other propulsion modes, are the natural precursors of automated travel . . . the electric system readily lends itself to 'no hands' travel . . ."

—Dr. Michael Ference Jr., *vice president, scientific research staff, Ford Motor Co., page 78.*

New materials are contributing to **AEROSPACE** *advances as are miniaturized electronics.*

by **Elmer P. Wheaton,**
vice president, research & development, Lockheed Missiles & Space Co.



THE FUTURE COURSE of aerospace research and development will be influenced significantly by political, social, and military situations confronting the United States.

Militarily, near-term emphasis will be upon tactical weapon systems in support of Vietnam-type conflicts. And, to an increasing extent, aerospace-based technologies will be applied to such diverse areas as oceanography, riot control, and civil government data handling systems.

While many factors will influence the future course of the aerospace industry, the significant achievements in 1968 will be the culmination of many endeavors initiated and pursued during the past several years. The broad scope of aerospace development programs in recent years permits discussing only the most significant subjects in this 1968 overview.

Research and development undertaken to meet the need for advanced structural materials has made marked progress. Metal matrix composites provide many properties not available in single metals or in alloys—high strength and modulus-to-density ratios and superior creep behavior at high temperatures. Among these materials, boron filaments, coated to prevent interaction with matrix metal at elevated temperatures, should undergo engineering evaluation of structural application this year.

Another unusual material under development for aerospace vehicles is glassy carbon. Possessing high-temperature strength, a high strength-to-density ratio, resistance to mechanical and chemical erosion, and high heat of vaporization, glassy carbon materials have numerous applications. During 1968, production of the material in thicknesses up to 1.3 cm will be achieved. In addition to applications in space vehicles, it will find use in lift-glide reentry vehicles and leading edges of aircraft.

Because of the interest in nuclear-powered vehicles, further development of materials capable of withstanding intense nuclear environments will receive increased attention during the coming year. Composites bonded by high-temperature, radiation-resistant adhesives will yield materials with a variety of properties unattainable in monolithic metals.

Improved manufacturing techniques will permit the use of several materials in large aircraft structures in a most effective manner. Significant increases in the design stress of aluminum alloys will be achieved through the use of special aging cycles. Further improvements in forming processes, especially forging, will contribute to the wider use of titanium in large structures.

***SHADOWGRAPH** shows both flow and sound field characteristics of a Mach 2.5 supersonic jet at Wyle Labs.*

Another materials-related development that should achieve notable progress in 1968 is long-term storage of cryogenic fluids in space. Greatly improved insulation materials, improved cryogenic "hardware," in conjunction with advances in the supercooling or slushing of cryogenic fluids, will provide the nation the capability to store cryogens for hundreds of days in orbit.

Two space system propulsion developments should be watched closely this year. The "Aerospike" engine gives strong promise of a major improvement in the mass ratio while high chamber pressures (3,000 to 5,000 psi) give equal promise of major improvement in specific impulse. Both of these significant development projects will be evaluated further during the coming year.

Miniaturization trend

Electronic sciences will continue to influence significantly progress of aerospace technology. Microminiaturization of electronic systems already has had a major impact on size, weight, and reliability of guidance, propulsion, navigation, and instrumentation systems. Miniaturization based on solid-state components will be rapidly extended to microwave circuits, data storage equipment, and analog signal processing systems.

The unending quest for both reliability and miniaturization will bring single-crystal techniques to electronic manufacturing. The most likely applications in the near-term future will be components made from rare earth transition metal compounds and in high quality magnets.

Another electronic development apt to achieve major importance this year will be Gunn-effect microwave signal sources. Possessing high (20%) efficiency and the ability to be integrated into complex antenna arrays, these oscillators may replace many klystrons, traveling wave tubes, and magnetrons in communication and radar equipment.

Simple to fabricate, compact (less than 1.6×10^{-11} m^3), possessing wideband tuning capability, and needing no external resonant circuits in many applications, these devices offer substantial cost reductions for high frequency systems over a wide frequency range.

Lasers will find widening applications—not only in space programs but also in scientific, medical and industrial use. Steady progress will be achieved in development of the laser as an accurate, relatively inexpensive

gyro for attitude-sensing systems in aircraft and space vehicles.

Thin-film bismuth and bismuth-antimony infrared detectors may provide the possibility of real time infrared horizon sensors for incorporation in attitude control systems. These same detectors also will find initial application in laser communications in the 8- to 14-micron atmospheric "window." Another application in which the bismuth or bismuth-antimony detectors will be applied is in photomixing systems.

Aerospace 'spinoffs'

Of necessity, the anticipated developments touched upon here are but a small component of the overall program of aerospace technology. Most developments have been initiated to help extend man's knowledge of his environment and his universe.

But the usefulness of these developments will not be restricted to aerospace systems. They are transferable to a broad spectrum of undertakings leading to a better understanding of our terrestrial environment and to the solution of our numerous and extremely urgent social problems.

The oceans, for instance, hold tremendous food and mineral resources to replenish man's diminishing land reserves. Aerospace technology now is finding, and will continue to find, direct applications to the expanding field of oceanography.

In 1968, for example, the life support system technology used for space capsules will be applied increasingly to man's efforts to live and work in the ocean's depths. Men soon should be able to work at the 300 m level for four or five days with little more than portable breathing apparatus. Deep diving submersibles will be available to support such divers, or at much greater depths, carry out inspection or repair tasks on undersea petroleum systems.

To provide vision at great depths aerospace technology is creating advanced optical and electronic imaging systems.

To handle and streamline the burgeoning mass of data at all levels of government, the data processing systems developed for missile and space test programs rapidly are being introduced in government agencies dealing with crime, welfare, and disaster planning systems.

Aerospace technology will continue to advance rapidly and will be applied expeditiously to the solution of those programs deemed of greatest benefit to the nation as a whole, whether those programs involve space exploration, defense, oceanography, or deriving answers to social problems. ■

Truly interdisciplinary in nature, the **CHEMICAL** *industry will advance most rapidly in polymers, catalysts, and molecular biology.*

by **Dr. David M. McQueen,** *director, Central Research Dept., E. I. du Pont de Nemours & Co.*

THE CONCEPT that the chemical industry is based strictly on chemistry and chemical processes is long outdated. Today, the industry overlaps numerous other industries in a complicated pattern of sophisticated customer-supplier relationships. The net result is a strong trend toward highly diversified companies.

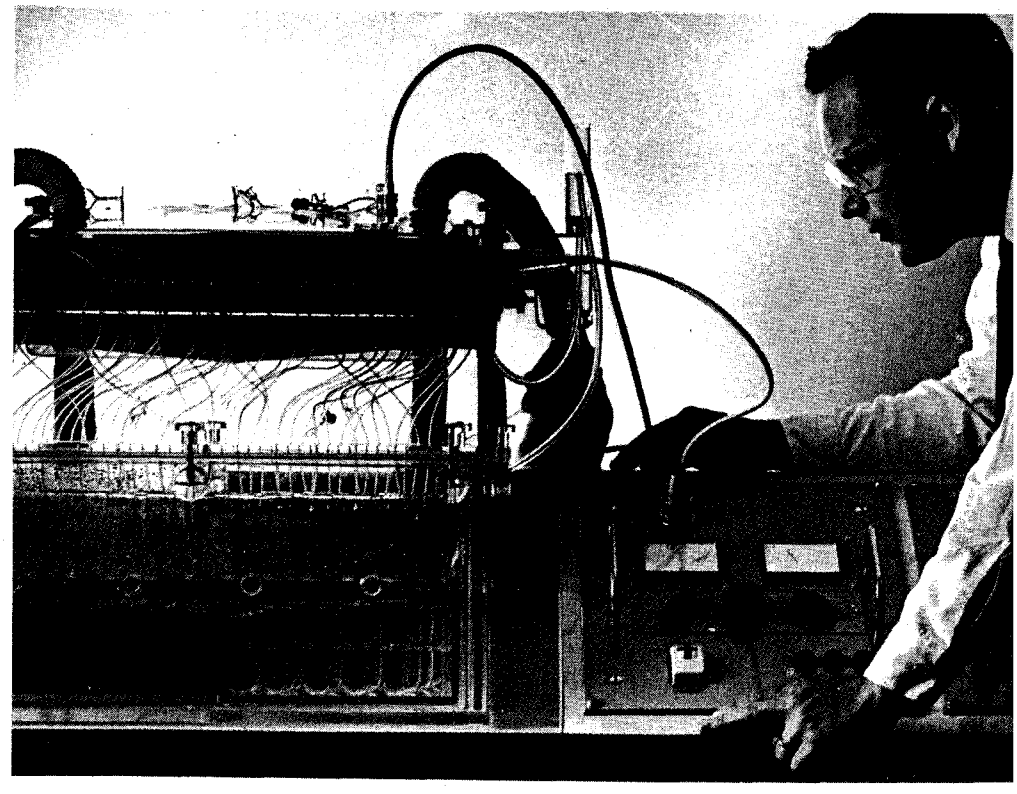
Truly interdisciplinary industrial laboratories have emerged as the result of this expanding scope of interests. The modern spirit of research in the industry is becoming that of a broadly interpreted "materials science," ranging from the biology of pharmaceutical "materials" to the physics of inorganic solids.

The wellspring of research, however, continues to be the new chemistry of basic organic and inorganic chemicals, which is yielding continual transformation and upgrading to more complex materials.

Synthetic organic polymers, major creative achievements of the chemical industry, continue to be the subject of intensive research. Far from settling down to a few commodities, new products are being introduced at a phenomenal rate, a condition which should continue for many years.

Polymers set pace

Physical and chemical modifications to achieve specific properties in standard large-volume polymers have become possible through advances in polymer science and engineering. For example, copolymers of ethylene bring new properties to the polyolefin plastics; in the elastomers field, ethylene/propylene terpolymers provide a new order of environmental stability. Polysulfones and polyphenyleneoxides are aiming at the high-performance plastics markets. Mixtures of polymers and grafted compositions, such as the



ELECTROPHORESIS, *the movement of particles in solution by means of an electric current, is used by molecular biologists at Du Pont to purify proteins in a fundamental research project.*

acrylonitrile-butadiene-styrene (ABS) polymers, have been developed with excellent property/cost relationships.

These property-tailored polymers are appearing in increasing numbers. Resistance to high temperatures is becoming an important goal, and several candidates—primarily the polyimides and perfluorinated polymers — are making headway in various segments of this field. For the highest temperatures, it is probable that composite structures will be required; we can expect significant developments here.

Polymer science is one of the most vital fields of industrial research, and there seems to be no end to the new knowledge and structures coming from the laboratory. Although today there still are few academic centers for polymer study, it is expected that these will increase in number to keep pace with industry's demand for well-trained scientists and engineers.

New catalysts to come

Increased academic emphasis on the oldest branch of chemical science—inorganic chemistry—recently has brought a remarkable change to industrial research in this area. Chemistry of the transition elements has been especially productive in contributing selective catalysts for a variety of processes, and more intensive exploration is forthcoming.

The development of solid-state physics as a full-fledged science has called the chemical industry's attention to sophisticated specialty uses for inorganic solids. New compositions and structures with specifically designed properties are being synthesized for such uses as luminophors and laser crystals.

Development of ultrafine refractory oxide fibers for insulation and reinforcement uses is among the most active research areas. In magnetics, discoveries of new materials such as chromium dioxide and single-domain iron particles are expected to provide advances in information recording and magnet fabrication.

Research on new and improved processes for the large-volume chemicals serving as basic intermediates will continue to engage industry's attention as a means of increasing earnings and minimizing industrial interference with man's environment.

Engineering research and catalyst studies rapidly are changing traditional relationships. For instance, acrylonitrile has become a low-cost, large-volume chemical, in dramatic contrast to its earlier specialty position. Packaged plants and superscale single-stream installations have become the order of the day for many chemical staples, including such items as ammonia and methanol.

Advanced technology is creating many new demands for both organic and inorganic intermediates by developing complex materials of higher value for application as surfactants, stabilizers, petroleum additives, and refrigerants.

Influence of bioscience

Nowhere is the interdisciplinary approach so promising as in biology. Molecular biology, brilliantly developed in university and government laboratories, is beginning to make its mark on industry. It seems sure to lead the way to methods for selective control of specific functions of living cells. The direction of this work is toward molecules designed to modify cellular processes in subtle ways, perhaps by stimulating natural defense mechanisms.

Already there are indications of the possibility of interfering with the course of specific virus diseases by at least two synthetic chemicals—herpes simplex of the eye, by localized application of iododeoxyuridine; and influenza A2, by preventive dosage with amantadine hydrochloride. Along with the ability to design specific molecular controls, more sophisticated testing methods will be derived to insure the absence of injurious side effects to patients.

The molecular biology and biochemistry of plants and insects, often forgotten because of preoccupation with needs in human medicine, are receiving an increasing share of industry attention. The already dramatic growth of the agrichemicals market will accelerate and continue, spurred by high labor costs and the threat of worldwide food shortages. Herbicides, fungicides, and insect control agents are as necessary to modern agriculture as fertilizers. Soon to be added to this list are chemicals exerting selective growth regulation in several types of crops.

Looking further ahead, the chemical industry has many strengths that speak for an exciting and highly productive future. The industry is intimately tied to the betterment of man's lot through provision of materials for clothing, shelter, food, and improved health; we are a "basic need" industry.

The industry depends on original research for achieving man's aims. It has a straightforward ability to bring together engineers and scientists of different backgrounds in an interdisciplinary approach to problems of mutual interest.

Most important of all, the chemical industry has a group of creative and knowledgeable scientists and engineers whose acts in laboratories and plants will help determine the shape of the future in a way now impossible to forecast. ■

Wider application of existing **ELECTRONICS** *technology will spur major advances in the nation's growth industry.*

by **Dr. Arthur M. Bueche,**
vice president, Research & Development Center, General Electric Co.

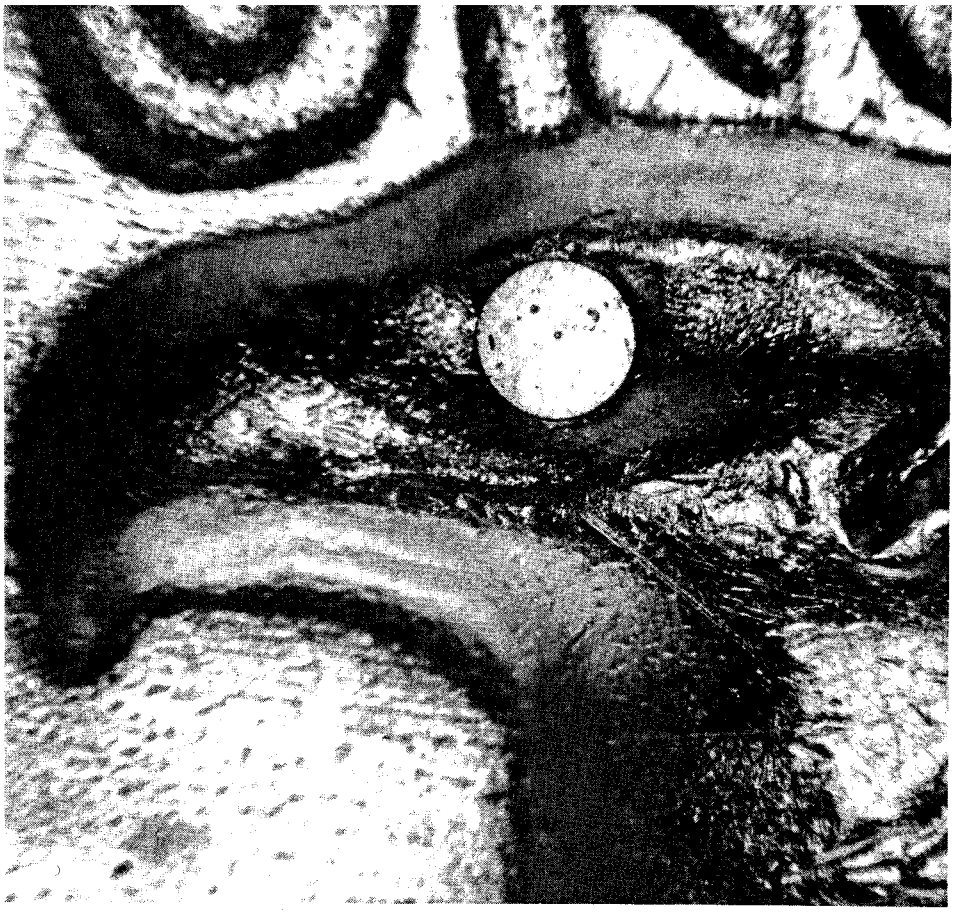
WHEN ASKED to predict the future, it always is tempting to give special attention to conspicuously novel devices, gadgets that never have been seen on land, sea, or in the air. This makes for good science fiction, or nonfiction, as the case may be. But many of the most profound technological changes are those that impinge on economics, sociology, and, of course, politics.

Thus, predicting the short-term future of any technology usually is not a matter of explaining what is *technically* new or possible. What will happen in electronics during this new year—or the next two or three years —already is happening. Major changes will result from the focusing of a variety of skills (not exclusively technical skills) on the engineering design, manufacturability, and marketability of existing ideas.

Let us, therefore, consider briefly not new electronics *per se*, but rather the continuing impact of electronics on such major business areas as electric power, industrial processes, consumer goods, transportation, and information handling.

The electric power business will continue to adapt to the vastly improved ability of solid-state switchgear to handle larger currents and higher voltages.

Within a year or so it should be commonplace to talk about a-c—d-c



THE TINY *black ring in the center of the gold disk is a microminiature varactor produced by Autonetics Div., North American Aviation Inc. It was photographed on the head of an eagle on a U.S. 25¢ piece.*

converters rated to 200 kilovolts and thousands of amperes. Power services will become more "customized" as inverter and cycle converters make it easy for the customer to have everything from d-c to 20 kilohertz (and in a few more years up to 100 kHz) available for special jobs. And, of course, the application of electronic data-handling and control systems will improve the reliability of our nation's increasingly complex and interrelated power networks.

Certainly, integrated circuits will dominate the thinking of those who design virtually every type of future electronic gear. The area of industrial process control is no exception. Integrated circuits will be introduced into industrial systems through new kinds of a-c adjustable-speed electric motor drives, for example. This step may not sound particularly glamorous in our space age, but it can have a far-reaching impact on productivity in many major industries.

The present proliferation of low-cost consumer electronic products will continue to be spurred by decreasing cost to the consumer and by improvements in batteries. We are seeing only the beginning of the individual consumer's fascination with and interest in inexpensive ways to record his own voice and actions.

In the home, it is becoming increasingly possible to satisfy consumer demands—at attractive prices—for new switching and control systems for lights, windows, doors, and appliances. And community antenna television (CATV) is on the verge of providing such relatively primitive feedback systems as fire and police alarms and, conceivably, "instant polling."

In transportation, the electronic industry will be hard pressed to keep abreast with the growing problems of air traffic control, let alone to solve them. Experimental system studies for automated and semi-automated rapid-transit programs will continue.

In the field of personal transportation, the potentially huge application of electronic controls in electric vehicles must await a significant improvement in either batteries or fuel-cell systems. The latter possibility seems very unlikely, at least for the near term.

Computer growth continues

The unprecedented growth in recent years of the computer and information-handling business is being stimulated further by substantial reductions in user costs, especially in the area of time-sharing systems. Time-sharing now is entering a new phase, in which remote terminals will themselves become sophisticated small computer-processors.

We can expect to see better display devices at these remote stations, displays with memory, and more elaborate computational ability. A present limitation on time-sharing systems is the bandwidth of the communication lines that are used.

Costs will be minimized and service improved only when the user has a more powerful terminal of his own. Such a terminal would make it necessary to go back to the large central computer only when the operator couldn't use his terminal economically.

All of this will hasten the need for simpler computer languages that can be translated on-site. We are going to find that it costs too much to have machines that talk only to highly trained specialists. Languages more closely matched to the users' will become available; the computer will become more useful to those who do not have extensive, specialized computer training.

There also will be a proliferation of remote, computerized sensing and feedback control functions. Through this arrangement, large centralized computers will be tied directly to user systems in such areas as hospital patient care, research experimentation, industrial processes, and school classrooms.

'Shoe-box' computer

As we review future trends in electronics, it becomes apparent that integrated circuits will be the largest single source of improvement and change. As large-scale integration (LSI) continues, the number of electronic functions that can be delegated to a single piece of silicon will increase sharply.

At present, a 200-component chip generally is regarded as average. In two or three years these chips will have become wafers—perhaps several square inches in area—and we may have up to a million components per wafer. The "shoe-box" computer is certainly more than a year or two away, but obviously we are moving in that direction.

Fabrication techniques for integrated circuits have been vastly improved and simpler systems now are almost routine. However, we are approaching the natural limits of the photographic processes involved, and must anticipate the need for improved electron-beam and "fly's eye" electron lens techniques for making future ultra-microminiature circuit patterns.

To summarize, there probably is no electronic device or system that will have a major impact on society in the next one to three years that is not technically feasible today. However, even over this brief period, there are countless new applications of present knowledge that can—and will—gain common use. ■

Improved metals, composites, and bonding methods are being developed by the **METALS** *industries to meet the demands of designers in aerospace, transportation, and other advancing industries.*

by **Max W. Lightner,** *vice president of applied research, United States Steel Corp.*

***SINE WAVE** beams can be accurately welded using a technique developed by Martin Marietta Corp. These beams will be used in the first U.S. supersonic transport.*

TO MEET THE GROWING requirements for tough new specialty metals by industries such as aerospace and transportation, research scientists and engineers are scrutinizing all of the traditional metal-producing and metalworking areas.

During the coming year, their studies will range from new ways to use superplasticity in difficult-to-fabricate metals, computerized welding, and new composites, to "prescription steels," and high-purity, high-strength whiskers.

Probably the highest strength metal ever made has been iron whiskers. Modern metalmaking is approaching iron's theoretical strength of 2- to 3-million psi with whiskers having a tensile strength of almost 2-million psi. Chromium whiskers having a strength of 1-million psi have been produced, and cobalt, copper, and nickel with strengths of ½-million psi have been tested. The highest strength metals commercially available are fine wires drawn from eutectoid steels. For example, piano wires have long been available with strengths up to almost ½-million psi.

By employing special steelmaking practices and closely controlled patenting and wire drawing, wire can be drawn in excess of 95% reduction to high-strength levels without encountering embrittlement. Production quantities of 0.13 mm missile guiding wires having strengths near 600,000 psi have been produced and it is reasonable to predict that strengths 100,000 psi above this figure are not far in the future.

High strength—low weight

New construction materials are desired that possess higher strength-to-weight ratios, greater stiffness, better fracture toughness, and more resistance to environmental degradation than those currently available. The need of the aerospace industry (covered elsewhere in the issue) for higher strength-to-weight-ratio construction materials has spurred the development of steels with yield strengths over 200,000 psi.

Traditionally, such strengths were obtained with high-carbon contents and judicious combinations of alloying elements, coupled with various thermal and/or mechanical treatments. For rigorous new applications, however, steels with greater fracture toughness are demanded to insure against unstable crack propagation at stresses below yield strength.

The timely advent of the new class of 18% nickel maraging steels a few years ago provided steels with considerably better fracture toughness at yield strengths up to nearly 300,000 psi. They also offered better weldability and simpler heat treatment with better dimensional stability.

Very high strengths of these essentially carbon-free steels result from nickel-martensite formation and precipitation hardening by extremely minute particles of intermetallic compounds (Ni_3Mo and FeTi). This is a result of solution annealing and low temperature aging, rather than carbon-martensite formation and carbide particle hardening as in conventional quenched-and-tempered alloy steels.

More recent experimental work has indicated that this mechanism of strengthening can be exploited even further to achieve yield strengths of 400,000 psi and above. At the same time, other investigations have shown that the toughness of these steels may be markedly improved by reducing embrittling residual and impurity elements to extremely low levels. More effective steel refining methods currently being developed may provide economical production of such premium alloys within the next few years.

A marked improvement in the strength-ductility-toughness relationship observed for conventionally processed steels appears feasible by producing ultrafine grain microstructures.

American Society for Testing Materials grain size numbers in the range of 10 to 15 have been obtained in certain thermomechanically processed steel, and similar ultrafine grain sizes have been obtained by rapid thermal cycling techniques in heat treatment. Improvements in yield strength with essentially no loss in tensile ductility or notch toughness have been observed in these ultrafine-grained steels.

Multicycled, rapidly heat-treated steels currently are in the laboratory stage, but they may become available commercially in the near future. Significantly, the technique permits better combinations of strength and toughness with less alloying.

Updating welding

Higher strength materials require the development of more sophisticated joining methods to fabricate them into useful structures. High voltage power sources using electrogasdynamics will permit the use of electron beams for welding and cutting in air and in partial vacuum.

Automatic computation of welding procedures to produce welds of desired properties now is at hand. It will permit rapid computer evaluation of possible welding procedures for any

given fabrication without the need for costly and time-consuming cut-and-try methods used today. Solid-state lasers operated in the pulsed mode already have been used to produce holograms of weld defects. Development of continuously operating lasers will greatly enhance the use of this application, in this as in other industries.

Composite fabrication appears to offer the only feasible means for generating truly "engineered" materials. In this way we can use the extreme high strength and rigidity of very fine whiskers, fibers, and filaments of certain substances, such as tungsten, molybdenum, beryllium, graphite, boron, and sapphire.

High-strength, lightweight composites of such fibers in plastic and metal matrices already are being fabricated experimentally for trial in certain extreme duty applications. They offer important foreseeable advances. Increasing interest is being focused on this area.

In the meantime, it seems certain that increasing application will be made of more conventional types of composites, such as laminated steel plates, segmented steel forgings, layered pressure vessels, and wirewrapped steel pipe and pressure vessels, to obtain higher strength-to-weight ratios and improved fracture toughness in large structures like machinery and pressure vessels.

Reference has been made recently to the possibility of designing steels by "prescription." Desired properties would be fed to a computer and the prescription, including the composition and the processing methods, would be read out immediately. Mathematical models programed on a digital computer now are starting to be used to simulate the effects of alloying elements and processing combinations in designing some steels.

The need for laboratory verification of predictions will diminish as the interacting effects of alloying elements and processing variables on mechanical properties are better correlated.

Deformation of certain metals at elevated temperatures and at very slow strain rates imparts extremely high ductility known as "superplasticity." Investigations of this phenomenon in various alloy systems are determining the limits of chemical composition, temperature, and strain rate required to establish high ductility.

The first use of superplasticity probably will be in the forming of high-cost metals, such as titanium, into complicated sections. Titanium fabrication now requires expensive machining operations with high metal losses. Current interest in this material is likely to spur advances. ■

The trend in today's modern **SCIENTIFIC INSTRUMENTS** *is toward direct data handling for quick solutions to analytical problems.*

by **Dr. William F. Ballhaus,** *president, Beckman Instruments*

NINE MONTHS AGO, a life scientist who took raw data from 200 samples in a liquid scintillation system on a Wednesday felt satisfied if he had test results analyzed by the weekend. Today, this two-day data reduction task is routinely handled in 70 seconds!

This advancement is indicative of what probably will be the most significant trend in scientific instrumentation during the coming year—data enhancement.

Currently there are several different approaches to data processing:

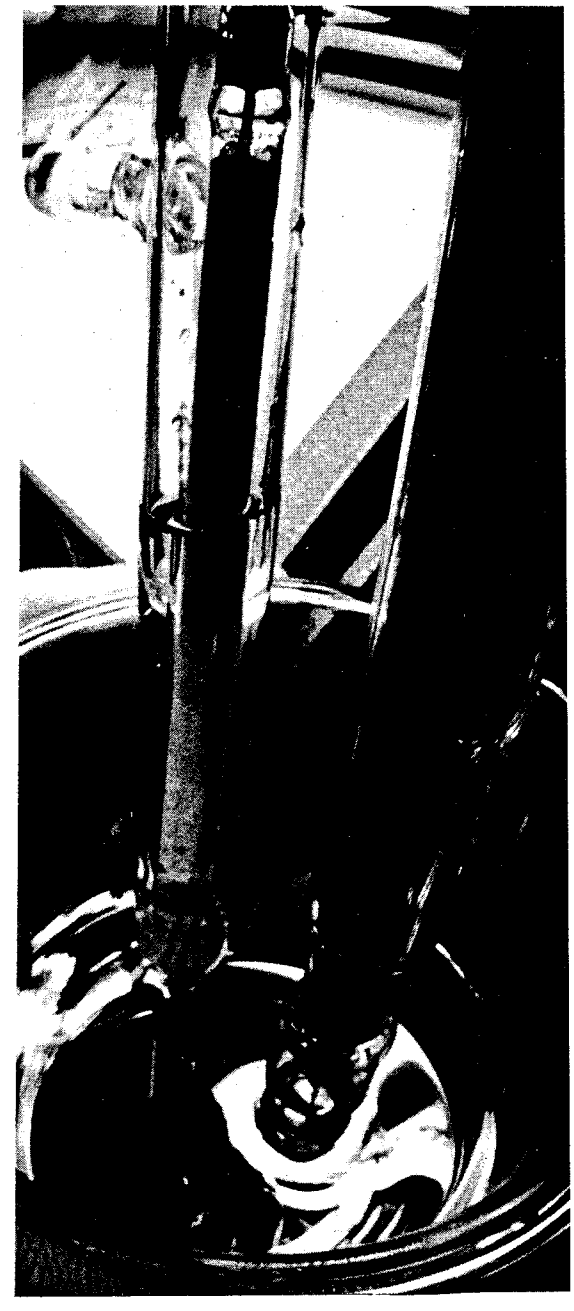
- Off-line data reduction, where the chemist takes his material to a large computer center for analysis.
- On-line data reduction, where he uses a small processor connected to or built into an instrument, "dedicated" to a specific function.
- Time-shared computing, where his analytical instrument is tied to a terminal that permits access, on an as-needed basis, to a remotely located digital computer.
- Semiautomated operations, where he uses simpler data-handling items such as programed desk calculators, electronic integrators, and digital readout devices.

Simply stated, the emerging trend toward data enhancement will permit analytical chemists to arrive at answers to their problems *directly*.

The use of dedicated or on-line computers will become more common for specialized work in which tests are run on a more or less continuous basis. More and more of the simpler data-handling devices also will be applied. A strong subsidiary trend will involve more extended use of the concept of time-shared computing.

A number of recent developments is responsible for making continuing advancements in direct data-handling possible:

- A conversational computer language which uses standard English words and abbreviations has been developed, allowing the scientist to "talk" his problem into the computer without consulting a computer programer. This speeds up the process considerably, and reduces user costs.
- The development of small dedicated computers and their availability at relatively low cost has made them feasible for use in a wider variety of applications than was formerly the case.
- Interfacing hardware that con-



***ELECTRODES** in this close-up photograph are used to measure the pH of the solution in the beaker. PH meters are among the most common directly read analytical instruments in use.*

verts analog output from analytical instruments to a digital form usable in computers now is readily available. This new family of instrumentation—interfacing hardware or couplers—permits readout to be converted automatically to punched paper or to be fed directly into a dedicated special-purpose computer.

■ The growth of the computer time-sharing industry in the U.S. permits a scientist to purchase computer time, by the hour, over the telephone. He merely calls a time-sharing company and feeds his data to the computer via telephone wires by means of a teletype terminal at his desk. He can either communicate directly with the computer, or data can be fed to it from the analytical instrument.

Bypassing secondary analysis

Until recently, a chemist using an instrument such as the spectrophotometer received only a partial solution to his problem—a very complex waveform, about which he had to know a great deal. Upon getting the waveform, it often was necessary for him to consult with other chemists or to check reference texts before arriving at a final answer.

During the past year, in an effort to provide complete solutions to problems, devices have been developed that will make analytical instrument output compatible with computer systems, a most significant step.

A number of products offering computer compatibility already is available from the industry, and more will be introduced during the coming year. In addition, work on software and data-handling equipment for a number of analytical applications is being conducted within the industry.

To complement these efforts by instrument manufacturers, I feel that the computer industry also could make a significant and much-needed contribution to chemistry research by developing a wider variety of specialized computer languages. While the new conversational language is easier to use than the established and more complicated FORTRAN, it still is not designed basically for the analytical chemist. The growing computer market among instrument users could well use software designed specifically for the chemist, the physicist, and the physician—in much the same way that COBOL has proved to be useful to the businessman.

The impact of these new methods for rapidly *processing* data will be considerably lessened, however, if we cannot also *acquire* data at top speed. Consequently, increased attention will be given to automated methods to speed up sample-handling procedures.

Improved sample-handling speed will complement rapid data reduction capabilities, and the automation of these processes will free technicians and supervisory personnel for more important tasks. A number of breakthroughs and innovations in this area also can be expected during the coming year.

In taking a closer look at the futures of specific instruments and technologies within the scientific laboratory community, we should think in terms of two categories: research laboratories on one hand, and industrial production and quality control labs on the other.

Research labs will show an increasing interest in the more sophisticated equipment. This trend reflects the highly complex technologies that are receiving increased emphasis today: circular dichroism, electron microscopy, mass spectroscopy, nuclear magnetic resonance, nuclear quadrupole and electron spin resonance, the Mossbauer effect, Raman spectroscopy, gel-permeation chromatography, far-infrared spectroscopy, and interferometry, to name a few. These rapidly growing technologies, of course, are generating a great deal of interest among instrument company R&D staffs.

For instance, because of the rising interest in the study of macromolecules, as in polymer research, and the increasing number of persons entering this field, there is a greater emphasis on new and improved separation techniques. Instrument makers will meet this increasing customer demand with improvements in existing instruments, such as ultracentrifuges, gas and liquid column chromatographs, and with the development of new techniques.

Increased interest in the measurement of kinetic rates also will stimulate activity in related instrument areas, notably those involving ultraviolet, atomic absorption, fluorescence, and electrochemistry techniques. In the electrochemical area, particular interest also is being shown in the development of new specific ion electrodes for analytical instruments.

Undoubtedly, because of the complexity of emerging technologies, instruments for this segment of the scientific community are going to have to be more sophisticated. Customer demand for the big, versatile, and expensive items will most likely increase. This, in turn, will allow instrument makers to plan for larger and more economical production runs. Closing the circle, these economies will make these instruments available to still more labs, increasing volume and demand even further. ■

As the number of people utilizing **TRANSIT** *modes increases, complex interfaces will need solutions.*

by **Dr. Michael Ference Jr.,**
vice president, scientific research staff, Ford Motor Co.

PERHAPS THE MOST significant trend in transportation science, especially in ground transportation, is the total application of systems analysis to the complex problems of moving people and goods.

By total application, I mean recognition of the fact that sociological, economic, and political pressures as well as technology are important influences on the timing and type of future transportation systems.

The application of systems analysis (a technique of proven value for hardware optimization) to such a large question as how transportation systems design affects and is affected by the urban environment is relatively new.

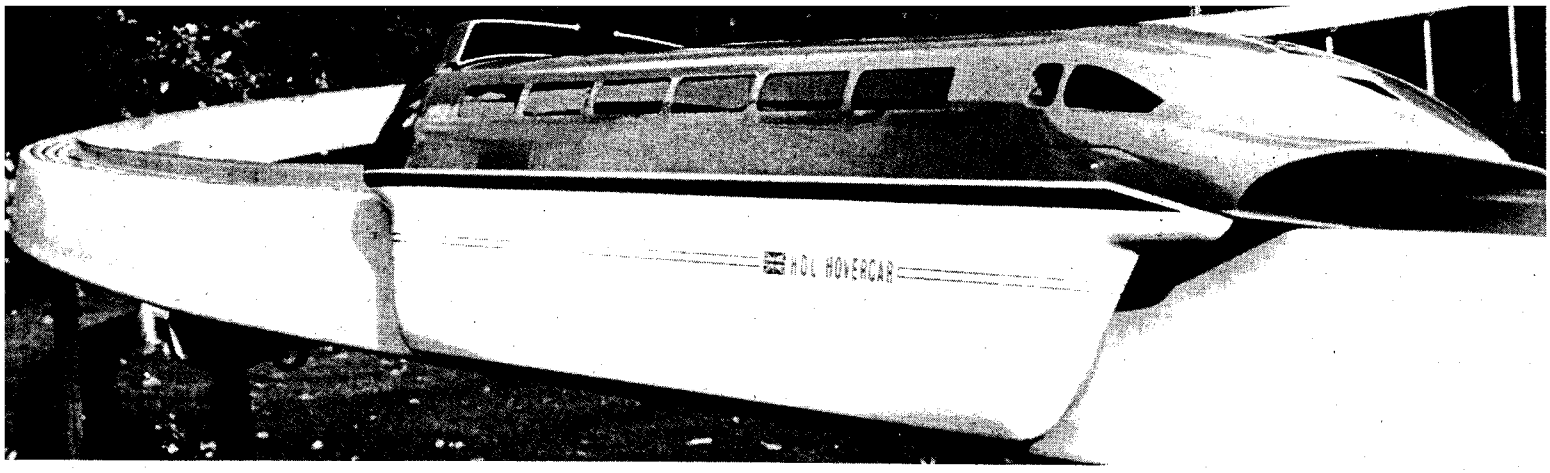
We now recognize that urban planning and transportation planning cannot be separated. But adequate tools for such comprehensive analyses only recently have become available.

The urgent need for this kind of analysis can be demonstrated by comparing typical performance of several transportation modes—first, in terms of the performance capability of the equipment itself, and then, when we consider the time involved getting to and from the various modes without allowing for the interface problem of waiting time.

I'd rather fly, but . . .

It has been demonstrated that most people will not walk for more than 10 minutes if they have the choice of making the trip in an automobile. But for longer trips, the proper choice of mode is not so clear cut.

Compared to an auto, a 150-mph train should save about 10 minutes for a trip distance of 32 kilometers (20 miles) or 20 minutes for a trip of 64 km, but this potential saving of 10 to 20 minutes easily is lost in getting to the train station, waiting for the train, and getting to the final destination.



TRACKED *hovercraft, designed by Hovercraft Development Ltd., England, glides swiftly on a cushion of air.*

When realistic connecting delays are applied to the potential performance, the picture changes drastically. Five minutes must be added to each end of an auto trip for parking and walking to and from the car. Fifteen minutes or more must be added to each end of a train trip for the walking, driving, parking, and waiting involved in getting to and from the stations. And 30 to 45 minutes must be added at each end of most air trips to get to and from the airports.

Under these conditions, the choice of mode is a highly complex process having very little to do with the speed of the vehicles in question. Clearly, the overall "goodness" of urban transportation depends primarily on total system design—not on the performance potential of individual components of the system.

But time is only one criterion by which transportation systems are evaluated. Other goals are expressed in physical, economic, social, and aesthetic terms.

By using models and simulation techniques, a region's growth and its transportation demands may be predicted and tested. Predicted requirements are then used in a cost-benefit analysis to select the system that provides the best transportation at lowest cost. It should be emphasized that the transportation system directly affects future development of a region and that the system must be evaluated with this in mind.

Using such parametric criteria as time, generalized studies of this kind, when applied to existing multi-modal transportation systems, have pinpointed the mode *interfaces* as the bottleneck in dire need of imaginative resolution.

For example, freight containerization, although not itself concerned with movement, already is revolutionizing the marine trades and gathering momentum in the railroads. As this service grows, the impact on rail and highway operation will be great: containers can eliminate the costly and time-consuming handling between modes. Eventually, similar concepts will lead to complete integration and profound upgrading of freight and passenger services.

One of the ways in which urban environment influences transportation motive power is illustrated by the revival of interest in the electric automobile, an old concept that recently has received great stimulus because of a combination of desired attributes and the promise of greatly improved technology.

Electrics—a comeback

The earlier demise of the electric car was due primarily to its unfavorable comparison to gasoline-powered vehicles in the following terms:

- Limited energy storage (in watt-hours/pound of battery) resulting in limited single-charge operating range.
- Low acceleration, poor hill-climbing ability, and limited top speed due to limited power storage of battery.

The lead-acid battery, with an energy density of 10 W-hr/lb and a power density of 32 W/lb, simply was not adequate. However, within recent years, several promising experimental battery developments have been announced.

Also, we can expect some significant improvements in the weight-to-power ratio of electric motors. Current progress in the development of lightweight motors utilizing electronic commutation (versus mechanical commutation —"brushes" in conventional designs) suggests the possibility of motors with a specific weight of about 2 lb/kW—at least a fivefold decrease from the weight of traction motors used in early electric cars. We should expect to see experimental vehicles incorporating some of these advanced components within the next few years.

Electric vehicles and hybrid vehicles, systems combining electric and other propulsion modes, are the natural precursors of automated travel by means of the dual-mode vehicle. Electric propulsion readily lends itself to "no hands" operation on completely automated guideways. At the end of the automatic trip, the vehicle would continue to its destination on ordinary streets under manual control.

Dual-mode vehicle operation probably represents the next quantum jump in ground transportation system hardware. Because of the speed and headway improvements that derive from automatic control, one lane of guideway will be able to accommodate a traffic flow equal to five to 10 lanes of conventional expressway.

In this sense then, the guideway is similar to a rapid transit rail system. But in addition, because the same vehicle makes the whole trip from ultimate origin to ultimate destination, the troublesome interface between personal vehicle and mass-transit vehicle is eliminated.

The potential benefits of such a system are most impressive but—again—great sophistication is required to plan and change the urban environment if these benefits are to be realized.

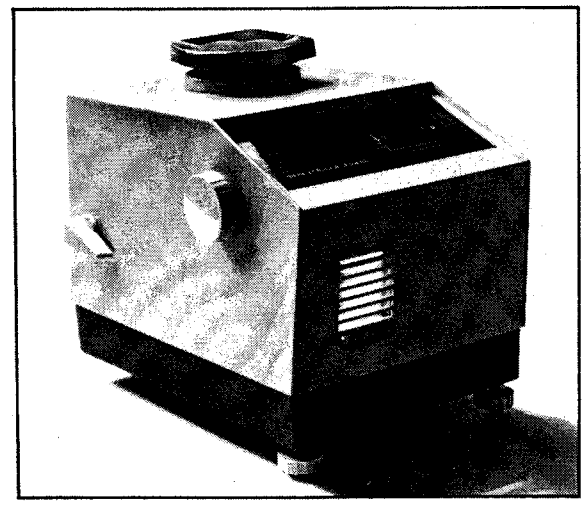
The more conventional concepts of mass transit are currently the object of intense activity in hardware research and development. High-speed trains in particular are receiving a great deal of attention. Popular approaches range from improvements in steel-wheel on steel-rail technology to tracked air-supported vehicles capable of speeds in the upper regions of the subsonic range.

Through improvements in automatic control and signaling, and particularly with the development of dynamic suspension systems, the first of these approaches could lead to rail rapid transit with a speed capability as high as 320 kph. The swifter air-supported vehicles are of interest primarily for intercity rather than intra-urban use.

All of these mass transit systems, however, will not meet potential passenger capacity unless much more attention is given to the problem of collecting and distributing passengers to, from, and in the transit terminals. This problem brings us back to the broad systems approach and provides yet another illustration of why systems planning developments represent a significant trend in transportation. ■

Wouldn't it be great if someone designed a 160 g top-loader with 1 mg accuracy and all-digital readout?

Someone has. Sartorius.



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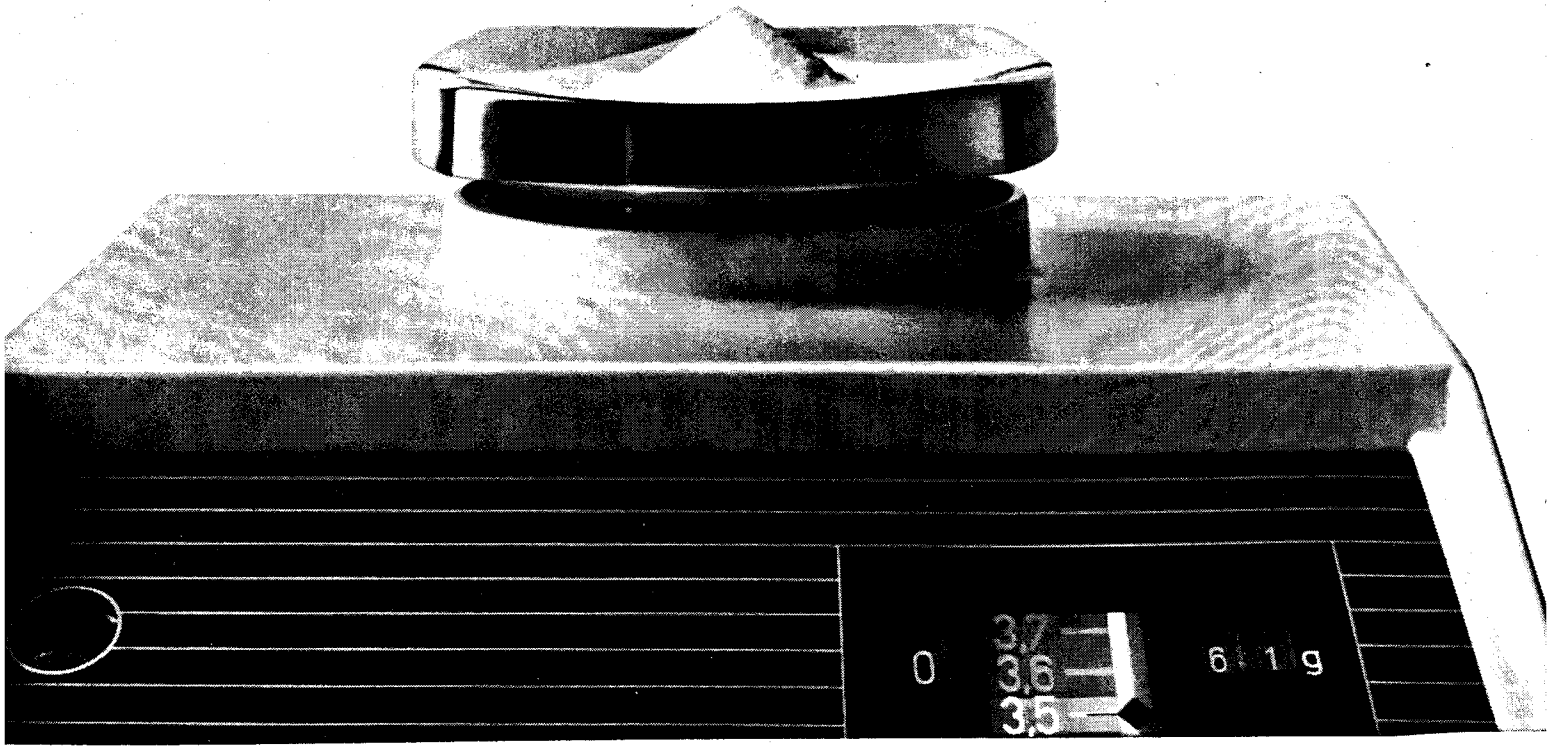
sartorius balances

See inquiry card 80.



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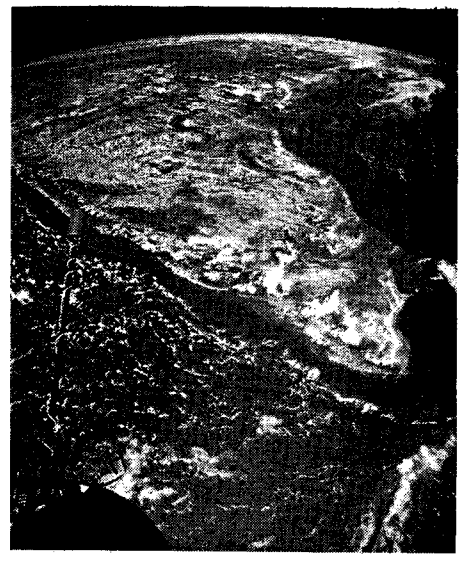

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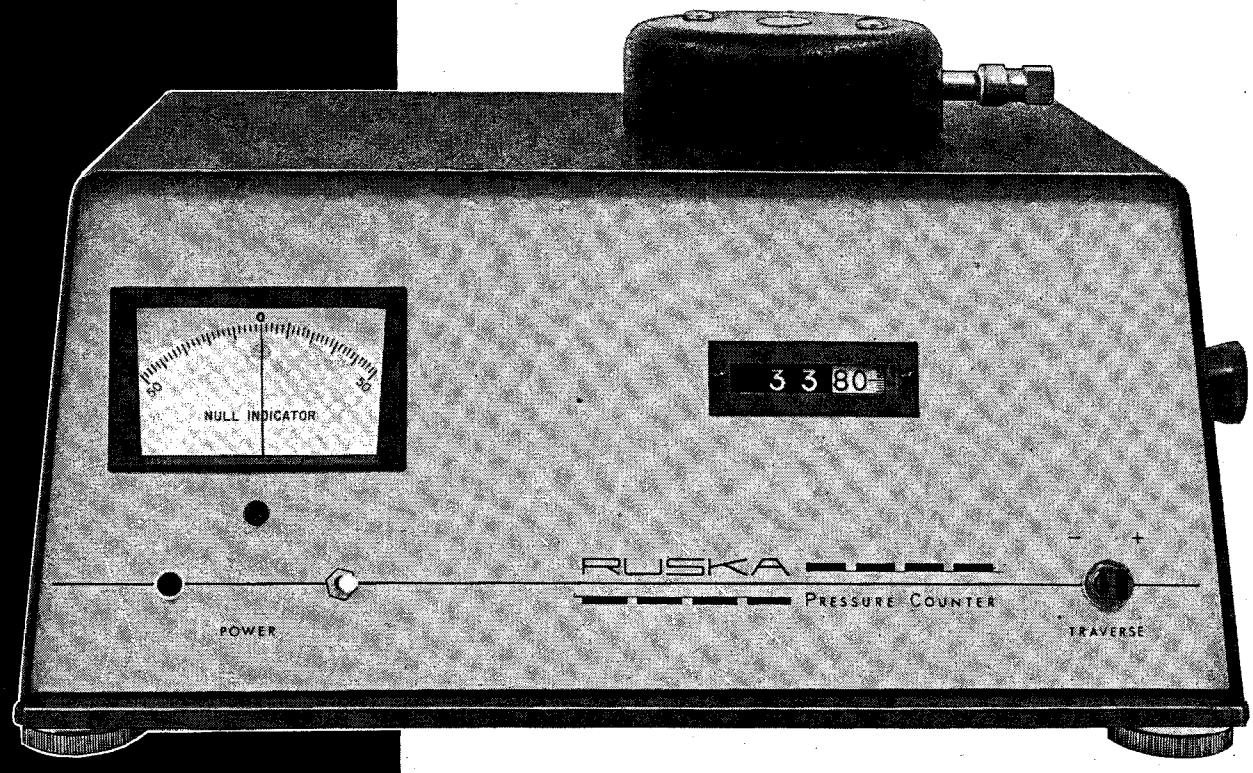

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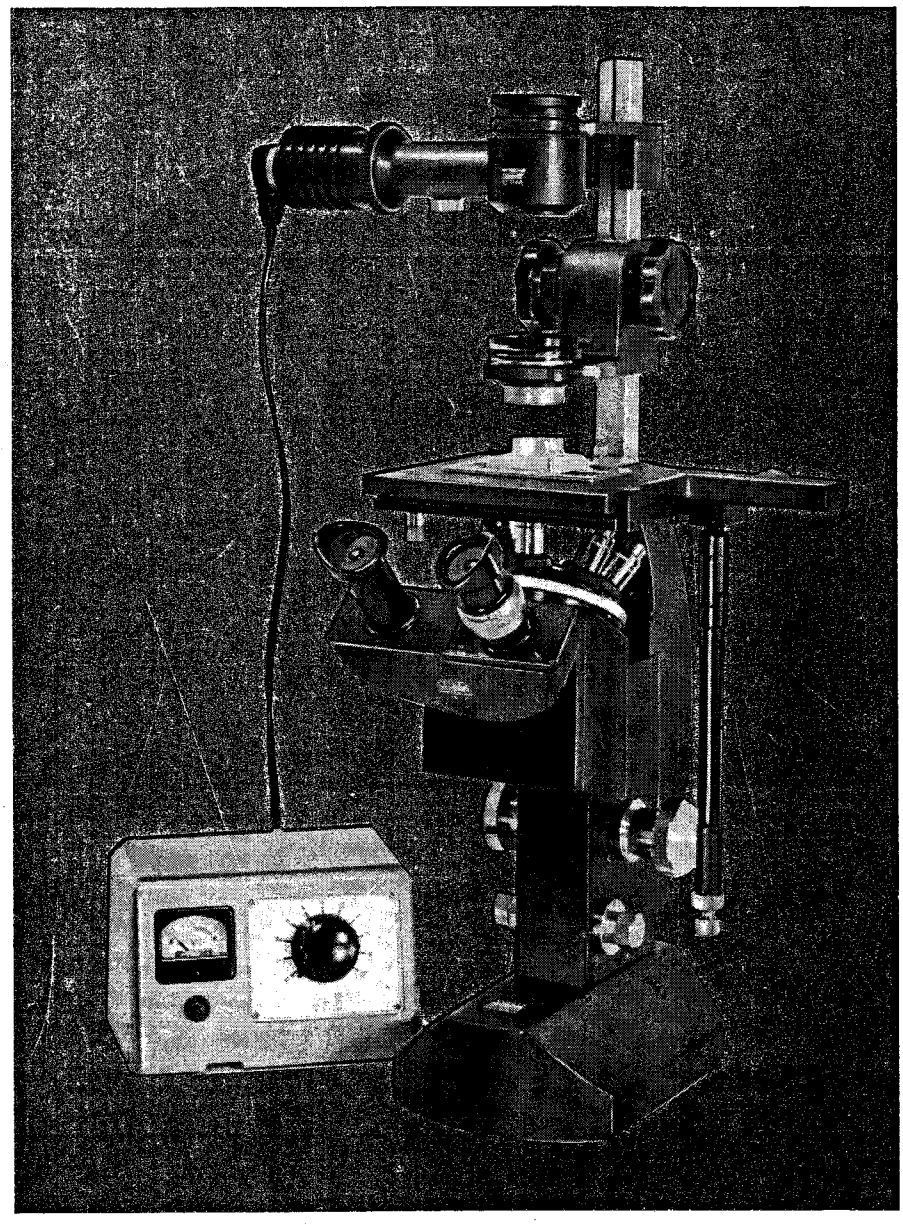
See inquiry card 83.

Why doesn't somebody design an inverted microscope specifically for tissue culture and other biological studies?



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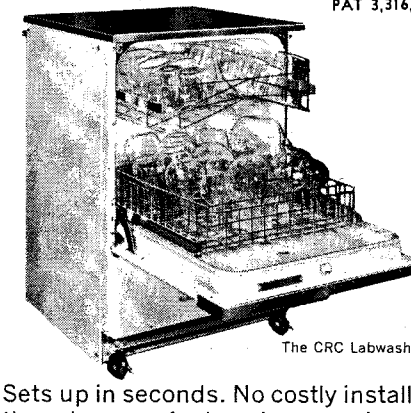

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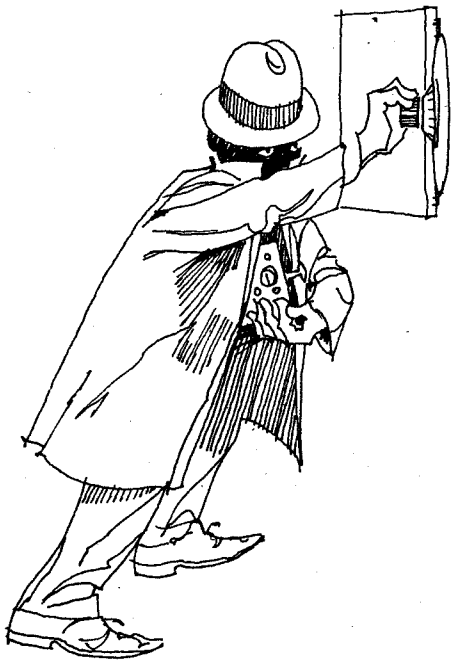
See inquiry card 84b.

confuse secret academic research with development in hot debate

To the Editors:

I feel that both sides in the "secret research" debate in the October issue missed the main point of the argument. To start with, both the *Summit* and *Spice Rack* projects stand in the same relation to the science of biology as does fabrication of a new radar device to the science of physics. Both are *development*, not research.

Whether or not a university should engage in development is a subject in its own right. It should be noted that organizations such as the MIT Instrumentation Laboratory have done excellent development work, on classified projects, without damage either to the standards of the university or to the secrecy of the projects. The absence of commercial bias in their operation puts these organizations in a good position to act as advisors to the Government.



However, opponents of such activities can argue with considerable justice that this is not a proper field for universities, and that the same benefits could be obtained from the use of other nonprofit organizational arrangements. Either way, the discussion of development projects in a university is not germane to a discussion of research.

Regarding true research, as opposed to development, there is very little to argue about. The Air Force Office of Scientific Research has 1,000 grants and contracts currently active, mostly with American colleges and universities. In all of these, we encourage open publication of results, and in no case is the research itself considered classified. Some scientists do have so-called classified contracts, but the sole purpose of these is to allow these individuals access to classified data which they might require in the performance of their research (for instance, to extract unclassified data from a classified report).

Naturally, this requires some care to, assure that they do not inadvertently disclose classified information which they obtain in the course of their work. However, in over 15 years of existence, the Air Force Office of Scientific Research has not encountered a single case of such inadvertent disclosure. And the results of the work itself, aside from any classified data which may have gone into it, are always unclassified. We do not even require prior review before publication. We ask only for submission of manuscripts to us and to the journal simultaneously. Similar policies are followed by other agencies, such as the Army Research Office and the Office of Naval Research.

Thus, I find that the debate about classified research is mostly not about research; and that it grossly exaggerates the size and scope of the problem. One of the biggest contributions which could be made to the debate is to label research and development properly, and not confuse one with the other.

Joseph P. Martino, Major, USAF
assistant executive director
Research Communication
Air Force Office
of Scientific Research (OAR)

. . . and debate goes on

To the Editors:

You are to be complimented for the timely and excellent debate on secret research which appeared in the October issue, and for the keen observations in your editorial on the erosion of privacy.

Dr. Krieger and others who conduct controversial secret research such as Project *Spice Rack* should be commended for their courage, just as the Defense Dept. should be for its honesty in admitting the nature of this research. Far better to admit that such research is being done, than to attempt to disguise it.

To accuse scientists who perform secret research of doing low-quality work because such work is not open to the scrutiny of the entire scientific community is to point an accusing finger at thousands of industrial scientists whose work must be kept secret.

It strikes me that sponsored research, private or public, is a permanent feature of the modern university. If a university should desire to accept such projects, then it should be allowed to do so. It should not, however, lose sight of the fact that the grantor of funds, whether government or industry, has the right to make the rules regarding the dissemination of information resulting from such research.

Dr. Jerry F. O'Donnell
senior research chemist
Pittsburgh Plate Glass Co.
Corpus Christi, Tex.

'Doing' outscores 'results'

To the Editors:

All this "hoo-rah" over secret university research for the DOD simply confirms my conclusion that far too many of the ivy set are either emotionally immature individuals or deliberate subversives; most are in the former group, used by the latter.

Most of this activity stems from the snow-balling tendency of colleges to make professors out of last year's PhD candidates, who know little more than they were just taught, and nothing of education. Suddenly, they *know* what is best for their colleagues in other disciplines; what university policies should be; and which companies the graduates shouldn't work for.

What the whole problem boils down to is that the purpose of a university is to teach—not just facts, but techniques and disciplines for getting at and analyzing facts. In the sciences, this means the professor must be knowledgeable in the current related technology, and that means he must be doing research.

What has been overlooked is that for academic purposes it is the "doing" that is important, not necessarily the "results." And while the researching teacher should be able to compare notes with other colleagues, it is not necessary that his work be scrutinized by the entire scientific community.

However, "results" can be useful. And the group that is willing to relieve an institution of the cost of research—while retarding teacher obsolescence and providing students with essential practice — might reasonably be entitled to control dissemination of the results of that research. This is simply what a company of government unit would do in its own lab.

The alternative is increased pressure on research-oriented people to leave

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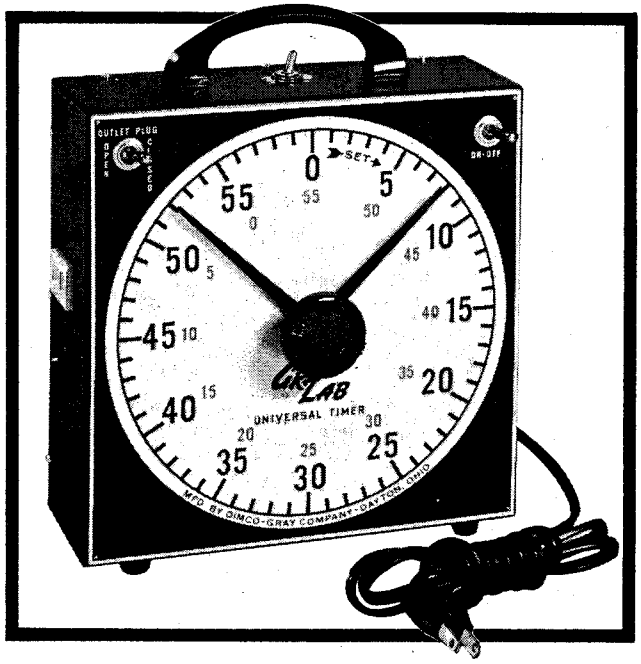

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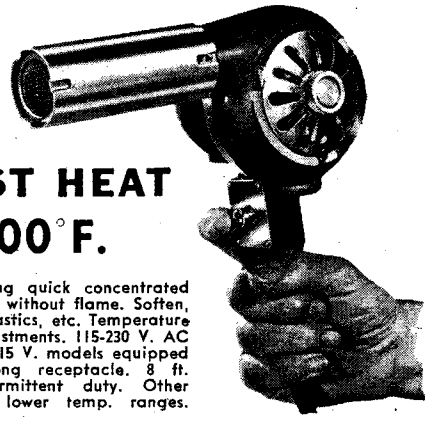

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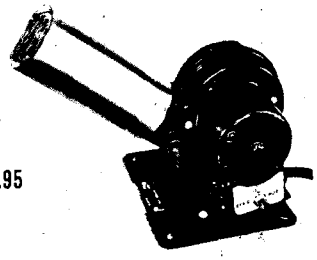

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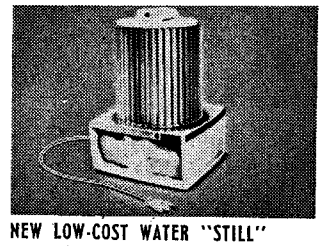

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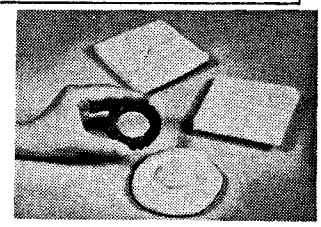

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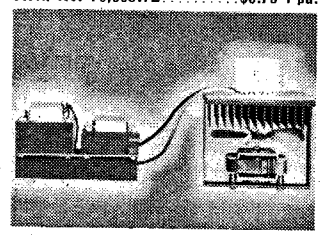

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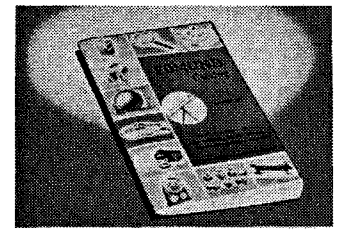

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universities for private laboratories, further reducing both that cross-talk which occurs in the less parochial academic research laboratories, and the pressure to make results public.

The only criteria for university research should be:

- The availability of suitable facilities with which the research can be safely performed.
- The willingness of any teacher or student to perform the subject research within whatever restrictions are imposed.
- The determination that the research is indeed of *academic* value.

Mass dissent which encourages unreasoning participation, or physically interferes with the rights of others to their own education (or to make their own decisions), is *prima facia* evidence of unfitness for the responsibilities of the academic community. College administrators who take any position but this on such dissent, either regarding research contracts or any other aspect of policy, program, or decision properly established, do an unconsciouable disservice to the majority of their students and faculty.

It is sickening to find so-called teachers and members of purportedly "enlightened generation" of students displaying an attitude which says "I'm right: things will be done my way or not at all." This reflects a degree of dogmatism unparalleled since the Inquisition.

Both as student and as practicing engineer, I have found universities to be populated by mortals; no more nor less objective, not specially endowed with greater insight, having no keener or duller moral sensitivity than the men who do research for government or industry, and not (*per se*) appreciably better informed.

Edward D. Henze
senior development engineer
Mobil Chemical Co.
Richmond, Va.

Survive first; publish later

To the Editors:

Until now, I have been only an interested spectator to the quarrel over secret defense research in universities. Rather than engaging in a point-by-point discussion, let me state my personal position in general terms:

- Nature's first law is survival; neither insects, nations, nor university professors are exempt from this law.
- There is no second prize in war —unless you happen to lose to the U.S. — nor are there sportsmanship awards. History has shown that the only war criminals are losers.
- Totalitarian governments may seem to be generous to their academi-

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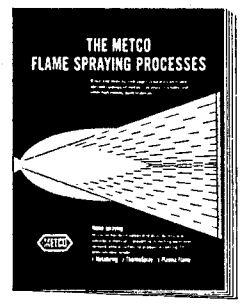

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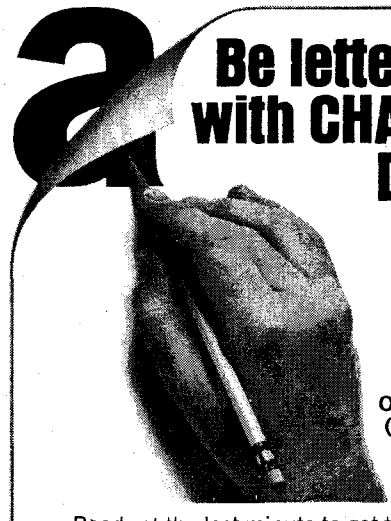

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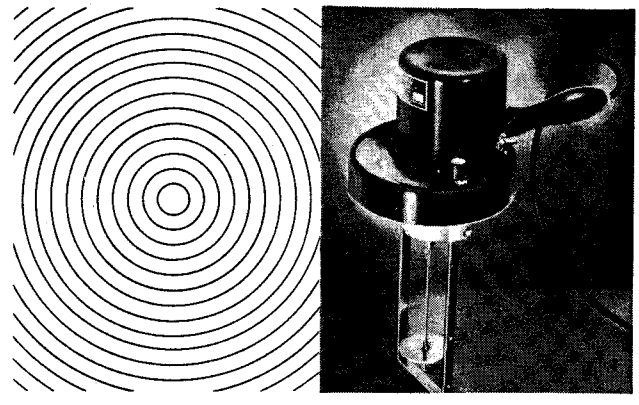

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cians, but they will not take "no" for an answer: remember the Lysenko case.

■ Should a new world conflict break out, there will not be sufficient time for mobilization of our physical and intellectual resources. The war will have to be fought with the means at hand—we dare not fall behind.

The feeling that the "best minds" have much better things to do than maintain our readiness, which may be serving our theoretical long-range interests, will not serve to help us survive, and we must survive in order to reach our more worthy goals.

The university itself, even as does its students, owes direct service to the defense of the nation, not at some time of its own choosing, but when the need arises. And one assumes the universities would seize this responsibility willingly because of their favored tax status and the great amount of federal support at all levels.

Furthermore, I can have no respect for those who would gamble away personal human freedoms by clinging to their "academic freedom" above all else. This is the attitude of the "dog in the manger," and lowers these people from an exalted position of general respect to the status of merely another bunch of freeloaders looking for something for nothing.

Robert S. Rabinowitz
senior analytical chemist
Norwich Pharmacal Co.
Norwich, N.Y.

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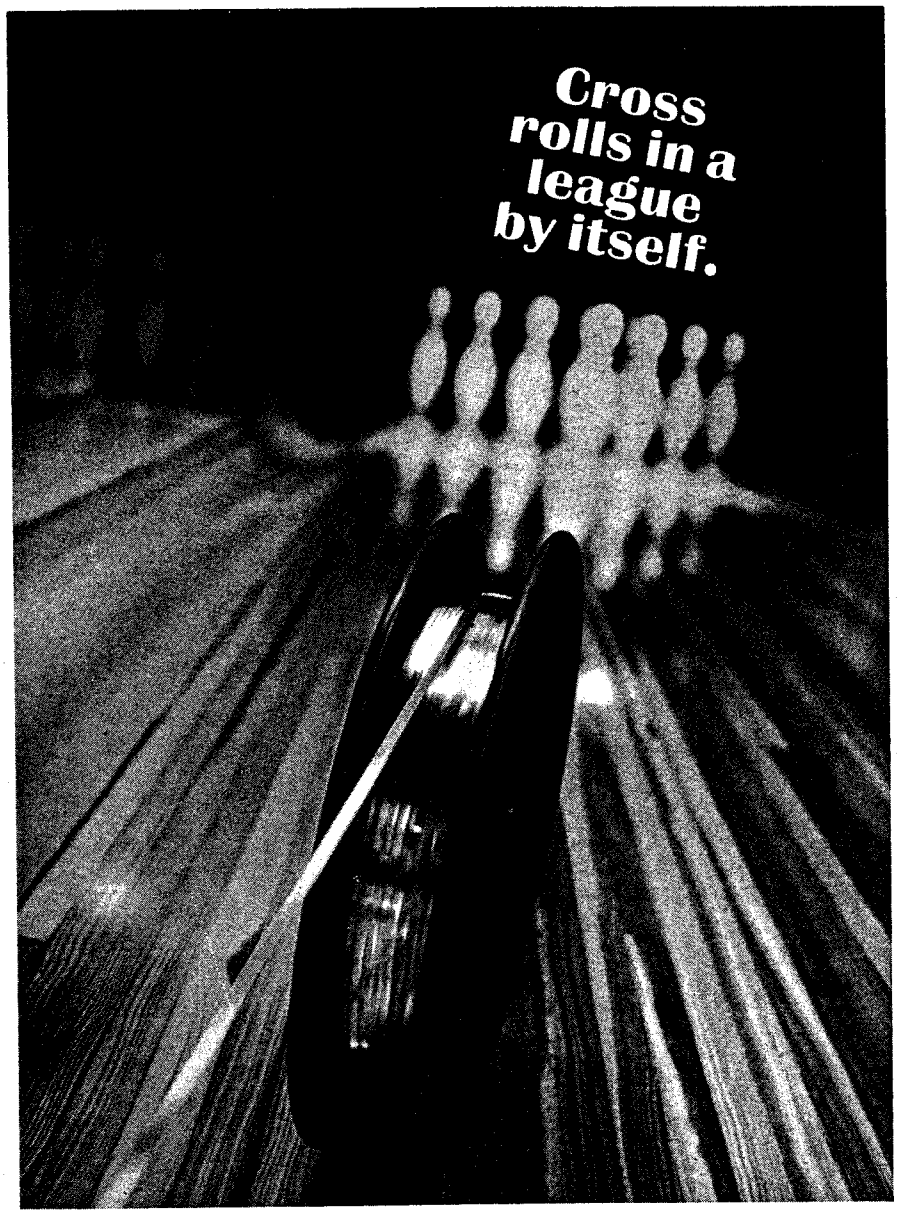

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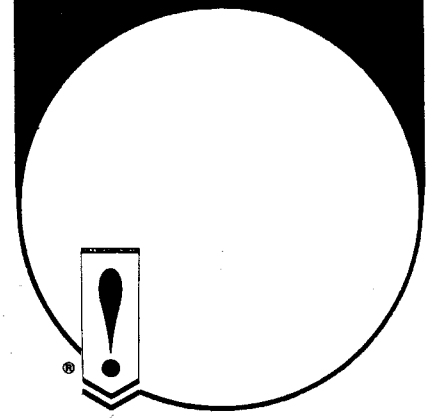

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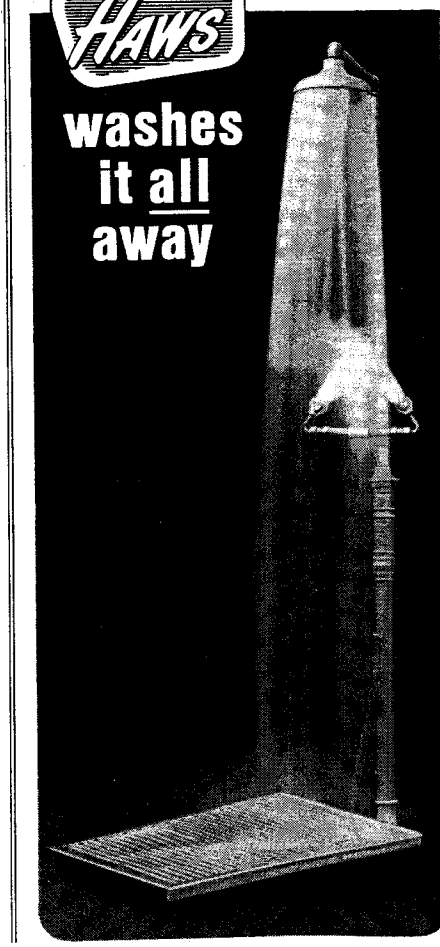

See inquiry card 92b.

evolving society and economy: planners describe the year 2000

SCIENTIFIC ADVANCES of the last 25 years have made it progressively easier to do without what once was referred to as an "open mind" about the future. So much of the creative thinking that went into science fiction in the 1930s is now in hardware that few are startled by appraisals of the year 2000.

Futurians have no doubt that we are well into the seminal period of modern technology.

What form will this unprecedented period of technical growth press onto the societies — indeed the world — in which it takes place? What will be the effect on the personal lives of those who live to see the year 2000? Will man continue to control technological advance, or, as the novelist John Barth has suggested in his novel "Giles Goatboy" (also recommended reading), will the machine take over man? How much? Will life be tolerable? Will we care whether it is or not?

There has been a recent spate of books on the future. Two books in particular are of interest to science-oriented readers:

- "The Year 2000, a Framework for Speculation on the Next Thirty-Three Years," by Herman Kahn and Anthony J. Wiener, published by Macmillan Co., New York (431 pp, $9.95).
- "Designing the Future: The Role of Technological Forecasting," by Robert W. Prehoda, published by Chilton Book Co., New York (310 pp, $8.50).

Institutionalizing research

The hinge upon which both of these books turn is the extent to which innovation becomes institutionalized in tomorrow's socioeconomic scheme.

"The Year 2000" makes a straightforward attempt to extend trends that have been enshrined in Western history since the 11th or 12th centuries. Through the use of "scenarios," the authors "play" the future through to its several likely ends (or points of continuation, as the case may be).

Implementing both the pessimistic and optimistic long-range views of science, international politics, war, and social change, the authors present no really rock-ribbed predictions, but provide, as the subtitle of their book suggests, some departure points for speculation on the next 33 years. (*For a partial list of innovations they deem likely during this period, see this issue's "Opinion Poll."*)

The authors have some interesting questions to ask about the role of the individual in the world of increased leisure and decreasing individual productivity. What will take the place of the benefits our culture has ascribed to productive work: role, status, sense of striving, feeling of productivity, competency, and achievement?

Problems and answers

Prehoda addresses a major portion of "Designing the Future" to this question. The answer: a research-oriented society — extensive institutionalization of research, innovation, development, and diffusion of findings and benefits. Prehoda wants our society to confront the future with a preconceived, self-conscious goal. He sees the salvation of the individual in personal devotion to the problems, applications, and new directions that the current burgeoning technology will make possible.

The difficulty with this approach is that cultures don't usually define their needs in the full light of reason and then forge ahead toward them.

The U.S. certainly has not; we are more apt to see an immediate need, such as winning World War II, gear up for it, do it, and then lapse back to normalcy. Trends overtake society. We often find ourselves confronted with a new, unexpected, unprovided-for event which prompts short-term reaction.

Furthermore, how can the political leadership of a country address itself to such a gigantic question as imposing a predetermined long-range future on a society? How will Congress, for instance, be motivated to take such progressive steps as to make possible the future Prehoda wishes to see?

Such an event would be for the world tomorrow of as great a significance as the Declaration of Independence or the Bill of Rights have been for the last 200 years. Current budget cuts in programs many scientists consider essential to progress are being made by the very persons who would have to be motivated to fund projects to make such a future come about.

It is far more likely that *events* will lead to this kind of future than that we will be able to impress on our society the importance of taking the steps to enable its creation *in advance*.

But Prehoda's major point in this

outstandingly readable book is that the acceptance of technological forecasting as a major policy tool could make his approach possible, and for this contribution, he is to be applauded.

The dybosphere

Another book which addresses itself to the problems of the future is Richard R. Landers' "Man's Place in the Dybosphere." Landers contends that "two great trends characterize our times. One is to mechanize humans; the other is to humanize machines." Using these as a point of departure, the author leads his reader through the maze of tomorrow — the dybosphere—the realm of artificially created things that behave in a lifelike fashion. "Man's Place in the Dybosphere," by Richard R. Landers, published by Prentiss-Hall Inc., Edgewood Cliffs, New Jersey, 266 pp, $5.95. — F. RICHARD ADAMS, SPECIAL PROJECTS EDITOR. ■

Other publications

LANGE'S HANDBOOK OF CHEMISTRY, 10th ed., compiled and edited by N. A. Lange; McGraw-Hill Book Co., 330 W. 42nd St., New York 10036, 2001 pp, $12. This is the latest revision of the authoritative compilation of facts and data for every aspect of chemistry. Includes recent changes in concepts and technology, particularly the use of carbon-12 as a basis for atomic weight calculations.

THE ENCYCLOPEDIA OF BIOCHEMISTRY, edited by R. J. Williams and E. M. Lansford Jr.; Reinhold Publishing Corp., 430 Park Av., New York 10022, 876 pp, $25. This compendium of articles (some 800 in all) is written both for laymen and specialists. Detailed treatments in the rapidly growing field of biochemistry are presented in this form for the first time.

SCIENCE, TECHNOLOGY, AND AMERICAN FOREIGN POLICY, by E. B. Skolnikoff; The M.I.T. Press, Cambridge, Mass. 02142, 330 pp, $8.95. Written by a former presidential advisor on science and technology, the book sheds light on a widely accepted but ill understood aspect of public policy.

TECHNOLOGY, ECONOMIC GROWTH, AND PUBLIC POLICY, by R. R. Nelson, M. J. Peck, and E. D. Kalachek; The Brookings Institution, 1775 Massachusetts Av., NW, Washington 20036, 238 pp, $6. The result of a Rand Corp. and Brookings Institution study, this book analyzes the way in which technical advances occur, the impact of new technology on the economy, and the changes in governmental policy needed to stimulate advances. ■

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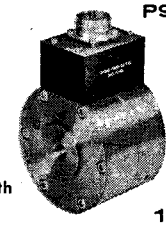

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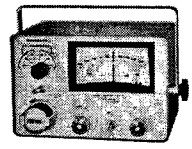

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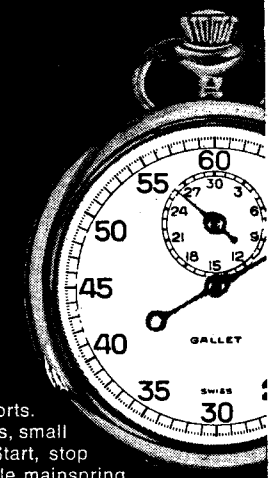
See inquiry card 95a.

when seconds count



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Precision timer for industry or sports. Long hand registers fifths of seconds, small hand registers minutes up to 30. Start, stop and flyback from crown. Unbreakable mainspring, 7 jewel. #300, $38.40. For complete catalog showing world's largest collection of timers and chronographs, write to: Jules Racine & Co., Inc., 521 Fifth Avenue, N.Y. 10017

Above Price is Approximate

See inquiry card 95b.

MARKET RESEARCH

It pays to know your market.

Whether you are planning a new technical business venture, expanding your product line, or need to know the reason for lagging sales—you'll be better equipped to handle the problem if you have all the facts.

The Research Dept. of Industrial Research Inc. has the capabilities to conduct or assist with market research projects for technical companies and organizations on a fee basis.

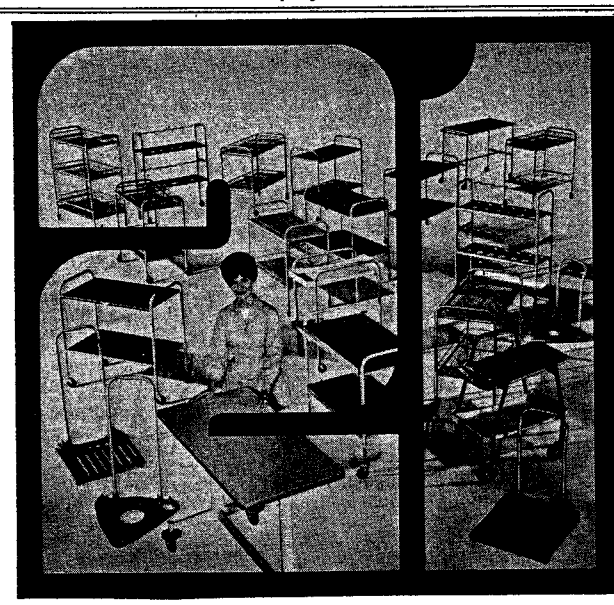
Gathering data is our business. We've been doing it for years and have completed numerous reports dealing with instruments, materials, components, and other technical areas.

We have the staff and the experience to conduct personal interviews anywhere in the country as well as telephone and mail surveys. For additional information, return inquiry card.

Research Department

INDUSTRIAL RESEARCH
BEVERLY SHORES, IND. 46301

See inquiry card 95c.



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See inquiry card 95d.

readers disagree on the merits of classified university research

SCIENTISTS AND ENGINEERS were almost equally divided over whether or not universities should perform secret research, a question currently in debate on the nation's campuses. Of the 1,160 respondents to the October "Opinion Poll," 39% voted in favor of secret research; 37% were opposed; and 24% said "in some cases."

Backing up their stand with individual reasons, proponents of secret research said that universities had the best people and facilities available; that national security and defense were at stake; and that academic minds should support national goals.

However, the opposition claimed that secret research was contrary to a university's role of discovering and freely transmitting knowledge; that universities were poor security risks; and that other agencies could do the job just as well.

Still, a considerable number of respondents felt that secret research was justified in some cases, such as emergencies involving national security and welfare, and when the best personnel to do the research could be found only at universities.

Almost all the respondents favored sponsored research for both government agencies and industrial organizations when the results could be made public. But when it came to secret research, the number dropped to 51% for government research compared to only 29% for industry-sponsored research.

Tabular results of the October "Opinion Poll" follow:

Q 1: Should universities perform secret research?

Yes	39%
No	37
In some cases	24

Numerous reasons were cited for the above answers, most of which were mentioned in the preceding summary.

Q 2: Do you agree with these statements made by opponents of secret university research:

. . . Academic research must be open to scholarly criticism?

Yes. . . . 69% No. . . . 31%

. . . Secret research causes a rift in academic staffs between those who have security clearance and those who do not?

Yes. . . . 53% No. . . . 47%

. . . A university tends to relegate its overall goals to those of the secret research sponsor?

Yes. . . . 35% No. . . . 65%

. . . Secret CB research violates principles taught by other schools within the university?

Yes. . . . 36% No. . . . 64%

. . . Universities are poor security risks?

Yes. . . . 57% No. . . . 43%

Q 3: Do you agree with these statements made by proponents of secret research at universities:

. . . University scientists must be aware of secret research so they can examine the harmful effects of experiments on our biosphere?

Yes. . . . 62% No. . . . 38%

. . . There are no legal restraints on CB research and no such thing as "bad" knowledge?

Yes. . . . 70% No. . . . 30%

. . . It is necessary to perform secret research for the sake of the nation's security and the contribution of university scientists should not be discouraged or forbidden?

Yes. . . . 70% No. . . . 30%

Q 4: Should universities perform sponsored research for:

Government agencies where the results are available to all	90%
Industrial organizations where the results may be published	90
Government agencies where research results must be kept secret?	51
Industrial organizations where the results must be kept proprietary?	29
No sponsored research	7

Q 5: In your opinion, what functions should a university perform?

Instruction of students	98%
Performance of original research	87
Serve as an impartial critic to society	47

Other frequent suggestions included: support of our nation's goals, service to the community, and a repository of knowledge for consultation by government and industry.

This month, the "Opinion Poll" questionnaire deals with your forecast of future technological advances. ■

OPINION POLL

which technical innovations will be realized by year 2000?

IN THEIR BOOK, "The Year 2000," Herman Kahn and Anthony J. Wiener present a list of technical innovations that will be very likely, less likely, or unlikely to occur during the last third of the twentieth century.

The editors of *Industrial Research* would like to obtain *your* opinions concerning these proposed innovations—your estimates of when, if ever, you expect them to become realities.

The 98 possible technical innovations listed below were abstracted from the Kahn and Wiener compilation of 135 items. Adjacent to each innovation is a rating scale that you can use to indicate your opinion of the time period during which each innovation will be realized.

We would like to thank McMillan Co. for permission to abstract the list of innovations. A review of the book, "The Year 2000," appears in the "Books & Reports" column in this issue.

1. More reliable and longer-range weather forecasting.
2. Intensive and/or extensive expansion of tropical agriculture and forestry.
3. New methods of water transportation (such as large submarines, flexible and special purpose "container ships").
4. Major reduction in hereditary and congenital defects.
5. Extensive use of cyborg techniques (mechanical aids or substitutes for human organs, senses, limbs, or other components).
6. New techniques for preserving or improving the environment.
7. Relatively effective appetite and weight control.
8. New techniques and institutions for adult education.
9. New and useful plant and animal species.
10. Controlled and/or surpereffective relaxation and sleep.
11. New or improved uses of the oceans (mining, extraction of minerals, controlled "farming," source of energy, and the like).
12. Three-dimensional photography, illustrations, movies, and television.
13. Automated or more mechanized housekeeping and home maintenance.
14. Extensive and intensive centralization of current and past personal and business information in high-speed data processors.
15. Other new and possibly pervasive techniques for surveillance, monitoring, and control of individuals and organizations.
16. Some control of weather and/or climate.
17. Other (permanent or temporary) changes—or experiments—with the overall environment.
18. Use of direct electronic communication with and stimulation of the brain.
19. Human hibernation for relatively extensive periods (months to years).
20. Cheap and widely available central war weapons and weapon systems.
21. New and relatively effective counterinsurgency techniques.
22. New techniques for very cheap, convenient, and reliable birth control.
23. New, more varied, and more reliable drugs for control of fatigue, relaxation, alertness, mood, personality, perceptions, fantasies, and other psychobiological states.
24. Capability to choose the sex of unborn children.
25. Improved capability to "change" sex of children and/or adults.
26. Other genetic control and/or influence over "basic constitution."
27. New techniques and institutions for the education of children.
28. General and substantial increase in life expectancy, postponement of aging, and limited rejuvenation.
29. Generally acceptable and competitive synthetic foods and beverages.
30. "High quality" medical care for undeveloped areas (e.g., use of medical aides and technicians, referral hospitals, broad spectrum antibiotics, and artificial blood plasma).
31. Design and extensive use of responsive and supercontrolled environments for private and public use.
32. Physically nonharmful methods of overindulging.
33. Simple techniques for extensive and "permanent" cosmetological changes (features, "figures," perhaps even skin color, and physique).
34. More extensive use of transplantation of human organs.
35. Permanent manned satellite and lunar installations—interplanetary travel.
36. Permanent inhabited undersea installations and perhaps even colonies.
37. Automated grocery and department stores.
38. Extensive use of robots and machines "slaved" to humans.
39. New uses of underground "tunnels" for private and public transportation.

Please check the box corresponding to the time period during which you feel the adjacent technical innovation will occur.

After completing this month's questionnaire, cut out on rule and enclose it (together with any product inquiry cards) in the postage-paid envelope provided by Industrial Research *in this issue.* ■

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	Prior to 1975	Between 1975 and 2000	After 2000	Never
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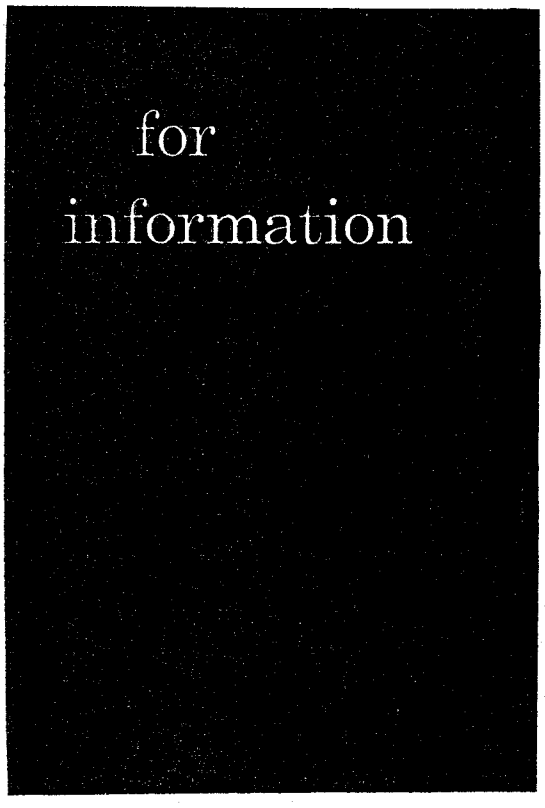
98.	☐	☐	☐	☐

40. Automated universal (real time) credit, audit and banking systems.
41. Chemical methods for improving memory and learning.
42. Improved chemical control of mental illness and senility.
43. Mechanical and chemical methods for improving human analytical ability more or less directly.
44. New techniques for keeping physically fit and/or acquiring physical skills.
45. Recoverable boosters for economic space launching.
46. Individual flying platforms.
47. Simple inexpensive home video recording and playing.
48. Inexpensive high-capacity, worldwide, regional, and local (home and business) communication.
49. Practical home and business use of "wired" video communication for both telephone and TV and rapid transmission and reception of facsimiles.
50. Shared time computers generally available to home and business.
51. Other widespread use of computers for intellectual and professional assistance (translation, teaching, literature search, medical diagnosis, traffic control, crime detection, computation, design, analysis and to some degree as intellectual collaborator generally).
52. Very low-cost buildings for home and business use.
53. Personal "pagers" (perhaps even two-way pocket phones) and other personal electronic equipment for communication.
54. Direct broadcasts from satellites to home receivers.
55. Inexpensive (less than $20), long lasting, very small TV receivers.
56. Home computers to "run" household.
57. Home education via video and computerized and programmed learning.
58. Stimulated and planned and perhaps programmed dreams.
59. Inexpensive (less than one cent a page), rapid high-quality black and white reproduction; followed by color and high-detailed photography.
60. Conference TV (both closed circuit and public communication systems).
61. Flexible penology without necessarily using prisons.
62. Common use of individual power sources.
63. Inexpensive worldwide transportation of humans and cargo.
64. Inexpensive road-free (and facility-free) transportation.
65. New methods for rapid language teaching.
66. Extensive genetic control for plants and animals.
67. New biological and chemical methods to identify, trace, incapacitate, or annoy people for police and military uses.
68. Artificial moons and other methods for lighting large areas at night.
69. Extensive use of "biological processes" in the extraction and processing of minerals.
70. "True" artificial intelligence.
71. Practical use of sustained fusion to produce neutrons and/or energy.
72. Artificial growth of new limbs and organs (in situ or transplantable).
73. Room temperature superconductors.
74. Major use of rockets for commercial or private transportation.
75. Effective chemical or biological treatment for most mental illnesses.
76. Almost complete control of marginal changes in heredity.
77. Suspended animation (for years or centuries).
78. Practical materials with nearly "theoretical limit" strength.
79. Conversion of mammals (humans?) to fluid breathers.
80. Direct input into human memory banks.
81. Direct augmentation of human mental capacity by the mechanical or electrical interconnection of the brain with a computer.
82. Major rejuvenation and/or significant extension of vigor and life span—say 100 to 150 years.
83. Chemical or biological control of character or intelligence.
84. Automated highways.
85. Extensive use of moving sidewalks for local transportation.
86. Modification of the solar system.
87. Practical laboratory conception and nurturing of animal (human?) foetuses.
88. A technological equivalent of telepathy.
89. Some direct control of individual thought processes.
90. Life expectancy extended to more than 150 years (immortality?).
91. Almost complete genetic control (but still homo sapiens).
92. Major modification of human species (no longer homo sapiens).
93. Antigravity (or practical use of gravity waves).
94. Interstellar travel.
95. Practical and routine use of extrasensory phenomena.
96. Laboratory creation of artificial live plants and animals.
97. Lifetime immunization against practically all diseases.
98. Substantial lunar or planetary bases or colonies.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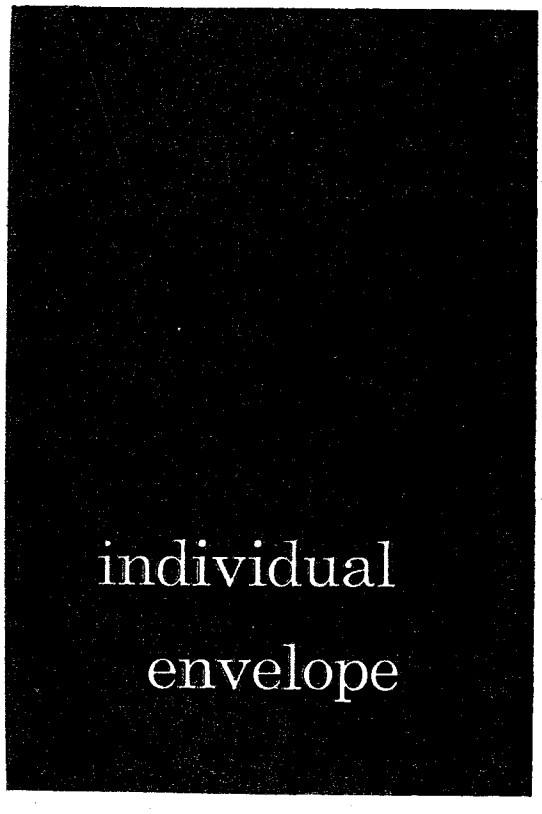
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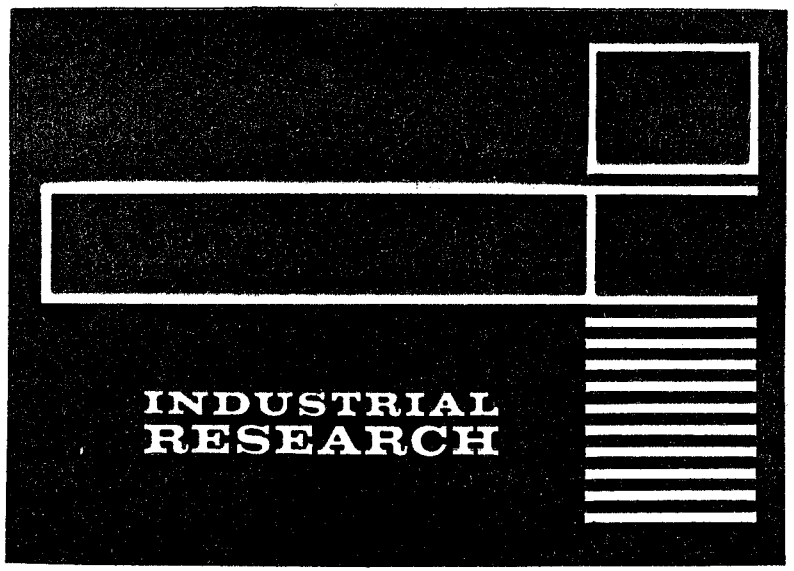
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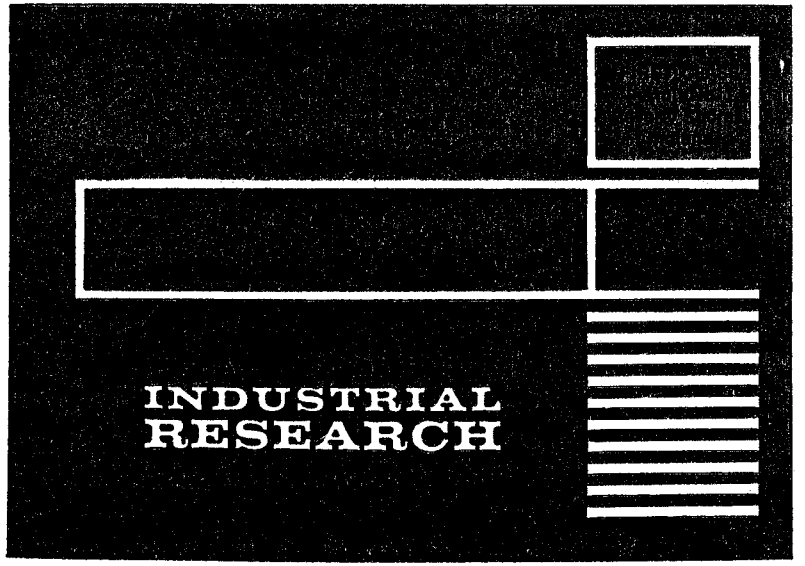
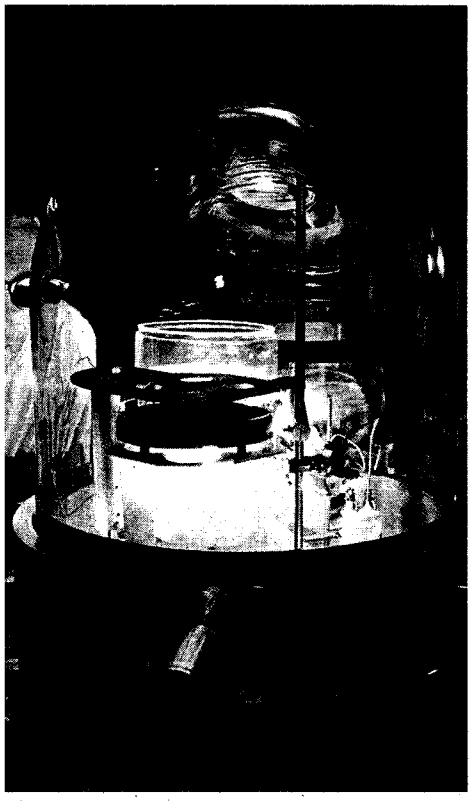

INDUSTRIAL
RESEARCH

etching technique increases yield of integrated circuits

Further information about the new products and processes in the following columns may be obtained by circling the appropriate number on inquiry card 99. The colored inquiry cards may be used as a convenient (and non-superlative) abstract of products, services, and employment opportunities offered in this issue. For fast response to inquiries, use the postage-paid I•R envelope provided.

electronics



[1] AN IMPROVED METHOD of etching narrow, precisely defined isolation slots in silicon has been developed at Bell Telephone Laboratories, Murray Hill, N.J.

The technique allows more beam-leaded integrated circuits to be fabricated in a silicon slice than possible with standard etching procedures.

Precise control of the rate and direction of etching is possible, because a "preferential" etchant attacks the three main crystal lattice planes of silicon at different relative rates. The technique requires the use of a preferential etchant and a unique orientation of the etching mask on a specific lattice plane of a silicon crystal.

To take full advantage of the difference in etch rates, two conditions are required:

- The face of the silicon disk to be etched is made parallel to the lattice planes having a high etch rate.
- The edges of masked areas are aligned parallel to a second lattice plane with a negligible etch rate.

Under these conditions, slots are formed with slanted sides in the shape of flat-bottomed wedges. Because each slot steadily becomes narrower (not wider) as etching progresses, its depth and width are precisely defined by the etching mask and etching rate.

Etching terminates when the two sloping sides of the deepening slot meet or when it etches through the slice—whichever occurs first.

The class of preferential etchants under investigation at Bell Laboratories consists of strongly basic (or alkaline) solutions. One such etchant formulated for silicon is comprised of potassium hydroxide, propanol, and water.

Masking operations are performed after the desired devices have been fabricated on one side of a slice. The mask delineates the slots for etching. Because the sides of the slots are stationary, only relatively simple etching controls are required.

An important feature of the Bell technique is that the mask shape is altered to compensate for undercutting at the outside corners of the mask where the third main lattice plane of silicon is exposed.

The etch rate of the third plane can be made much slower than the primary etching plane, but it still is significant. Therefore, enlarged corner areas of calculated size and shape are added to the etch mask to compensate for the undercutting at the corners.

Before the improved etchant was developed, a mixture of hydrofluoric and nitric acids often was used to etch silicon. This mixture and other etchants used in fabricating integrated circuits essentially have the same etch rate in all directions in semiconductor crystals. Thus, they are "isotropic" or nonpreferential etchants.

Little danger of over-etching exists with the Bell method—despite thickness variations in a slice, because the shape of the slot cut by the new etchant is that of a flat-bottomed wedge —the sides of which maintain a constant angle (about 55 degrees) from the top surface of the slice. The slot, therefore, becomes narrower as etching progresses.

Circle "1" on card 99 for more information.

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GO MICRO
. . . with precision optics systems produced by *Olympus Corp. of America*. Featured capability is in metallographic equipment. See advertisement for system characteristics, then check and return this card for details on the ☐ MGK; ☐ MG; ☐ PMD; or ☐ PME system(s).
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. . . The *Industrial Research* Technical Brochure Service may be able to help you. The I•R staff conceives, gathers data, writes, edits, designs, illustrates, and supervises the typesetting and printing of technical product, capability, recruitment, and other literature.
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. . . from *Cary Instruments* follows the tradition of dependability, simplicity, and versatility established by former Cary models, yet has greater variety of attachments. Absorbance is 0.002 near zero and 0.0005 at expanded scale. Return card for additional information.
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SCANNING
. . . electron microscope made by *Engis Equipment Co.* offers: ☐ Resolution of 150 to 300 A at 20 kV; ☐ Usable magnification range from 14X to 50,000X; ☐ Sample scan of 5 x 5 mm area at 20X; ☐ Interchangeable final apertures. Return this card for more details.
see page **9**

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see page **10**

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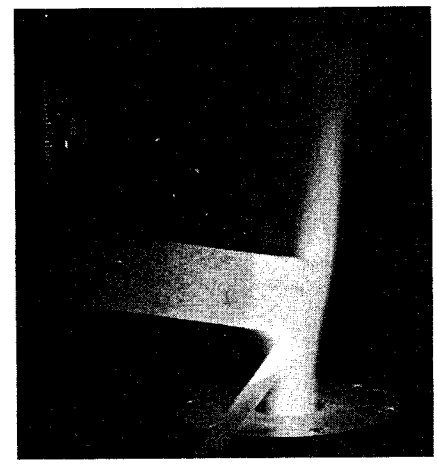
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

process equipment



[2] INDUCTION PLASMA air heater for producing high-temperature, low-velocity hot gas streams has been developed by Tafa Div., Humphreys Corp., Concord, N.H. The heater finds primary applications in quartz working as shown in the photograph above. Plasmas as large as 15 cm in diameter have been produced at velocities near 12 m/sec. The velocity range is lower than a conventional oxygen flame and, therefore, does not disturb molten surfaces in the areas being melted. The same plasma generators were used to grow OH-free clear quartz ingots for fabricating infrared transmitting lenses and windows. Circle "2' on card 99 for literature.

[3] HEAT-TREAT and quench processing line in a compact package unit is being offered for the first time by Pereny Equipment Co., Columbus, Ohio. The Model PT-2030 consists of an open loading apron upon which alloy baskets may be filled with parts to be treated; a silicon carbide element-type heat-treating furnace with a roll-back insulated cover; a recirculating quench tank; and drip pan with drain. To facilitate one-man operation, a traveling, electrically operated chain hoist with remote hand control is provided. Pereny reports the unit assures ease and efficiency in carborizing and quenching not only relatively large or long parts but small miscellaneous parts in alloy baskets. Circle "3" on card 99 for more information.

[4] LIQUID FILTERS and separator/filters are available from Fram Corp., Industrial Filter Div., Tulsa, Okla. The separator/filters remove essentially all solids and 100% of all free or entrained water, even from products treated with corrosion inhibitors forming tight emulsions. The degree of required removal can be specified. Circle "4" on card 99 for free bulletins covering both product lines.

COMPUTER KNOWLEDGE
... is available from *Digital Equipment Corp.* Experience in designing and building computers for a variety of applications is offered in either written or spoken form. Lecturers, books, papers, and primers are available. Return this card for complete details.
see page **12**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

LASER COMPONENTS
... from *Laser Optics Inc.* enable you to improve CW and pulsed laser output. Super-smooth surfaces are characteristic of all optical components from Laser Optics Inc. Special optical requirements also can be met. Return this card for descriptive literature.
see page **25a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

SPECIAL SUPPLEMENTS
... are being bound into the regular monthly issues of *Industrial Research.* Check your interest below and return this card to receive a verification form for the supplement of your choice. ☐ Vacuum & Cryogenics (monthly), ☐ Nuclear, and ☐ Lasers (both bimonthly).
see page **25b**

name
position
company
address
city state zip code
remarks I•R Pat. Pend. Jan 68

COMSAT EMPLOYMENT
... opportunities are blossoming with the construction of the new *Comsat* Laboratories near Washington, D.C. Are you interested in ☐ RF transmission, ☐ Communications processing, ☐ Spacecraft, ☐ Physics, or ☐ Systems research? Check your interest and return this card.
see page **27**

name
present position
primary experience
home address
city state zip code
remarks I•R Pat. Pend. Jan 68

NEBULIZER
... made by *Macrosonics Corp.* uses high-frequency ultrasonic energy to disperse fine liquid particles into a gas. Aerosols in the 0.4 to 10-micron range can be generated. The "Ultramist III" is portable, and uses 115 V current. Return this card for further details.
see page **28a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

OSCILLOSCOPE CAMERA
... from the *Coleman Engineering Co.* affords ready change of recording ratio without use of additional lenses. The MIIA Oscillotron records at any object-to-image ratio from 1:1 to 1:0.5, and can be used with standard 4 x 5 camera backs. Return this card for catalog.
see page **28b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

EXPLOSIVE-ACTUATED
... components from *Atlas Chemical Industries Inc.* convert electrical, mechanical, or pneumatic energy into powerful mechanical forces. Small but mighty, the units save critical space and weight in one-time performance systems. Return this card for literature.

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

ALBUQUERQUE
... Sunshine. No crowds. No smog. You can golf and ski on the same winter day. Two universities, symphony, opera, and much more in New Mexico. Return this card to learn more about Albuquerque from the *Albuquerque Industrial Development Service.*
see page **29**

name
position
company
address
city state zip code
remarks I•R Pat. Pend. Jan 68

SMALL ACCELERATORS
. . . are ideal for training graduate students in physics. *High Voltage Engineering Corp.'s* 0.4 and 2 mev Van de Graaff accelerators can produce particles at precisely controllable energies. Van de Graaff's largest extends investigation possibilities. Return for catalog.
see page **30**

name
position
company
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city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

PHYSICS TEACHING LAB
. . . from *High Voltage Engineering Corp.* is a complete accelerator-based teaching system selling for less than $50,000. The equipment includes a 400 kev Van de Graaff accelerator. Return this card for technical literature from High Voltage Engineering Corp.
see page **31**

name
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company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

RECORDING NEEDS?
. . . Look to *Clevite Corp., Brush Instruments Div.*, for the answer. There's the Mark 200 series of modular systems plus a complete line of portable and general purpose recorders. Return card for free catalog describing the complete line of recorders from Brush Instruments.
see page **32**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

'MARK 200' RECORDER
. . . from *Clevite Corp., Brush Instruments Div.*, features a patented pressurized inking system that puts traces into the paper—not just on it. Accuracy is 99½%. Choose between 32 different preamplifiers and numerous penmotor combinations. Return this card for data.
see page **33**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

RARE CHEMICAL CATALOG
. . . from *Aldrich Chemical Co.* contains over 5,000 computer-coded building blocks of research. Thousands of chemicals are listed in the "Library of Rare Chemicals" — be it for screening or identifying an unknown. Return this card for your copy.
see page **34**

name
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city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

MATERIALS INFORMATION
. . . on products mentioned in the "Materials Applications" section may be obtained by circling the appropriate number and returning this card.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
see page **35**

name
position
company
address
city state zip code
remarks I•R Pat. Pend. Jan 68

MICROSCOPE CATALOG
. . . from *Unitron Instrument Co.* describes bright field, dark field, and phase contrast models; monocular or binocular; familiar upright or unusual inverted stands; and models with attachable or built-in cameras and illumination systems. Return card for catalog.
see page **37**

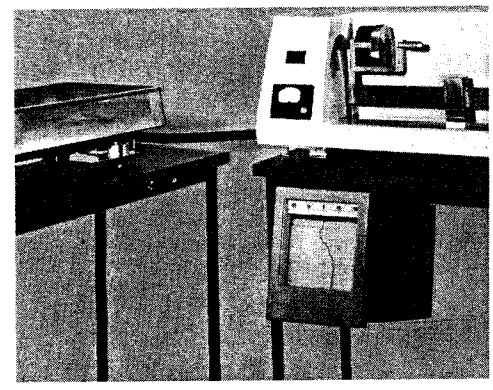
name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

INSTRUMENT CABINETS
. . . from *Bud Radio Inc.* are available in two new models that present unusual advantages to builders of instruments and control systems. The "Tilt-a-View" and "Mark-T" are just a part of the all-inclusive line of enclosures made by Bud. Return this card for literature.
see page **38a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

lab apparatus

[5] COLOR-CODED PIPE for industrial and research applications has been announced by Fibercast Co., Sand Springs, Okla. The five new grades include black BL-2025 epoxy pipe for corrosive conditions to 95 C; white CL-2025 reinforced vinyl ester type for carrying chlorine-caustic and oxidizing acids at elevated temperatures where epoxy pipe is not suitable; olive green OG-2025 epoxy pipe for handling a broad range of corrosive chemicals at temperatures to 120 C; rust brown RB-2530 epoxy pipe for severe corrosive combinations at temperatures to 150 C; and gray GR-3040 epoxy pipe for vacuum systems and severe corrosive conditions at temperatures to 150 C. Fibercast meets specifications previously filled only by expensive and exotic metals. Circle "5" on card 99 for details.



[6] METABOLIC WEIGHING system, shown above, has been developed by Brookline Instrument Co., White Plains, N.Y., for continuous weight monitoring of animals. Total body weight is measured to the nearest gram. Fluid balance can be monitored over an extended period, while evaporative heat loss can be measured in calories/hour. Cage weight may be zeroed out so that the weight of the subject always is recorded. Movements of the animals will not affect readings. The Model 80-A is designed for animals weighing up to 11 kg, while the Model 100-A, with an upper-limit extension of 200 kg, accommodates larger animals. Circle "6" on card 99 for details.

[7] RECORDING VISCOMETER from Fann Instrument Corp., Houston, is a versatile instrument for handling fluids ranging from very low to high viscosities. A new torque sensing mechanism in the Model 39 permits viscosities to be measured from one to several thousand centipoises without having to change any of the components. Infinitely variable speeds will hold constant at any setting between 3 and 600 rpm. Circle "7" on card 99 for literature.

INVERTED PIT FURNACE
. . . expressly developed for work where the material requires careful loading procedures and close thermal gradients at temperatures to 2750 F is available from *Pereny Equipment Co.* The unit includes a motorized elevating hearth. Return this card for more details.
see page **38b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

FLAT-FIELD MICROSCOPES
. . . from *Bausch & Lomb* offer flat, edge-to-edge images at prices competitive with conventional, achromatic systems. Check your interest(s) and return this card for ☐ a laboratory microscope brochure and index reproduction or ☐ a demonstration.
see page **39**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

OPTICAL WINDOWS
. . . of ceramic-to-sapphire can endure 1200 C for several hundred hours, and can withstand repeated temperature cycling. Ceramic-to-metal and ceramic-to-sapphire technology has been a specialty at *EIMAC Div. of Varian* for 13 years. Return this card for more information.
see page **40**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

SCANNING MONOCHROMATOR
. . . the Heath "700" priced at $1,195 is a basic module of a new series of systems from *Heath Co.* Other modules coming this year include UV-VIS source, sample-cell, photomultiplier, log-linear current, and photographic modules. Return this card for data sheets.
see page **41**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

METAL FRAMING
. . . from *Unistrut Corp.* saves time three ways: designing, construction, and after. Experiments, set-ups, benches, mechanical and electrical equipment, walls, floors, ceilings—all can be supported with Unistrut metal framing. Return this card for a free catalog.
see page **42**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

RADIATION SIMULATORS
. . . are available in five models from *Physics International Co.* A gamma dose rate of 10^{11} rads/sec or electron energy of 600 joules in 20-n-sec, for example, are produced by the smallest "Pulserad 310" simulator. Return this card for descriptive literature.
see page **43**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

ELECTRIC SWITCHES
. . . from *Cherry Electrical Products Corp.* are available in two new models: ☐ Snap/Reed E-66 combining reed reliability with snap switch utility and ☐ Matrix Selector Switch with 100 to 2,780 switching positions. Check your need(s) and return this card for data.
see page **44a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

YOUR HEATING SYSTEM
. . . can be built with *Lindberg Hevi-Duty* building blocks of heat. Flexible low-cost elements that can be assembled in countless ways have excellent capacity, high watt density, and can be controlled manually or automatically. Return this card for further information.
see page **44b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

VACUUM INSTRUMENTS
. . . from *Norton, Vacuum Equipment Div.*, covers an inclusive range of advanced designed units—priced down to half the cost of other equipment. Return this card for a complete price list and performance literature on the new NRC 800 Series of vacuum instruments.
see page **45**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

MASSACHUSETTS
. . . the site chosen by Texas Instruments for its manufacturing facilities, offers industry a cooperative work force, many schools, and research complexes. Return this card to learn more about Massachusetts from the *Massachusetts Dept. of Commerce & Development.*
see page **46**

name
position
company
address
city state zip code
remarks I•R Pat. Pend. Jan 68

PHOTO STUDIO IN YOUR LAB
. . . fits on a desk top. The *Polaroid* MP-3 industrial view Land camera produces black and white prints in 15 seconds, full-color prints in 60 seconds, prints and negatives in 20 seconds, and continuous tone slides in two minutes. Return this card to receive more information.
see page **47**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

NULL DETECTOR
. . . from *Leeds & Northrup Co.* enables you to utilize the full potential of your highest precision potentiometers and bridges. Sensitivity of the Model 9838 guarded nanovolt null detector is 0.005 nanovolts. Return this card for more information.
see page **48**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

PHYSICS LITERATURE

... about products described in the "Advance Conference Report" is available from manufacturers who will exhibit at the *American Physical Society Meeting*. Circle for details.

1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18

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name
position
company
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city state zip code
remarks I•R Pat. Pend. Jan 68

CLEAN THERMOCOUPLES

... with "Airbrasive" from *S. S. White*. Cleaning cut-off ends of thermocouple assemblies used to take several minutes. Airbrasive's jet of finely graded abrasive particles does it in two seconds. Check and return this card for ☐ more information and/or ☐ a demonstration.

see page **50**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

STEREO MICROSCOPE

... from *AO Instrument Co.* gives you high resolution, new convenience, and a wide magnification range from 3.5 to 210 X—with a choice of five, interchangeable, rotatable zoom power bodies. Return this card to learn more about the "StereoStar/Zoom."

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name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

ONE MEV IN SIX NANOSECONDS

... at about two cents a volt may be obtained in *Ion Physics'* FX-15-S, a small system for pulse radiolysis, biomedical research, radiation effects studies, and flash radiography. The system converts from electrons to x-rays in less than 30 minutes. Return this card for details.

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name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

TUBE FITTINGS

... from *Crawford Fitting Co.* are available in any machineable metal or plastic in sizes ranging from 1/16-in. through 1-in. OD. Return this card to learn more about the size ranges, materials, and delivery of "Swagelok" fittings from Crawford Fitting Co.

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name
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Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

THERMOCOUPLE WELDER

... from *Dynatech Corp.* can weld wires ranging from 20 to 55 gage to form thermocouples with less than 0.01 C variation from each other. Return this card for more information about the ☐ "Model 116 SRL" and/or ☐ other portable welding units from Dynatech Corp.

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name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

SPECIAL PAPER NEEDS

... can be answered by *Appleton Coated Paper Co.* A variety of technical or printing and decorative papers are readily available, including: electrophotographic, gumming, image master, magnetic recording, labels, lithos, tags, and bristol-covers. Return card for details.

see page **55**

name
present position
primary experience
home address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

TEMPERATURE CONTROLLERS

... are a specialty at *Alnor Instrument Co.* Check your interest(s) below and return this card for ☐ a free copy of the brochure, "How Alnor Temperature Controllers Make Good Machines Perform Better," and/or ☐ a demonstration of Alnor reliability.

see page **57**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

VACUUM PUMPS

... from *Kinney Vacuum* make clean vacuums from dirty environments. The "Liquid Jet" pumps handle large quantities of water vapor or solvents, even slugs of liquid. They are unharmed by dust or grit. Only one moving part. Return this card for descriptive literature.

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name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

VISUAL CONTROL BOARDS

... from *Rol-a-chart* never run out of space. Schedule orders, production, men, machines, projects, and EDP. Color brochure shows 7 sizes—includes free Planning Kit with sample chart section to try and a new 16-page Guide to Visual Control. Return this card for your free kit.

see page **65**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

TOP-LOADING

... balancer from *Sartorius Div., Brinkman Instruments*, has 160 g capacity with 1 mg accuracy and all-digital readout. The Sartorius 2255 has no discernable swing and large optical scale makes reading easy. Return this card to receive your copy of a 40-page catalog.

see page **80**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

PHOTOMICROGRAPHS

... can be taken automatically with the *Nikon* AFM. There no longer is a need to measure, calculate, and time each photomicrographic exposure. With its light sensor and computer-control unit, the AFM does it for you. Return this card for literature.

see page **82**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

PRESSURE COUNTERS
. . . from *Ruska Instrument Corp.* are priced from $995. Featured are a fused quartz bourdon tube, digital display counter, pressures to 1,000 psi, and rechargeable battery pack for field operation. Accuracy is 0.025% fs, resolution 0.01% fs. Return this card for details.
see page **83**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

INVERTED MICROSCOPE
. . . specifically for tissue culture and and other biological studies is available from *Wild Heerbrugg.* The Wild M-40 is no modification. It features state-of-the-art design in inverted microscope construction. Return this card to learn more about the Wild M-40.
see page **84a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

AUTOMATIC 'LABWASHER'
. . . is ready for use when you attach a quick disconnect coupling, with universal adapter, to any water tap. Plug in the three-wire, eight-foot cord and your lab is equipped for automated glassware washing. Return this card for a free bulletin from *Chemical Rubber Co.*
see page **84b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

THYRATRON POWER CONTROL
. . . for automatic or manual operation now is incorporated in *Lepel* generators at no additional cost. The Lepel T-660 is a versatile, all solid-state electronic power control. Return this card for more information from Lepel High Frequency Laboratories Inc.
see page **85**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

300-PRODUCT CATALOG
. . . of refractories and cermets from *Consolidated Astronautics* features descriptions which include borides, carbides, nitrides, and silicides of the refractory metals. Metallic powders and superalloys in powder form also are available. Return card for your copy.
see page **86a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

ELECTRONIC MATHEMATICIAN
. . . lets you key in equations exactly as you would write them. "Mathatron" by *Wright Line* prints the equation and solution almost instantly. Provided are parenthecation, powers of 10 exponents, decimal points, and square root. Return this card for data.
see page **86b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

'PEAK LOK'
. . . from *Control Data Corp.* measures positive, negative, or bipolar peaks with 1% full-scale efficiency, then holds the reading in an analog state until you reset it. Pinpoints transients, monitors peaks for testing and research. Return this card for details.

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

ALL-PURPOSE TIMERS
. . . from *Dimco-Gray Co.* are easy to read and set. A large 8-in. dial may be set for any time within a range of 3,600 settings. At the end of the pre-set interval, an alarm sounds and the external load is switched automatically on or off. Return this card for free catalog.
see page **87a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

SCIENTIFIC PRODUCTS
. . . for hobbyists, experimenters, and manufacturers are available from *Edmund Scientific Co.* See page 87b, check your interest(s), and return this card for details on ☐ water "still," ☐ modeling plastic, ☐ thermoelectric cooling system, and/or ☐ free 148-page catalog.
see page **87b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

FLAMELESS BLOWTORCH
. . . for applications requiring quick concentrated heat blast up to 1000 F without flame—is available from *Master Appliance Corp.* Temperature can be varied by air intake adjustments. There also is a blower for heated air up to 750 F. Return this card for details.
see page **87c**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

LABORATORY EQUIPMENT
. . . of "KemMetal" is experience-designed to serve every scientific need. It is engineered to take abuse and its components combine to fit each other and the laboratory surroundings. Return card for a free copy of *Kewaunee Mfg. Co.'s* metal laboratory furniture catalog.
see page **87d**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

IR MICROSCOPE
. . . enables temperature measurement on very small, inaccessible, delicate, or dangerous targets. Offered by *Barnes Engineering Co.*, the unit will take the temperature you need from any angle, without touching the target or altering its state. Return card for bulletin.
see page **88**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

TEMPERATURE FACT FILE
. . . features cabinets from 1.5 to 24 cu ft with pulldowns from ambient to —140 F. *Revco* cabinets are used the world over for industrial, medical, and scientific research projects. Return this card for your free fact folder, "Revco Ultra Low Temperature Equipment."
see page **89a**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

FLAME SPRAYED COATINGS
. . . of premium metals or ceramics to base materials result in products with longer service life and lower production costs. A free bulletin, "The *Metco* Flame Spraying Processes" describes the latest developments in flame spraying. Return this card for your copy.
see page **89b**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

TRANSFER LETTERING
. . . from *Chart-Pak Inc.* offers a quick and easy source for camera-ready copy. More than 70 popular type faces are now available in a wide range of sizes. Return this card to receive a kit of free samples and a catalog that lists other graphic aids offered.
see page **89c**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

PORTABLE VISCOMETER
. . . from *Brookfield Engineering Labs* features eight speeds, seven spindles, and 56 measuring ranges. You get direct readings from one to 64-million centipoises. The Brookfield instrument is accurate to ±1% of full scale. Return this card for the latest catalog.
see page **89d**

name
position
company
address
city state zip code
Application: ☐ Immediate ☐ Future
remarks I•R Pat. Pend. Jan 68

measuring & testing

[8] TORQUE TRANSMITTER from Industrial Electronetics Corp., Melbourne, Fla., adapts directly to most torque transducers — eliminating slip ring noise and brush wear problems. The radio telemeter, designed to replace slip rings on existing torque cells, includes a battery power supply, frequency modulated subcarrier oscillator, and a miniature radio transmitter. The torque transmitter produces a full scale output of ±2 volts with an input ±250 micro strain when used with IEC's telemetry receivers. Data bandwidths from 500 to 3,000 Hz are available. All units are capable of handling both static and dynamic strains. Temperature range is —40 to 175 C. The transmitter can tolerate immersion in water, oil, and most industrial solvents, in addition to acceleration to over 20,000 g's. Circle "8" on card 99 for more information.

[9] SILICON PLANAR TRANSDUCER from Stow Laboratories Inc., Stow, Mass., is billed as the world's most sensitive pressure transducer. The Model PT-2 "Pitran" has its emitter-base junction mechanically coupled to a diaphragm located in the top of a TO-46 can. When a pressure or point of force is applied to the diaphragm, a large, reversible change is produced in the transistor's characteristics. A linear output range of at least 2 V can be achieved without external amplification. Conversion efficiency (electrical energy out/mechanical energy in) is said to be four orders of magnitude higher than that of conventional transducers. Sensitivity is 4 V/g point force. Circle "9" on card 99 for literature.

[10] TACK TESTER from Thwing-Albert Instrument Co., Physical Testing Div., Philadelphia, provides a profile of the rate of cohesion development in a layer of fluid adhesives between two substrates. Two flexible substrates or a combination of one flexible and one rigid substrate can be tested. Open time is controlled by an electric timer from 0.7 sec to 2 min and closed time from 1.2 sec to 2 min. Circle "10" on card 99 for literature.

[11] TORQUE MEASURING transducer from Vibrac Corp., Chelmsford, Mass., uses a lamp-photocell and segmented discs instead of conventional strain gage elements and differential transformer techniques to measure mechanical torque. The new transducer, Vibrac explains, embodies the key advantages of existing torque transducers without incurring the defects of either technique. Owing to its conceptual simplicity that eliminates electronics and other complexities, the

SOLUBLE SILICATE DATA
. . . is available from *Philadelphia Quartz Co.* See page 90; note your interests on the remarks line below; or fill out the PQ coupon to receive the literature of your choice. A postage-free I•R envelope in this section is provided for your convenience.

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INERT GAS MIXER
. . . from *Modern Engineering Co.* allows you to mix two, three, four, or more gases with 100% mix-accuracy. The mixer gives a positive, homogeneous mixture, even with a wide variation of densities or ratios of flow. Return this card for an illustrated bulletin.

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ENGINEERED OVEN
. . . from *Despatch Oven Co.* has an operating range of 650 F, solid-state controls, and a sensitivity of 0.5 F for precise control in laboratories, testing, production, and research. Return this card for a free bulletin describing the new "Lad1-42-H."

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MACHINE PARTS
. . . with the new "Maximat 7" from *American Edelstaal Inc.* The machine combines a lathe, vertical mill, and drilling press in one compact unit selling for $595. Ten models are available for lab or shop. Return this card for a detailed catalog from American Edelstaal Inc.

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LASER BOOK
. . . provides an introduction to the use, development, and practical applications of the laser. Special appendices cover health hazards, Raman scattering, and development of special lasers. Offered by *Pergamon Press.* Use this card to receive more information.

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ROLLED METAL
. . . is the specialty of *H. Cross Co.* Tungsten and molybdenum rolling can be done within tolerances of ±0.0001 inch for all thicknesses. Other metals and alloys can be held to ±0.00005 inch. Custom orders can also be accommodated. Return this card for details.

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PROPORTIONING CONTROL
. . . the "Power-O-Matic 70" from *Blue M Electric Co.* has a range from zero C to +300 C—provides a control tolerance of ±0.2 C. Features, such as ambient temperature and line voltage compensation, are built-in. Return this card for a descriptive brochure.

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PROTECTION
. . . against contamination by harmful chemicals is offered by the *Haws Drinking Faucet Co.* Emergency drench showers and eye/face washing fountains quickly cleanse chemicals, radioactive material, and foreign matter from personnel. Return this card for catalog.

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FRICTION AND WEAR
...testing apparatus from *Dow Corning Corp.* has ☐ Oscillating or unidirectional motion; ☐ Bearing pressures to 110,000 psi; ☐ Infinitely variable speeds; ☐ Automatic shut-off for unmonitored operation. The device accepts both metals and nonmetallics. Return card for data.
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BIODEGRADABLE CLEANERS
...from *Alconox* can save you up to 66¢/lb in laboratory cleaning detergents. Check your need(s) and return card for data about ☐ "Alconox" manual cleaner, ☐ "Alcojet" for mechanical washers, ☐ "Alcotabs" for test-tube washers, and/or ☐ "Liqui-Nox" manual cleaner.
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ELECTRONIC CALCULATORS
...from *Wang Laboratories Inc.* can be used to figure everything from monthly mortgage payments to rocket engine thrust coefficients. Add-on compatability enables you to build to a powerful computing system. Return this card to learn more about the Wang calculators.
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LOW PRESSURE TRANSDUCER
...and transducer indicator are available from *Pace Wiancko.* Check your interest(s) below and return this card for data about the ☐ Model P90D low pressure transducer, the ☐ Model CD25 transducer indicator, and/or ☐ the complete line of pressure transducers.
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WHEN SECONDS COUNT
...count them with the Gallet Model 300 fifth-second timer with an unbreakable mainspring from *Jules Racine & Co.* Long hand registers fifths of second, while the small hand registers minutes to 30. Return this card for additional information and a free catalog.
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KNOW YOUR MARKET
...when you plan a new venture, expand your product line, or seek reasons for lagging sales. The Research Dept. of *Industrial Research Inc.* can define your market with surveys, projects, and data-gathering. Return this card to learn about I•R's market research capability.
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LABORATORY CARTS
...that are corrosion-proof at a low cost are available from *Labconco Corp.* The units are made of heavy-gauge steel with all-welded joints; all surfaces are electrostatically coated with a light green epoxy. Return this card for your free catalog.
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DOUBLE DE-IONIZER
...features two "Illco-Way" throw-away IonXchange cartridges in a duplex mounting fixture. Two cartridges give you more than twice as much purified water as one cartridge and the water is more "polished." Return card for data from *Illinois Water Treatment Co.*
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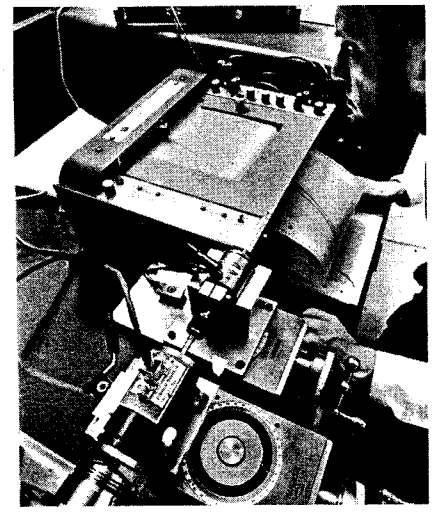
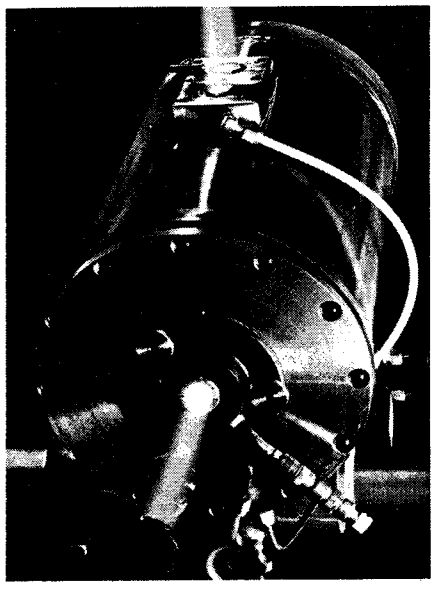


unit, shown above, costs less than strain gage or differential transformer types. Price of the complete transducer set is $745. Conventional torque measuring sets usually cost twice the price. The instrument provides a zero to 8,000 rpm speed range or zero to 20,000 rpm with special bearings. The Model TQ finds applications in checking motors for accelerating torque, running torque, and "pullout" torque, checking magnetic brakes and clutches for current-versus-torque performance, and measuring viscosity in the chemical and related industries. Circle "11" on card 99 for more information.

[12] POTENTIOMETRIC RECORDERS can be converted into universal temperature systems by adding "T into V" probes and modules from Atkins Technical Inc., Gainesville, Fla. In use, operators set the temperature start point digitally at any temperature between −100 and 200 C. Then the desired span to be covered above the start point is set. Spans can be 100, 50, 20, 10, or 5 C. When the probe temperature rises through "start point" temperature, a linear mV output is generated over the set span. Output to the recorder is zero to 1, 10, 50, or 100 mV, rear-panel setting to match user's recording capabilities. A second output is provided by the module for connection to any digital voltmeter for direct digital display of the temperature. Circle "12" on card 99 for data.

[13] CONTINUOUS LEVEL MEASURING systems are included in a new line of instruments from Acoustica Associates Inc., Los Angeles. The units use an acoustic echo-ranging technique to give continuous level measurement of all liquids and solids in powdered, flaked, granulated, or similar forms. In addition to gaging the contents of stationary and moving containers, the instruments can monitor river, sewage, and reservoir levels, as well as wave motions without contact. Circle "13" on card 99 for details.

NEW MODEL 1000A 2700°C $3575.



Astro's new MODEL 1000A ULTRA-HIGH TEMPERATURE FURNACE is designed for general lab use with inert, oxidizing or reducing atmospheres, or vacuum — and features a 2.4 inch diameter by 6 inch long hot zone with a heat-up time of 20 minutes to 2700° C.

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PRODUCT-PROCESS DATA
. . . on developments mentioned in "New Products and Processes" may be obtained by circling appropriate numbers.

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11 12 13 14 15 16

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TAX ADVANTAGES
. . . for business is the subject of a brochure offered free by the *New York State Dept. of Commerce.* Details are given on how to predict state tax, save on personal-property tax, and how to write off assets and new research facilities. Return card to receive your copy.

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VACUUM FURNACES
. . . are a specialty at *Richard D. Brew & Co.* Customer needs have inspired Brew engineers to continually seek new ideas and solutions. Note your requirements on the remarks line below and return this card to learn more about Brew's systems and capabilities.

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MARZ-GRADE
. . . zone-refined materials from *Materials Research Corp.* are now resistance-ratio tested. Available on most metals, the ratio values are guaranteed. Metals in ingot, wire, foil, sheet, forms, rod, and crystal are offered. Return this card for complete information.

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14-CHANNEL RECORDER
. . . is the newest in *Geotech's* series of long term/frequency modulation single speed tape recorders. Record on one-inch tape; play back any one channel. The portable recorder features three way power choice and four recording speed options. Return card for data.

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CALIBRATE TRANSDUCERS
. . . automatically with calibration systems from *Texas Instruments Inc.* Even when many calibration points are required, relatively unskilled operators can handle the job quickly, easily, and accurately. Repeatability is ±1 part in 100,000. Return this card for details.

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2700 C IN 20 MINUTES
. . . that's the heat-up time of *Astro Industries'* new Model 1000A ultra-high temperature furnace. The unit is designed for general lab use with inert, oxidizing, or reducing atmospheres; or vacuum. Astro can custom engineer a furnace to your requirements.

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FIBERGLASS FUME HOODS
. . . manufactured by *Labconco* are inexpensive to buy and maintain, easy to clean, corrosion resistant, easily assembled, look good, will not peel (or crack), and are available in various configurations—ranging in face width from 28 to 70 in. Return this card for catalog.

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LIST YOUR PRODUCTS

. . . and services in the 1969 *Industrial Research Yearbook & Buyers' Guide*. If your company manufactures instruments, materials, or components or performs services for the $24-billion R&D industry, you'll want to be included. Return this card for listing form.

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1968 I•R BUYERS' GUIDE

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REACHING THE MOON

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ENVIRONMENTS

. . . at ambient and extreme temperatures are available in chambers and controllers from *Missimers Inc.* They range in size and complexity from bench-top systems to fully temperature/humidity-controlled rooms. Return this card for details on systems of interest.

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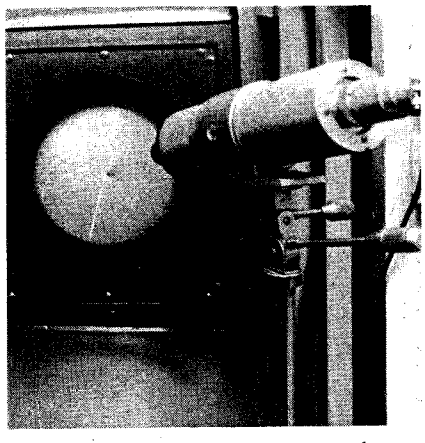
photography & optics

[14] LASER Q-SWITCH and plug-in miniature high-voltage pulser that generates Q-switched laser pulses with rise times less than 5 nanoseconds has been developed by Crystalab Products Corp., Rochelle Park, N.J. The device consists of an electro-optic modulator, Model EOM-512, and a GS-7A high-voltage pulser. The EOM-512, a KDP crystal modulator available with apertures of 0.375 to 0.625 in. (0.954 to 1.59 cm), can be used alone as a light modulator at frequencies to 50 mHz. The GS-7A is capable of switching 10 kV in 5 nsec when triggered by a 25-V input pulse. Typical time delays are under 15 nsec. When used as a Q-switch, the modulator is plugged into the GS-7A and the combination is placed in the optical cavity of a laser. Circle "14" on card 99 for more information.



[15] CCTV TELEVISION CAMERA, shown above, permits clear viewing of detailed images under poor lighting conditions. The Model ST-3, introduced by Diamond Power Specialty Corp., a subsidiary of Babcok & Wilcox Co., New York, incorporates a gamma correction circuit that permits operators to adjust the intensity of black-to-white shades as necessary to improve the contrast of any high-detail analog signal. The capability for controlling shading gradations and providing 1,200 lines of horizontal resolution, said to be the highest possible with a vidicon unit, makes the ST-3 particularly suited for radar screen scanning, remote x-ray readings, and microscope magnification and intensification. Circle "15" on card 99 for literature.

[16] HOLOGRAPHY KIT, available from University Laboratories Inc., Berkeley, Cal., for only $195, includes everything necessary to create original three-dimensional holograms. The Model 210 can be used with any visible spectrum gas laser with an output power over 0.3 mW. Circle "16" on card 99 for more information. ■

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**Appearing only in the Laser Edition.

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FEBRUARY

CALENDAR OF TECHNICAL MEETINGS

1-2	**American Chemical Society Middle Atlantic Meeting**	Marriott Hotel, Philadelphia
1-3	**American Astronomical Society Program on Solar Astronomy**	Tucson
4-7	**American Crystallographic Assn. Meeting**	Tucson
4-8	**American Society of Heating, Refrigerating & Air Conditioning Engineers Meeting**	Columbus, Ohio
5-6	**Society of Photo-Optical Instrumentation Engineers Seminar on Underwater Photo-Optical Instrumentation**	San Diego
5-7	**Society of Rheology Meeting**	San Diego
5-8	**American University Course on Data Communications**	Washington, D.C.
5-9	**Tustin Institute of Technology Course on Vibration & Shock Testing**	Los Angeles
5-15	**Short Course on High-Speed Aerodynamics & Physics of High-Temperature Gases**	Univ. of Tennessee, Tullahoma
5-23	**Australian School of Nuclear Technology Radioisotope Course**	New South Wales, Australia
6-7	**ASTME Assembly Seminar**	Marriott Hotel, Chicago
6-7	**Sanitary Engineering Conference on Waste Disposal from Water & Wastewater Treatment**	University of Illinois, Urbana
7-8	**ASTME Seminar on High Velocity Forming of Metals**	Marriott Hotel, Chicago
7-9	**American Assn. of Petroleum Geologists Convention**	Wichita Falls, Kansas
8-9	**American Marketing Assn. Conference**	New York City
8-9	**Forging Industry Assn. Safety Workshop**	Hollenden House, Cleveland
8-9	**Institute on Engineers in Private Practice**	University of Wisconsin, Madison

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12-15	**American University Course on Vital Records Protection**	Washington, D.C.
13-15	**IEEE Convention on Aerospace & Electronic Systems**	International Hotel, Los Angeles
14-15	**ASTME Numerical Control Seminar**	Chase Park Plaza, St. Louis
14-16	**International Solid State Circuits Conference**	Univ. of Pennsylvania, Philadelphia
14-16	**Automatic Laboratory Techniques Exhibition & Conference**	London
14-16	**Offshore Exploration Conference**	Jung Hotel, New Orleans
16	**American Marketing Assn. Conference**	Cleveland

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18-21	**American Institute of Chemical Engineers Meeting**	St. Louis
19-21	**TAPPI Annual Meeting & Exhibit**	Hilton Hotel, New York
19-23	**American Society of Civil Engineers Meeting**	San Diego
19-23	**ASTME Clinic on Productivity & Punching Process**	Hotel America, Hartford, Conn.
19-28	**National Electronics Conference Seminar on Electronic Circuit Design by Computers**	Pheasant Run Lodge, St. Charles, Ill.
19-29	**Short Course on Modern Materials Technology with Emphasis on Fiber Composites**	Univ. of Tennessee, Tullahoma
21-23	**Workshop on the Use of Digital Computers in Process Control**	Louisiana State University, Baton Rouge
22-23	**American Marketing Assn. Conference**	Atlanta

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25-29	**AIME Annual Meeting**	Waldorf Astoria, New York
26-28	**American Physical Society Meeting**	Boston
26-1	**Course on Lasers & Their Engineering Applications**	University of California, Berkeley
28-1	**IEEE Scintillation & Semiconductor Counter Symposium**	Shoreham Hotel, Washington, D.C.

25-29

Announcements of forthcoming technical meetings should be sent to **Industrial Research,** Beverly Shores, Ind., at least four months prior to the scheduled date of the conference to be included in the I•R monthly calendar.

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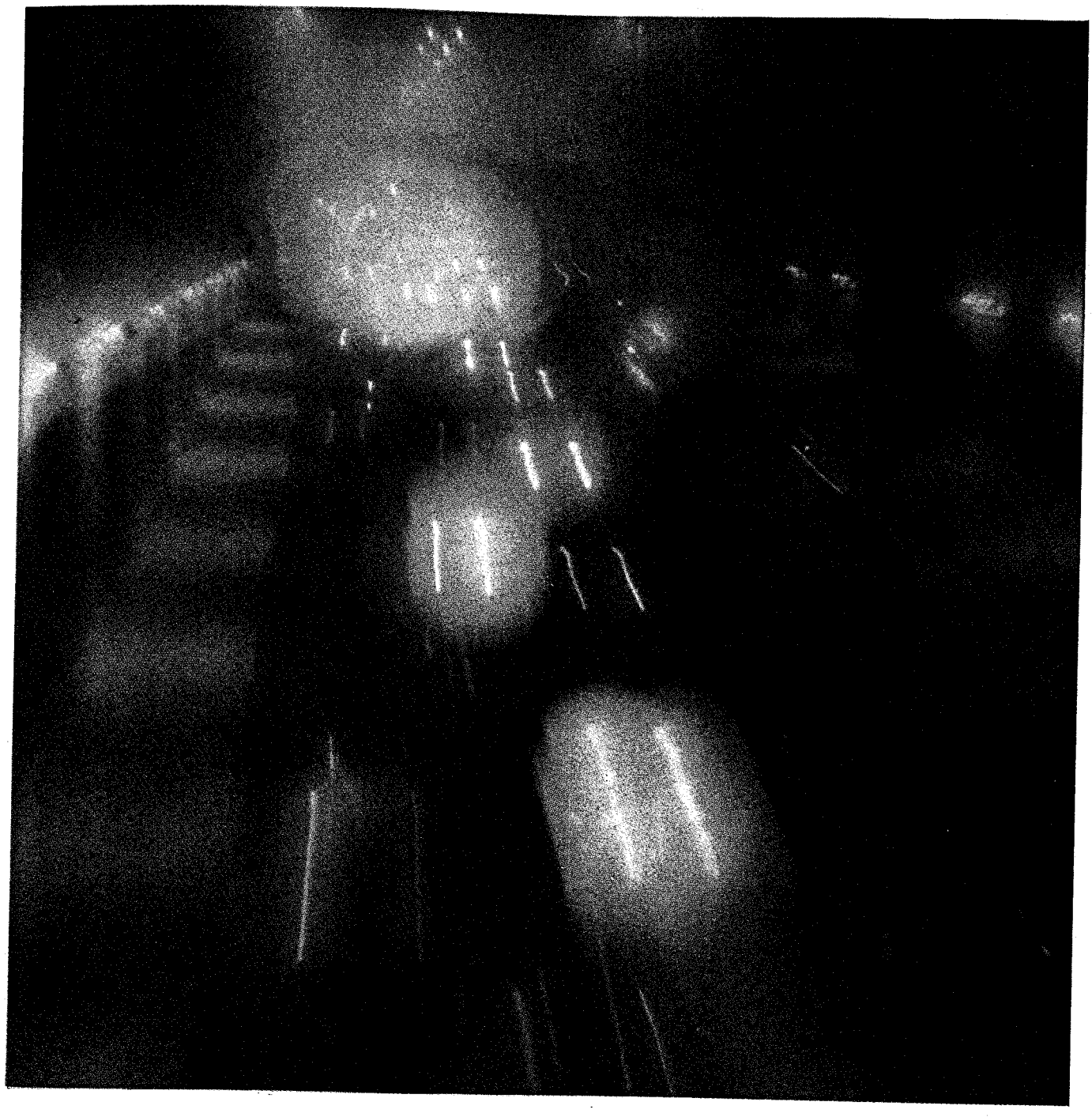

Is a change called for in your product or its manufacture? Time and again the most direct practical route is *not* expensive new equipment, not a costly change in formulation, but the resourceful use of a Sinclair petrochemical.

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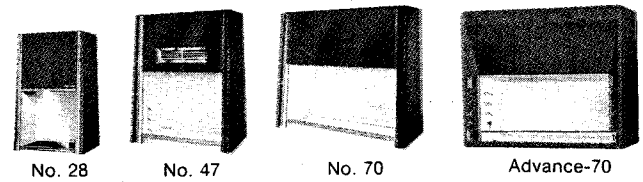
We have a complete line of fiberglass fume hoods, ranging from 28" to 47" to 70" face widths, with or without motors and blowers, with or without fixtures, with or without induced air. And we've got a complete line of fume hood accessories.

For a fully illustrated catalog containing all models, accessories, specifications and prices, contact your laboratory supply dealer or write to LABCONCO CORPORATION, 8801 Prospect, Kansas City, Mo. 64132.



No. 28 Fume Hood | No. 47 Fume Hood | No. 70 Fume Hood | Advance-70 Fume Hood

LABCONCO ...where new ideas become better products.

KJELDAHL and GOLDFISCH APPARATUS ■ CORROSION-PROOF LAB CARTS ■ CORROSION-PROOF BLOWERS ■ FIBERGLASS GLOVE BOXES

See inquiry card 116.