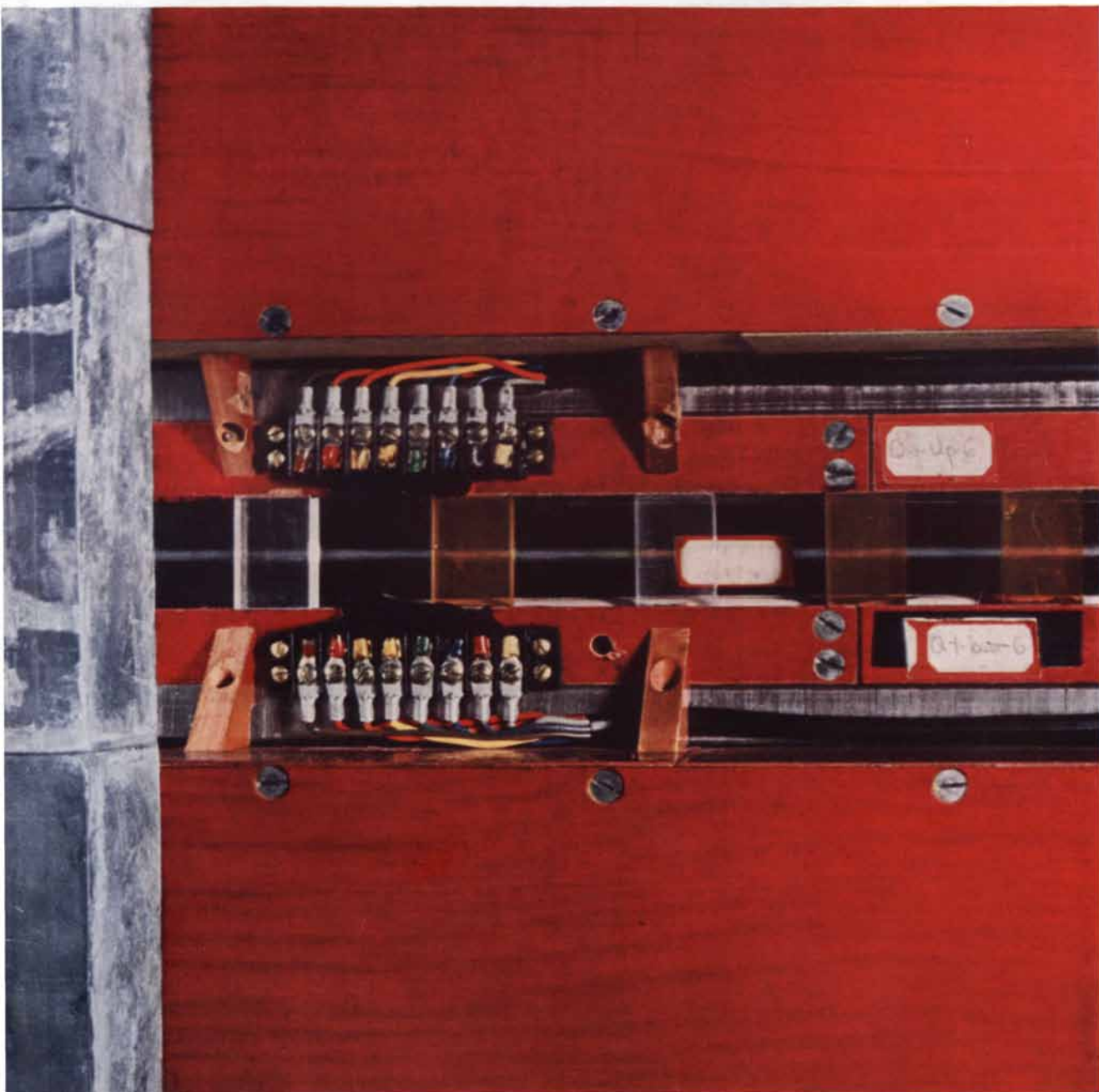


SCIENTIFIC AMERICAN



SYNCHROTRON BEAM

FIFTY CENTS

March 1958



Molecular model of ethylene oxide—one of the basic building blocks in Union Carbide's chemistry.

Helping to shape the future

More new things are on the way to you—because of research

EVER WONDER what causes the stream of new and better products that enrich our lives today? The answer is research . . . the kind of research that's going on constantly at Union Carbide.

Work-saving detergents get clothes cleaner, faster, because they contain synthetic chemicals created through research. Other Union Carbide synthetics help make possible life-saving wonder drugs . . . glamorous textiles . . . and fast-drying paints and lacquers.

In the exciting world of plastics, Union Carbide developed the versatile vinyl plastics, used for so many things—from rugged, colorful flooring to unbreakable phonograph records. And the handles on pots and pans stay cool because they're made of heat-resistant phenolic plastics . . . another product of Union Carbide research.

In many other fields, too, research by the people of Union Carbide helps build a better future for all of us.

FREE: Learn how research at Union Carbide helps improve many of the products you use every day. Write for "Products and Processes" booklet B.

Union Carbide Corporation,
30 East 42nd St., New York 17,
N. Y. In Canada, Union Carbide
Canada Limited, Toronto.

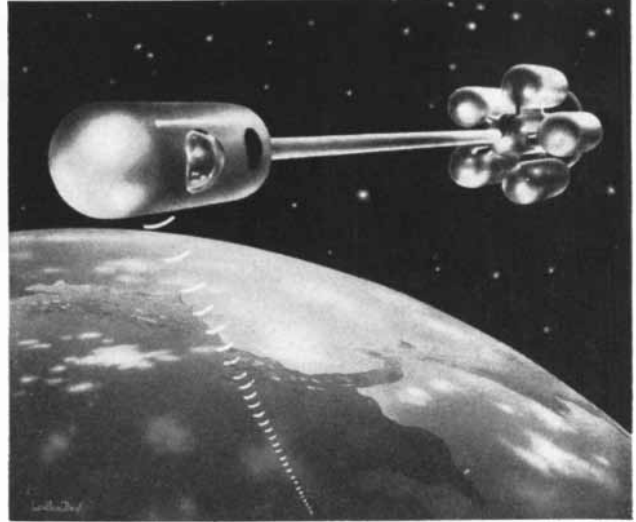


UCC's Trade-marked Products include

PREST-O-LITE Acetylene CRAC Agricultural Chemicals EVEREADY Flashlights and Batteries ELECTROMET Alloys and Metals
LINDE Oxygen SYNTHETIC ORGANIC CHEMICALS PRESTONE Anti-Freeze HAYNES STELLITE Alloys VISKING Food Casings
PYROFAX Gas BAKELITE, VINYLITE, and KRENE Plastics NATIONAL Carbons UNION Calcium Carbide UNION CARBIDE Silicones



TEST INSTRUMENTS Bulova's rugged Tachometer Tester for all jet and reciprocating systems meets MIL-T-945A requirements—is accurate to 0.1% with engines on or off. Simple to operate and maintain, this field unit also serves in maintenance depots. Precise Bulova testers include the dual purpose Torqmeter—a dynamometer or calibrated torque source.



RECONNAISSANCE SYSTEMS Bulova-developed miniaturized sensor packages, geared to specific tactical missions, feed combat surveillance data to Bulova analysis and display systems. Camera, infra-red, TV and radar techniques, combined and integrated, aid decision-making on land and in space. Satellite applications? Unlimited!

Bulova's capability helps to solve today's most challenging problems

To conceive, develop and manufacture a broad range of advanced electronic and electro-mechanical devices...this is the Bulova capability.

Meeting the needs of defense and industry is an unusually creative group of scientists, engineers and technicians, backed by 80 years' experience in precision production.



BULOVA
watch company

BULOVA RESEARCH AND DEVELOPMENT LABORATORIES, INC.
BULOVA PARK — JACKSON HEIGHTS — NEW YORK

With dynamic imagination, Bulova's capability has invaded the often uncharted technological areas to originate many modern-day miracles in miniaturized systems and components.

Here is a proven capability ready to assist you from concept to mass production. For full information, write Department G.I.S.-2.



INFRA-RED COMPONENTS Bulova's advanced IR projects include mosaic cells that will automatically filter out unwanted wave lengths and picture targets clearly against any background. Bulova infra-red R&D covers lead selenide and lead sulfide cells, missile seeker cells, reticles, filters and thermistor bolometers...for defense and industry.

SEE US AT THE IRE SHOW BOOTH #S 1811-1813



INFRA-RED SYSTEMS Bulova's IR illuminators put unseen spotlights on night objectives. Bulova's development capability extends to fire control systems that detect, track and automatically lock on target. Designed for accuracy and simplicity, these high resolution units will serve our nation's land, sea and air forces.



Beware the White Knight!

Consider well, old friend, lest your Queen be lost! And while you're at it you might give some *serious* consideration to those personal assets of yours.

Are they going to accomplish just what you wish, for you and your family? Or will some combination of taxes, inexperienced administration, and oversight shrink your estate alarmingly? In short, do they promise *real* security for you and yours . . . tomorrow, . . . next year, . . . next generation?

If not, someone may be sadly shortchanged. Our personal trust services are designed to protect and enhance *your* financial position. A sound idea: write for a free copy of "WHAT YOU SHOULD KNOW ABOUT PERSONAL TRUSTS" *today*, before you forget it.

The **FIRST**
NATIONAL CITY BANK
of New York

Personal Trust Services are
Administered by our Affiliate:

CITY BANK FARMERS TRUST COMPANY

Dept. M, 22 William Street, New York 5

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

ARTICLES

- 29 **ATOMIC POWER IN BRITAIN, by Sir Christopher Hinton**
An economic and technological discussion of the world's most advanced program.
- 36 **THE FIRE ANT, by Edward O. Wilson**
This South American import has become a serious pest in our southern states.
- 42 **NORMAN CASTLES, by Brian Hope-Taylor**
Originally they were wooden towers set on stilts in the center of Norman forts.
- 64 **PARTICLE ACCELERATORS, by Robert R. Wilson**
To study smaller and smaller objects, physicists must build ever-larger machines.
- 81 **"IMPRINTING" IN ANIMALS, by Eckhard H. Hess**
Experiences in a critical period of early life strikingly affect later behavior.
- 94 **HELMHOLTZ, by A. C. Crombie**
The law of the conservation of energy is one of the products of his versatile genius.
- 104 **HYPOTHERMIA, by Raymond J. Hoek and Benjamin G. Covino**
Chilling a patient to slow his metabolism is an important new surgical technique.
- 118 **THE MICROSOME, by Paul C. Zamecnik**
This small body, found in animal cells, plays a major role in protein synthesis.

DEPARTMENTS

- 8 **LETTERS**
- 12 **50 AND 100 YEARS AGO**
- 20 **THE AUTHORS**
- 50 **SCIENCE AND THE CITIZEN**
- 128 **MATHEMATICAL GAMES**
- 134 **THE AMATEUR SCIENTIST**
- 145 **BOOKS**
- 160 **BIBLIOGRAPHY**

BOARD OF EDITORS Gerard Piel (Publisher), Dennis Flanagan (Editor), Leon Svirsky (Managing Editor),
James R. Newman, E. P. Rosenbaum, C. L. Stong, Esther A. Weiss

ART DIRECTOR James Grunbaum

GENERAL MANAGER Donald H. Miller, Jr.

ADVERTISING MANAGER Martin M. Davidson

RADIOACTIVITY AT WORK...#1

Our business is radioactivity—applying it, measuring it, protecting against it

Since our business might have bearing on yours, this is the first in a series of reports on work we're doing for a variety of clients, not only in the nuclear industry but in such diverse fields as chemicals, petroleum, pharmaceuticals, medicine, steel and coal.

Nuclear reactor developers and operators call on us for such services as analysis of reactor fuels, decontamination studies, and the development of data relating to the production of atomic power.

Research people and industrialists in all fields draw upon our specialized skills and equipment for applying the phenomena of radioactivity to improving processes and for highly complex studies which were not possible with "yesterday's" techniques.

So many people these days are curious about the possibilities of applied radioactivity, we thought you might be interested in reading about some of our current projects.

ENVIRONMENTAL RADIOACTIVITY SURVEYS

Since we started in business, one of our important activities has been conducting site surveys for operators of nuclear reactors. These studies are undertaken prior to start-up to determine the level of "background" radioactivity in the area surrounding the reactor.

This then provides a basis for measuring any increase in radioactivity after the reactor is in operation. Environmental radioactivity studies are required. Such studies should also be made on a continuing basis not only for safety's sake but to provide "third party" legal protection against lawsuits and insurance claims.

In conducting a site survey, NSEC takes samples from the surrounding area. These may be soil, ground water, plants, animals, fish, rainwater, dust, sewage or other materials. We consider carefully the nature of the facility, the terrain, direction of air movement, and surface and ground water flow. The samples are processed and analyzed in our labs. We are then able to establish the radioactivity level, the kinds of isotopes producing it, and the possible sources of these isotopes.

NSEC has conducted more site surveys of nuclear facilities than any other company in the United States. *For information on environmental radioactivity surveys of your nuclear site, phone us at HOMestead 2-4000 in Pittsburgh. We can either conduct the survey for you, or train your personnel on proper procedures.*

PREVENTING BEACH POLLUTION

Recently, in the largest radioactive tracer study ever conducted in the United States,

We'll be glad to furnish detailed information on any of these studies. And if you'd like to keep abreast of new developments in the field, just ask us to put you on the mailing list for our monthly publication "Radioactivity at Work."

Our technical staff is available for consultation on your specific requirements and will make proposals and quotations without obligation.

Nuclear Science and Engineering Corporation

DEPT. SA-1, P. O. BOX 10901, PITTSBURGH 36, PENNSYLVANIA

NSEC successfully traced the dispersion of sewage effluent flowing into ocean waters. Our study helped the City of Los Angeles in planning expansion of its sewage system. First we injected the isotope scandium-46 into sewage about to be released into Santa Monica Bay. This enabled us to measure the pattern of sewage diffusion and its dilution in sea water to one part in ten thousand.

Write for a copy of "Radioactive Tracer Study of Sewage Field in Santa Monica Bay" by Dr. Ralph L. Ely, Jr. (He's our Vice President and Technical Director.) Or ask about our forthcoming study for the Republic of Venezuela, in which we will investigate littoral drift, using radioactive sand, to determine the feasibility of a certain harbor location.

RADIATION SICKNESS

It's common knowledge that excessive radiation produces harmful effects in human beings, ranging from mild nausea or skin burns to cancer and death. Recent experiments under the direction of Dr. A. Edelmann, Manager of our Department of Biology and Medicine, have indicated that radiation can also produce a toxic factor which appears in the blood. Analysis of the blood of rats subjected to X-rays under varying conditions not only indicates that a toxic element is produced but that it may be transferred by injection from one animal to another.

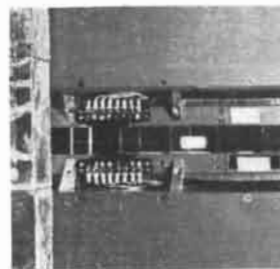
When and if this toxic substance is identified, it may be possible to devise an antitoxin to alleviate some of the effects of atomic radiation. *Medical and pharmaceutical applications of controlled radioactivity open up entirely new means of studying existing problems. Contact Dr. Edelmann about your problem.*

DETERMINATION OF BORON IN SILICON

A major problem plaguing the electronics industry is achieving ultra-pure silicon for transistors. Current methods are slow and costly, but effective. Nevertheless, boron still remains as a damaging impurity even in minute quantities of only a few parts per billion. Ordinary chemical methods cannot detect the presence of boron in such small concentrations.

However, NSEC scientists are now perfecting a process by which the boron is transmuted into radioactive carbon-11 and subsequently measured by its radioactivity.

This new method of analysis will be helpful in the quality control of silicon during production. *Once a routine method is established it will be offered on a commercial basis. Interested? Drop us a letter.*



THE COVER

The photograph on the cover shows a section of the electron synchrotron (see page 64) at Cornell University. The luminous horizontal line in the middle of the photograph is light emitted by electrons as they speed around the tube of the synchrotron.

THE ILLUSTRATIONS

Cover photograph
by William Vandivert

Page	Source
30-32	British Information Services
33	Bunji Tagawa
34	Irving Geis
36-37	Ross E. Hutchins
38-39	James Egleson
40-41	Ross E. Hutchins
43	Eric Mose
44	<i>The Bayeux Tapestry</i> , Phaidon Press, 1957
45	Victoria and Albert Museum
46-48	Eric Mose
64	Brookhaven National Laboratory
65	European Organization for Nuclear Research
66-69	Bunji Tagawa
70	University of California (top), Cornell University (bottom)
71	Brookhaven National Laboratory (top), Sovfoto (bottom)
72	Gordon Coster
73-76	Bunji Tagawa
81	Eckhard H. Hess
82-86	John Langley Howard
88	Eckhard H. Hess
94	Gernsheim Collection
96-100	New York Public Library
104-106	René Martin
108	James Egleson
110-112	Bunji Tagawa
114	Therm-O-Rite Products Co.
119	George E. Palade
120	James Egleson
128-132	Irving Geis
135-140	Roger Hayward

Largest Special Metals Company Formed

MALLORY-SHARON

NOW INTEGRATED PRODUCER OF

TITANIUM, ZIRCONIUM, SPECIAL METALS

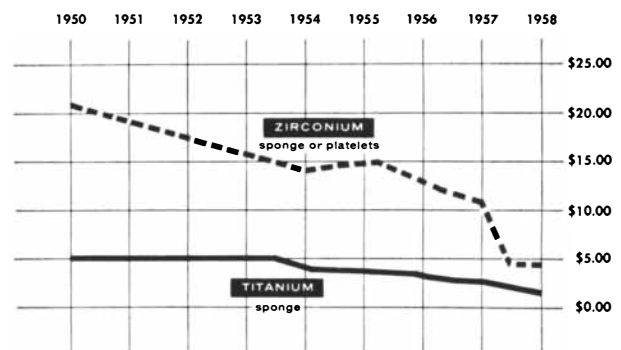
Mallory-Sharon Titanium Corporation has broadened its scope in the special metals field with acquisition of all the titanium and zirconium sponge production facilities of National Distillers & Chemical Corporation, plus full ownership of Reactive Metals, Inc., formerly owned jointly by Mallory-Sharon and National Distillers.

Our new name is Mallory-Sharon Metals Corporation. Our products include titanium, zirconium, and hafnium in sponge form and in a broad range of mill products including sheet, plate, rod, bar, billets, etc. Planned for the future are other special metals.

LOW COST PROCESS—Now a fully integrated producer, Mallory-Sharon will use the new sodium reduction process for making titanium and zirconium sponge. This process is believed to be the lowest cost method developed to date for this purpose, and produces metal of unusually high ductility. It will contribute to making titanium and zirconium economically attractive in more and more applications.

WHAT THIS MEANS TO YOU—Mallory-Sharon's leadership in the special metals field will mean continuing

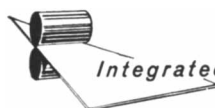
improvements and importance to these metals. In addition to titanium's broad use in aircraft and missiles, and zirconium's in the nuclear field, both metals provide exceptional corrosion resistance—offering lower costs in a broad range of processing and industrial applications. Let us help you design ahead with these new metals.



Regular price reductions in titanium and zirconium sponge have also been reflected in lower prices for mill products. This trend shows the wisdom of evaluating titanium and zirconium now for your new products.

MALLORY-SHARON

METALS CORPORATION • NILES, OHIO



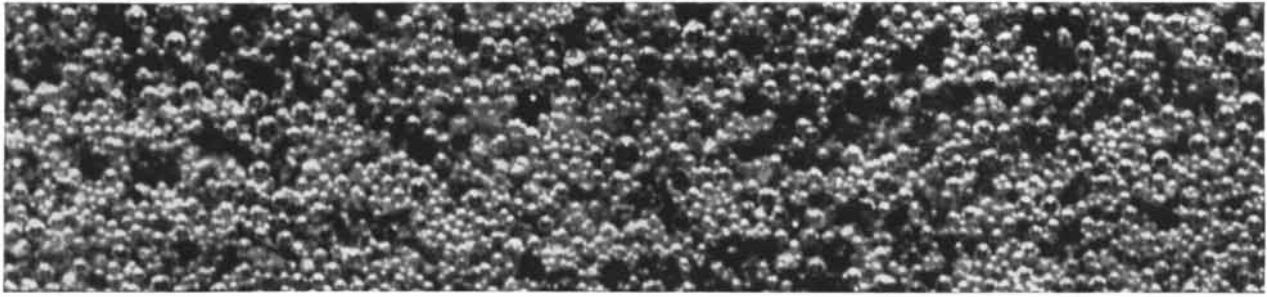
Integrated producer of Titanium • Zirconium • Special Metals

**Take
two minutes
to discover**

"Microballoon"

Spheres





"Microballoon" spheres are an exciting material on which to launch new creative ideas. Here they are shown magnified sixty times under a microscope. Read their story below and see if their successful applications may solve your research problems.

For new scientific discoveries...

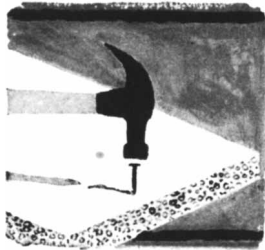
Have you ever heard of "Microballoon"® spheres? Do you know what they have done, or what they may be able to do? Have you ever worked with these tiny spheres yourself?

What are they?

"Microballoon" spheres are the latest development in phenolic plastics. These hollow, unicellular spheres have an average diameter of only .0017 inch. Their density is 3 to 5 lbs. per cubic foot. They are resistant to hydrocarbons and acids. In bulk, "Microballoon" spheres look like reddish brown flour.

What have they done?

Used as a low density filler, these spheres which contain an inert gas, make it possible to control density and physical properties. Researchers tried them as fillers for plaster and paper. They found that the plaster would take a driven nail without cracking. Paper was found to be more opaque without being heavier.

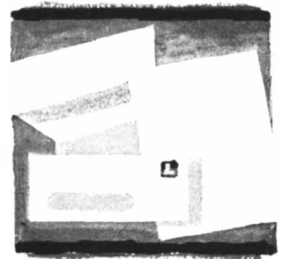


Crack-resistant plaster

"Syntactic foam" is another promising development. "Microballoon" spheres in an epoxy binder form a putty-like cellular

substance that makes possible a type of controlled foam for on-the-spot installation in construction. After the binder cures the result is a strong sandwich core which has been used for boat hulls. Other advantages are light weight and insulating properties.

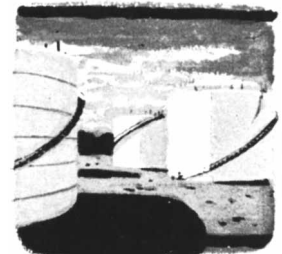
Though permeable to water, these hollow plastic spheres will float on crude oil. They form a blanket that reduces the evaporation of costly volatiles, and many oil companies have used them successfully on cone-roofed storage tanks for more than three years.



Opaque paper

Bakelite Company can help your research

Your own investigation of this promising material may yield substantial rewards. As a start, learn more about "Microballoon" spheres first-hand. Bakelite Company's laboratory facilities, experience, and resources will help. Write for the latest technical information. Samples are available.



Evaporation control

ADDRESS: Bakelite Company, Foam Division, New Products Engineering Department, 420 Lexington Avenue, Room 2840, New York 17, N. Y.

*Registered Trade-Mark of the Standard Oil Company (Ohio)

BAKELITE
BRAND
PLASTICS

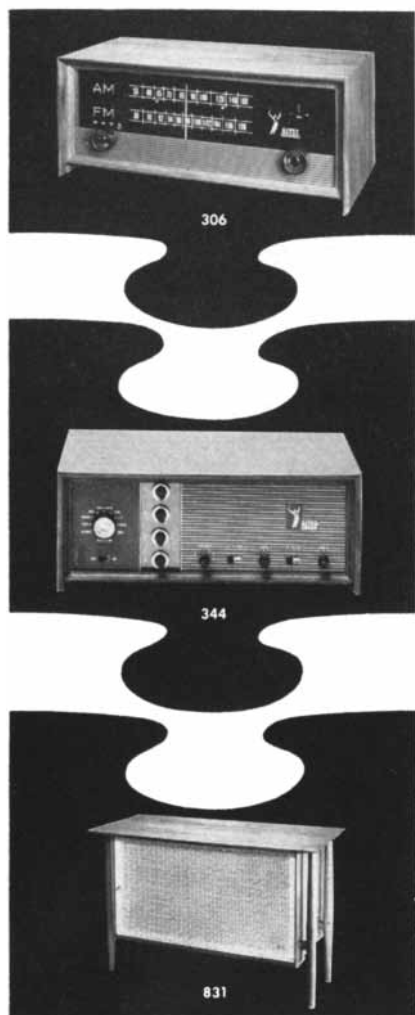


BAKELITE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

The terms BAKELITE and UNION CARBIDE are registered trade-marks of UCC.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario.

LETTERS



Matched

for exciting sound and style by ALTEC LANSING

The puzzle of matching your component home hi fidelity system both for flawless tonal balance and perfectly integrated styling is solved for you by ALTEC LANSING.

This is possible because ALTEC manufactures a complete line of home hi fidelity components — all designed and engineered for perfect match and balance for the utmost in listening pleasure. And all ALTEC products are guaranteed to meet or exceed their published performance specifications.

Complete systems priced from \$300 to \$1600.



For complete information write

ALTEC LANSING CORPORATION, Dept. 35A
1515 S. Manchester Avenue, Anaheim, Calif., or
161 Sixth Avenue, New York 13, N.Y.

For pure sound enjoyment insist on ALTEC, for years the leader in precision engineered tuners • pre-amplifiers • amplifiers • speakers • speaker components • speaker systems • enclosures • scientific audio instrumentation

12-20

Sirs:

When allowance is made for scaling, the athletic performance of the grasshopper would appear to be relatively inferior among animals, and not superior as claimed by Graham Hoyle ["The Leap of the Grasshopper"; *SCIENTIFIC AMERICAN*, January].

Principles of scaling are familiar to physicists and are the stock in trade of people like naval architects and aerodynamicists who must often infer, from experiments with small-scale models, the predicted performance of the ships, aircraft or missiles whose full-scale versions may not yet have been built or that may be too large to fit into testing basins or wind tunnels. Not all biologists realize that animals, too, of varying sizes should be expected to conform to laws of scaling.

Imagine a sequence of cats, all similarly proportioned, and with all manner of sizes between some smallest cat that might be no larger than a mouse and some largest cat that might be as large as a lion. "Similarly proportioned" means that if one cat is half as long as another it will stand just half as high, and that each muscle or bone of the one will be just half as long, half as broad and half as high as the corresponding muscle or bone of the other. If all the cats are made of the same materials, it follows that their muscles will be able to exert forces proportional to their cross-sectional areas, and thus to the squares of their lengths. The weights of the cats will vary as the cubes of their lengths. Therefore the weight that a cat could lift (if a cat could be induced to lift it), divided by the weight of the cat, would vary inversely as the cat's length; and thus a cat three inches long could lift 24 times as many multiples of its own weight as could a cat six feet long. When starting to leap, a cat would accelerate with a number of centimeters per second per second that was inversely proportional to its length, since acceleration varies as force divided by mass; the distance through which the cat accelerated itself would vary as its length; the product of the acceleration and the accelerating distance would thus be a constant, independent of the length of the cat. Since the square of the velocity achieved varies as the preceding product, the velocity reached by jumping would be constant from cat to cat; and since the distance a cat can jump ver-

tically or horizontally depends on its "launching" velocity, all the cats could jump equal distances vertically, and equal distances horizontally. They would all have equal athletic performances—not in cat-lengths but in meters.

Dr. Hoyle calls the grasshopper's jump one of the most remarkable performances in the biological world. It may be, indeed—but remarkably poor, not good. The feat of a grasshopper four or five centimeters long, in jumping only 45 centimeters vertically or a meter horizontally, merits little admiration because many other animals including cats, men and lions vastly out-jump the grasshopper.

A two-gram locust is said to exert a force of 30 grams with both legs together while accelerating. As we have seen, force varies as the square of length, or the two-thirds power of body weight, among similar animals. Thus, were the two-gram locust scaled up to a man's 80 kilograms, he could exert a force of 30 grams times the two-thirds power of 40,000, or about 35 kilograms. This performance is completely outclassed by that of an 80-kilogram man—the man outperforms the grasshopper twice without even trying, by merely supporting his own weight! Alternatively, imagine that a man, strong enough merely to support his 80-kilogram weight with bent knees, were scaled down to the two-gram weight of the locust. His two legs would together be able to exert a force of about 68 grams, as compared to the locust's 30.

The muscle of a grasshopper is said to be able to exert a force of 800 grams although it weighs only 1/25 of a gram;

Scientific American, March, 1958; Vol. 198, No. 3. Published monthly by Scientific American, Inc., 415 Madison Avenue, New York 17, N. Y.; Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer.

Editorial correspondence should be addressed to The Editors, *SCIENTIFIC AMERICAN*, 415 Madison Avenue, New York 17, N. Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

Advertising correspondence should be addressed to Martin M. Davidson, Advertising Manager, *SCIENTIFIC AMERICAN*, 415 Madison Avenue, New York 17, N. Y.

Subscription correspondence should be addressed to Jerome L. Feldman, Circulation Manager, *SCIENTIFIC AMERICAN*, 415 Madison Avenue, New York 17, N. Y.

Change of address: Please notify us four weeks in advance of change. If available, kindly furnish an address imprint from a recent issue. Be sure to give both old and new addresses, including postal zone numbers, if any.

Subscription rates for U.S.A. and possessions: 1 year, \$5; 2 years, \$9; 3 years, \$12.50. Canada and Latin America: 1 year, \$6; 2 years, \$11; 3 years, \$15. All other countries: 1 year, \$8; 2 years, \$14; 3 years, \$18.

ONLY THE ACF POOL TRAINING REACTOR

OFFERS ALL THESE FEATURES.

1. Versatility of Pool Type Reactor
2. Safe, Simple operation
3. Full scale instrumentation and control system
4. Complete experimental facilities
5. Flexible fuel arrangement
6. No excavation . . . can be housed in existing buildings
7. Minimum maintenance and operation costs.

ACF will prefabricate, deliver and install, at customers' site complete reactor including instrumentation and shielding. ACF will also supply operator training, service guarantee, laboratory manuals, and assistance in preparation of hazards report.



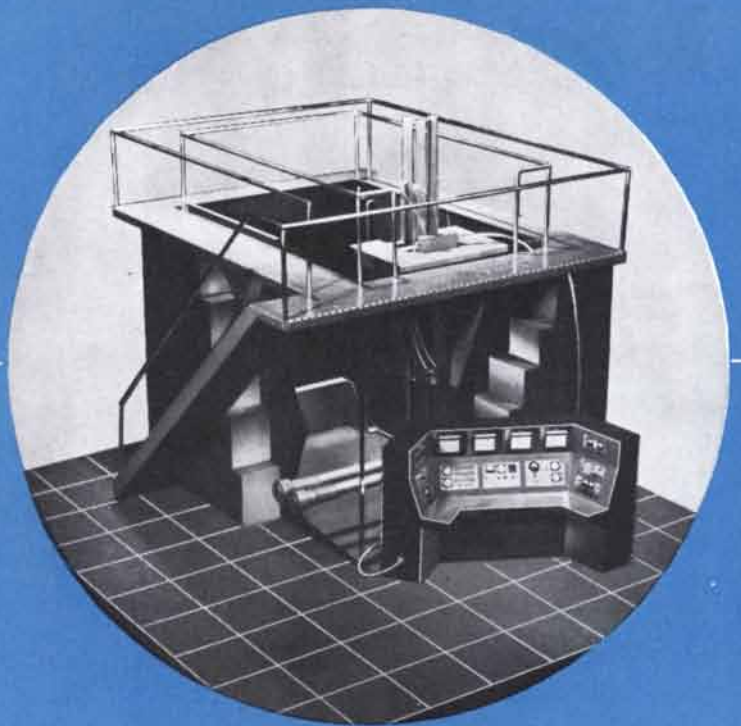
pool training reactor



SCHOOLS
INDUSTRIES



Whether you are purchasing for your college or university, or you are a part of a forward looking industry who understands the need for nuclear study, contact ACF so that together we may work on the answer to your requirements.



NUCLEAR PRODUCTS-ERCO

Division of ICF Industries Incorporated

508 Kennedy Street N.W.,

Washington 11, D.C.

INSTRONin action
in industry

At the Owens-Corning Fiberglas Product Testing Laboratories, the Instron performs a strength test on Fiberglas Prefabricated Duct (a highly efficient air-conditioning air transfer product) to compare its crushing strength with that of old-type metal ducts.

How Owens-Corning Fiberglas Uses the INSTRON TESTER

Owens-Corning Fiberglas Corporation utilizes the Instron for testing problems ranging from the tensile strength of a single glass fiber (3 microns in diameter) to the compressive strength of structural type insulating boards requiring several thousand pounds loading force.

Instron's record of performance in leading laboratories like this is your best assurance that — whatever your field, or your materials testing problem — this most modern of physical test equipment can help you solve it better and more efficiently.

Discover for yourself how much *more* the electronically controlled Instron can do for you on all types of materials. Write for the complete facts booklet today.

INSTRON
ENGINEERING CORPORATION

2502 Washington Street, Canton, Massachusetts



The Instron comes in various models and sizes, to suit the widest applications — for tests under all sorts of environmental conditions — with load ranges from 2 grams full scale to 10,000 lbs.
ILLUSTRATED: TABLE MODEL.

or 20,000 grams of force per gram of muscle weight. We have seen that this ratio scales inversely as the length of the animal, and therefore inversely as the cube root of the animal's weight. A man's muscle is stated to exert about 2,000 grams of force per gram of muscle weight. If an 80-kilogram man were scaled down to a weight of two grams, his muscles would then exert a force of 68,000 grams per gram of muscle weight, much excelling the 20,000 grams per gram exerted by the muscles of the grasshopper.

THEODORE E. STERNE

Harvard University
Cambridge, Mass.

Sirs:

Professor Sterne calculates that a sequence of cats of all sizes could jump equal distances vertically and horizontally. On the same basis a man-sized grasshopper should be able to jump as high and as far as the real one. But in another calculation Sterne finds that the grasshopper would be too feeble to support its own weight. Cats stay ever strong whilst 'hoppers just grow feebler! On looking into Professor Sterne's calculations one finds the reason for the anomaly. In making his comparison of cats of different sizes he has neglected to allow for the fact that whilst the cat is busy accelerating its mass it must also at the same time support its bulk against the inevitable force of gravity. Its strength is increasingly required for this purpose as its size increases. This factor must be added to the accelerating force. The weight can hardly be ignored in the case of a lion-sized cat. This creature would be a weakling. Yet a lion-sized cat (*i.e.*, the lion) exists in nature and it is a splendid athlete.

Imaginary scaling operations of this kind are misleading on all counts, for they do not take into account the complexity of muscles. The reason for the apparent weakness of the man-sized grasshopper is that its muscle fibers will have been increased in length by 34 times, so that they take up 34 times as much valuable space without being made any stronger. The lion exists because it has been able to increase the number of its muscle fibers per muscle to a greater extent than is possible simply by an increase of scaling, which allows only an increase in area proportional to the linear scaling for the insertion of additional muscle fibers. The lion has done much better than this by evolving

extensive ramifications of the tendinous strands to which the still comparatively short muscle fibers are attached. A man-sized grasshopper, should it have existed, would have done the same thing.

The primary force developed by a muscle is determined by properties of the contractile protein actomyosin (in a few cases paramyosin), and it may be the same for all kinds of muscle. The force actually developed on a load attached to the muscle is determined by the properties of viscous-elastic elements in series parallel with the actomyosin. These secondary elements are very different in cats and grasshoppers. The ultimate force of actomyosin could only be realized in a thin sheet having no other elastic material in it at all. Its force would be thousands of grams per square centimeter or many millions of grams per gram. Such is the energetic material from which the muscle machinery has been built up; it is capable of forces and speeds far in excess of any which have yet been evolved. The limitation has been imposed by the weakness of the skeletal materials. Attenuation has been realized by the use of elastic material.

Muscles having different functions in the animal body require different aspects of their functioning to be emphasized: speed, force, extent of shortening, and so on. In comparing muscles we may use a variety of criteria, such as force per unit cross-sectional area, force per unit mass, extent of shortening, rate of shortening at maximum speed, rate of working per unit cross-sectional area, rate of working per unit mass, and so on. Two muscles with exactly the same shape and volume may be quite differently designed. Thus one may have long parallel fibers and be able to shorten over a great distance. The other may have ramifying tendons with short muscle fibers and only be able to shorten over a small distance. But the former would be able to lift only a much smaller load than the latter. If we are to compare the two muscles from the point of view of their *design* as instruments for developing *force* we must determine their maximum force per unit mass. This was the unit I chose. Felix Plateau and D'Arcy Thompson long ago debunked the notion that insect muscles are unusually *strong*, but in the units force per gram of muscle the grasshopper muscle is a winner every time.

GRAHAM HOYLE

The University
Glasgow, Scotland

FOR THE NUCLEAR PROGRAM

Several divisions of the Norton Company are making important contributions to the field of nuclear energy. Some of the products that are proving helpful in furthering progress in nuclear energy are:

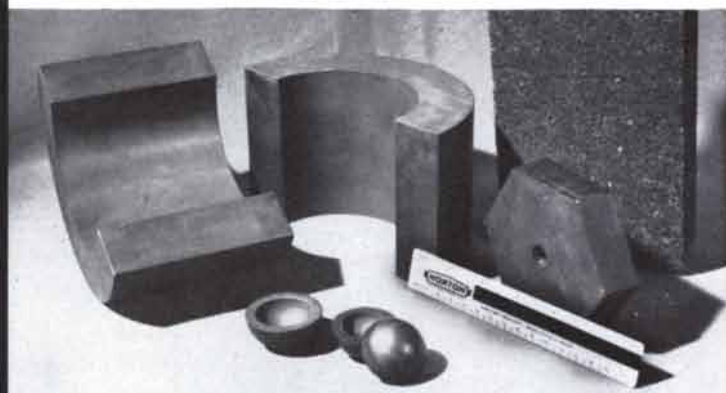
- Ceramic fuel units, from sample lots to full core loadings.
- Reactor shield and control rod materials, particularly boron carbide, in a wide range of special shapes.
- Metallurgical refractories for processing and reprocessing nuclear fuel materials and other unusual alloys and metals.
- Source or intermediate materials, such as oxides or carbides, for use in producing zirconium and other materials for reactor construction.
- Diamond cut-off wheels for dicing or wafering — that eliminate waste and assure dimensional accuracy of the costly materials being cut.

The Norton organization includes an engineering staff experienced in atomic development — available for cooperation where electric furnace products may be of interest. Facilities are available for the production of, or research in, classified items. For further facts, write to NORTON COMPANY, 542 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries



Ceramic Fuel Pellets For Nuclear Reactors. Those illustrated are of a thorium-uranium oxide mixture. They are typical of the ceramic fuel element components available in a wide range of compositions made to exact specifications.



These Reactor Parts Are Made Of Boron Carbide, known as NORBIDE* — a hard, stable, lightweight material. They absorb neutrons without becoming radioactive. Besides the shields and other structural parts shown, Norton boron carbide may be molded into control rods, tubes, discs, segments, etc.

NORTON

REFRACTORIES

Engineered... R_x ... Prescribed

*Making better products...
to make your products better*

NORTON PRODUCTS

Abrasives • Grinding Wheels
Grinding Machines • Refractories

BEHR-MANNING DIVISION

Coated Abrasives • Sharpening Stones • Behr-cat Tapes



High Purity Refractories Vital To Metallurgy include crucibles, made of MAGNORITE* pure magnesia, zirconia and thoria, suitable for melting uranium, plutonium, thorium, etc. A special Norton laboratory devoted exclusively to nuclear problems is developing other unique ceramics for the atomic program.

50 AND 100 YEARS AGO



MARCH, 1908: "Dr. Alexander Graham Bell's gigantic man-lifting kite, the *Cygnets*, was sent up in December, 1907, both with and without a man. In it Lieut. Selfridge, of the U. S. Army, ascended to a height of 168 feet and remained in the air for over seven minutes. While Dr. Bell's ultimate object is to secure a flying machine that will support itself in the air at a moderate rate of speed, the experiments with the *Cygnets* have been mainly studies in stability. The wonderful steadiness of the tetrahedral structure championed by Dr. Bell is shown by the fact that the *Cygnets* descended from 168 feet to the water so slowly and evenly that the man aboard did not realize he was dropping until he found the kite in water. Dr. Bell's next step will be to put a powerful, light motor on a modified form of the *Cygnets*."

"On February 25 there were opened with appropriate ceremonies the twin tunnels from 15th Street, Jersey City, to Morton Street, New York, which form the first section of the important system of tunnels designed to facilitate travel between Jersey City and New York. Two trains, carrying respectively Governor Hughes of New York and Governor Fort of New Jersey, started from New York and Jersey City, and met beneath the state line at the center of the Hudson. Here the governors shook hands from the front platforms of their respective trains; and thus was this great work placed at the service of the public."

"The motor omnibus made its debut in America last summer. It has entirely superseded the old horse stages that formerly supplied the only form of regular public vehicular conveyance on Fifth Avenue in New York City. The Fifth Avenue Coach Company has put into service 15 French De Dion buses of 1906 model. The bodies are of the double-deck type so popular in the large cities of Europe. They have seats for 34 passengers—16 inside and 18 on the upper deck. The prime mover is a De Dion gasoline engine having a French



A good word for quality
phenolic molding compounds
in their widest applications

is **PLENCO**

... a good word, too, for dependable counsel. Whether you take our advice or not, you can't help but profit from your consultation with Plenco's problem-solving specialists.

And, in production, you can't help but benefit from the wide-ranging knowledge with which these modern molding materials are formulated and the precision with which they are produced.

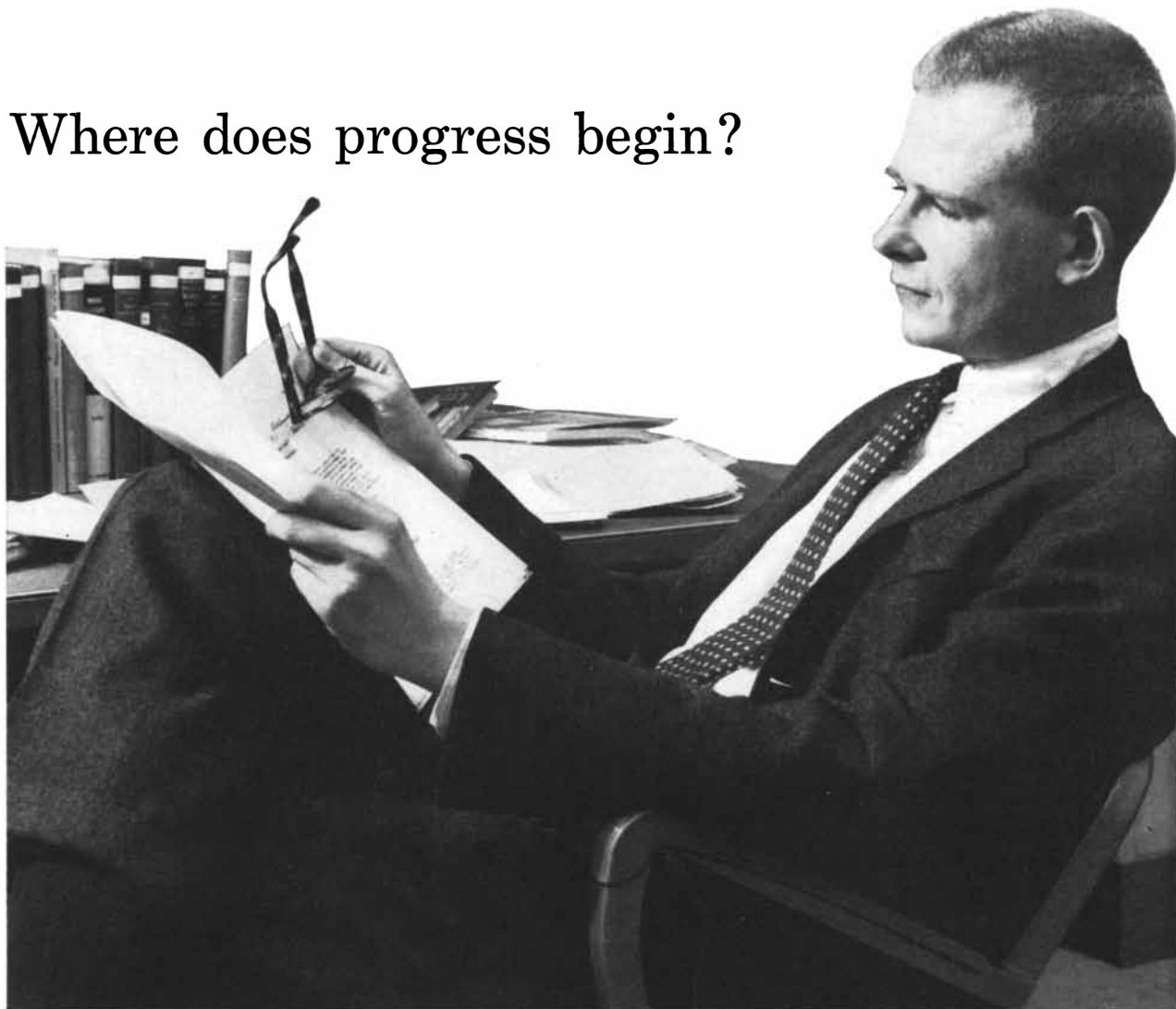
Does phenolics have the answer for you? Then, chances are that Plenco compounds, in their exceptional variety, versatility and quality-controlled uniformity, can provide it. We invite you to let us demonstrate that.

**PLASTICS
ENGINEERING
COMPANY**
Sheboygan, Wisconsin



Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

Where does progress begin?



Kendall Preston Jr., S.M. in engineering from Harvard University . . . graduate of the Laboratories' Communications Development Training Program.

Progress begins in the mind—in the perception and appreciation of new ideas. In the past the ideas that sparked progress too often had to wait on the random interest of genius. Today more and more new ideas come from men trained to an awareness of that which is yet to be accomplished.

At Bell Laboratories, communications science is entering upon its most challenging era in history. As never before, progress will depend upon men who have acquired the special training needed to think creatively in this exciting field.

Bell Laboratories provides the young college graduate with unique opportunities to develop his creative

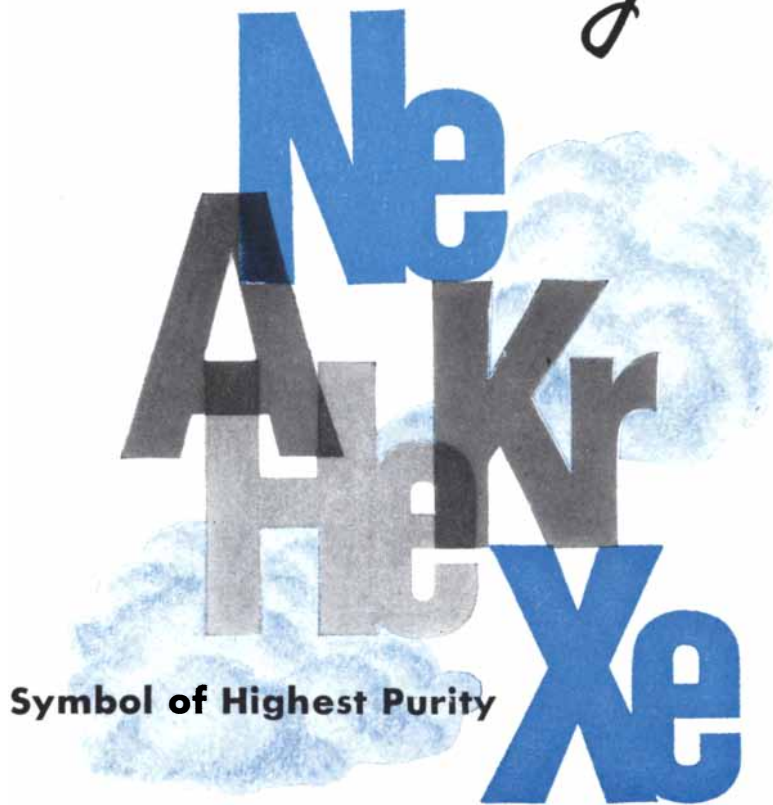
abilities. During his first two years, he spends two or three days a week as part of his job, taking postgraduate courses in basic mathematics, physics and electronics. This he does at a graduate study center which has been established at the Laboratories by New York University. As he gathers a broad fundamental knowledge which will enable him to tackle every type of communications problem, he also gathers credits toward advanced degrees. To round out his education, he spends a third year on special phases of communications technology.

By helping scientists and engineers to reach their top development, Bell Laboratories has helped to make your telephone system the world's best—and will keep it so.

BELL TELEPHONE LABORATORIES
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



LINDE *Rare Gases*



Symbol of Highest Purity

- ...in cloud and bubble chambers**
- ...in radiation detecting equipment**
- ...in gas discharge devices and glow tubes**
- ...as protective atmospheres for
crystal growing**

Rare gases produced by LINDE are continuously analyzed by mass spectrometer, gas chromatography, and chemical and physical methods. These analytical checks assure you of the purest rare gases obtainable.

LINDE argon, neon, helium, xenon and krypton are available in one- and two-liter glass bulbs, or in steel cylinders under pressure. Mixtures of gases are also available to your specifications. Prompt delivery is assured.

For detailed data on the physical and electrical properties of LINDE Rare Gases, write Dept. R-3. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.



The terms "Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

rating of 24 horse-power and an English rating of 28 horse-power. The cylinders are cast separately and have integral water jackets with brass caps. Solid rubber tires of American manufacture are fitted all around. The route covered extends from Washington Square to 90th Street, a distance of more than four miles. The buses run on a five-minute headway, and are allowed one hour for the round trip, including stops and a five-minute wait at each end. During the first six months of the new service it was found that the motor buses maintained their schedule."

"A telegram from the Lowell Observatory, Flagstaff, Ariz., recently announced the discovery that the atmosphere of Mars is very rich in water vapor. This information, gained by Mr. Slipher from a comparison of the spectra of Mars and the moon, is a notable contribution to our knowledge of water supply on the ruddy planet. At present the astronomical world is divided over the question of Mars and its canals. On one side we have Mr. Lowell and his followers, who by visual observations with the telescope and the recent photographs have discovered the presence of hundreds of thin line markings aggregating thousands of miles in length. The remarkable straightness of these canals, their systematic arrangement, and the changes that have been noted in their appearance at different seasons have proved to Mr. Lowell that these canals are the result of human ingenuity, and that their purpose is to irrigate the desert planet and render it fit for human habitation. Conclusive as these arguments seem to be to the observers at Flagstaff, the majority of the first-class astronomers in the world do not agree with them."

"A duplicate of the Farman prize-winning aeroplane, fitted with the regular Antoinette 50-horse-power water-cooled motor or with an air-cooled Renault or R.E.P. engine if the purchaser prefers it, can now be had in England for \$6,000, or in America for \$8,400, which includes the import duty of 40 per cent *ad valorem*."



MARCH, 1858: "In the transactions of the Royal Astronomical Society of London, lately published, Mr. Alvan

THE PEACEFUL ATOM

...can propel a ship one year without refueling

New Study Shows Nuclear Power May Be Practical and Economic for Merchant Ships

Some gray dawn in the early 1960's a heavily laden supertanker will shoulder her way through the steep Atlantic swells to a landfall in Delaware Bay. She'll be homeward bound for Philadel-



FOR SHIPS LIKE THIS...

No more dependent on thousands of tons of payload-stealing fuel oil, tomorrow's ships will range worldwide trade routes without refueling.

phia, 19 days out of Kuwait with nearly 40,000 tons of oil.

In the last twelve months she will have made eight trips to the Persian Gulf hand running. Now at last she is due for her annual refit...and her annual refueling.

Competitive at sea

A nuclear power plant for a ship of this type was the subject of a study recently completed by Atomics International for the Maritime Reactors Branch of the Atomic Energy Commission. Costs of building and operating a vessel powered by an Organic Moderated Reactor were compared with those for an oil-burning ship—a typical modern supertanker of some 38,000 dead-weight tons.

Total costs for the OMR tanker, depreciated over 20 years, were only moderately higher than for today's conventional ship. But costs for oil-burners

are on their way up, with steadily rising fuel prices seen from now on—whereas the cost trend for the OMR is downward, as nuclear technology is improved. An OMR tanker has greater cargo capacity because its fuel takes up little space. And it needs refueling less than once a year.

Bigger payloads, longer hauls, faster turn-arounds—this is the new pattern of operation. Shipowners can begin plans right now, for the Organic Moderated Reactor promises to put the atomic mer-

Another OMR power station is planned for a Latin American country.

First OMR now in operation

All this stems from the results being achieved with the Organic Moderated Reactor Experiment, conducted by Atomics International for the Atomic Energy Commission. The Organic Moderated Reactor Experiment is being carried on at the AEC's National Reactor Testing Station in Idaho to establish the basic engineering data for this



...ATOMIC ENGINES LIKE THIS

AI's Dr. A. B. Martin shows on this OMR tanker model how the compact power plant will free thousands of cubic feet of fuel space for revenue-producing cargo.

chant ship on a sound commercial basis.

Versatile on land

The same features that make the OMR applicable for seagoing use are also in its favor for central power stations ashore. The basic simplicity and safety of this system point to economic nuclear electricity for many areas of the world today.

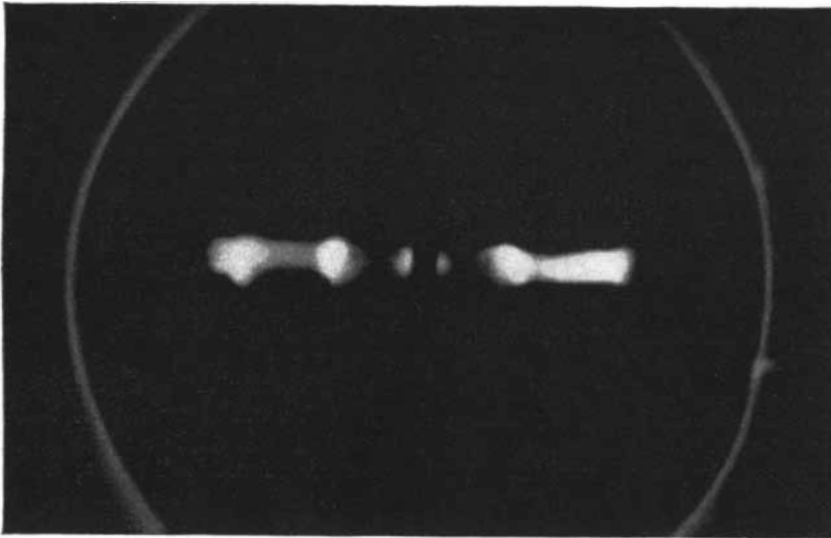
Plans are already underway to build an OMR plant in Piqua, Ohio, which will increase the city's electrical generating capacity by 12,500 kilowatts.

type plant. Atomics International is also operating the Sodium Reactor Experiment, a nuclear power project for the AEC. Another power reactor concept, the Advanced Epithermal Thorium Reactor, is under study for the Southwest Atomic Energy Associates. AI research reactors are now operating in Japan, Germany, Denmark, and the United States. Another is being built for Italy. ATOMICS INTERNATIONAL, P.O. Box 309, Canoga Park, Calif. Cable address: ATOMICS.



ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM



Magnetic fields, acting as a double piston, drive luminous ionized shock waves through transparent tube. One-tenth microsecond exposure in STL's Physical Research Laboratory.

MAGNETOHYDRODYNAMICS and SPACE TECHNOLOGY

Magnetohydrodynamics provides one of the most promising approaches for attaining the velocities and specific impulses that will be required for manned space flight to a planet, landing, and returning.

The critical problem in attaining velocities of hundreds of thousands of miles per hour is the containment of temperatures comparable to those in the interior of stars. Because the temperature of the driving reaction will have to rise as the square of the exhaust velocity, temperatures greater than one million degrees will be encountered in reaction chambers. Magnetohydrodynamics offers a unique solution to the basic problem of containing the reaction without contact with the chamber walls.

Briefly, the physical principles of magnetohydrodynamics are these. Since gas at such temperatures is completely ionized and is an effective conductor of electricity, the introduction of currents in the gas (in this state called a plasma) creates an electromagnetic field. This field makes it possible to control the plasma by applying an external opposing magnetic field which creates a magnetic bottle to contain the charged gas particles. Similarly, a magnetic-field piston can be used to accelerate the particles. Such magnetohydrodynamic reactions are expected to develop exhaust velocities that are an order of magnitude greater than those generated by present chemical rockets.

At Space Technology Laboratories, both analytical and laboratory work are proceeding in the field of magnetohydrodynamics. This work illustrates the advanced research in STL's Physical Research Laboratory, which emphasizes the application of basic physical principles to the requirements of space technology.

In support of its over-all systems engineering responsibility for the Air Force Ballistic Missile programs, and in anticipation of future system requirements, STL is engaged in a wide variety of research and experimental development activity. Projects are in progress in electronics, aerodynamics, propulsion, and structures.

The scope of work at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding the many opportunities on the Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA

Clark of Boston, Mass., celebrated for his skill as an astronomical instrument maker, is paid a high compliment by the Rev. W. R. Dawes for his astronomical discoveries, especially of new double stars. Regarding one of these, Dawes says, "This star is about as difficult as the closest of the Poulkova catalogue, and, though on a fine night visible with the eight-inch object glass I now have in use, it would require the full power of a 15-inch refractor to divide it. That it attracted Mr. Clark's attention as a double star is sufficient to prove that his eye, as well as his telescope, must possess extraordinary power of definition." This was accomplished by Mr. Clark with an object glass whose aperture is only seven and three-quarter inches."

"Samuel Colt, the famous pistol patentee, has presented a petition for the extension of his patent through Mr. Bishop, a member of the House, from Connecticut, and it is now in the hands of the committee, awaiting their action. Colt, it is known, has become immensely wealthy. He has undoubtedly one of the finest manufactories in the world for this particular kind of business, and is thereby enabled to manufacture his style of revolving arm quite as cheaply as, if not more cheaply than, any other establishment can do it. He is also able to put forth with great facility extraordinary efforts to prosecute his application before Congress or any other tribunal. There is, therefore, great danger that this pistol patent may be extended during the present session. Inventors, in most instances, are pushed forward by parties interested, who tell piteous tales of personal suffering. Such tales, whether true or false, are all the members hear in many cases, and are well calculated to move their sympathies; and, unless they can get behind the scenes and see all the actors, they are liable to be imposed upon themselves and to recommend measures which have no real merit to back them."

"It has been announced that the vessel which has recently sailed with the now celebrated Dr. Livingstone for the southeast coast of Africa has on board a peculiar steamboat provided by the British Government to enable the veteran traveler to prosecute his investigation of the Zambesi River. The vessel is a paddle steamer, her dimensions being: length, 75 feet; breadth, 8 feet; and depth, 3 feet. She will not draw more than 12 or 14 inches, so that she is expected to be able to navigate the shallowest parts of the river."

New Molding Opportunities with Rigid, Heat-Resistant

MARLEX* 50 POLYETHYLENE



MARLEX 50 polyethylene is the preferred molding resin for a wide variety of heavy-duty industrial uses . . . wheels, corrosion-proof pump impellers, low-load gears, bearings and other mechanical components . . . glossy, colorful appliance housings, pipe thread protectors . . . and many other die-cast items requiring a low-cost, tough, abrasion-resistant plastic that is chemically inert.



New Sales Service Lab at Bartlesville is completely equipped with latest commercial processing machinery and research apparatus. Phillips experienced technical service staff will assist you in developing new products and processes using MARLEX plastics. Please make arrangements through your local MARLEX sales representative. Meanwhile, for complete data on MARLEX 50, send for our latest illustrated technical brochure.



Ease of extrusion, low permeability, chemical resistance and rigidity of MARLEX 50 plastic make it ideal for blow molding many types of food and drug bottles, squeeze bottles and aerosols. Its stiffness permits reductions in wall thickness with consequent savings of resin. Conventional processing techniques produce high-quality blown products with glossy surfaces and minimum internal stress.



Toys and housewares are a natural for this unbreakable, heat-resistant, non-toxic material. Its high tensile and impact strength and lack of brittleness at extremely low temperatures suggest many new applications unsuited to conventional polyethylenes. Molders can profit from the fact that form stability at higher temperatures frequently permits quicker mold ejection and shorter cycle times.

*MARLEX is a trademark for Phillips family of olefin polymers.

PLASTICS SALES DIVISION, PHILLIPS CHEMICAL COMPANY

A Subsidiary of Phillips Petroleum Company, Bartlesville, Oklahoma



DISTRICT OFFICES

NEW ENGLAND

322 Waterman Avenue,
East Providence 14, R. I.
Geneva 4-7600

NEW YORK

80 Broadway, Suite 4300
New York 5, N. Y.
Digby 4-3480

AKRON

318 Water Street,
Akron 8, Ohio
Franklin 6-4126

CHICAGO

111 S. York Street,
Elmhurst, Ill.
Terrace 4-6600

WESTERN

330 Security Bldg.,
Pasadena, Calif.
RYan 1-6997

SOUTHERN & FOREIGN

Adams Building,
Bartlesville, Oklahoma
Bartlesville 6600, Ext. 8108



**ADVANCED
MATERIALS
TECHNOLOGY**



L.

Space Age *Sun-Burst...*

ADVANCED MATERIALS MAKE POSSIBLE
NEW POWERFUL SYLVANIA FLASHBULB



MIDGET-SIZED SUN: New Sylvania bulb produces virtually as much light as a bulb 4 times its size. Shredded zirconium, instead of the conventional metallic filling, makes the difference. Look for the new bulbs in neighborhood stores soon.

Zirconium, the new atomic age metal developed because of its special value as a container for uranium fuel elements in nuclear reactors, now makes possible a remarkable new photo flashbulb produced by Sylvania Electric Products Inc.

Scarcely bigger than a thimble, the new M-25 zirconium filled bulb has a light output virtually equal to that produced by flashbulbs four times its size. New opportunities are opened up for improved flash photography by professionals and amateurs alike.

The zirconium used by Sylvania is one of the family of advanced materials made by the Carborundum Company. Originally so rare and costly that every pound was reserved for the nation's atomic program, zirconium is now available from Carborundum in sufficient quantities and at a drastically lowered cost that will permit its use in many commercial applications. High strength, extreme resistance to corrosion, transparency to thermal neutrons and other advantages suggest many uses in chemical and other industries.

The variety of Carborundum advanced materials provides a solution for almost every problem of today's increasingly complex industrial technology, involving unusual conditions of heat, corrosion or abrasion.

If you face a challenge in finding new materials and ways to meet problems beyond the capabilities of conventional materials, perhaps Carborundum can help you. Write to Carborundum, Research & Development Division, Dept. SA, Niagara Falls, N. Y.

AM-3

Get your free subscription to industry's newest publication

ADVANCED MATERIALS TECHNOLOGY

The Science of Materials for Profit

"ADVANCED MATERIALS TECHNOLOGY" is a new quarterly publication devoted to news and ideas for all concerned with finding new materials and methods to meet severe service applications. It deals with problems of high

temperature, extreme abrasion and corrosion and new ways to combat them. To get your name on the free subscription list, write to Carborundum, Research & Development Division, Dept. SA, Niagara Falls, N. Y.



Where conventional materials fail... call on

CARBORUNDUM

REGISTERED TRADEMARK

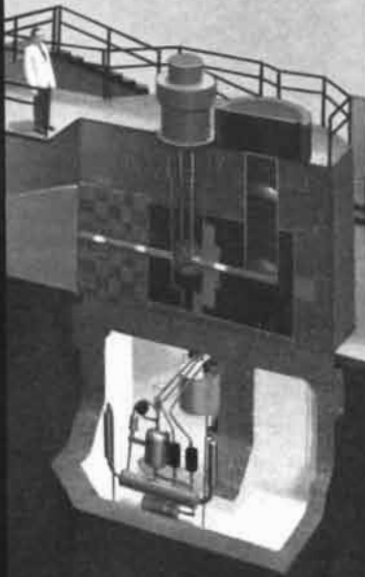
*Do you
think of
pressure
transducers?*



**ATOMICS
INTERNATIONAL**

DIVISION OF NORTH AMERICAN AVIATION, INC.

does... and uses Statham pressure transducers as part of the control instrumentation in the construction of its nuclear reactors which open entirely new fields in industrial research and development by providing an on-the-spot source of high-energy gamma rays and neutrons.



**WHEN THE NEED
IS TO KNOW...FOR SURE
SPECIFY STATHAM**

*Accelerometers
Pressure Transducers
Load Cells*

Catalog, complete with prices,
available upon request.

Statham

**INSTRUMENTS, INC.
LOS ANGELES 64**

THE AUTHORS

SIR CHRISTOPHER HINTON ("Atomic Power in Britain") directed the design and building of the atomic energy factories at Springfields, Capenhurst, Windscale and Calder Hall. The son of a Wiltshire schoolmaster, he left school at 16 to serve a five-year engineering apprenticeship in the locomotive works of the Great Western Railway Company. Eventually he became a draftsman for the railway. In 1923 he won a scholarship to the University of Cambridge where he took first class honors in mechanical sciences and received a prize for research on the vibration of railway bridges. He then went to work for Imperial Chemical Industries, becoming a chief engineer before the age of 30. During World War II the British Government put him in charge of the Royal Explosive Filling Factories. Sir Christopher was a member of Britain's Atomic Energy Authority until last year, when he became chairman of the Central Electricity Generating Board. He is a Knight Commander of the British Empire, a Fellow of the Royal Society and an Honorary Fellow of Trinity College, Cambridge.

EDWARD O. WILSON ("The Fire Ant") was born 28 years ago in Birmingham, Ala. After acquiring a B.S. and M.S. from the University of Alabama, he went to Harvard University, where he held a National Science Foundation fellowship and later a junior fellowship in the Society of Fellows. He received his Ph.D. from Harvard in 1955, and was appointed assistant professor of biology in the following year. He now teaches courses on evolutionary theory and devotes his research to the evolution of ants. "The imported fire ant was among my earliest acquaintances," reports Wilson, who has been studying it since his undergraduate days. However, it is only one of over 1,500 species of ants which he has collected and observed in the U. S., the West Indies, Mexico, Australia, New Guinea and Ceylon.

BRIAN HOPE-TAYLOR ("Norman Castles") is a successful painter, wood engraver, book illustrator, writer and lecturer as well as a professional archaeologist. Archaeology, however, has been his ruling passion since childhood. As an archaeologist, Hope-Taylor specializes in the delicate methods required to reconstruct the pattern of

ancient wooden buildings. In addition to Norman castles he has recently excavated the palaces of the Anglo-Saxon kings of Northumbria at Yeavering in Northumberland. Hope-Taylor is archaeological consultant to the Ministry of Works of Great Britain and secretary of the Medieval Research Committee of the Council for British Archaeology.

ROBERT R. WILSON ("Particle Accelerators") moved so many times in his childhood that his school record lists seven grammar schools and five high schools in various parts of Wyoming, Colorado and California. This resulted in poor grades which made it difficult for him to enter college. Yet before joining the freshman class of the University of California he had already built a rudimentary laboratory in which he made high-vacuum pumps of his own design. Wilson majored in electrical engineering, but a near-failing grade in freshman physics challenged him to study physics instead, against the advice of his teachers and in spite of the handicap of poor health. By his senior year he was doing original research in gaseous discharges under Ernest O. Lawrence, and had discovered an original way to study the time lag of the spark discharge. As a graduate student at Berkeley Wilson turned to nuclear physics and was the first to work out the theory of the cyclotron. In 1940 Wilson joined the faculty of Princeton University. There he invented a way to separate uranium isotopes, with the result that at the age of 28 he found himself in charge of a \$500,000 project employing 50 people. Wilson and his staff were soon moved to Los Alamos, where he led the cyclotron group. Eventually he became head of the Experimental Nuclear Physics Division and mayor of the community. Since World War II Wilson has taught at Harvard University and Cornell University. At Cornell he built the first strong-focusing synchrotron and has experimented with thermonuclear reactors, none of which have worked so far. He is one of the founders of the Federation of American Scientists. In his spare time he likes to carve sculptures in wood.

ECKHARD H. HESS ("Imprinting in Animals") is associate professor of psychology at the University of Chicago. The work on imprinting which he carries on there is a part of his larger campaign of research on the experience of infant animals and how it affects their behavior. Hess was born in Germany, graduated from Blue Ridge College and acquired M.A. and Ph.D. degrees from

Parsons' experience record includes—Laboratories and test facilities for chemical, biological, food processing, and industrial studies...

Design and operation of installations for weapons environmental research...

Shielding studies and methods for handling nuclear materials.

Your inquiry concerning design, procurement, or operating problems is invited.

NUCLEAR FACILITIES

for radiation research



Means Nuclear Pioneering

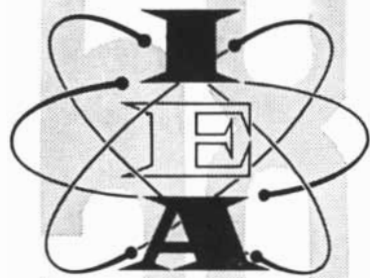
THE RALPH M. PARSONS COMPANY

ENGINEERS • CONSTRUCTORS
LOS ANGELES

NEW YORK
PASADENA
WASHINGTON

ANKARA
BAHCESEKIR
BEIRUT
JERUSALEM
KARACHI
MADRID
NEW DELHI
PARIS
TORONTO

i
n
t
e
r
n
a
t
i
o
n
a
l



e
x
h
i
b
i
t
i
o
n

INSTRUMENTS
ELECTRONICS
AUTOMATION

16-25 APRIL 1958 LONDON, ENGLAND

You are cordially invited to the 1958 Instruments, Electronics and Automation Exhibition.

MORE THAN 250 BRITISH MANUFACTURERS will be showing the latest and most comprehensive range of exhibits.

OVER 100 OVERSEAS EXHIBITORS will be displaying their achievements in the rapidly developing fields of instruments, electronics and automation.

Note the date NOW.

I.E.A. — the exhibition no progressive industrialist can afford to miss.

A conference will be held throughout the period of the Exhibition. For further details of both Conference and Exhibition contact the nearest British Embassy or Consulate, or write to:

INDUSTRIAL EXHIBITIONS LIMITED
9 ARGYLL STREET, LONDON, W.1, ENGLAND

the Johns Hopkins University. He is the author of "Space Perception in the Chick," which appeared in the July, 1956, issue of SCIENTIFIC AMERICAN.

A. C. CROMBIE ("Helmholtz") lectures on the history and philosophy of science at University College London. In addition he edits *British Journal for the Philosophy of Science*. He is the author of two books: *Augustine to Galileo* and *Robert Grosseteste and the Origins of Experimental Science: 1100-1700*. Crombie recently spent a year as visiting professor of philosophy at the University of Washington. His interest in Helmholtz is a part of his concern with the history of the reduction of life phenomena to physicochemical terms.

RAYMOND J. HOCK and BENJAMIN G. COVINO ("Hypothermia") both studied the adaptation of animals to cold at the Arctic Aeromedical Laboratory of the Air Force in Fairbanks, Alaska. Hock is now chief of the physiology department of the Laboratory. He graduated from the University of Massachusetts, and received a Ph.D. in zoology from Cornell University in 1949. As a graduate student he observed homing birds from an airplane over the Gaspé Peninsula with Donald R. Griffin, and later studied the body temperatures of birds at the Arctic Research Laboratory in Point Barrow, Alaska. After a stint of teaching at the University of Arizona, Hock returned to the north to become a biologist on the staff of the U. S. Public Health Service Arctic Health Research Center at Anchorage, Alaska. Thus Hock has served in all three of the U. S. Government's Arctic laboratories. Covino was born in Lawrence, Mass., and earned a Ph.D. in physiology from Boston University. He served at the Arctic Aeromedical Laboratory as an Air Force research physiologist. Now he is assistant professor of pharmacology at Tufts College School of Medicine.

PAUL C. ZAMECNIK ("The Microsome") heads the executive committee of Harvard Medical School, where he is Collis P. Huntington Professor of Oncologic Medicine. He graduated *magna cum laude* from Dartmouth College in 1933, and received his M.D. from Harvard three years later. Since then he has pursued his career at Massachusetts General Hospital and Harvard, with a year out for study in the Carlsberg Laboratory in Copenhagen and another two years as a research fellow at the Rockefeller Institute for Medical Research in New York.



why beware
of soldering...
when you can
be sure of...
CRIMPING!

*a quick check of indent-depth tells you
this electrical connection is safe!*

There's no way to check a soldered connection—without destroying that connection! The modern Burndy crimping method affords a quick check for electrical and mechanical safety—simply by measurement of this depth of indent. The cross-section view (right) shows how this indent is designed to coin conductor and connector into intimate contact...for a strong connection, as electrically sound as the conductor itself. And the depth of indent is controlled by the installation tool! Unlike solder which can weaken at high temperatures frequently encountered by modern equipment, the Burndy crimped connection with its wide tolerance endures in all environments. Too—Burndy electrical connections get rid of human error—no skill or training is required. The control is engineered into the connector and the tool! Put a crimp on rising production costs!—send for the full story on Burndy crimp-type connections, today!



first piece check
guarantees electrical
connections for the entire
production run

BURNDY

57-13



Norwalk, Connect.

SEE MORE AT I.R.E. BOOTH 1318

Toronto, Canada

HIGH PURITY RARE EARTHS

Available in quantities at surprisingly low cost

a report by LINDSAY

A few months ago, in one of these reports, we presented this table of high purity rare earth and yttrium oxides. We anticipated inquiries, of course, but the flood of letters requesting detailed information really startled us.

What interests us particularly, and will you, is the fact that so many research people are intrigued with the practical possibilities of these unique materials. The large amount of research now being done on high purity rare earth oxides in a wide variety of industries encourages us to suggest the likelihood that they may offer you opportunities for potentially profitable investigation.

Already, in a little more than two years since rare earths in purities up to 99.99% became available in commercial quantities, they are being used as basic production materials in many chemical and industrial operations.

Production Up—Costs Down

We have expanded our production facilities to keep up with demand and now have more than 100 ion exchange columns in continuous operation. Quantities are large enough to assure you a dependable source of supply. Prices are low enough to make their use on a production basis economically sound.

Most of the high purity rare earth and yttrium oxides are available for prompt deliveries in quantities of an ounce to hundreds of pounds.

We can't tell you how to use high purity rare earths in your production operations, nor can we promise that one of them may be the missing element in new process or product developments on which you are working. We can, however, supply you with data which you will find interesting, revealing and quite possibly of immediate importance to you.

TYPICAL MAXIMUM IMPURITIES IN LINDSAY PURIFIED RARE EARTH AND YTTRIUM OXIDES

ATOMIC NO.	OXIDE	CODE	PURITY	% RARE EARTH MAXIMUM IMPURITIES AS OXIDES
57	La ₂ O ₃ . LANTHANUM OXIDE	528 529	99.99 99.997	0.01 Pr, 0.001 Ce. 0.0025 Pr, 0.0005 others
58	CeO ₂ . CERIC OXIDE	215 216	99.8 99.9	0.2 (largely La + Pr + Nd). 0.1 (largely La + Pr + Nd).
59	Pr ₆ O ₁₁ . PRASEODYMIUM OXIDE	726 729.9	99 99.9	1 La + Nd + smaller amounts of Ce and Sm. 0.1 Ce + Nd.
60	Nd ₂ O ₃ . NEODYMIUM OXIDE	628 629 629.9	95 99 99.9	1-4 Pr, 1-4 Sm, 0.5-1 others. 0.1-0.4 Pr + 0.1-0.4 Sm + 0.5 others. 0.1 (largely Pr + Sm).
62	Sm ₂ O ₃ . SAMARIUM OXIDE	822 823	99 99.9	0.2-0.7 Gd, 0.2-0.6 Eu, and smaller amounts of others. 0.1 (largely Nd + Gd + Eu).
63	Eu ₂ O ₃ . EUROPIUM OXIDE	1012 1011	98-99 99.8	1-2 Sm + smaller amounts of Nd + Gd + others. 0.2 (largely Sm + Gd + Nd).
64	Gd ₂ O ₃ . GADOLINIUM OXIDE	928.9 929.9	99 99.9	1 Sm + Eu + trace Tb. 0.1 Sm + Eu + trace Tb.
65	Tb ₄ O ₇ . TERBIUM OXIDE	1803 1805	99 99.9	1 Gd + Dy + Y. 0.1 Gd + Dy + Y.
66	Dy ₂ O ₃ . DYSPROSIUM OXIDE	1703 1705	99 99.9	1 (largely Ho + Y + Tb + small amounts of others). 0.1 Ho + Y + traces of others.
67	Ho ₂ O ₃ . HOLMIUM OXIDE	1603 1605	99 99.9	1 (largely Er + Dy + small amounts of others). 0.1 Er + Dy + traces of others.
68	Er ₂ O ₃ . ERBIUM OXIDE	1303 1305	99 99.9	1 Ho + Dy + traces Yb and Y. 0.1 Ho + Tm.
69	Tm ₂ O ₃ . THULIUM OXIDE	1405 1403	99.9 99	0.1 Er + Yb + trace Lu. 1 Er + Yb + trace Lu
70	Yb ₂ O ₃ . YTTERBIUM OXIDE	1201 1202	99 99.9	1 Er + Tm + trace Lu. 0.1 Tm + trace Lu + Er.
71	Lu ₂ O ₃ . LUTETIUM OXIDE	1503 1505	99 99.9	1 Yb + Tm + traces of others. 0.1 Yb + Tm + traces of others.
39	Y ₂ O ₃ . YTTRIUM OXIDE	1112 1115 1116	99 99.9 99.9+	1 Dy + Gd + traces Tb and others. 0.1 Dy + Gd + traces Tb Approx. 0.05 Dy + Gd.

For detailed information and prices, write for our bulletin
"Purified Rare Earth and Yttrium Oxides"



LINDSAY CHEMICAL COMPANY

World's Largest Producer of Thorium and Rare Earth Chemicals

264 ANN STREET • WEST CHICAGO, ILLINOIS

How to cut costs, improve product design with stainless steel close-tolerance castings

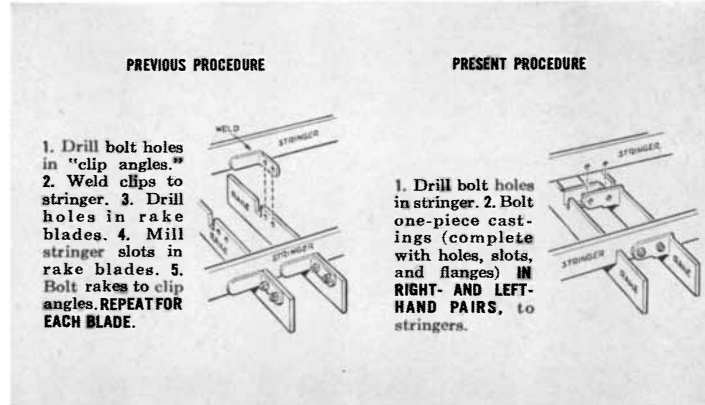
Cooper Alloy design collaboration with advanced casting techniques can simplify your fabrication, cut your costs. Here's how:



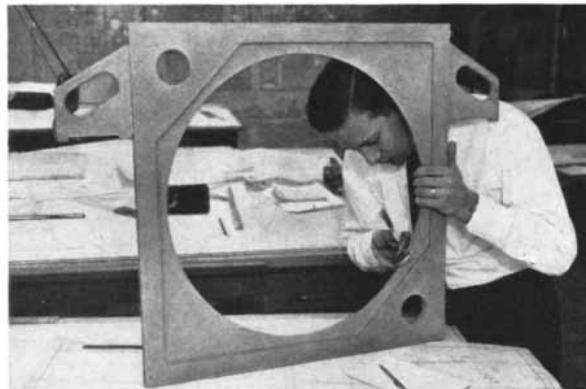
Casting of intricate parts: Jet engine afterburner component, cast for Pratt & Whitney Aircraft by Cooper Alloy, is a tangle of projections and cavities. Required, however, were the most precise dimensions to make for automatic precision machining. Shellcast® shell coring and CO₂ process cut down rejection and machining costs.



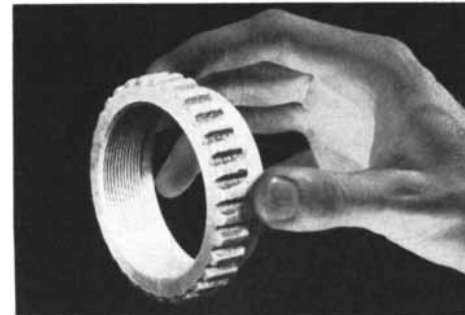
Strength and quality: Castings stronger than forgings! These Cooper Alloy nuclear service fittings possess high-temperature yield strengths 20% higher than minimum code specifications. Tough quality requirements have been met and bettered on a regular repetitive quality basis.



Part redesigned, simplified, assembly costs lowered. Classifier rake blade, Shellcast® by Cooper Alloy for Dorr-Oliver Inc., was originally made by welding cast and machined elements. Close-tolerance, smooth-surface shell castings made possible design change to one-piece cast unit, eliminating welding and much of the assembly costs.



Casting of thin-walled close-dimensioned parts. Tennessee Eastman filter frame plate previously required a good deal of careful milling on thin inner web. Combined use of shell core-in a sand mold held tolerances, eliminated milling operation.



Product improvement: Gear lugs on adjusting ring for Manning, Maxwell & Moore pressure safety relief valve, formerly sand cast, are now being produced directly by Shellcast® process. Dimensional accuracy possible with shell castings permitted re-design of part to give more lugs, finer adjustability in use.

If you haven't looked over your fabrication and assembly costs lately, check the unusual cost-saving techniques listed in the capsule stories shown above. They are typical of Cooper Alloy advanced casting know-how. Many parts and assemblies that you probably haven't even considered as makable by castings, can be now by Cooper Alloy, specialists for over 35 years in casting *only* stainless steel.

Want more information? To learn more of how Cooper Alloy know-how can help cut *your* manufacturing costs, write for our free 16-page booklet, "Cooper Alloy—Pioneering in Stainless Steel." Also available, information on the other problem-solving Cooper Alloy products listed below.

COOPER  ALLOY

Corporation • Hillside, New Jersey

SPECIALISTS in *Stainless Steel valves, fittings, castings; Plastic pumps, pipe, valves, fittings*



*this crew
tests America's*

'SUNDAY PUNCH!'

**UNDER THE BLINDING GLARE OF LIGHTS
EXPERT TECHNICIANS AND SCIENTISTS TOGETHER
READY ANOTHER GIANT MISSILE FOR FLIGHT**

where



fits in this picture

THESE LONG, sleek birds of the ICBM, IRBM and "Air-Breathing" Missile Programs represent years of work and dreams by our top teams of military, scientific and industrial experts. In urban centers, in small towns, in remote and hidden corners of the globe, specialists in every branch of our armed forces work to prepare the

trained men, the missiles and the bases which are needed to assure the security of America and the free world.

Special military and industrial crews go over each giant bird, section by section. It is their job to fire up the engines . . . to send power coursing through the intricate maze of electronic circuitry. Every part is thoroughly tested . . . checked . . . and tested again.

What part does AC play?

AC builds the intricate guidance system whose job it is to control these missiles in flight. This system, which AC calls the AChiever, has already proved its capabilities in flight in the Air Force's "Thor" and "Matador" missiles, as well as in the Navy's "Regulus."

In fact, this is the guidance system which was in full control during the successful launching of the Air Force's "Thor" missile from Cape Canaveral on last December 19th.

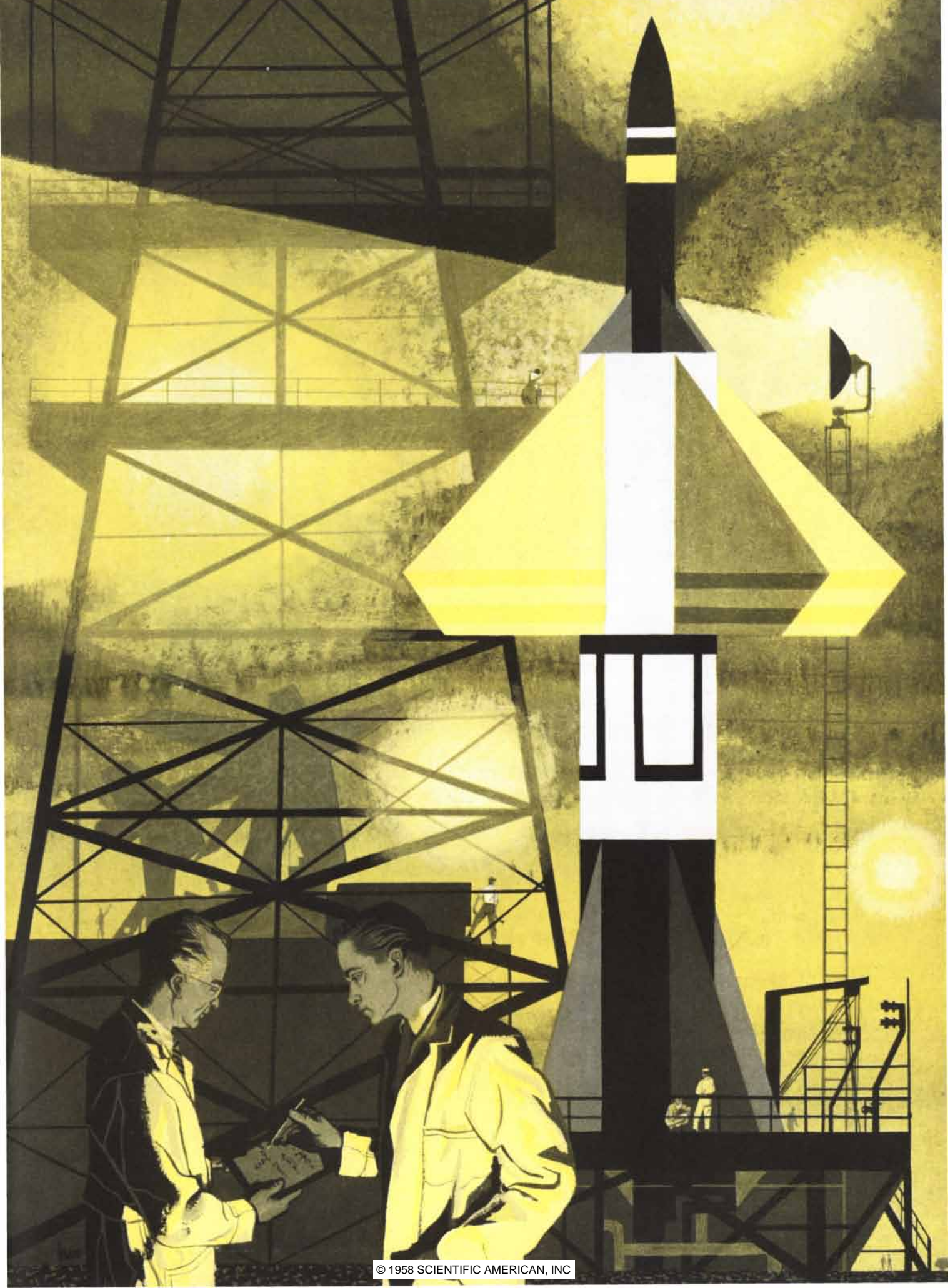
It is an inertial system which is completely self-contained. Nothing can jam it. Nothing can deter it from its chosen course . . . or deflect the missile it guides from the appointed target.

Most important of all—AC inertial guidance is in volume production. The research and development phase is past. AC is mass-producing the AChiever now!

What's more, all of AC's and General Motors' technical "know-how," facilities and trained personnel are available to support this program to the fullest.

If you are a graduate engineer with experience in the fields of mechanical or electrical engineering and believe that you have something to offer to this important program—and, if you are not now a member of the armed forces—write the personnel section of AC in Milwaukee.

AC SPARK PLUG  THE ELECTRONICS
DIVISION OF GENERAL MOTORS





René Descartes...on the light of reason

"Hence we must believe that all the sciences are so interconnected, that it is much easier to study them all together than to isolate one from all the others. Therefore, if anyone wishes to search out the truth of things in earnest, he should not select any one special science; for all the sciences are con-

joined with each other and interdependent: let him think only about how to increase the natural light of reason, not in order to solve this or that difficulty of a scholastic nature, but that his understanding may direct his will to its proper choice in every contingency of life."

—*Regulæ ad Directionem Ingenii*, 1629

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA

A nonprofit organization engaged in research on problems related to national security and the public interest

Atomic Power in Britain

With the Calder Hall reactors feeding into its national power grid and several other stations nearing completion, Britain leads the world in the peaceful application of atomic energy

by Sir Christopher Hinton

On October 17, 1956, Her Majesty the Queen officially opened the nuclear power station at Calder Hall when she switched electrical power generated from its reactors into the distribution mains of the Central Electricity Authority. She was making history, for this was the first time anywhere in the world that nuclear power had been used to generate the electricity used in factories and homes. The weather during the week preceding had been dismal: on the day before the opening ceremony the clouds were right down on the power station. During the night a gale blew in from the sea and flattened a refreshment tent, but on the morning of October 17 the clouds had blown away and the ceremony was performed under a blue sky with a fresh wind whipping the flags and bunting on the stands. The weather was appropriate to the occasion, for on that day the United Kingdom atomic energy program, which had been through a good deal of depressing weather, broke through into the sunshine of international prominence.

We had undertaken our atomic energy developments at the end of the war with little help from the great wartime research and industrial program in the U. S. A few of our scientists had worked in that program; a larger number had been on the team that developed the immensely successful research reactor that was built at Chalk River in Canada. But we had only one or two engineers who had experience in nuclear work and

no management staff which had operated factories. The MacMahon Act denied us access to U. S. information.

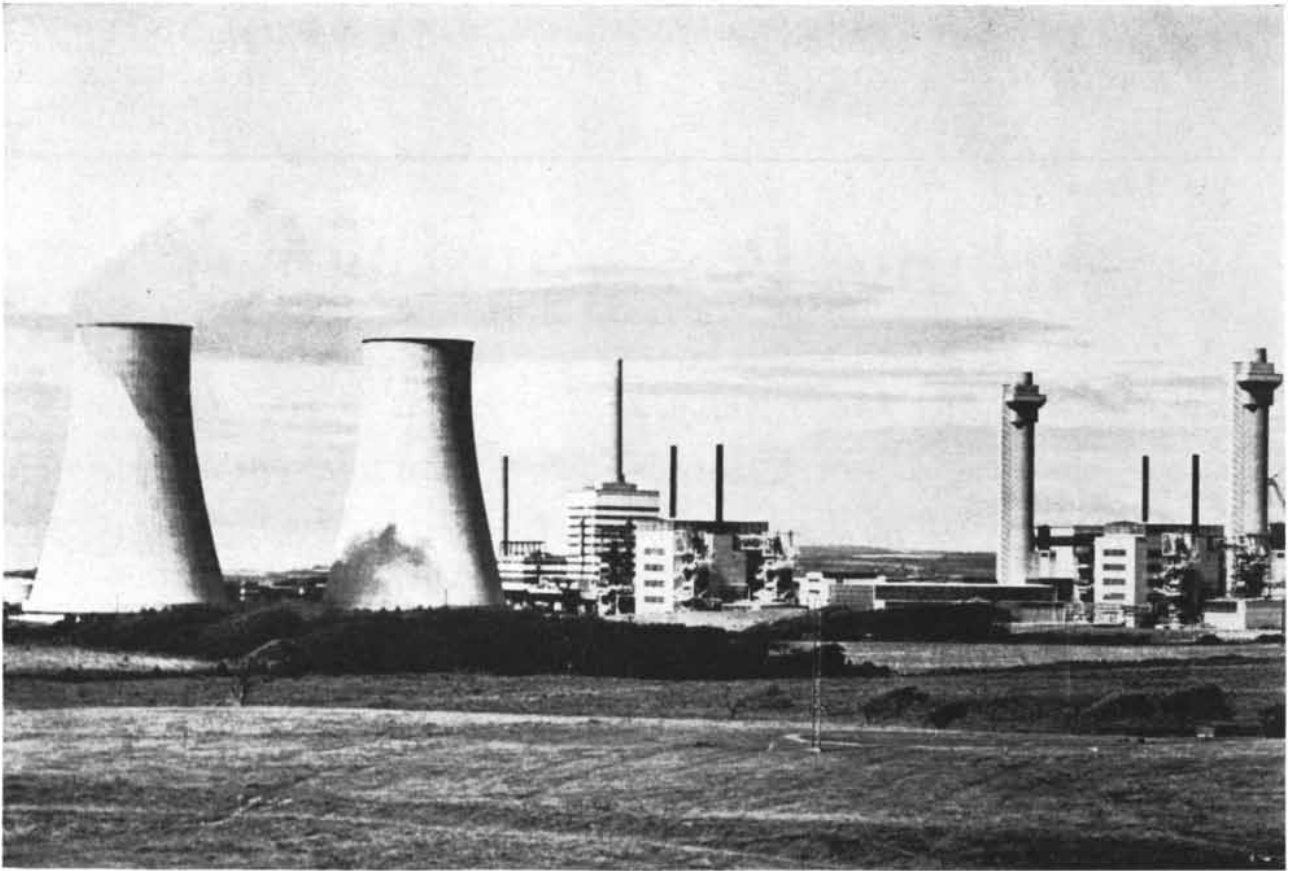
Toward the end of 1945 the decision was taken to build a nuclear research station at Harwell, and in December of that year I was asked to set up an organization to design and operate industrial atomic-energy establishments. Our office at Risley was opened on February 6, 1946, with a total staff of 18, including clerks and typists. Our first tasks were to design a research reactor for Harwell and at the same time to construct a plant to process the uranium ore and manufacture the fuel elements required for that reactor and for the larger reactors needed for plutonium production.

It was at first intended that these large reactors should be of a design similar to those at Hanford in the U. S., *i.e.*, thermal (slow) neutron reactors, graphite-moderated and water-cooled. But at that time it was not possible to build reactors of this type with inherent stability. During operation they might become supercritical and disperse radioactive fission products over a fairly large area of the countryside. The reason is that the coolant which surrounds the fuel elements in a water-cooled thermal reactor acts both as a moderator and as a neutron absorber; that is to say, it serves the useful function of helping to slow neutrons down, but at the same time it has the undesirable characteristic of capturing them so that they are no longer avail-

able to cause further fissions. The net effect of the water is to slow down the chain reaction. Now if the flow of cooling water is suddenly stopped, and if the control rods fail to operate, the heat of fission will vaporize the water and eject most of it from the reactor. The neutrons which had been absorbed by the water become available to cause fissions and so increase the activity of the reactor. If the automatic control devices operate satisfactorily, the reactor is safeguarded, but they cannot be completely infallible. If they fail, the activity may build up so quickly as to cause the fuel elements to vaporize and disintegrate. Today it is possible to avoid this instability in graphite-moderated, water-cooled reactors, but in 1946 we did not know how.

The recognized instability of the Hanford reactors had led the Americans to locate them remotely in barren country. In large and thinly populated nations like the U. S. it is reasonably easy to choose sites having the necessary degree of isolation. In the United Kingdom, however, the problem of finding a site sufficiently remote to comply with the safety distances which had to be observed was extremely difficult.

We realized that if we could cool our reactor with gas instead of water we should achieve inherent stability and could then place our reactor in a comparatively accessible site. Gases such as carbon dioxide absorb very few neutrons but do act as moderators. Hence their net effect is to accelerate rather than



CALDER HALL STATION appears at the left in this photograph. In the foreground are the cooling towers for the two reactors, which are housed in the buildings in center. At right can be seen the plutonium factory at Windscale, across the River Calder.

slow down the chain reaction. So if the coolant is lost from a gas-cooled reactor, the activity of the reactor will diminish and it will tend to shut itself down.

We knew that during the war the Americans had wished to build a large gas-cooled reactor, but were discouraged by the difficulty of obtaining the huge blowers that were required. The attractions of gas cooling were, however, so great that we started an intensive study of the problem. We came to the conclusion that, by putting cooling fins on the fuel-element cans and compressing our coolant gas, we could design gas-cooled, graphite-moderated reactors which would not only produce plutonium but would at the same time generate electrical power. Power could not be generated, however, unless the temperature of the gas leaving the reactor was reasonably high, and the problems of achieving these temperatures involved more research than we had time for. We realized that by temporarily sacrificing our objective of generating electrical power and by using air at atmospheric pressure as our coolant we should be able to build a reactor for the production

of plutonium which would be inherently safe and which would not need to be built in a remote locality.

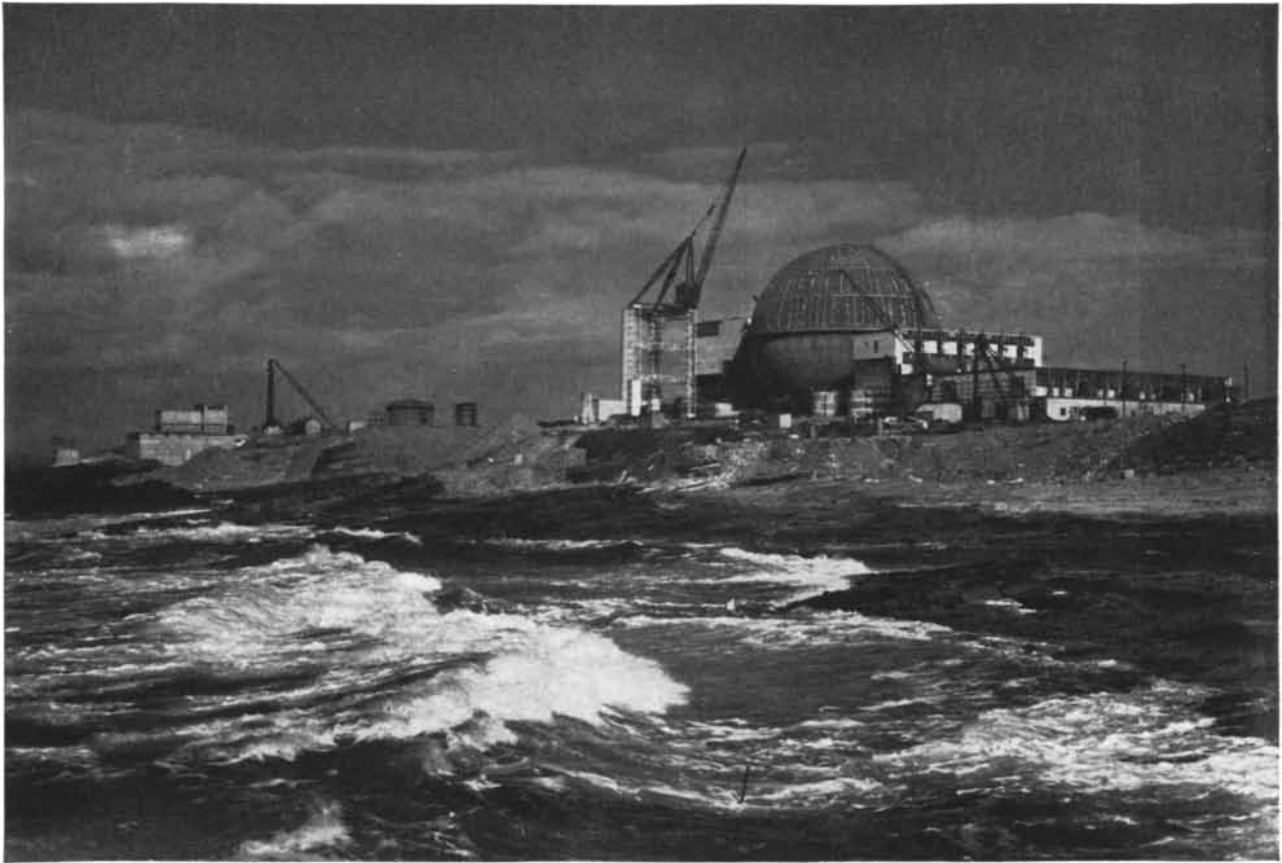
In the autumn of 1947 we began the construction of two such reactors at Windscale; they were completed during the first half of 1950. They are cumbersome and extravagant plants, but they had the great merit of enabling us to produce plutonium at the date which had been demanded. They also gave us invaluable experience.

Meantime we continued to work on the problems of developing a gas-cooled reactor for the production of useful power. By 1953 we had arrived at a practical scheme. In that year there was an additional demand for plutonium for defense purposes, and we decided that this requirement should be met by building graphite-moderated gas-cooled reactors which would produce electrical power as a by-product. We already owned a site opposite the Windscale works on the banks of the River Calder. The site was part of an old estate called Calder Hall Farm, which gave its name to the reactor now known throughout the

world. We initially planned to build one reactor, but a few months after the work had been started the defense demands were increased and a second reactor was begun. Three years later the plant was again extended by two more reactors, and a second plant of identical design was inaugurated at Chapel Cross in southern Scotland.

The first reactor "went critical" in May, 1956, and by July of that year was developing electrical power which was used at the Windscale works. By October, when power was turned into the distribution network of the Central Electricity Authority, the reactor was working practically at full-rated capacity.

In the Calder Hall reactors the heat of fission is removed from the fuel elements by cooling them with pressurized carbon dioxide gas instead of with atmospheric air, as in the Windscale reactors. The uranium fuel elements are arranged vertically in the mass of the graphite moderator, and the whole of the reactor core is enclosed in a steel pressure vessel which is more than 40 feet in diameter. Hot gas leaving this vessel is passed through ducts to the heat



FAST-BREEDER REACTOR is being built at Dounreay, on the north coast of Scotland. The spherical structure is a pressure vessel

surrounding the reactor. This experimental device will be fueled initially with enriched uranium, and ultimately with plutonium.

exchangers in which it gives up its heat to water and so generates steam which is used in conventional turbogenerators to make electric power. The carbon dioxide gas cooled down in this way passes through other ducts to the blowers which force it back once more into the nuclear-reactor core.

In the middle of 1954, when the construction of the first Calder Hall reactor was only in its early stages, we felt quite certain that it could form the basis of a national program for the large-scale development of nuclear power, and we produced a report which set out a long-term scheme for this development. In preparing this scheme we realized that nuclear power could not, in its early stages, compete with conventional power unless some industrial use were found for the by-product plutonium. Our scheme therefore envisaged the use of this plutonium as fuel in reactors of more advanced types.

Our long-term plan envisaged the construction of 12 stations by 1965 which would have a capacity of between 1.8 and 2 million kilowatts, an electrical output equal to that from five to six mil-

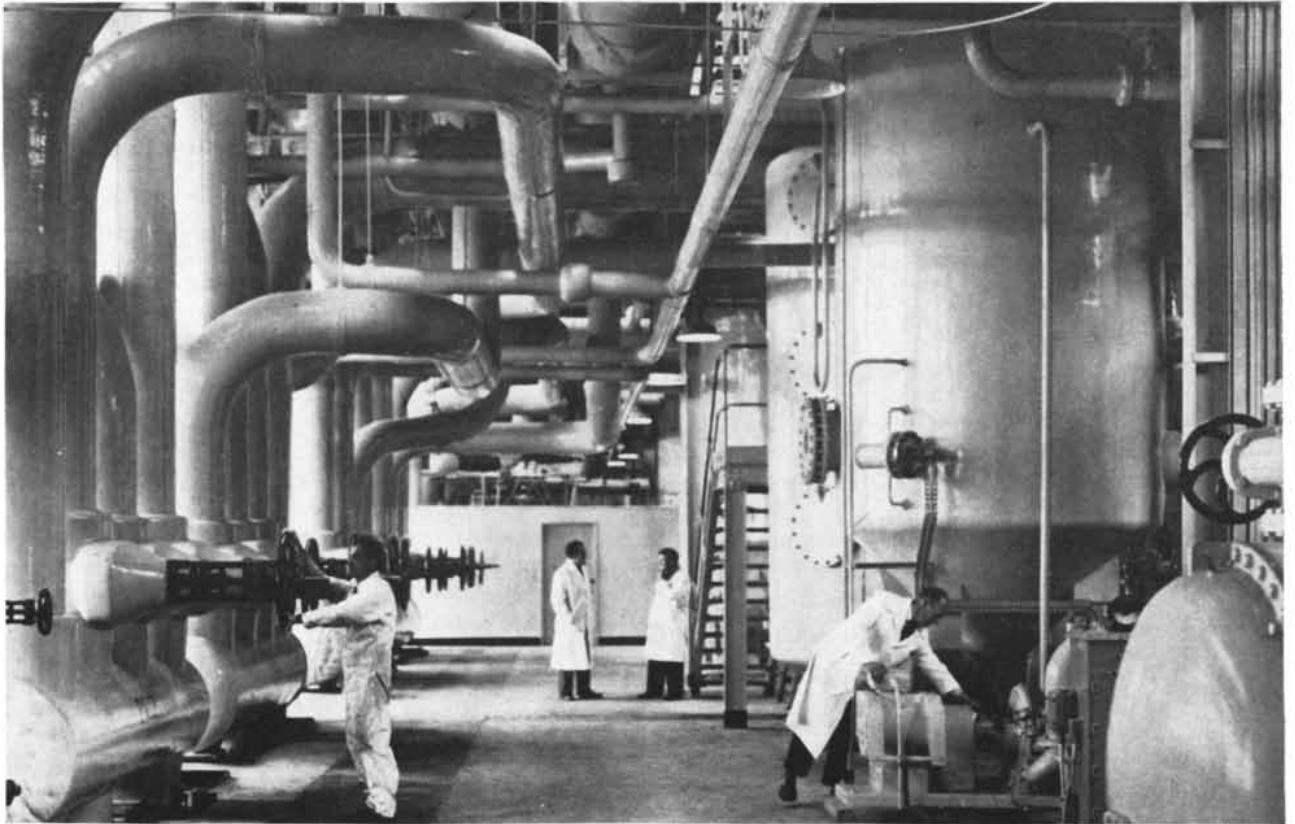
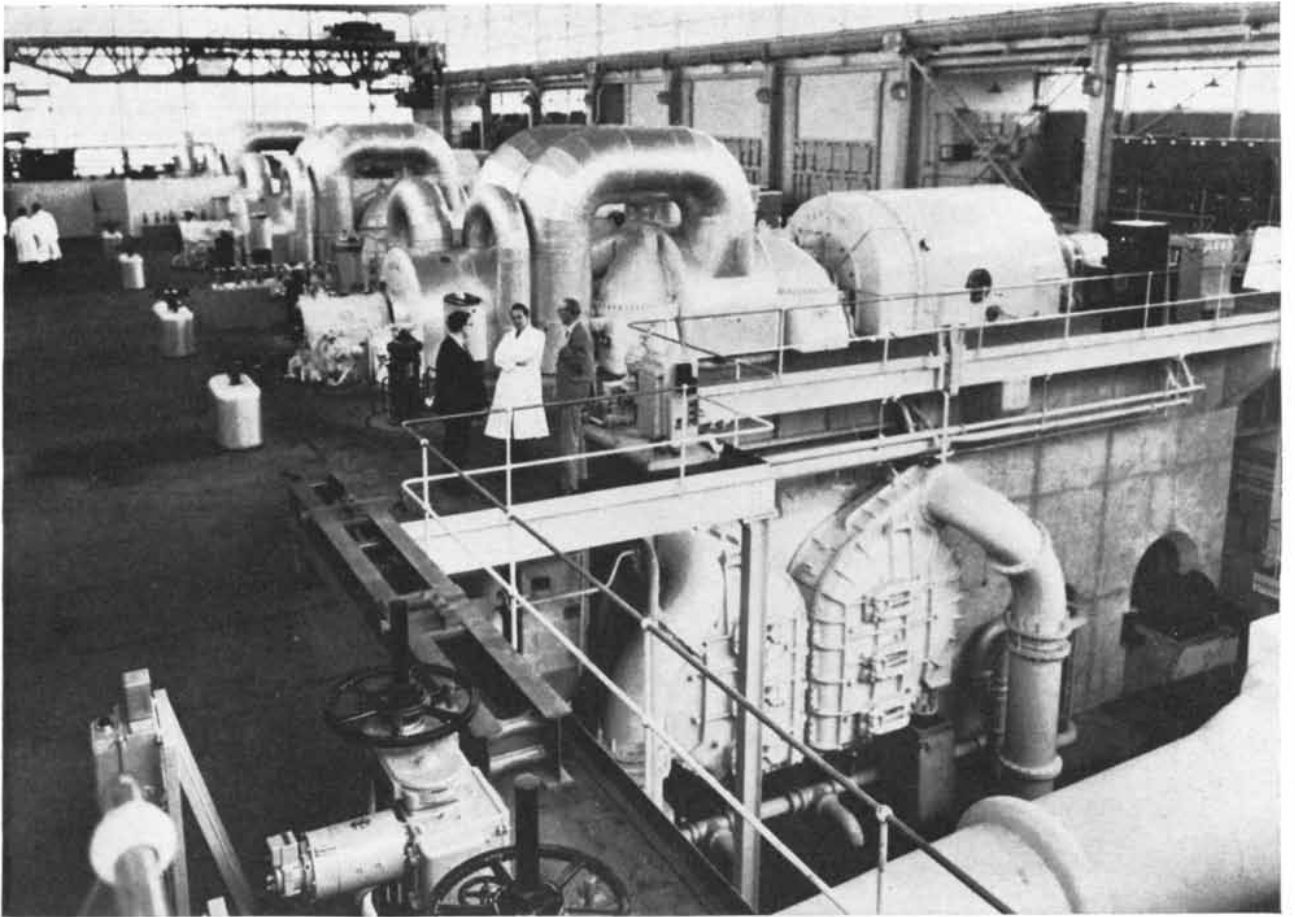
lion tons of coal a year. Further construction would then increase nuclear power capacity to the equivalent of 40 million tons of coal a year by 1975.

Up to that time all of our nuclear power plants had been designed, built and operated by the British Atomic Energy Authority. It was now decided to bring industry into the program. The four largest British manufacturers of conventional electricity generating plants were therefore approached. It was suggested to them that they should associate themselves with other firms in the field to form combines which would be trained in the design of nuclear power plants. These combines could undertake the design and construction of the industrial nuclear stations required both in the British program and in the export market we hoped to develop. Engineers from these combines were put through extended training courses by the Atomic Energy Authority. It was further decided to turn over the operation of the nuclear power plants in England to the Central Electricity Authority, and in Scotland to the South of Scotland and

North of Scotland electricity boards. Engineers from these three nationalized concerns were therefore given training courses also.

On December 13, 1956, the Central Electricity Authority placed orders with the industrial combines for the first two industrial nuclear power stations. One of the stations is at Bradwell on the Thames estuary while the second is at Berkeley on the River Severn. These two plants are now well advanced. Six months after the first orders the South of Scotland Electricity Board placed an order for its first station, and its construction is now proceeding on the Ayrshire coast; the Central Electricity Authority placed an additional order a few weeks later for the largest station of all, which has just been started on the north coast of Somerset. The total value of all of these orders amounts to around 200 million pounds; the capacity of the stations is approximately 1.4 million kilowatts.

We had originally expected that the capacity of each station would be around 150,000 to 200,000 kilowatts, but engineering developments by the four industrial combines showed that far larger



TURBOGENERATORS AT CALDER HALL are driven by steam produced in the heat exchangers of the two reactors. At top is the

turbine room itself; at bottom is the basement in which can be seen the pipe system bringing steam from one of the reactors.

stations were possible, and that such stations would have a great advantage in economy of construction cost. As a result it was decided that the program could be enlarged without materially increasing the number of stations to be built in the first 10-year period. The present plan calls for the construction of between five and six million kilowatts capacity by 1966.

It must be realized that Calder Hall was built essentially for the production of plutonium, and that electrical power is generated only as a by-product. It would therefore be unrealistic to attempt to estimate the cost of nuclear power by a direct calculation of the cost of the electricity which is produced in the reactors there. The cost of nuclear power can, however, be assessed from the capital cost of the plants which are being built for the electricity authorities and by analogy with the operating experience at Calder Hall. Such analysis shows that the cost per kilowatt-hour of electricity sent out will be of the order of .66 pence. This is about 10 per cent more expensive than the price at which electrical power can be produced in the most modern conventional plants. However, the cost of coal in the United Kingdom has risen steadily in terms of real money values. Although this upward trend may be diminished by the extensive plans of the National Coal Board to mechanize coal mining, it appears most probable that it will not be entirely halted. This rise in the price of coal will naturally improve the competitive position of nuclear power, and, with improving technology, the cost of producing electricity in the nuclear stations will certainly come down.

In a conventional power plant about one third of the cost of each unit of electricity sent out is accountable to capital charges, the other two thirds arising from coal and operating costs. In a nuclear power plant this proportion is roughly reversed: only one third of the cost of each unit sent out is accountable to fuel and operating costs, and two thirds arise from capital charges. Conventional power plants can be built in Great Britain today at a cost of between 40 and 50 pounds per kilowatt sent out. The capital cost of the first nuclear power plants ordered was of the order of 140 pounds per kilowatt. In the later plants this figure is more nearly 120 pounds per kilowatt, and there is every indication that the downward trend in capital cost will continue.

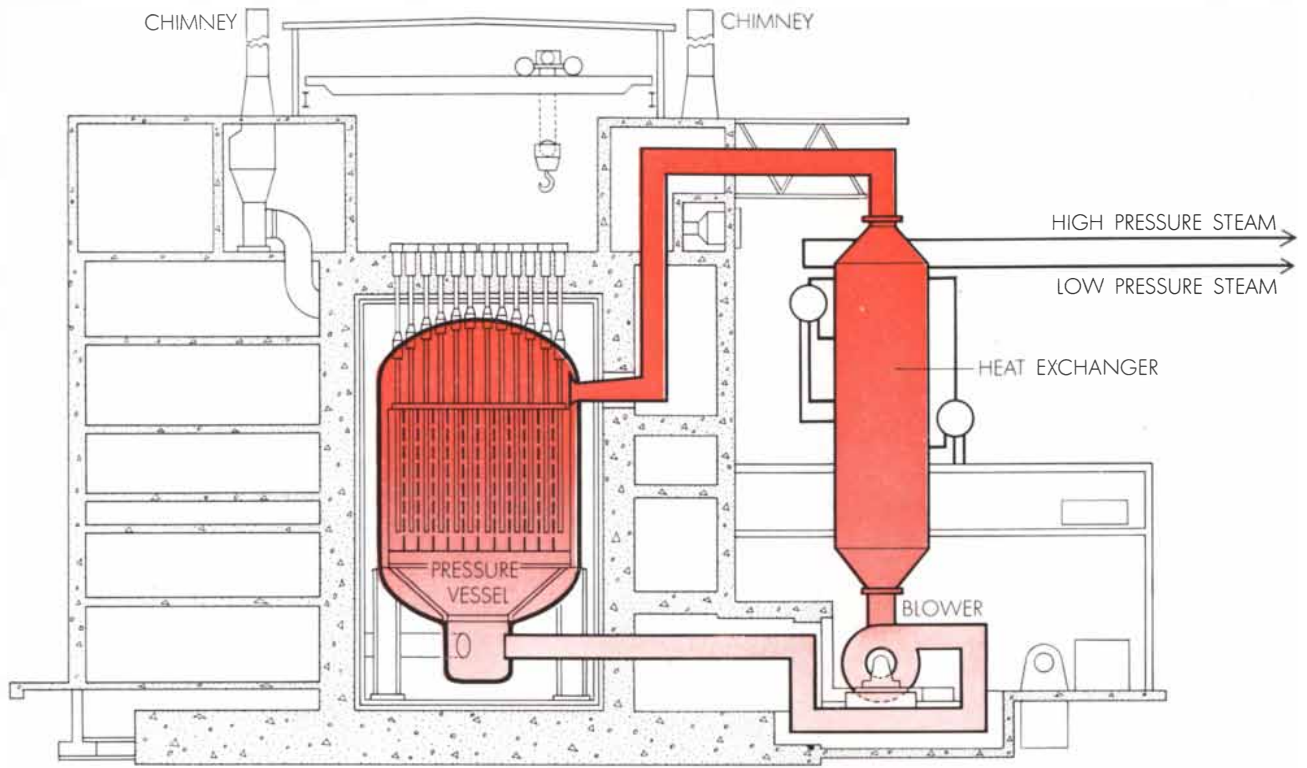
Up to now the decrease in capital cost has been achieved largely by the

straightforward engineering development of the Calder Hall plants. The combines which are designing the new plants have found it feasible to use thicker plate for the pressure vessels and better techniques for the manufacture of the heat exchangers. This has made it possible for them to design units of great-

er capacity and, as always happens, this higher capacity has reduced the capital expenditure per kilowatt. There is, however, a limit beyond which these purely engineering improvements are unlikely to go, and in the long run reduction in capital cost of nuclear power plants must arise (as it has in the case of convention-

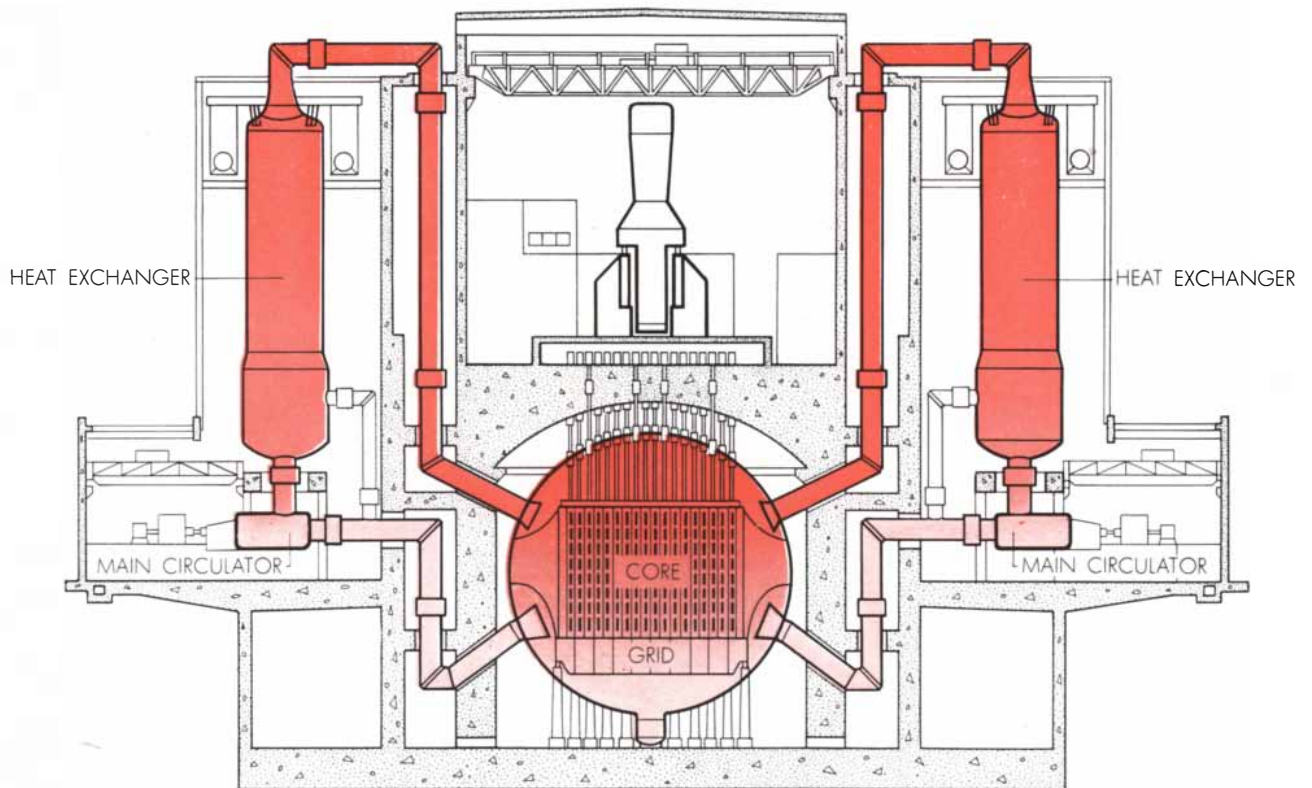


ATOMIC POWER STATIONS will soon be scattered over much of Great Britain. Map shows locations of these sites and of experimental installations mentioned in this article.



COOLING CYCLE of the Calder Hall reactors is shown in color. Cool gas (*light color*) enters core at bottom and is blown through

ducts around the fuel rods. Hot gas (*dark color*) emerges at top and passes to an exchanger where its heat is used to make steam.



BRADWELL REACTOR, here diagrammed in cross section, is one of the power plants being built by industrial groups in Britain.

Its design is basically like that of the Calder Hall reactors, but it will produce more power. The cooling cycle is in color.

al power plants) from the use of higher temperatures in the gas cycle.

Fundamentally the problem lies in the fuel elements. In existing reactors the fuel elements are bars of uranium approximately one inch in diameter. These are enclosed in magnesium-alloy cans to protect them from oxidation and to contain the fission products. The melting point of magnesium is around 600 degrees centigrade; this sets a definite limit to the temperatures that can be achieved. To go higher it will be necessary to use casing materials other than magnesium. Beryllium appears to be suitable, but it is expensive and its use in reactors cannot be afforded unless the specific rating of the fuel element is increased; that is, unless the amount of heat released from each ton of fuel elements is far higher than in present reactors.

But as we try to take more heat from the fuel elements we run into difficulties within the uranium itself. The heat of fission must be conducted from the center of the fuel element to the surface from which it is removed. This requires a temperature gradient within the metal, and with high ratings the difference in temperature between the center of the fuel element and its surface is considerable. If we attempt to achieve higher ratings while using fuel elements of the present form, we find that the temperature in the center of the uranium is dangerously high. To avoid this we have to use elements having a smaller cross section; this is unfavorable from the point of view of nuclear physics and demands the use of enriched uranium. This again increases the price of the fuel elements and cannot be justified unless high burn-ups are achieved, that is to say, unless the fuel elements can be left in the reactor for considerable periods of time. It is unlikely that we shall be able to achieve these high burn-ups with metallic uranium; in all probability we shall have to go to uranium in a ceramic form, which further increases the cost. However, all these expenses will be justified if they lead to the higher temperatures which make possible improved thermal efficiencies and more compact units of lower capital cost.

Reduction in capital cost is essential. Nuclear power has been given a temporary advantage which it cannot hope to hold indefinitely. These early nuclear plants are being used as base-load stations, that is, they are operated continuously. Obviously when a power plant has a high capital cost and a low fuel cost it is most economical to keep it

in operation on full load for as many hours as possible during the year. The initial plants will generate electricity at all times except when they are shut down for repairs. By 1965 it will be impossible to give this advantage to the nuclear power plants. Then the total installed capacity of nuclear power will be such that nuclear stations will have to carry a share of the peak loads, and it will be impossible to run them steadily at their designed capacity. This will result in an increase in the capital charges per unit sent out, and unless the capital and operating costs of nuclear plants have been brought down they will no longer be able to compete with conventional plants. It is at that date that nuclear power will have to meet its second crisis. Its first crisis occurred during 1956, when the operation of Calder Hall had to establish that our plans were well founded.

Nuclear power engineering in the United Kingdom has not been confined to the development of reactors of the Calder Hall type. We have studied various other forms of thermal reactors, including the pressurized-water reactor (which is the preferred type in the U. S.), the sodium-graphite reactor and others. Our studies suggest that for the United Kingdom these reactors offer no advantages over the gas-cooled type. In the thermal-reactor field we have thought it worthwhile to concentrate our resources on the further development of gas-cooled systems, which appear to us to be the most promising.

It has already been pointed out that these first-stage reactors can only be economical if a buyer can be found for their by-product: plutonium. It would be possible to use this by-product as fuel in thermal reactors, but there is a serious disadvantage in doing so. Plutonium absorbs thermal neutrons to form higher isotopes which are not fissionable and which capture neutrons; these higher isotopes act as "poisons" in the reactor. On the other hand, plutonium will not absorb neutrons which have not been slowed down in a moderator. Thus it is more effectively and economically used as a fuel in a fast-neutron reactor. Even before ground was broken for the Calder Hall reactors, we had begun to develop a fast reactor. We realized that in the long run it would almost certainly form an essential part of an integrated power program, and that the technological and scientific problems involved were extremely complex and would require a long time for their solution. This fast reactor is now about to go into operation at Dounreay in the north of Scotland. It

should not be regarded as anything more than a large experimental prototype. Many years of work probably lie ahead before we can say whether its design is sound. But certainly the reactor at Dounreay is giving invaluable information on the problems involved not merely in the design of fast breeder-reactors but also in the design of highly rated reactors of all kinds.

The first land-based reactor for the generation of appreciable quantities of power from nuclear energy in the U. S. went into operation at Shippingport, Pa., in December, 1957. The Calder Hall reactors have now been in steady operation for more than 18 months. It would therefore seem reasonable to say that, starting from nothing in 1946, the British are, temporarily at any rate, ahead of the U. S. in the industrial-reactor field.

I hope it will not be taken amiss if I attempt to analyze the reasons for this. To attribute it to any deficiency in research on atomic energy would surely be wrong. From the information available to us we have the impression that U. S. basic research has been a little more advanced than ours. To attribute it to an alleged lack of American ability to bridge the gap between scientific research and industrial achievement would also be wrong. That ability was handsomely demonstrated by the wartime atomic-weapons program and by the outstandingly successful work on the nuclear propulsion of submarines.

The real reason for the present relative positions of the U. S. and the United Kingdom in the industrial application of nuclear power seems to lie in the well-known relation between necessity and invention. British supplies of coal are running short. All of our oil is imported. From the outset we realized that we would need nuclear power and need it soon. Our organization was compact, and the collaboration between scientists and engineers was first-class. Above all, the program was carried through with relentless singleness of purpose and with the conviction that failure was unthinkable. The competition among industrial engineers increased the rate of progress.

There is no reason to believe that Americans could not have organized with equal success, but you did not have the same need. Now that your first industrial reactor is in operation, we look forward to competition and collaboration, not merely between teams working in the United Kingdom, but between teams working in our two countries.

THE FIRE ANT

An imported species of this insect has become a serious pest in the South. It is studied both to find means to control it and to learn how a species adapts itself to a new environment

by Edward O. Wilson

“Fire ant” is the common name of many ant species distributed throughout the tropical and warm temperate regions of the New World. The sting of these ants causes a burning sensation, hence the name. Three species of fire ant are native to the

southern U. S.; a fourth (*Solenopsis saevissima*) was introduced from South America around 1918. For 10 years the imported fire ant lived within the city limits of Mobile, Ala.; then it began to spread. It has now become a dominant species over a large part of the South,

and has developed into a serious pest.

It is not only a serious pest but a versatile one. In South America the normal diet of the fire ant appears to consist mostly of seeds, the flesh of insects and “honeydew” gathered from living insects such as aphids. But its dense



FIRE ANTS swarm out of a fire-ant mound which has been broken open. These ants are workers, which sting fiercely. The mound is

honeycombed with passages. It is built by the workers out of tightly packed particles of soil; thus it has considerable strength.

populations in the U. S. have extended this diet to include, to the grief of farmers, the seedlings of several important food crops and the newborn young of poultry and livestock. Nesting fire ants build large mounds, numbering up to 50 an acre, which hamper plowing and harvesting. Moreover, worker ants swarm aggressively out of the nests at the slightest disturbance, making manual labor in infested fields painful and difficult. Some farmers who have heavily infested land are unable to hire sufficient help, and are forced to abandon land to the ants. In two counties of southern Alabama the crop damage caused by fire ants was recently estimated at more than \$50,000. The total agricultural loss in the South probably extends into millions of dollars.

The onslaught of the fire ant has reached such proportions that the Federal Government has undertaken to conduct a special control program. Last spring Congress appropriated \$2.4 million to the Department of Agriculture for this purpose. The Department's plan, which is being put into effect now and is scheduled to last for several years, calls for the spraying of 20 to 30 million acres with Dieldrin, a hydrocarbon insecticide many times more toxic than DDT. The Dieldrin will be distributed both from the ground and from airplanes.

This unhappy tale has a special interest for the student of organic evolution. A fundamental problem of evolution is: How does a species adapt itself to a new environment? The problem is dramatized by the special case of animals and plants transported by man to areas far from their native ranges. Some transplanted species are immediately successful, building up huge populations until they become dominant members of the local fauna and flora; related species completely fail to establish themselves. Still other species follow a more baffling pattern. For a time they maintain a limited and precarious "beachhead"; then suddenly and unpredictably they explode into a phase of rapid expansion. The imported fire ant occupies the last category.

Like most other ants, fire ants are dispersed by the nuptial flights of males and winged virgin queens. During the flight a queen may travel as far as five miles from the colony of her origin. After she mates with the male she descends to earth, excavates a simple burrow in the soil, and over a period of several days lays approximately 100 eggs. The



FIRE-ANT MOUNDS dot a field in Mississippi's Lowndes County. The mounds interfere with plowing and harvesting. The ants also infest the seedlings of several important crops.



INFESTED FIELD in Lowndes County is sprayed with insecticide in a water emulsion. One treatment is capable of eliminating the ant from a field for as long as three years.

first brood of worker ants then develops very rapidly. The eggs hatch in about nine days, the larvae change to pupae after about the same period, and adults emerge from the pupae about a week later. Often small groups of queens cooperate to found colonies. Later, however, the first emerging workers execute the surplus queens so that only one remains. Once established, the young colony grows with startling speed. Within four or five months it contains over 1,000 workers. In a year it seethes with tens of thousands of workers and has reached sexual maturity; that is, it has begun to produce the winged males and queens which start the life cycles of new colonies.

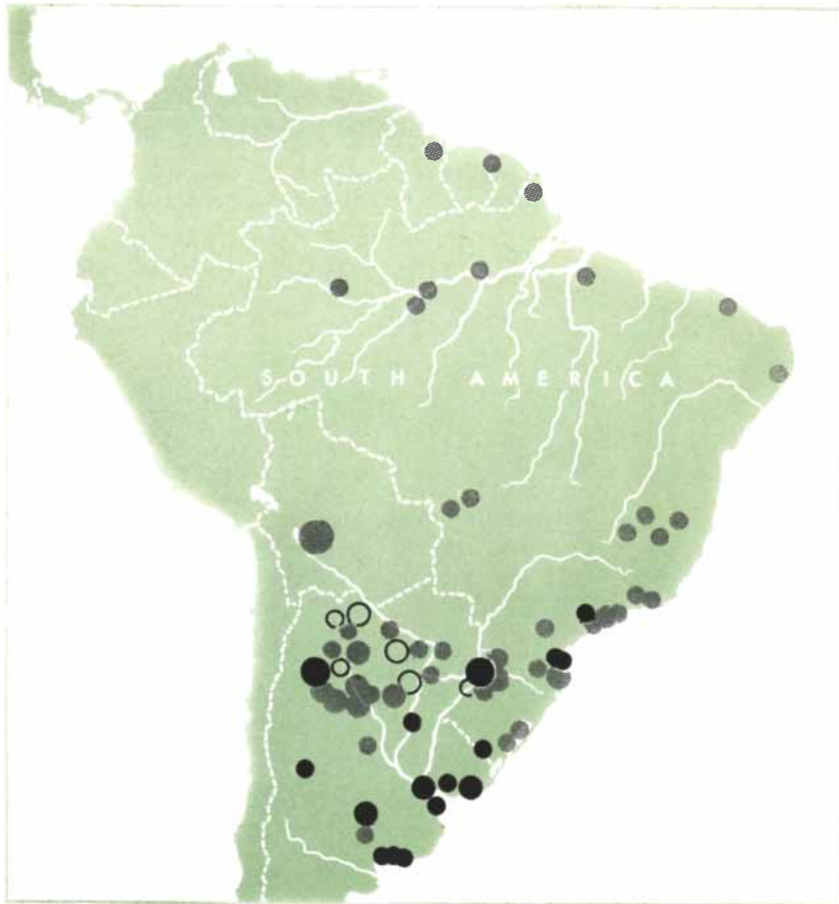
Given this means of dispersion, exactly how did the imported fire ant spread in the U. S.? As I have indicated, the imported population was at first quiescent and then exploded. We now know that at the beginning of the explosive phase an important change in the genetic structure of the population occurred. In the 1920s, following the in-

roduction of the colony into Mobile, it consisted entirely of a relatively large, blackish-brown form that corresponded exactly to the southernmost race of the mother population in South America. The range of this race is northern and central Argentina and part of southern Uruguay. The founding colony (or colonies) may have come from Buenos Aires or Montevideo in ships. Once established in Mobile, the dark form was not notably successful. William S. Creighton, a Harvard University graduate student in entomology who studied the population in 1928, found it limited to Mobile and the suburban community of Spring Hill. There was no inkling of the explosion to come.

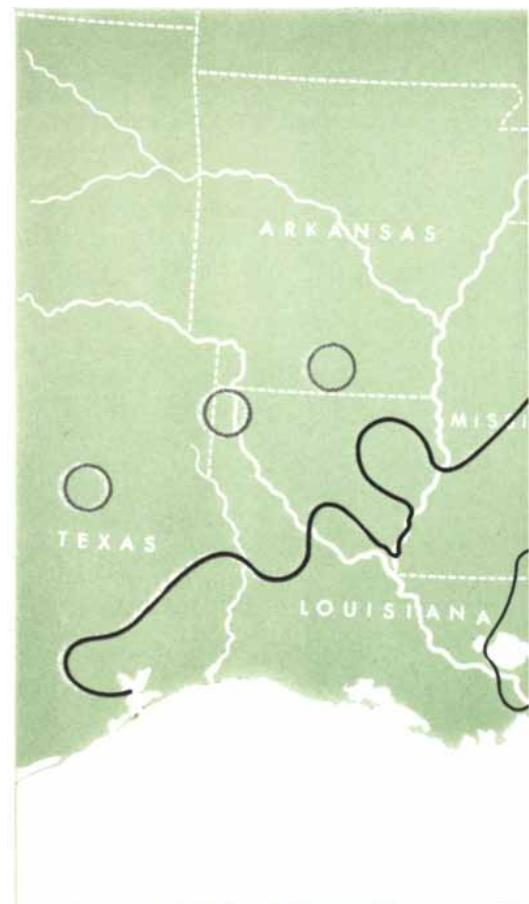
Sometime in the 1930s a second form of the imported fire ant made its appearance in the Mobile area. It was reddish-brown in color, smaller in size than the original immigrant, and it built smaller nests. Its origin is not positively known. Three possibilities have been considered: (1) that the second form was introduced from another part of South

America, (2) that it was a mutation of the original dark form, (3) that it represented a recombination of genes already present in the dark form. Several lines of evidence point to the first alternative. Where light and dark colonies meet we find colonies of many intermediate colors. This suggests that the variation in color is controlled not by one gene but by several. Moreover, the light and dark forms differ in characteristics other than color, and these characteristics vary independently of one another; thus they are probably controlled by different groups of genes. So it seems unlikely that mutation or recombination can account for the sudden appearance of the complex genetic structure of the light form.

Furthermore, recent studies have shown that the light form, or its close equivalent, occurs abundantly in certain parts of northern Argentina and southern Bolivia. Perhaps like the dark form it was introduced into the U. S. in cargo shipped out of Buenos Aires or Montevideo. Whatever the origin of the light form, the significant fact is that it



FIRE-ANT SPECIES imported from South America is widely distributed there. Black dots represent the dark form of the species; circles, the light form; gray dots, all other forms.



SPREAD OF SPECIES began about 1918. Black lines show the limits of the central

appeared at just about the time that the population as a whole began its rapid growth in all directions out of Mobile.

When I first began to study the imported fire ant in 1949, I noticed that the two color forms were distributed around Mobile in a curious and significant pattern. The dark form was very rare within the city itself, despite the fact that it had been the predominant or exclusive form when Creighton studied it there 20 years earlier. Now it was limited to a few isolated localities concentrated mostly along the southern periphery of the range [see map at right below]. Everywhere else in the Mobile area the teeming colonies were composed of the light form. To the north, in the Mississippi towns of Meridian and Artesia, there were small secondary populations consisting entirely of the dark form. Investigation showed that these localities had been colonized by ants from the Mobile area during the 1930s, probably while the dark form still predominated in the primary popu-

lation. Other isolated populations were found at Thomasville and Selma in Alabama. These consisted entirely of the light form. As one might have predicted, it was subsequently disclosed that these light-form populations were quite recent in origin, being no more than five years old in 1949. Compared to the dark-form populations of Mississippi, they were remarkably successful and fast-growing. The Selma population, in fact, already exceeded in size both Mississippi populations taken together.

All this information clearly indicated that the imported fire ant was in the midst of a rapid evolutionary change. The conclusion seemed inescapable that the light form, which had originated in the Mobile area sometime after the introduction of the dark form, was adaptively superior to the dark form and was replacing it over most of its range. Additional field studies conducted by William L. Brown and myself in 1956 and 1957 have corroborated this interpretation. We found that in the interval between 1949 and 1957 the dark form had con-

tinued to decline in the center of the main population, while the growing edge of the population had come to consist almost entirely of the light form. In some areas where the dark form had been abundant in 1949 it was now absent; only the light form persisted. By 1957 the dark-form population at Meridian had been engulfed by the northward-expanding main population, and the light form was quickly rising to predominance there. The Artesia population, 70 miles to the north of Meridian and still isolated, remained uniformly dark in composition, but its rate of spread had been far less than that of nearby light-form populations.

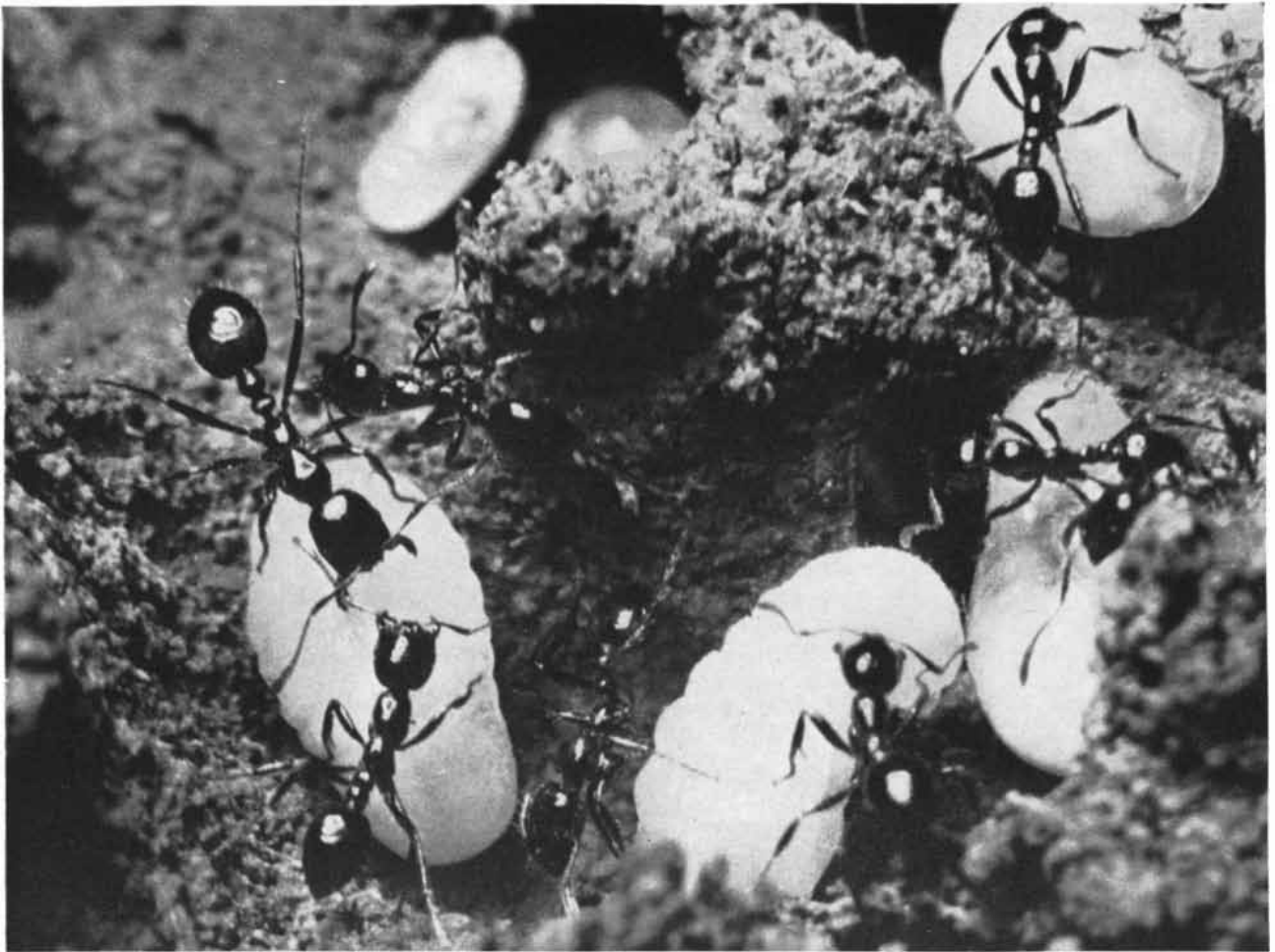
These most recent studies indicate that replacement of the dark-form genes is proceeding not only by genetic "swamping" but also by direct conflict between colonies. The dark form appears to be losing out in the struggle because its nest-founding queens and young colonies are destroyed by the fiercely aggressive mature colonies of the light form. Young dark-form colonies are



population by years. The gray lines indicate the limits of secondary populations in 1957.



DARK FORM OF SPECIES comprises more than 20 per cent of population in dark areas; 20 to 5 per cent in heavily hatched areas; less than 5 in light hatched. Dots are small colonies.



WORKER ANTS remove larvae from exposed part of nest. When the nest is disturbed, workers rush out to sting the interlopers. The

sting is not so painful as that of a honeybee or a wasp, but it is extremely effective when delivered by large numbers of ants.



YOUNG QUEEN ANT shown in this photograph is winged, as is the male. When the male and the queen make their nuptial flight,

they may travel as far as five miles. Four or five months after they have mated, the new colony contains more than 1,000 workers.

very rare today in areas where mature colonies of the light form exist in any number. To look at it another way, the dark form appears to be declining because, under competitive pressure from the light form, it is unable to reproduce itself adequately.

The future of the imported fire ant in the U. S. is difficult to predict. Energized by the highly adaptive genes of the light form, its rapidly growing populations may within the next 10 or 20 years come to cover all of the southeastern states. As a warm temperate-zone species that nests exclusively out-of-doors, it may never succeed in pushing north much beyond its present limits in Alabama and North Carolina, but within this range it will undoubtedly continue to wax as one of the most noxious of all insect pests.

The Department of Agriculture of course hopes to deal a lasting blow to the fire-ant population. But there are many potentially hindering complications in a program as broad as the one proposed. The possibility always exists that the natural enemies of the fire ant, including its various predators, parasites and competitors, will be hit harder by the Dieldrin insecticide than the ant itself. The subsequent relief of this form of environmental pressure on the ant may result in its rapid resurgence a few years after the spraying, perhaps to population densities even higher than those before the spraying was started. Another drawback lies in the generally poisonous nature of Dieldrin. Officials of several conservation organizations have recently joined in opposing the Government program on the ground that Dieldrin is extremely toxic to animals other than ants and in sufficient quantities is even dangerous to man. Indeed, field studies on the effects of Dieldrin have produced some alarming information. While evaluating the biological results of the sandfly control program in Florida's St. Lucie County, R. W. Harrington, Jr., and W. L. Bidlingmayer of the Florida State Board of Health found that a pound of Dieldrin per acre of marshland destroyed the entire fish population of more than 30 species! Virtually all crustaceans also succumbed, and for a short period of time the only larger animals left alive in the treated water were mollusks. Thus a large and vital part of the aquatic fauna had been wiped out in one stroke.

It is probably too soon to judge whether similar detrimental side-effects will follow from the fire-ant control program, but it is at least clear that long-

range control of such vast insect populations is going to be a very complicated matter. It is likely that biological control—the introduction of new parasites and predators which attack the fire ant—will have to be attempted. This technique, which has been so effective in stopping other insect pests, has not yet been investigated with respect to the fire ant. Finally there is the ironic fact that the fire-ant infestation, if left alone long enough, would probably abate by

itself. A general characteristic of introduced populations is that in time native elements adjust to them and eventually reduce their density. But the period of adjustment could take years or decades, and continued research on control measures seems economically imperative. Meantime the imported fire ant will provide valuable clues as to the kind of genetic processes that underlie the adaptation of animal species to new environments.



WORKERS TEND APHIDS (small white objects) on the underside of a leaf. At certain times of year the fire ant feeds on the "honeydew" secreted by aphids and similar insects.

NORMAN CASTLES

When the Normans invaded England in the 11th century, their first fortresses were made not of stone but of wood. Recent excavations have shown what these wooden castles looked like

by Brian Hope-Taylor

“. . . and they filled the land full of castles. They cruelly oppressed the wretched men of the land with castle-works; and when the castles were made they filled them with devils and evil men. . . .”

These bitter words, written in the 12th century by an anonymous Saxon monk, describe one of the principal weapons with which William the Conqueror and his barons had secured their conquest of England. The Norman cavalry overran the country. The Norman castles held it. At the time the monk's lament was written, moreover, similar castles had been built by petty warlords who had seized power during a breakdown of the central government.

In the mind's eye a "Norman castle" conjures up something out of *Ivanhoe*—massive stone battlements and a grim masonry tower. The Normans did indeed build castles of this sort during the later stages of the Conquest. From their crumbling remains we have learned much about the way in which the invaders consolidated their rule and exploited their new lands. But the first Norman castles, erected in the campaign that began in 1066, were made of wood, not stone. They could be built quickly to provide strong points from which the invaders could keep the surrounding countryside under surveillance and control until the inhabitants were pacified.

All that remains of these castles today are the great flat-topped mounds of earth on which their wooden structures stood. Such earthworks, shaped like inverted washtubs and long since overgrown, are to be seen not only in England, but also in Wales and Scotland and even in northern Ireland. Most of those originated in the internal conflict and

external land-grabbing which accompanied the establishment of feudalism in Britain during the two centuries after 1066. But some of them are true monuments to the Conquest itself.

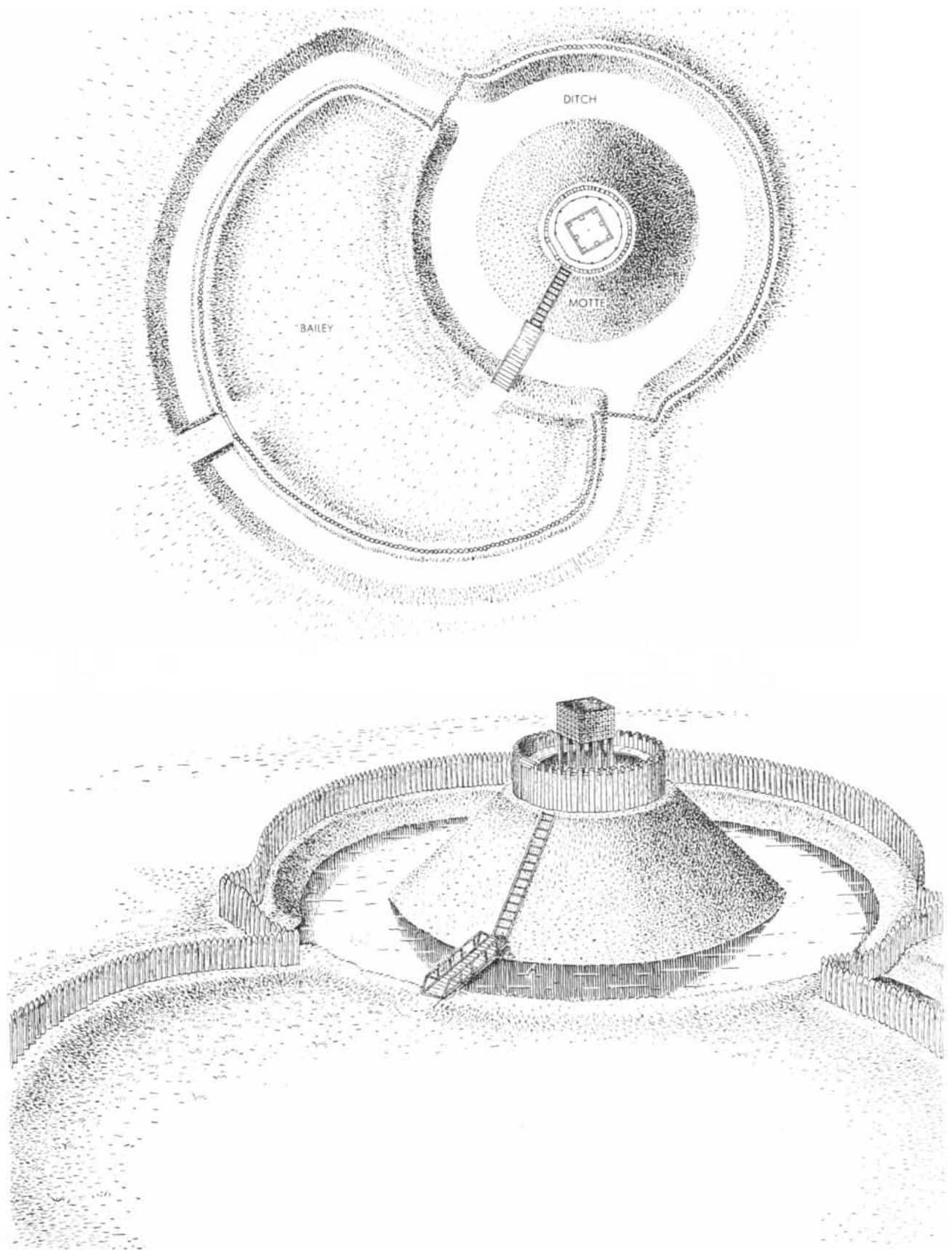
To oppressed Saxons like our anonymous chronicler these wooden castles may well have seemed the work of devils. An island people with no interest in foreign conquests, they had little experience with such sophisticated military devices. Their society had no need of feudal castles. The typical Saxon fortification was a communal affair: a town enclosed by a ditch or palisaded earthen bank, not unlike the primitive defensive stockades of prehistoric Europe. England's Saxon kings gave the nation a well-knit administration, encouraged religion, the arts, trade and agriculture, but neglected to modernize the country's defenses. Edward the Confessor, whose death opened the way to the Normans, was a pious but a weak king. While allowing his Norman favorites—a potential fifth column—to build private castles in England, he concentrated on the building of Westminster Abbey.

The Normans, by contrast, were dominated by an aristocracy of landowning warriors under a warrior duke. Their conquests, ranging from the British Isles to Palestine, made them quick to adopt and develop military devices; the feudal structure of their society filled their lands with private strongholds. In their businesslike exploitation of the lands they seized, they remind us of the Romans, and in William's ruthless generalship we can see something of Julius Caesar. But William was an unlettered Caesar and left us no commentaries on his wars, no manual of military method to explain his prowess and success. Indeed, though the Norman Conquest is one of the most familiar events in Eng-

lish history, our knowledge of its first and purely military phase is sparse and generalized. Documents like *Domesday Book*, William's famous tax survey of his English lands, give us a vivid and detailed picture of the Norman as a landholder and administrator. But the Norman soldier in action is represented only by sketchy accounts in the chronicles of the time, by a few scenes in the famous Bayeux Tapestry, and by the overgrown mounds of earth on which his wooden castles stood.

The wooden castle typically surmounted a fortification that combined two elements, the "motte" and the "bailey." The bailey, a relatively large area in which the garrison was lodged, resembled the primitive defensive stockade; it was surrounded by a deep ditch, the earth from which was heaped in a rampart along the inner edge and topped by a sturdy fence or palisade. The motte was the steep-sided mound of earth, heaped up from a formidable ditch that encircled it. On its flat top stood the castle proper.

When the castle had served its purpose, it was dismantled, burned or left to rot. At sites of permanent strategic importance the wooden castles were replaced by stone buildings. The Conqueror's motte at Windsor, for example, is crowned by the ancient stone Round Tower. Nothing remains of the wooden buildings but traces buried in the mottes. In theory this should present no great problems to the archaeologist. The soil should hold traces of the vanished timbers, if only as differences in color and texture, and from this it should be possible to map out the plan of the structure. In fact, the archaeologist finds that erosion and rabbits, tree-roots and treasure-seekers, have left more of a



WOODEN CASTLE at Abinger was reconstructed from excavations. The bailey, although characteristic of this sort of fortification, is conjectural; no traces of it survive at Abinger, possibly be-

cause of centuries of plowing. A typical bailey enclosed residential structures and other buildings. At Abinger the bridge, supported by an underwater causeway, could be removed in case of attack.



BAYEUX TAPESTRY shows a motte castle at Dol in Brittany. The ditch, shown in cross section, is spanned by a flying bridge.

The checkerboard pattern on the tower probably indicates "armor plating" of lead or hide squares, each with a large nail in its center.

mark on the motte than have its buildings. But despite these hazards the first systematic attempt to recover the plan of the timberwoods on a motte was wholly successful.

In choosing a site for our excavations we rejected those where the wooden castle had been replaced by stone buildings. At such sites the original surface is either sealed by masonry or so disturbed by rebuilding as to leave no coherent traces of the wooden structure. We chose a grassy mound near the manor house at Abinger, a village about 24 miles southwest of London. The manor house itself stands in what was probably the bailey. Though there are now no traces of surrounding earthworks, there is evidence of many later disturbances which could have removed them. The motte, however, has escaped damage. It proved an ideal subject for investigation. For one thing, the sand of which it is composed is a sensitive medium for revealing traces of timbers. For another, it is relatively small: it stands about 20 feet high and has a flat top about 35 feet in diameter. Mottes with relatively small tops were typical of the earlier history of these fortresses in England; it was only later that they were required to carry halls and residential structures.

Before excavating the motte itself we decided to investigate the surrounding ditch. We expected to find evidence which might help us to date the structure. Though this motte is of the same type as those of the Conquest, we knew there was no reason why one of these should have been built at Abinger. It seemed more likely that it was an illegal stronghold of the first half of the 12th century, when a struggle between two claimants to the throne threw England into anarchy. From the centuries of rubbish and silt which filled the ditch almost to the brim we hoped to get not only a date but, equally important, clues to the events which had affected the castle on its top. In our delicate excavations on the motte top we had to be ready for signs of repair or rebuilding.

Trenches dug across the ditch exposed a thick layer of 19th-century rubbish, and below it three feet of silted sand. We found that the sand had been deposited over a period of more than 600 years; halfway down were pieces of pottery from the time of Henry VIII, and at the base of the layer was a delicately made 13th-century jug. Below the sand the deposits changed in character, becoming damp and water-stained. The 13th-century jug thus gave us the ap-

proximate date when the ditch had become choked and dead [*see drawings on next two pages*]. These water-stained deposits, along with other evidence, showed that the ditch had been water-filled from the beginning. The motte's builders had deliberately located it so that the ditch would be fed by a spring. This is the earliest example in Britain of a castle with water defenses.

Our excavations went deeper yet, but still we saw no sign of the more intensive rubbish deposits which would mark a period of activity on the motte above. Then, at a depth of seven feet, there was an almost dramatic change. The silt became black charcoal thrown in from ancient fires. Among traces of decayed bones of ox, sheep and pig we found large fragments of soft, brown, unglazed cooking pots. The shape and finish of these pots were typical of the period around 1150. Here, indeed, was evidence of activity. Several large fragments of oak suggested that the motte's timberworks had been repaired or rebuilt at this time, a point to be remembered during the later digging. But we had not yet reached the bottom of the ditch.

At last the virgin sand of the ditchbed gleamed through the oozing water. On its surface we uncovered cooking pots of a different kind. These were almost globular and made of well-fired sandy ware. Their outer surfaces, below their flaring rims, were covered with swirling patterns of fine, parallel scratches, resembling an enlarged photograph of several superimposed fingerprints. This surface treatment, perhaps intended to give a surer grip to the carrier's hands, is characteristic of the period 1080-1140. A later date within this range seems most likely, since other evidence so clearly establishes the Abinger motte as a product of the 12th-century anarchy.

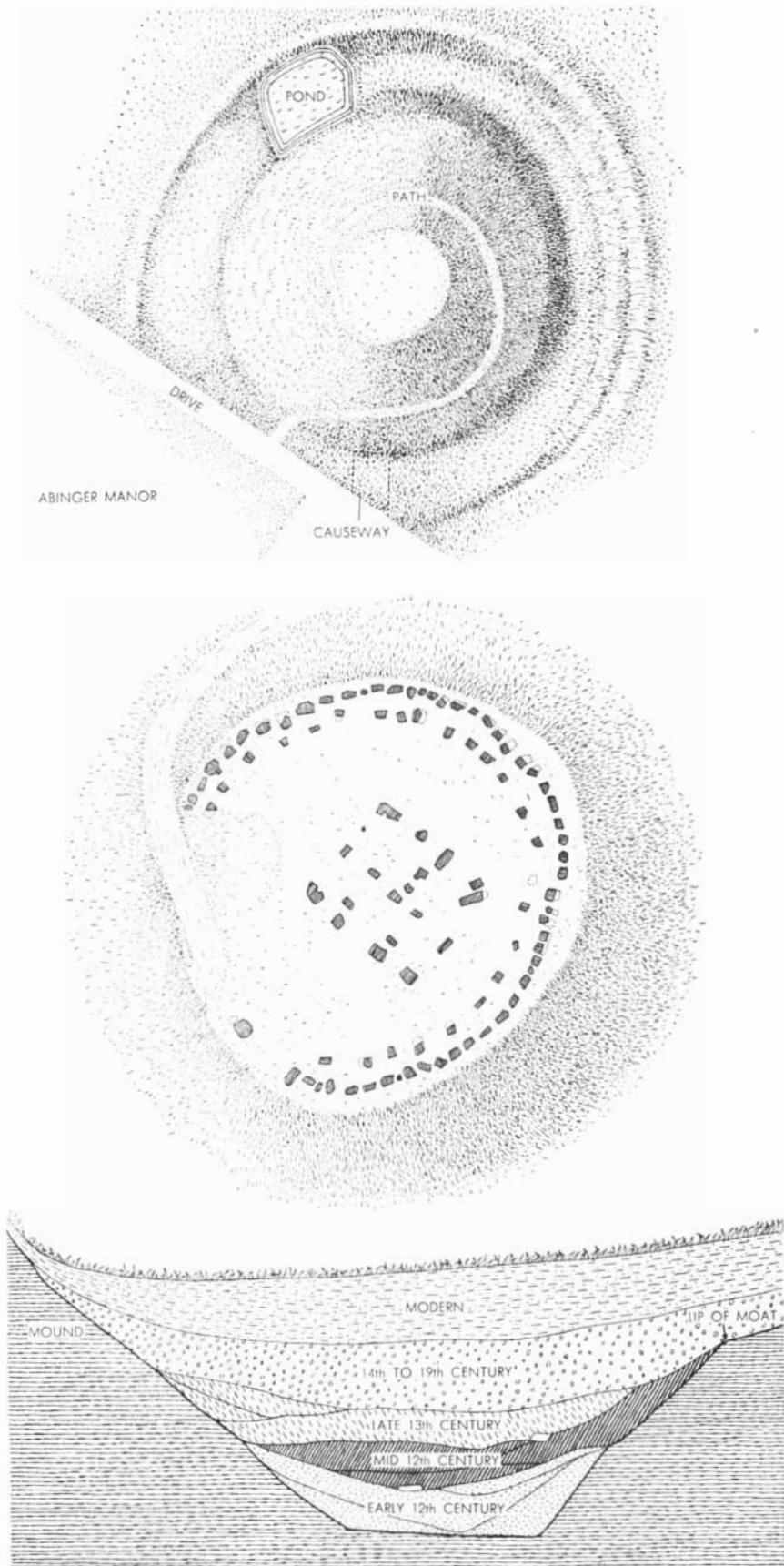
In addition to dating the motte, our excavations in the ditch uncovered an interesting and quite unexpected structure. This is a massive causeway of hard, undisturbed sand lying across the ditch. We had supposed the ditch to be an uninterrupted circle, and so it would have seemed to a medieval attacker, for this causeway was cunningly contrived. It was shaped rather like an executioner's block, with two rectangular humps at either end, obviously designed to bear a light wooden bridge. The humps were low enough, however, to lie out of sight below the surface of the water. With the bridge removed, like a ship's gangplank, the water in the ditch would have presented an unbroken surface.

We were now ready to begin the second and more difficult stage of the excavation, on top of the motte. The ancient bits of wood found in the ditch had been preserved by waterlogging. We could expect to find no such tangible relics in the dry sand of the motte, but only faint discolorations in the sand. Stripping the modern turf from the motte's flat top, we uncovered a layer of ash and clinker placed there in recent times to level the surface. Immediately below this layer we came upon the ancient deposits. The clean break between ancient and modern layers indicated that at some point the mound had been shaved down, by at least a foot.

Delicate skimming with bricklayers' trowels exposed the grayish-yellow sand which had been heaped up into the original mound. When every particle of the overlying ash had been removed with hand brushes, faint variations in the tone and texture of the sandy surface became visible. As our excavations spread across the motte top, these faint discolorations multiplied and formed a pattern. We recorded the markings in careful detail for later dissection, including those that suggested more recent disturbances by man and nature. As these various features were dissected we could distinguish the deep, cylindrical pockets of slightly dirty sand that were ancient postholes from the shallow, darker and more irregular stains caused by later tree roots. When this work was finished, we were able to draw up the first complete plan of a medieval timber castle [*see drawings on page 43*].

Around the edge of the motte was a ring of closely set postholes. About three feet within was another ring of postholes, shallower and more widely spaced. The first ring represented a stout palisade; the second, the supports of a walk or fighting platform along its inner side. Two deep postholes bounded a gap in the palisade—probably a gate. The plan thus far suggested little by way of departure from earlier methods of fortification.

In the center of the motte top, however, we found evidence of a structure to which all the rest was merely auxiliary. It was a free-standing wooden tower only 12 feet square. The depth of its corner postholes and the small area it covered showed that it was built for height, not capacity. This tower was the structure that the motte, and others of its type, existed to support and protect. Sentinels posted on its top could survey a wide area for the approach of enemies. If the manor were attacked, the tower



ABINGER MOTTE is shown as it exists today (top). The spiral path is a modern addition. Excavation of the motte top revealed the plan of the palisade and tower (middle). Deposits in the ditch, shown in cross section (bottom), contained pottery which dated the structure.

would become a vantage-point from which defending archers could pick off attackers who were floundering across the ditch.

The tower and its associated palisade actually belonged to the second phase of activity indicated by the fragments of oak in the ditch. Further excavation revealed traces of an earlier tower and palisade of a very similar plan. The original tower had been dismantled, probably because the newly built mound had settled and made it unstable. About 1150, judging from the first pot fragments we had found in the ditch, the motte had been heightened and leveled by the addition of a thick layer of sand, and the new tower had been erected. Though the accession of Henry II in 1154 brought stable government once more, the second fortress was not dismantled but left to rot.

Our excavations were finished, but our researches into wooden castles were only beginning. At Abinger, we soon realized, we had found a key to some of the more cryptic portions of the Bayeux Tapestry. This remarkable embroidery, made soon after the Conquest, shows the course of that struggle in a richly colored decorative frieze. It is so highly conventionalized, however, that its details have needed clarification from other sources. Our excavations show that many seemingly obscure features of the Tapestry are fairly plain statements of fact.

Some scenes, for example, center around structures once thought to be towns. We now know that they must be mottes, for the correspondence between these scenes and the structure at Abinger is conclusive. The Tapestry's picture of the scene at Dinan shows a washtub mound with its encircling ditch boldly drawn in cross section [see illustration on page 44]. A sturdy palisade crowns this motte, and above it looms a tower. In only two respects does the illustration depart from the Abinger evidence. First, it shows a fighting platform outside the palisade; this may occasionally have been a feature of the motte fortress. Second, the Dinan motte is reached by a flying bridge springing directly from the outer edge of the ditch to the palisade gate. All the Tapestry's castles have flying bridges of this sort. Doubtless this more permanent bridge could safely be used in the more important castles with strongly defended baileys. The Abinger castle had at best a weak bailey, and thus needed a bridge which could be removed if the bailey fell to the enemy.

The close agreement between the

structure we uncovered at Abinger and the castles pictured on the Bayeux Tapestry encouraged me to take up a new line of inquiry which now promises to explain how the motte originated. Historians and archaeologists have assumed that this type of fortification was a Norman invention. Since so little was known about its timber structures, they took the mound to be its central feature and credited the invention to the Normans because no such large mounds from pre-Norman times have been found. Further researches have convinced me, however, that the really distinctive element of the motte was not the mound but the tower. It was, I believe, a tower of a special type, which originated centuries before the Norman Conquest. Let us see if, from the Abinger remains and other evidence, we are able to reconstruct its history.

We know that the Abinger tower occupied a considerable portion of the small motte top. If it was boarded in from top to bottom it would certainly have hindered the defenders from moving freely about the fort. If, however, the tower was a sort of box on stilts, its defenders could have moved about on the motte between its supporting posts, while the enclosed top would shelter the soldiers there against arrows. Our excavations, though they suggested this picture of the tower, could not confirm its above-ground details.

Was there, perhaps, some clue in the Bayeux Tapestry, some small and hitherto-unnoticed detail? Indeed there was. The Dinan scene shows a soldier who is fighting apparently at the foot of the tower. His arm passes behind one of the cornerposts and reappears on the other side. This can only mean that the lower part of the tower was open and that the soldier was actually engaged in fighting underneath it.

Once one knows what to look for, the meaning of evidence which has long been overlooked almost leaps at one. I soon found further confirmation in a carved stone capital from the original building of Westminster Hall, which dated from the generation after the Conquest. (The immediate successor of this building still stands near Westminster Abbey.) The carving shows a stilted tower of the same type as that in the Tapestry. Beneath it crouches a soldier, chopping at one of the great cornerposts with an ax.

The tower in the Westminster carving is firmly tied to the castles of the Bayeux Tapestry by another significant element. The enclosed upper portion of the tower

is covered with small, carefully carved rectangles, each with a raised edge and a dimpled central boss. These rectangles must indicate pieces of hide or lead nailed to the tower, an early form of armor-plating. The appearance of a raised rim would be given by rows of nails about an inch from the edge of each plate. A single, large-headed nail hammered through the center of the plate would produce a central boss. This same treatment of the tower surface appears on the castles of Dol and Dinan in the Bayeux Tapestry, the alternate rectangles being embroidered in contrasting colors to form a gay checkerboard pattern. In every case the central boss is represented by a carefully stitched ring. There is no doubt, then, that both carving and tapestry depict the same type of stilted tower which we excavated at Abinger.

We are now ready to consider the question of whether the mound or the tower came first in history. A tall free-standing tower, built on natural ground, will need deep cornerpost holes for stability, and the posts must fit tightly in their holes. Using only pick and shovel, it is almost impossible to dig a hole which is both narrow and very deep, as anyone who has tried it knows. The trick of setting posts in concrete was not included in the techniques of ancient builders in timber, nor did they have pile-drivers capable of driving tall posts into the ground. A tower built on natural ground, then, would soon become unstable. In correcting this weakness the early builders, in my opinion, endowed their towers with a new strength, for it was this which seems to have led to the development of the motte.

As a first step in stabilizing a tower, its builders might well dig a ditch around it and heap the excavated earth inward around the cornerposts. Success will encourage the throwing-up of mounds around towers as soon as they are built. The importance of the post-holes dug in the ground will diminish. Eventually the towers will be supported by temporary frameworks while ever-bigger mounds are heaped up and rammed solid at their base. Meanwhile the military advantages of this method will have become apparent, for the higher mound and deeper ditch will themselves offer a formidable obstacle to enemies attacking the tower.

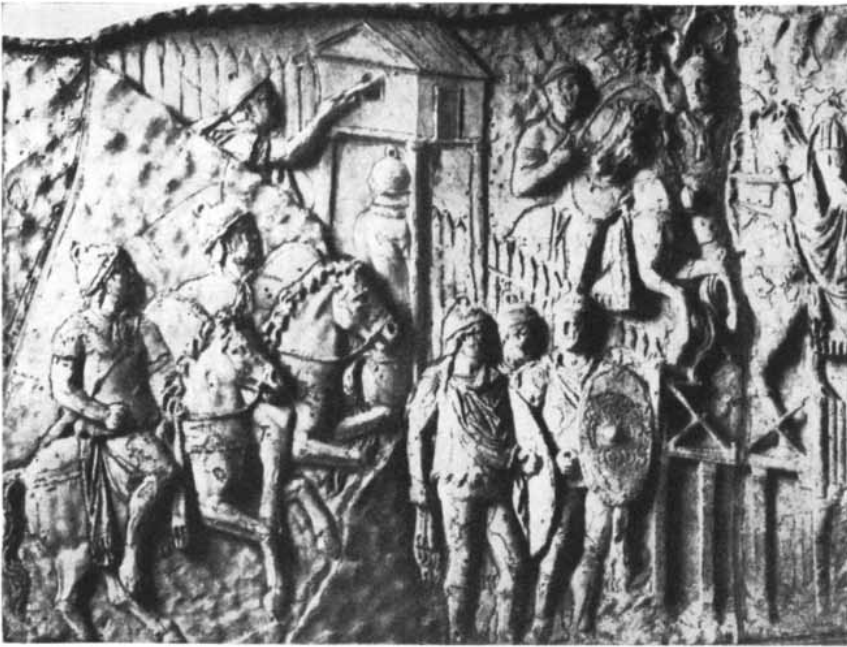
This line of deduction is also confirmed by the Bayeux Tapestry. It pictures a castle under construction at Hastings and shows workmen shoveling up



TYPES OF POTTERY from the Abinger ditch make it possible to set approximate dates for various phases of motte's history.

an earthen mound around an already-constructed tower framework. But we have even more concrete evidence. When Hans Stiesdal of the National Museum of Denmark excavated a small motte in eastern Jutland a few years ago, he discovered that the tower's cornerposts had run through the entire mound. At ground level they had rested on a bed of stones. Stiesdal agrees with me that the mound must have been built around the tower. As further evidence we have later medieval documents which refer to such "prefabricated" towers being transported by land and sea.

Clearly, then, the story of the motte begins not with the mound but with the



WATCHTOWER ON STILTS in Dacia (modern Rumania) is depicted on Trajan's Column in Rome. The Dacians may have borrowed this type of frontier fortification from Romans.

stilted tower. How did such a distinctive structure originate? The most likely answer is that it began as a platform or guardroom over the gateway of a pre-historic fort. Later the elevated platforms would be used separately, as a means of supervising an area of open country. Roman sculptures show structures of exactly this kind—small timber towers, each based on four stout corner-posts [see top photograph on this page]. Long lines of timber watchtowers were erected along the frontiers of the Empire. Excavation of several examples in Germany has shown that the earth from a circular surrounding ditch was thrown inward to form a low, flat-topped mound at the base of four corner-posts set in the ground. Here, surely, is the prototype of the motte, with all its essential features. One of these Roman proto-mottes is even set within a bailey-like earthwork enclosure. And the Romans, as did the Normans centuries later, often replaced the original timber towers with stone ones.



STONE CARVING from the original building of Westminster Hall shows a tower covered with carved squares, indicating the "armor-plated" structure depicted in the Tapestry.

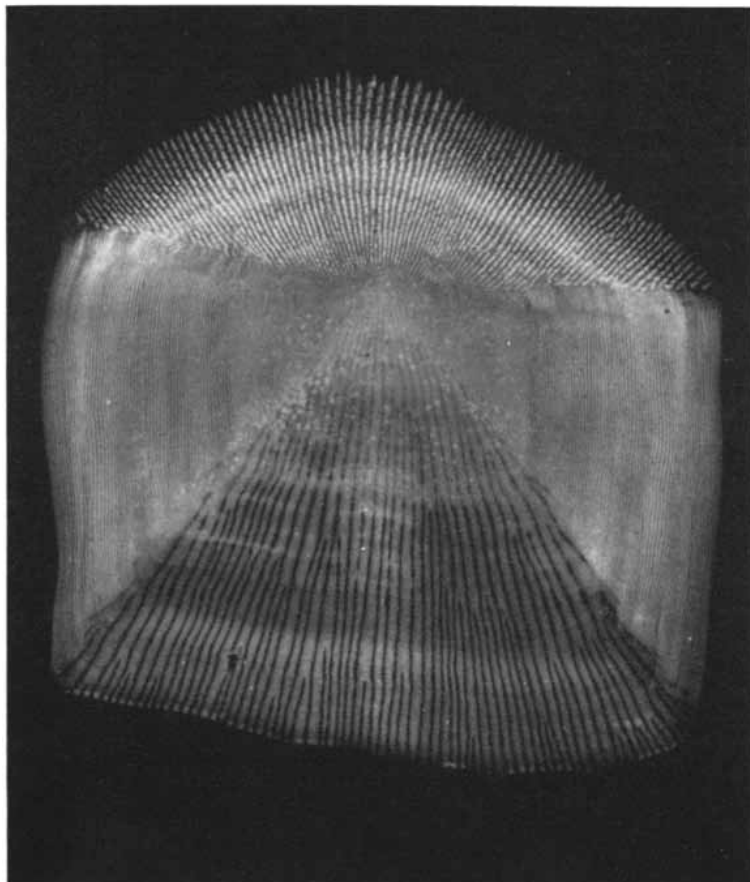
We can now summarize the history of the wooden castle. It begins with the banding together of families and tribes to build communal fortresses. Later a stilted tower is built over the fortress gate. As tribes coalesce into states and empires, the tower is detached from the fortress and becomes a frontier watchtower. Used extensively by the Romans, it is probably passed on by them to the Franks and by them to the Normans. In the Norman conquests, from Sicily to Scotland, the tower, now set firmly in a motte, reaches the climax of its history. But the story does not end with this blare of victorious trumpets. The motte begins to lose its martial character, turning into the "residential motte," with the lord's dwelling on the mound and the garrison in the bailey below. A few scattered fragments of a once-great tradition survive for centuries as a lingering anticlimax.

There is, however, an epilogue. The motte never reached the New World, but the palisade stockade—a sort of bailey—played an important part in the conquest of North America. And in the blockhouse we find a far-off echo of the motte tower.

Now, of course, the wooden castle is as extinct as the dodo. In our time we have seen castles in the air become reality, along with floating fortresses. So we beat our wooden palisades into newsprint, whereon we record the appearance of weapons which reduce all castles to ivory towers.

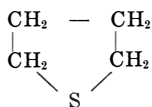
Kodak reports on:

a fish story with a picture to prove it . . . pressure from the gas company



This is a microradiograph of a striped bass scale. In microradiography one passes low-voltage x-rays through a specimen to a special fine-grain photographic emulsion in intimate contact with it. The resulting photographic image then becomes a subject for conventional photographic enlargement or photomicrography. If you already know that much, there is then some point in requesting of Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y., information about an improved material for this work which we hope to have available in the near future. The same source can also provide a recently updated bibliography on results and techniques with microradiography. But don't ask us about striped bass and the lessons to be learned from their stripes or scales. Ask the Fish and Wildlife Service of the U. S. Department of the Interior in Washington.

Tetrahydrothiophene



We had an inquiry from a gas company for tetrahydrothiophene. Feeling a little glum that day and aware that we cannot be expected to make 10 grams of each of the half-million-plus organic compounds that have been proved capable of existence,

we politely declined the gas company's offer. Back they bounced for a second try, asking for 100 grams or \$100 worth, whichever would be less. That constituted pressure. It also showed we were dealing with a party who understands the facts of life. We forgot the \$100 limit and shot the works.

We took a lot of *1,4-Dichlorobutane* (Eastman 5658) and sodium sulfide and put them into a solvent chosen by experience. We heated to

a temperature and for a time, both chosen by experience. By steam distillation we separated the oily product from the solvent and the sodium chloride formed. The water-insoluble material was then decanted and purified by distillation to BP 118-119 C. The job went rapidly, and the yield was excellent, amounting to five pounds of tetrahydrothiophene. It smells something like indene. The five pounds cost us only \$A. Five grams might well have cost the same.

Only in form was this transaction the sale of a certain chemical at a meaningless \$B per pound. In reality our persistent customer was buying a service which would either find the right reaction solvent, time, and temperature to produce what he wanted or else would silently take the loss if the entrepreneurs' judgment or execution proved faulty. Furthermore, we didn't even make him pay the whole shot but undertook to market *Tetrahydrothiophene* as Eastman 7516, searching for other buyers (as we do by these very lines) to share the cost with him. The list price is \$18.55 per 100 grams.

If A were given, you could compute B/A, a ratio that most widely held corporations disclose only for the business as a whole. A copy of our 1957 Annual Report will gladly be sent by Eastman Kodak Company, Public Relations Department, Rochester 4, N. Y. Tetrahydrothiophene, along with some 3600 other Eastman Organic Chemicals, is sold by the division called Distillation Products Industries, Rochester 3, N. Y.

Research organics and special materials for relatively obscure laboratory methods like microradiography are rather small business compared with Kodachrome Film, Brownie Starflash Cameras, or Chromspun Yarn. We console ourselves for their disproportionate drain on technical manpower with the thought that for public relations with certain segments of the public this activity might be almost as impressive as flush brochures and statements to the press. We caught on to this approach long before it was widely accepted that the good will of those segments—whether employed by gas companies, fisheries institutes, or astronomical observatories—is important.

Prices quoted are subject to change without notice.

Kodak
TRADE MARK



KENNAMETAL'S 94,000,000 YME puts the squeeze on "cylinder breathing"

- prevents leakage around pistons
- stands up under extreme abrasive and corrosive conditions
- reduces compressor downtime needed for replacements or repairs

In making polyethylene, gases are compressed at pressures as high as 35,000 psi. Under such pressures, cylinder liners of conventional materials deform and permit gas to leak around the pistons. This "cylinder breathing" must be held within defined limits.

One compressor manufacturer solved this problem with cylinder liners of Kennametal.* This unique metal with YME of 94,000,000 psi, three times that of the hardest steel, and its exceptional compressive strength, not only confined gas leakage within tolerable limits but outlasted any other metal due to its exceptional resistance to wear.

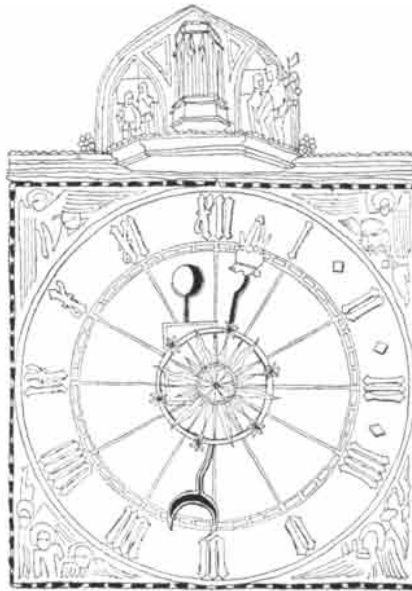
The high YME of Kennametal is being applied in many ways to improve products, processes or productive capacities. In addition to pump and compressor liners, it is used in spindles for precision instruments; integrator discs; shafts; grippers; rams; grooving blades and similar applications.

Other unique characteristics of Kennametal compositions, including high resistance to corrosion, heat, impact and cavitation are solving "metal problems" in the chemical industry in such parts as balls, seats, bushings, sleeves, valves, cones and similar components. Platinum bonded compositions are available for use where a combination of severe corrosion and abrasion is encountered.

Why not investigate Kennametal? A Kennametal carbide engineer will gladly discuss your problem with you. Or write for booklet B-111A, "Characteristics of Kennametal." KENNAMETAL INC., Dept. SA, Latrobe, Pennsylvania.

*Trademark

C-3025A



Fusion Power Progress

The possibility of obtaining useful power from controlled thermonuclear reactions has now been demonstrated. This seemed the unanimous reaction to last month's joint announcement on thermonuclear-power research by Great Britain and the U. S. There were varying appraisals of the actual experiments, which were reported in the *British Nature*; but, said Lewis L. Strauss, chairman of the Atomic Energy Commission, as to the long-run feasibility of thermonuclear power, "today there are almost no skeptics."

Perhaps the chief question at this stage is whether a true thermonuclear reaction has yet been achieved. A number of experiments with very hot, ionized gases (plasmas) have yielded neutrons which come from the fusion of deuterium nuclei. But whether the fusing atoms obtained their necessary speeds from local accelerations in the complex electrical fields of the plasma, or whether their energy came from a general heating throughout the gas—the condition for thermonuclear reaction—has been moot. Now Sir John Cockcroft of Britain's Atomic Energy Authority declares he is "90 per cent certain" that the English device known as ZETA has produced thermonuclear neutrons.

ZETA (for zero-energy thermonuclear assembly) is an aluminum doughnut, three meters in central diameter with a one-meter bore, in which deuterium gas is heated and "pinched" by a strong electric current [see "Fusion Power," by Richard F. Post; *SCIENTIFIC AMERICAN*, December, 1957]. The British report that they have operated with currents

of 200,000 amperes and heated the gas to five million degrees centigrade. A ring-shaped magnetic field running parallel to the axis of the tube helped overcome the tendency of the pinched body of plasma to destroy itself by writhing into the walls of the tube. The discharge was stabilized for periods of two to five thousandths of a second, and some three million neutrons were emitted on each pulse. The number and distribution of the neutrons, the experimenters say, are what would be expected from a thermonuclear reaction at that temperature.

Even if all the neutrons came from a thermonuclear process, the power released by the reaction was a completely negligible fraction of the power needed to produce it. To achieve a self-sustaining fusion reaction in deuterium will require a temperature of some 400 million degrees and a discharge lasting several seconds. (A deuterium-tritium fusion would become self-sustaining at 40 million degrees.) It is expected that ZETA's operating temperature will be increased to 25 million degrees this year.

A theoretical analysis of the ZETA experiments by Lyman Spitzer, Jr., of Princeton University indicates that the behavior of hot plasmas is still not completely understood. The rate of heating (speeding up) of the deuterium nuclei was measured by adding a few heavier atoms, which are not wholly ionized, and observing the Doppler shifts in the spectra they emit. According to Spitzer, the heating proceeded at a faster rate than can be explained by collisions between plasma electrons and ions, the only known means of acceleration. He concludes that "some unknown mechanism would appear to be involved."

Another British pinch experiment was reported by a group at Associated Electrical Industries, Ltd. In an aluminum doughnut called Sceptre III, about one third the size of ZETA, the industrial researchers have achieved a four-million-degree temperature in bursts lasting a few millionths of a second. The designers expect to raise the temperature to 12 million degrees soon, and they are building a larger device in which they hope to reach 40 million degrees, the break-even point for deuterium-tritium fusion.

U. S. papers told of experiments with two straight pinch tubes called Columbus II and Columbus S-4, and with a

ring-shaped device, the Perhapsatron. Columbus II has produced one-microsecond bursts of 10 to 100 million neutrons, which appear to be thermonuclear in origin. The other machines have demonstrated an ability to form "highly reproducible" and "well-stabilized" pinch currents. The Perhapsatron has operated at temperatures of six million degrees during pulses lasting two microseconds.

Another apparently successful experiment was announced later from Japan. Workers at the University of Osaka reported that they have achieved controlled thermonuclear fusion for one microsecond at a temperature of one million degrees, with the release of five million neutrons. Their apparatus was said to be similar to ZETA but smaller.

Publication of the U. S. and British papers represents a substantial relaxation of the secrecy which has surrounded thermonuclear research. However, according to Strauss, "certain areas . . . must remain classified in both countries at this time." Commenting on the security restrictions, the British magazine *The New Scientist* attributed them to "American fears" that neutrons from thermonuclear reactors could be used to manufacture fissionable plutonium from U-238. In this way, "small nations could quietly set about making atomic bombs," and they "would no longer be dependent on the U. S. or the Soviet Union for enriched fuel elements for more advanced types of [fission] reactors." Many U. S. scientists connected with the thermonuclear power program stated that secrecy had not hampered research. There were some dissents. Morton A. Levine of the Air Force Cambridge Research Center, one of the early workers on stabilized pinch discharges, attributed a lack of interest on the part of physicists in general to the secrecy surrounding the project.

Fission-Power Progress

A substantial advance in the economics of nuclear-fission power was announced last month by workers at Argonne National Laboratory. They have souped up their experimental boiling water reactor (EBWR) to the point where it puts out 50,000 kilowatts of heat instead of the 20,000 kilowatts for which it was designed. If the extra heat

Buy Now, Add Later

Microstar's Building Block Concept of design, exclusive with AO Spencer, lets you add parts as new needs arise.

No other microscope can offer you such a wide choice of interchangeable parts and accessories.

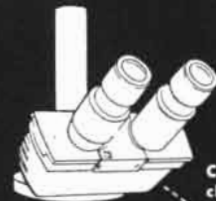
You can adapt the Microstar to your exact needs with various combinations of readily interchangeable

bodies, stages, bases and optics. You have more than 600 possible combinations or models to choose from.

Your Microstar will be "just right" for you in convenience, comfort and the economy of real quality.



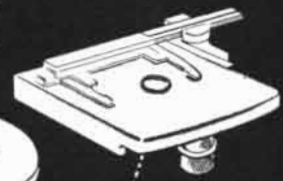
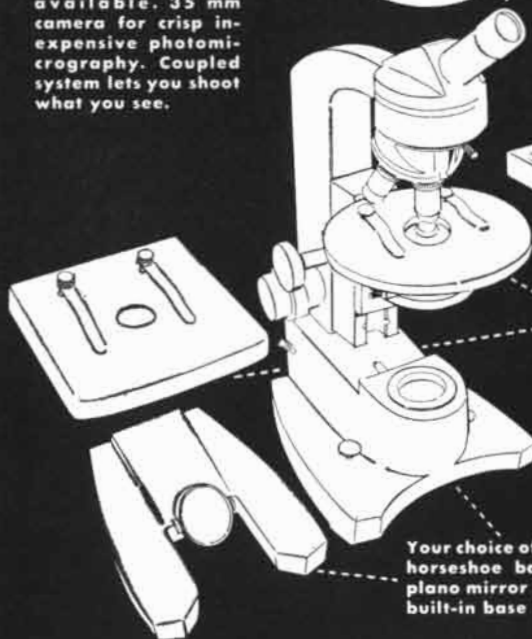
Special inclined monocular and vertical monocular bodies available. 35 mm camera for crisp inexpensive photomicrography. Coupled system lets you shoot what you see.



Choice of 3 interchangeable full 360° rotatable bodies, monocular, binocular and trinocular; inclined for comfort.



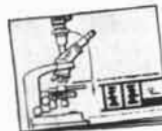
The large fork-type condenser mount allows you to interchange bright-field, phase and dark-field condensers quickly and precisely.



Focus the stage and the specimen to the objectives with low positioned coarse and fine adjustments. Choose from 3 interchangeable stages; graduated or ungraduated mechanical stages or the new Micro-Glide circular stage.

Your choice of interchangeable horseshoe base with double-plano mirror in fork mount, or built-in base illuminator.

Get your copy of the complete Microstar story. Write for BROCHURE SB124.



American Optical Company

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

"WHY I LIKE MY NEW Contoura-Matic"



"IT'S SO COMPACT AND
EASY TO OPERATE."



"COPIES EVERYTHING—EVEN
COLORED PENCIL NOTATIONS."



"THIS DISPOSABLE CHEMICAL
CARTRIDGE MEANS NO MORE MIXING."

\$189



• Least expensive automatic. Weighs only 12 lbs. Takes ½ the space of a typewriter. Write for folder.

Contoura-Matic

F. G. Ludwig, Inc., 1502 Coulter St., Old Saybrook, Conn.

were used to drive a generator (the turbine now attached to the EBWR is too small), the cost of the electricity produced would be an estimated 32 mills per kilowatt hour. This is the lowest figure for any U. S. reactor, representing a 40 per cent reduction from the present 52-mill cost of electricity from EBWR.

The increase in rating was achieved without changing the design of the reactor, simply by pulling out the control rods farther than was envisaged in the original operating specifications. This makes the water surrounding the core boil faster, thus increasing the rate of circulation and the rate at which heat can be extracted. The reactor responded so well that Argonne designers now contemplate a revised version that might cut costs to about 20 mills. Such a figure would be economical even today in some areas. In 10 years or so, the engineers believe, it should be possible to build a boiling reactor to produce electricity at 10 mills per kilowatt or less, which would be competitive with conventional power over much of the U. S.

As the name implies, a boiling-water reactor is one in which the cooling water is converted directly to steam in the reactor core and used to drive a turbo-generator. In other designs the coolant is not allowed to boil, but transfers its heat via an exchanger to a secondary water circuit in which the steam is raised.

Number Three

"Explorer," the third artificial satellite, was launched by the U. S. Army at 10:48 p.m. on January 31. It carries equipment for three geophysical experiments. Cosmic rays are recorded by a Geiger counter; temperatures at the outside surface and within the satellite are measured by their effect on the electrical resistance of strips of zirconium oxide; the impacts of micrometeorites are detected by a series of external wire meshes and by an interior microphone which picks up the sound of their collisions with the skin. The readings of these instruments are relayed to the ground by radio. There are two transmitters, one sending a 60-milliwatt signal at 108.03 megacycles and the other a 10-milliwatt signal at 108 megacycles. All countries participating in the International Geophysical Year have been informed of the telemetering code used in the transmissions.

The satellite, together with the case of its final rocket stage, is a cylinder 80 inches long and six inches in diameter. It weighs 30.8 pounds, of which instru-

ments, radios and batteries account for 11 pounds. Explorer was launched from Cape Canaveral, Fla., in a southeasterly direction at an angle of about 33 degrees to the Equator. Its orbit, as established by early radio observations, takes it around the earth in 114.95 minutes, passes within 219 miles of the ground at the closest approach and reaches a maximum height of 1,587 miles.

Having the brightness of a star of the fifth or sixth magnitude, the satellite is not easily visible to the naked eye. Initial tracking was done entirely by Mini-track radio stations. A receiving system designed especially for Explorer, called Microlock, can pick up the signal of a one-milliwatt transmitter at a distance of 20,000 miles.

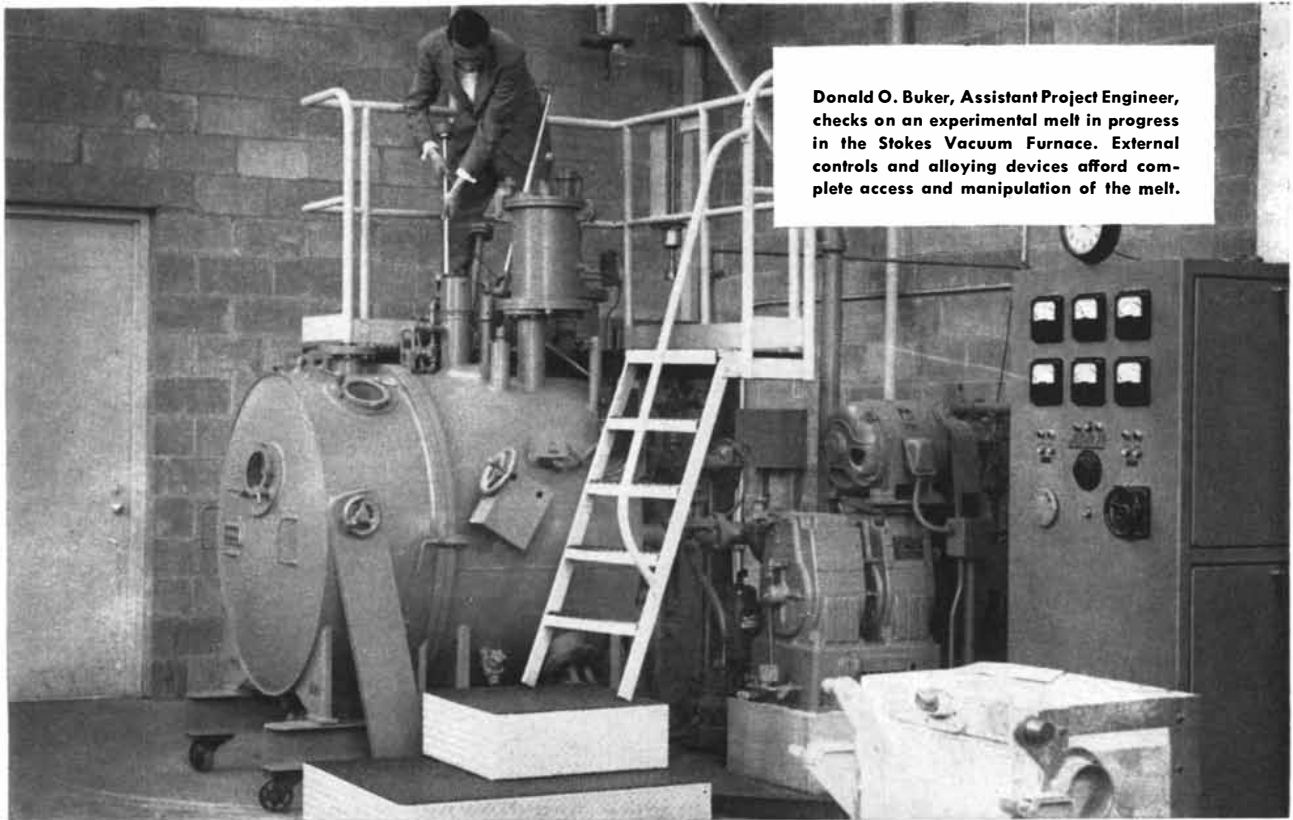
The four-stage rocket assembly which put the satellite into its orbit was reported to weigh 65,000 pounds at take-off. The first stage, a liquid-fueled Redstone rocket, developed 78,000 pounds of thrust and boosted the assembly to a height of 53 miles before exhausting its fuel and falling away. At this point the remaining stages had enough speed to coast to 200 miles. Then the last three stages, consisting of clusters of small solid-fueled rockets, were fired by remote control from the ground. They gave the satellite the necessary horizontal speed, about 18,000 miles per hour, to go into a stable elliptical orbit.

Science and the Budget

The President's budget for the fiscal year 1959 proposes a modest increase in Federal spending for science. Planned expenditures for research and development have been raised by 8.5 per cent over 1956 to a total of \$3,722 million. About four fifths of this total is scheduled for weapons research.

Basic research fares somewhat better in proportion: funds for it are set at \$285 million, a rise of nearly 25 per cent. The augmented figure, however, still represents less than 8 per cent of the total research budget. Basic research will also benefit from Department of Defense plans to transfer \$100 million of already appropriated funds to research. If Congress approves these plans, about half the sum is said to be earmarked for basic investigations.

The National Science Foundation, principal Federal civilian scientific agency, has had its budget tripled. The sharpest increase was in funds for developing student interest in science, improving teaching methods and teacher training, and for fellowships for ad-



Donald O. Buker, Assistant Project Engineer, checks on an experimental melt in progress in the Stokes Vacuum Furnace. External controls and alloying devices afford complete access and manipulation of the melt.

Vanadium Corporation of America keeps Stokes Vacuum Furnace busy in Ferroalloy research

A Stokes Vacuum Furnace System, installed in the Cambridge, Ohio Research Center of Vanadium Corporation of America is kept constantly on the go . . . exploring new ideas that may be applied to production procedures for ferroalloys and master alloys.

For example, various vanadium-containing alloys have been remelted . . . to determine property improvement and extent of gas removal under specified temperature and pressure conditions. Another use involves the melting of higher titanium-content alloys which would oxidize excessively in air. The research center is also concerned with alloys containing boron, calcium, lithium, chromium, magnesium, columbium and tungsten.

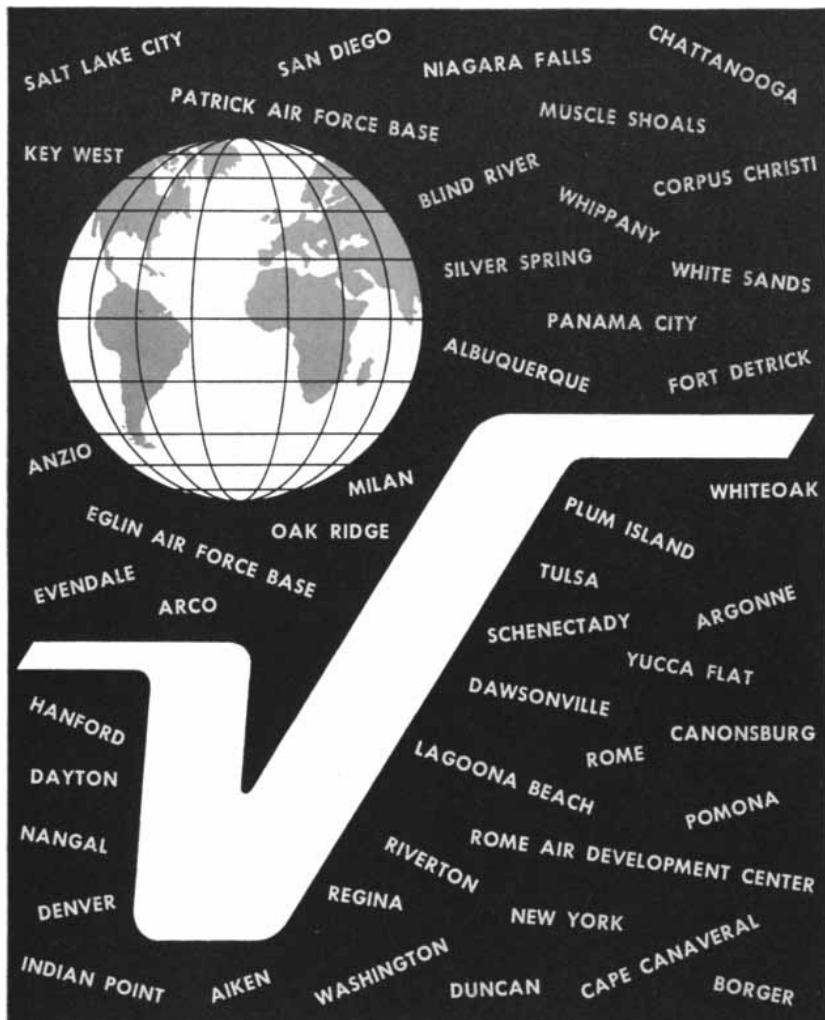
T. W. Merrill, Director of Product Research, advises "we have found that the furnace performs very satisfactorily, has met all our expectations in this regard."

Stokes Vacuum Furnaces are extremely flexible, ruggedly built units, designed for developmental or production runs . . . in sizes ranging from 17 lb. to greater than 5,000 lb. melts. Production units are fully engineered with charging and mold vacuum locks for semi-continuous operations. In all these units, a broad selection of accessories and features is available. Of particular interest is the fact that, as in the case of Vanadium, Stokes easily makes special customer accommodations to meet individual requirements.

Complete technical information and specifications are available on Stokes Vacuum Furnaces and accessories. For detailed application engineering, the Stokes Advisory Service is available for consultation and recommendations concerning your exact requirements. Write today.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES



Vitro... a leader

in the place names of progress

In these—and many other—place names of progress, Vitro engineers and scientists play key rôles in modern technology.

In weapon systems, nuclear energy, extractive metallurgy and other technologies of the Atomic Age, Vitro is one of America's leaders.

Vitro

CORPORATION of AMERICA

261 Madison Ave., New York 16, N. Y.

- ☞ Research, development, weapon systems
- ⊗ Nuclear and process engineering, design
- ⚙ Refinery engineering, design, construction
- ⚙ Uranium mining, milling, and processing
- ⚙ Thorium, rare earths, and heavy minerals
- ⚙ Recovery of rare metals and fine chemicals
- ✈ Aircraft components and ordnance systems
- ⊗ Ceramic colors, pigments, and chemicals

vanced study; these are to increase 400 per cent over last year. NSF Director Alan T. Waterman told a House of Representatives subcommittee, however, that the budget provided only \$40 million of the \$50 million the Foundation had asked for basic research, and only half of an additional \$25 million it had asked for the construction of research facilities.

The budget also proposes a temporary program of assistance to state and local educational authorities. This includes plans to spend \$605 million over five years to improve science and mathematics teaching in primary and secondary schools. These funds, which would match state and local grants, could be used to hire consultants on educational methods, increase salaries of teachers and purchase laboratory equipment.

One Third of IGY

Far below the northeast-flowing Gulf Stream another current carries water in the opposite direction; the thin hydrogen atmosphere which forms the corona of the sun may actually fill the void between earth and sun; auroras are visible at the same time in both hemispheres; the air at the South Pole contains as much carbon dioxide as industrial regions but has more ozone than New Mexico. These are a few of the discoveries made during the first third of the International Geophysical Year. The interim report was made by Hugh Odishaw, executive director of the U. S. National Committee for the IGY, in *Science*.

It has been found that X-rays are emitted by solar flares. When the X-rays reach the earth's atmosphere, they ionize a region below the D-layer (normally the lowest layer of the ionosphere). The additional layer, which may be about 12 miles thick, evidently absorbs short-wave-radio pulses and causes the "black-outs" in radio communications often noted after a solar flare. The normal ion distribution above the D-layer seems to remain undisturbed during a blackout.

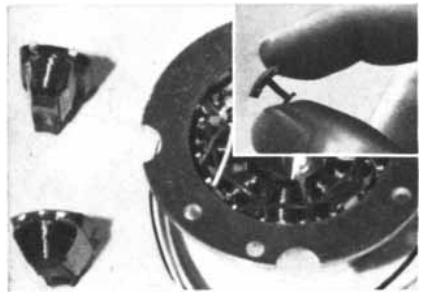
Observations from stations in the eastern Pacific confirm the existence of an electric current flowing high in the atmosphere above the Equator. This "electro-jet" may be evidence of a river of current circling the earth. It had been speculated that certain magnetic effects could be accounted for by three such rivers, one circling the earth at the Equator, the others circling the North and South magnetic poles.

The whistle-like signals originating in lightning flashes at the surface of the

Electronics Go Miniature

► Silicones Provide the Means

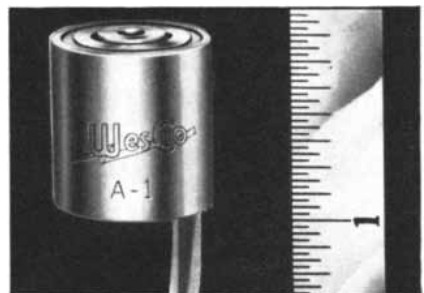
SMALLER, STRONGER MIDGETS WITH SILICONES—*Smaller, always smaller. Save weight, save space. These are standard in electronic specifications. As a result today's miniatures for home, industry and defense often pack as much power as their bigger predecessors. But when heavy work loads are concentrated in small units, heat problems frequently arise. Here's how Dow Corning Silicones help subdue the heat and make possible the highest efficiency for these electronic midgets.*



blies, such as calibrators, synchros, and similar components, the Servo is a fine example of how space and weight can be saved with silicones.

IT TAKES PULL — Solenoids are magnetic coils that “suck in” a metal plunger to activate a circuit, and they're rated on their pull. Naturally, you'd expect this pulling power to diminish with size. But with silicone insulation you actually get *more* pull in a smaller package.

By using Dow Corning silicone insulating components and Sylkyd* enameled magnet wire, the West Coast Electrical Manufacturing Corporation, of Los Angeles, produces miniature solenoids of surprising strength. The WESCO A-1, for example, weighs only 2½ ounces, yet



can pull 3½ pounds. An intermittent duty unit, the A-1 saves space and weight for manufacturers of industrial computers or airborne electronics systems. Another big plus: Silicones increase the solenoid's rated service life five times!



RUBBER SKULL-CAP — SAC's Snarks have silicones on the brain. Delicate electronic “thinking” centers in these missiles are embedded in RTV Silastic*, the Dow Corning silicone rubber that vulcanizes at room temperature.

Northrop Aircraft, producer of the Snark, finds that RTV Silastic fills a multitude of needs. First, it's easy and fast to apply . . . they squeeze it from a gun as you would a caulking compound. It sets up to a rubbery solid within 24 hours. Then come the operational advantages: RTV Silastic cushions the circuits against vibration or rough handling, protects against moisture, improves electrical properties, and is easily repaired with more RTV when it's necessary to open a unit for repairs.

No other material could supply these features and withstand heat in the bargain. That's why, for the Snark's intricate electronic brains, skull sessions start under RTV Silastic.

*T.M. REG. U.S. PAT. OFF.

“MIGHTY MITE” — To provide power in certain electronic control systems, Minneapolis-Honeywell has evolved a tiny new Servo motor. No larger than a golfball, and weighing a mere two ounces, this little unit nonetheless develops a stall torque of 0.75 ounce inches and will withstand operating temperatures of 500 F and higher.

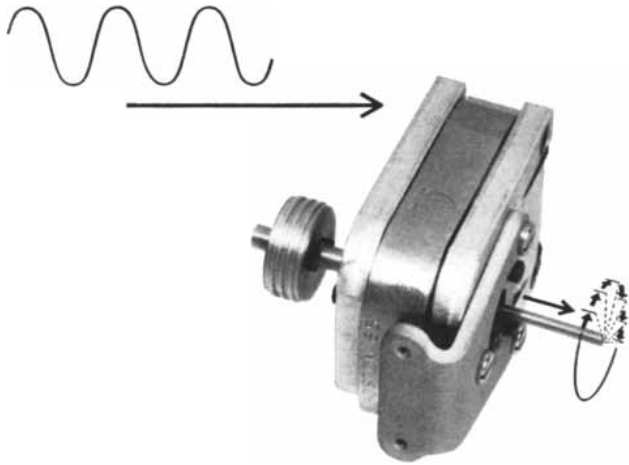
Secret of the Servo's efficiency? Silicones. Dow Corning insulating resins and molding compounds are used extensively. They make sure of the mighty mite's ability to stand up under heavy duty. Designed to drive various of Honeywell's control system assem-

FOR MORE INFORMATION on any of these silicone products or applications, write Dept. 983.



Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D. C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS



99% magnetic stepping motor— 1% moving part (TOUCHES ONLY BALL BEARINGS)

... 8000 STEPS PER MINUTE

... INSTANT START, NO SLIP, NO CLATTER

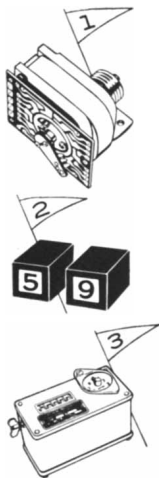
... IT WORKS

THE SIGMA CYCLONOME® STEPPING MOTOR* behaves like a 10-pole synchronous motor, but because of small inertia and high torque it comes to a dead stop between *each half cycle* up to rated maximum of 130 cps. It continues to run synchronously at frequencies well above this maximum, but eventually fails to stop on command on a selected pole.

Since stopping and starting torques are roughly equal, it makes a good counter of cycles or pulses. It accepts sine waves or square pulses, but requires reversals. These reversals may be provided by straight AC signals, DC pulses supplied alternately to separate windings, or DC pulses to one winding with a reference or bias DC in the other.

As proof that this dandy little motor works and can do some useful jobs, three "for instances" that we've built are shown. In (1), some rather elaborate switching is done by a commutating switch driven by the motor. At (2), it functions as a self-checking digital readout switch. In the third example (3), the motor is housed with and drives a 6-digit Veeder-Root register at rates up to 8000 CPM (sold for some time as the Sigma Cyclonome Counter).

*Pat. app. for



TYPE 12D CYCLONOME STEPPING MOTOR SPECS INCLUDE:

TORQUE OUTPUT: approximately 100 gram-cm. for every 18° of rotation (optimum input signal)

INERTIA: 0.6 gram-cm².

INPUT POWER: ½ to 12 watts depending on speed requirements

SIZE: 2½" x 2½" x 1½"

• Why you would want to get shaft
• positions out of electrical cycles is, of
• course, your business, but there is a
• thinly disguised feeling around here
• that (maybe?) one of these gadgets
• might be just what you've been looking
• for. If you can withstand the Tumult
• and get past the Lions, you can see a
• Cyclonome Motor stepping at BOOTH
• 2628-2630, at the athletic contest in
• March. If not, write for Bulletin.

SIGMA INSTRUMENTS, INC.

40 Pearl Street, So. Braintree 85, Massachusetts

earth are being used to study the farthest reaches of the atmosphere. The "whistlers," which swing far out into space in their journey from hemisphere to hemisphere, have been found to encounter ionic and molecular particles in unexpected density even at altitudes of twice the earth's radius. This seems to indicate that the atmosphere extends much farther than had been thought.

It was known that cosmic rays which shower the earth are attracted toward the magnetic poles, but surprisingly the "cosmic ray equator" (where cosmic ray intensity is lowest) has been found to deviate from the magnetic equator. The warping may indicate the presence of heretofore-unknown magnetic fields in space which alter the path of incoming cosmic ray particles.

Study of the earth's interior has been enhanced by the discovery that earthquake waves of intermediate length travel through the mantle (the layer below the outside crust of the earth). These waves, which have periods of about 100 seconds, reveal details that cannot be detected with the longer 400-second waves which had previously been used.

IGY scientists are probing the earth with instruments which measure changes in gravity in order to map the irregularities in the earth's shape. They are digging out cores of ice from polar icecaps to trace the history of the earth's climate, shooting up rockets to probe space, hauling up living sea-creatures from record depths. Weather reports from Antarctic stations have already improved forecasting in countries throughout the Southern Hemisphere, since cold fronts begin at the poles.

Other discoveries were disclosed after Odishaw's article had appeared. Sea levels in both Northern and Southern Hemispheres fall in the spring. In the Northern Hemisphere the average sea level is eight inches lower in March than in September, but mysteriously the volume of water lost in the north apparently does not show up in the southern seas. Part of an ice shelf in Antarctica has turned out to be a huge snow-covered island about 230 miles wide and 180 miles long. The island, formerly thought to be the Filchner Ice Shelf, lies in the Weddell Sea, east of Palmer Peninsula and south of the Atlantic Ocean.

Krypton Yardstick

The precious bar of platinum and iridium at Sèvres, France, against which all the world's distance scales are

How to speed up a digital computer

New Ampex Digital Tape System quickens input and output

Ampex's new digital tape equipment is to computers as a super-super highway would be to 1958's new 300 horsepower automobiles. Computer arithmetic can move at electron speeds—but previous input/output rates have been like bumper-to-bumper traffic. Now the jam is broken.

60,000 six-bit characters per second is one of several transfer rates available on the new Ampex Digital Tape System. Depending on how you can accept the data, some Ampex rates are even faster, others are somewhat slower.



FR-300 Digital Tape Handler

To achieve a livelier pace . . . a SYSTEM of new equipment

In a complete digital computer, the Ampex equipment provides two neatly packaged functions: input source and output receiver. By treating these as systems unto themselves, Ampex achieves optimum performance and reliability. In them, four interdependent items have been matched: tape handler, heads, amplifiers and magnetic tape. For the total result, the four are inseparable.

The Ampex FR-300 tape handler operates at 150 inches per second. With this new speed plus other format improvements contributed by the other Ampex components, transfer rates can be increased up to six fold over previous standards. Search times too can be reduced to one sixth.

The FR-300 starts or stops in 1.5 milliseconds. These times can be depended upon indefinitely. Hence they drastically reduce the buffer storage requirements of the computer system. Also, inter-



Complete Electronic Assembly

record distances are accurate and are shortened by half.

Despite its race-horse gait, the FR-300 is a workhorse machine thoroughly tested and perfected in a year-long component shakedown. Its dependability and low maintenance requirements are aimed at increasing the computer's available working hours per day.

Two other Ampex tape handlers, the FR-400 and FR-200A operate at lower speeds, serving smaller computers and auxiliary digital equipment such as converters, printers, etc.

Read/write heads and amplifiers work together to achieve higher bit-packing densities. On the Ampex system, the 200-bit-per-inch standard is conservative. Ampex's new heads can resolve pulses much closer than this. And the amplifiers easily handle the tremendous transfer rates achieved when closer bit packing and high tape speeds are combined. All-transistor design of the amplifiers achieves extreme reliability and compactness.

Ampex computer tape, a new specially formulated type, plays a key part in system reliability. To reduce significant dropouts and spurious noise to zero, the tape is manufactured in a completely air-conditioned plant. Employees wear lintless "surgical" clothing. And each reel is individually tested and packaged within two hermetically sealed wraps.

A tough new oxide binder on Ampex Computer Tape withstands many times the use of any previous "long wear" tapes. Virtually no oxide rubs off; heads need much less frequent cleaning. Precision reels, available as an option, protect the tape edges from damage and improve tape handling and guidance.



A newly published brochure is available describing all components of the Ampex Digital Tape System and explaining performance specifications. May we send you a copy?



Series FR-100



Model FR-400 Digital



Model FR-200A Digital



Series 800 Mobile and Airborne



Series FL-100 Loop Recorder



Model MR-100 Missile Recorder

INSTRUMENTATION
DIVISION

AMPEX
CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

SPACE
IS
Valuable

... So Use
the **A. W. HAYDON**
company's
**SUB-MINIATURE HERMETIC
ELAPSED TIME INDICATORS.**

You, too, can afford the space to keep track of time! From now on, these really small (1¼") Elapsed Time Indicators will keep company with the best of Electronic Miracles.



The illustration shows how the operating time of various sections of an electronic console can be monitored.

The dial type units read up to 2,500 hours in one hour increments, while the digital type units read up to 9999.9 hours in one-tenth hour increments. Designed for military applications, these 4½ ounce units can save valuable panel space in industrial and electronic applications.



The 400 cycle models now in production are described in Bulletin AWH ET 602.



What's the best way to measure radioactivity?

There are six main counting systems used to measure radioactivity. Of these, the NMC proportional counter offers the following advantages:

VERSATILITY—Detects every type of activity. Counts wider range of specific activity and energies. Handles more sample types.

YIELD—Highest yield possible in flat sample counting; full 2 pi geometry.

BACKGROUND—Lowest of the six.

PRECISION—Exceeded by none.

OPERATION—Counts more samples per hour than any other system.

DECONTAMINATION—Only system in which all standard chambers can be decontaminated in less than 10 minutes.

APPLICATION—Only system that effectively counts such widely differing isotopes as H-3, BaCO₃, C-14, P-32, S-35, K-40, Ca-45, Fe-59, Ni-63, Zn-65, Au-198, Fe-55, Pa-210, Th, U and Pu-239.

These are the main reasons why the NMC proportional counter is the most widely used system . . . why we recommend it as the best way to measure radioactivity. For proof, send in your sample for a precise count. Or ask for Data File SA-3.

NUCLEAR MEASUREMENTS CORP.

2460 N. Arlington Ave. • Indianapolis 18, Ind.
Telephone collect: LIberty 6-2415

POSITIONS AVAILABLE IN . . .

- Mathematics
- Physics
- Chemistry
- Aeronautics
- Electronics

... as analytically applied to the scientific evaluation of aerial combat systems.

The Institute for Air Weapons Research is engaged in the study of aerial combat systems for the Air Research & Development Command, United States Air Force. The Institute is interested in people with broad scientific background together with specialized knowledge in a field such as applied mathematics, mathematical probability, statistics, physics, or the engineering sciences. Excellent opportunities for advancement and formal education. Salaries commensurate with individual background and aptitude.

write to

**INSTITUTE FOR
AIR WEAPONS RESEARCH
UNIVERSITY OF CHICAGO
MUSEUM OF SCIENCE AND INDUSTRY
CHICAGO 37, ILLINOIS**

theoretically checked, may soon be melted down for wedding rings. An international advisory committee for the definition of the meter has now recommended the adoption of an atomic standard of length—an orange spectral line of krypton 86. The meter is to be defined as 1,650,763.73 times this wavelength. The krypton line is the sharpest of those currently available for length measurement. In practice a line of mercury is more commonly used, and probably will continue to be for ordinary laboratory measurements.

Radioactive Waste Disposal

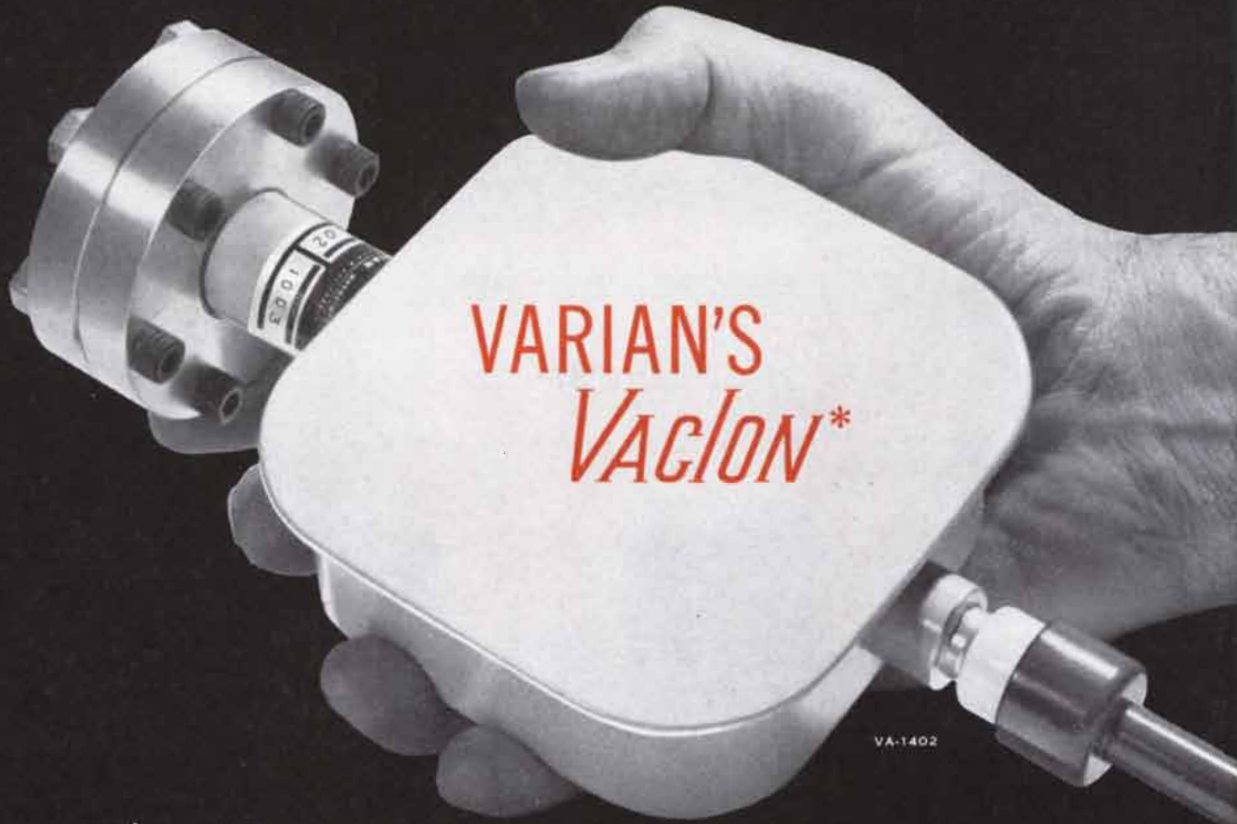
If atomic power is to be developed on an important scale, methods will have to be found for safely disposing of the vast quantities of radioactive "ashes" that will be produced by nuclear reactors. Last month a committee on waste disposal appointed by the National Academy of Sciences reported the results of a preliminary investigation of the problem.

At present, the committee said, the safest and most economical way to get rid of radioactive fission products is to store them in tanks. In the near future it should become feasible to bury the waste in underground salt deposits, either in worked-out salt mines or in formations especially hollowed out for the purpose. These deposits are impervious to water and can be used as natural storage tanks.

The next most promising method, economically, is to incorporate the waste into ceramic bricks which can be buried or kept in isolated sheds. A more remote possibility is to pump the material into porous subterranean limestone. Before this could be done, however, it would be necessary to find out how to prevent the waste solutions from clogging the pores of the stone.

Raw waste must be isolated for 600 years. But if the long-lived isotopes cesium-137 and strontium-90 are extracted, concentrated and disposed of separately, the remaining material will have to be contained for a period of only about 60 years.

Location of nuclear power stations and more particularly of fuel reprocessing plants should be planned with an eye to the accessibility of disposal sites, the committee warned. Many large areas of the U. S., for example the Atlantic seaboard, offer no convenient sites. Regarding the atomic power plant now under construction at Indian Point, N.Y., the report states that "almost certainly . . .



A
COMPLETELY NEW HIGH VACUUM PUMP

*TRADE MARK



VA-1403 PERMANENT MAGNET



VA-1302 POWER SUPPLY

Used where clean high vacuums are required... processing vacuum tubes... evacuating accelerator sections and ionization chambers... laboratory and industrial applications.

SIMPLICITY ITSELF—

The Vaclon high vacuum pump operates entirely electronically — no moving parts.

NO OIL VAPORS—

Cold traps or vapor traps are not necessary.

ULTRA HIGH VACUUM—

Creates vacuum in excess of 1×10^{-7} mm of Hg; one trillionth of an atmosphere. This small compact unit has a pumping speed of 10 liters/second at 10^{-7} mm of Hg.

LOW POWER CONSUMPTION—

At 10^{-8} mm Hg power consumption is only 0.24 watts. No continuously running fore-pump is required.

MEASURES ITS OWN VACUUM—

The current indication on the power supply meter provides a practical measurement of pressure.

SIMPLE INSTALLATION—

Complete unit consists of the Vaclon Pump shown above, a permanent magnet, and a power supply.

ONLY FROM VARIAN—

The Vaclon high vacuum pump has no equal for simplicity, cleanliness, and compactness. Get the complete story in the Vaclon High Vacuum Pump Engineering Bulletin — write for your copy today.

See it at the I. R. E.
 Booths Nos. 2911-13-15

THE
 MARK OF
 LEADERSHIP



VARIAN associates
TUBE DIVISION
 PALO ALTO 7, CALIFORNIA

Representatives thruout the world

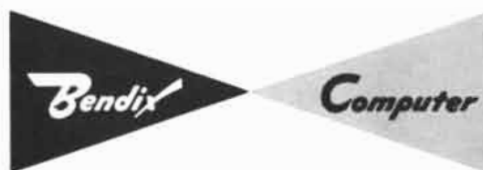
KLYSTRONS, TRAVELING WAVE TUBES, BACKWARD WAVE OSCILLATORS, LINEAR ACCELERATORS, MICROWAVE SYSTEM COMPONENTS, R. F. SPECTROMETERS, MAGNETS, MAGNETOMETERS, STALOS, POWER AMPLIFIERS, GRAPHIC RECORDERS, RESEARCH AND DEVELOPMENT SERVICES



“We learned to use the
Bendix G-15
computer in just
four hours.”

Anyone who can learn to operate a desk calculator can now use an electronic computer. New techniques developed for the Bendix G-15 Digital Computer make it so easy to use that the fundamentals can be mastered in thirty minutes... a working knowledge of programming in four hours or less. The G-15 can be used by the men who know their own problems best, right in their offices and laboratories, and often at 1/10th the cost of “computing center” installations.

G-15 ADVANTAGES Memory and speed of computers costing four times as much • Paper tape output and 250 char/sec paper tape input at no added cost • 1,200,000 words of magnetic tape memory available • Punched card input-output available • Extensive library of programs furnished • Strong users' sharing organization • Proven reliability • Nationwide sales and service • Lease or purchase.



DIVISION OF BENDIX AVIATION CORPORATION

Built and backed by Bendix, the G-15 is serving scores of progressive businesses, large and small, throughout the world. For the details, write to Bendix Computer, Department C-2, Los Angeles 45, California.

waste cannot be disposed of safely anywhere near this site.” Prospects at the Savannah River installation of the Atomic Energy Commission are “equally gloomy.”

The committee pointed out that the costs of storing radioactive fission products temporarily to “cool” them, of extracting long-lived isotopes and of shipping waste to distant points for ultimate disposal will have a major influence on the economics of nuclear power. The group urged that research be undertaken on the movement of liquids through porous rock, and that geologists and hydrologists be educated in the problem of radioactive-waste disposal.

Mental Retardation

That social factors play an important role in mental retardation is the conclusion of a three-year survey of research in the field. The report, by Seymour B. Sarason of Yale University and Thomas Gladwin of the National Institute of Mental Health, was released by the National Association for Retarded Children.

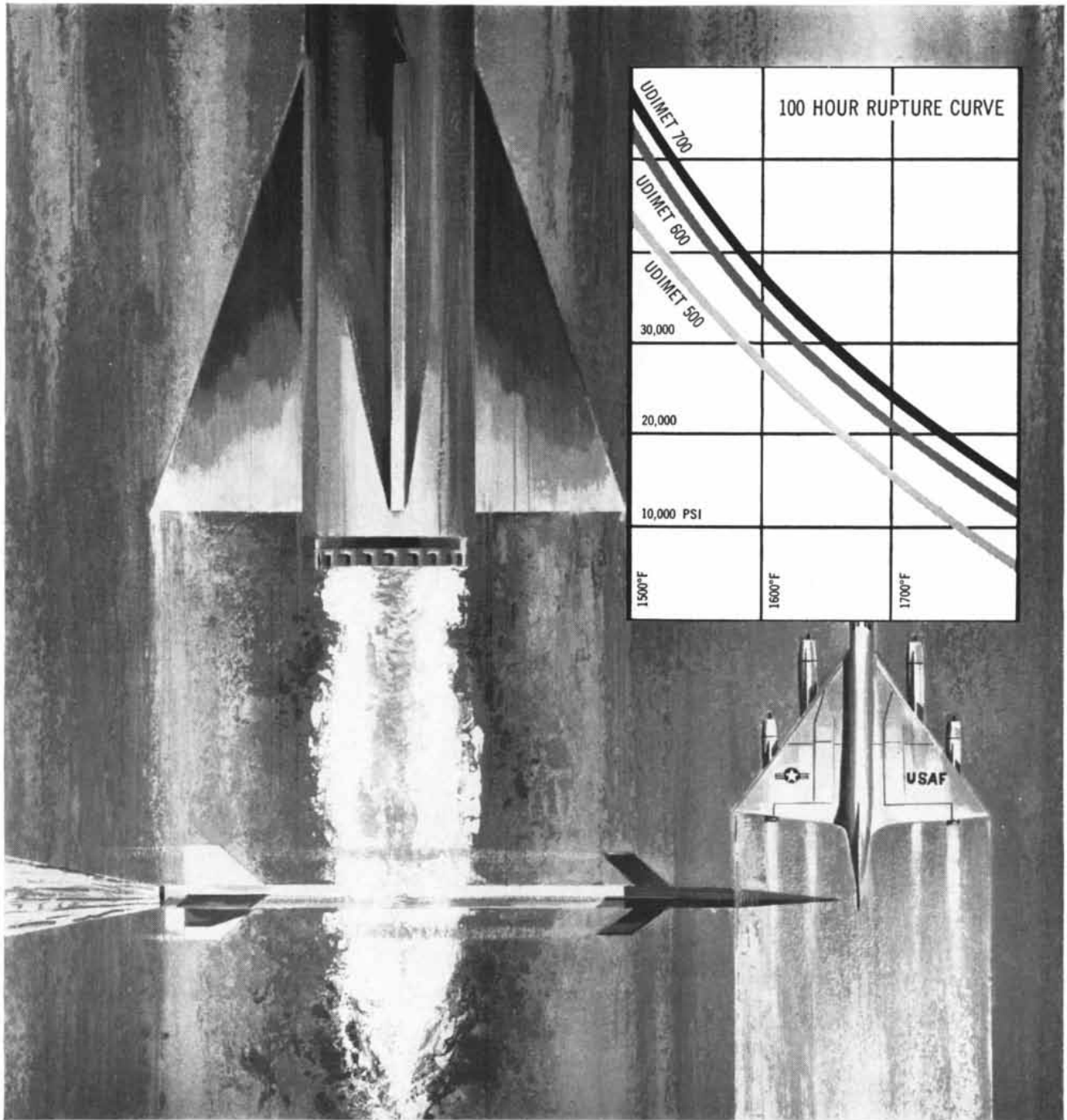
The survey stated that individuals whose retardation is not due to central-nervous-system damage come largely from the lowest economic groups, from culturally distinct minorities or from regions with poor educational facilities. Yet there has been no systematic study of how these social factors impede individual development.

Present methods of measuring mental capacity, the report said, seem to be faulty: many individuals classified as subnormal in school manage to function quite normally in later life.

Turning to the psychological problems of the retarded child, the report said that scientists have tended to assume that the deviant behavior of such a child is entirely “explained” by his low I.Q. There has been little attempt to clarify the mutual effects of intellectual and personality abnormality.

A companion study of the organic causes of mental deficiency, by Richard L. Masland of Wake Forest University, suggested that the hereditary factor in deficiency had been exaggerated. While some mental deficiency is hereditary, much of it is caused by prenatal damage, birth injury or diseases of early childhood.

Both studies stressed the need for further research in the field. More than 3 per cent of the babies born in this country each year, they stated, will never reach a 12-year level of intelligence.



MANY VACUUM INDUCTION MELTED METALS AND ALLOYS CAN NOW BE PRODUCED IN HEAT SIZES UP TO 5,000 LBS. BY UTICA METALS DIVISION

announcing Udimet 600 and 700

for a wider range of applications at elevated temperatures!

With the development of these two new alloys, the Utica Metals Division of Kelsey-Hayes scores another materials "break through" with vacuum induction melting. Producing only by the vacuum induction melting process, *Udimet 600 and 700 surpass the elevated temperature properties of any other known alloy which can be produced in quantity for critical high-temperature, high-stress requirements.* They not only possess excellent stress-rupture qualities but also exhibit high tensile strength at temperatures above 1500°F.

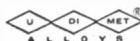
Like Udimet 500, Udimet 600 is now available in production quantities. Udimet 700 is available for development applications. Write for complete information.

vacuum induction melting develops

- High-temperature corrosion resistance
- Increased ductility
- Extreme cleanliness
- Precise chemical control
- Longer stress-rupture life
- Increased tensile strength
- Better fatigue resistance
- Greater yield strength
- Greater impact resistance
- Greater creep properties

UTICA METALS DIVISION OF **KELSEY-HAYES**

KELSEY-HAYES CO.

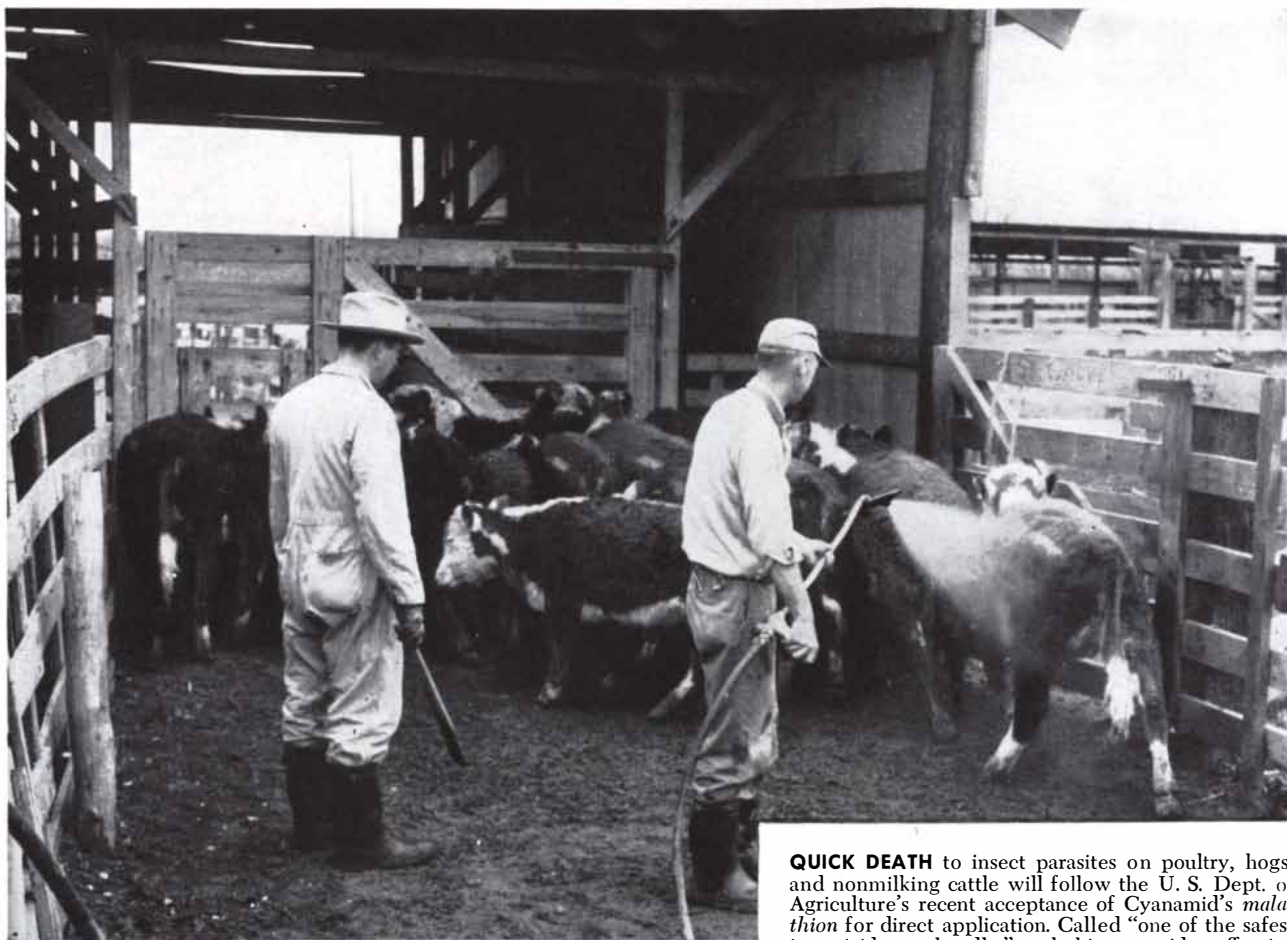


UTICA 4, NEW YORK

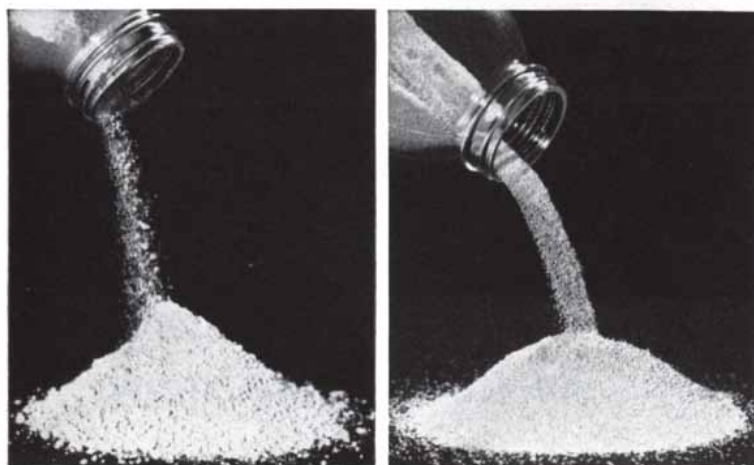
© T. M. REGISTERED

SOME ALLOYS COVERED BY U. S. PATENT #2809110

Life on the Chemical Newsfront



QUICK DEATH to insect parasites on poultry, hogs, and nonmilking cattle will follow the U. S. Dept. of Agriculture's recent acceptance of Cyanamid's *malathion* for direct application. Called "one of the safest insecticides to handle," malathion provides effective control of lice on swine, and lice and ticks on cattle. It is specially valuable in louse control, where indications are that it kills eggs as well as adults, thus extending protection. The broad-spectrum killing power of malathion is particularly useful on poultry where lice, mites and ticks are simultaneously brought under control. (Phosphates and Nitrogen Division)



NEW FREE-FLOWING PELLETS permit rubbermakers to handle the popular MBTS *Accelerator* with less dust and greater accuracy. The lumping and dusting typical of the powdered material are eliminated by these formed spherical pellets that pour freely and, shown on the right, are virtually dust-free. In the mixing operation, Cyanamid MBTS Pellets crush instantly and disperse uniformly. Pelletizing is the latest of several innovations made by Cyanamid's Rubber Chemicals Department toward producing a benzothiazyl disulfide accelerator with optimum handling and performance characteristics. (Organic Chemicals Division)

PUTTING A "BACKBONE" IN WATER is a recently developed role for *N,N'*-methylenebisacrylamide. Used in conjunction with acrylic monomers, it forms stable gels in which the water content runs as high as 95%. Added to the monomers which give normally water-soluble polymers, *N,N'*-methylenebisacrylamide forms stiff gels impermeable to water due to its cross-linking action. The setting time of each gel can be controlled to range from several seconds to hours. A data sheet is available from Cyanamid.

(Market Development Department)



STILL TOPS IN COLOR PERMANENCE are the Vat Dyes used for cottons, washable rayons and linens. Fixed for the life of these textile fibers, Vat Dyes withstand all the sun, wear and washing that the fabric itself can tolerate. Cyanamid *Vat Dyes* are available in an ever-widening color range, each conforming to the rigid industry standards endorsed by the Vat Dye Institute to which Cyanamid belongs. Buyers are assured of this high-quality performance when garment tags bear the statement "Guaranteed Vat Color." (Organic Chemicals Division)



REDUCING RAW MATERIAL AND PROCESSING COSTS are some of the benefits obtained through the use of **CYQUEST 40*** *sequestering agent*. Producers and purchasers of raw materials can use this remarkable sequesterant to maintain high-quality standards while avoiding costly purification steps to remove metal ions that spoil color, cause turbidity and catalyze degradation reactions. **CYQUEST 40** ties up troublesome metal ion impurities in raw materials, eliminating their detrimental effect on processes and products.

(Industrial Chemicals Division)

*Trademark

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

For further information on these and other chemicals, call, write or wire American Cyanamid Company



HUGE PROTON SYNCHROTRON under construction at Brookhaven National Laboratory is photographed from the air. Circular

tunnel housing its doughnut is 840 feet in diameter. This machine will produce particles of 25 to 30 billion electron volts (bev).

PARTICLE ACCELERATORS

The evolution of these huge machines is still proceeding at a lively pace. They are used for two purposes: to “see” fundamental particles of matter and to create new ones

by Robert R. Wilson

From time to time in the course of history men have been swept up by intense currents of creative activity. In the pyramids of Egypt, in Greek sculpture and in Florentine painting we find monuments to such bursts of expression. My favorite example is the Gothic cathedrals that so magically sprang up in 12th- and 13th-century France, for I like to relate that magnificent preoccupation with construction to an obsession of our own time—the building of nuclear accelerators.

Like nuclear physics today, religion at that time was an intense intellectual activity. It seems to me that the designer of an accelerator is moved by much the same spirit which motivated the designer of a cathedral. The esthetic appeal of both structures is primarily technological. In the Gothic cathedral the appeal is primarily in the functionality of the ogival construction—the thrust and counter-thrust that is so vividly evident. So, too, in the accelerator we feel a technological esthetic—the spirality of the orbits of the particles, the balance of electrical and mechanical motion, the upward surge of forces and events until an ultimate of height is reached, this time in the energy of the particles. In both cases we find the architects working at the very limit of technical knowledge. In both there is intense competition between localities, regional and national. Both structures are expensive: a really large accelerator can cost \$100 million; the cost of a cathedral, in terms of medieval economics, was possibly higher.

But where a cathedral was a community enterprise, with many people in the region participating in its financing and construction, and nearly everyone in its enjoyment, an accelerator is esoteric. Its presence in a community is usually unknown and unsung. Few are the workers

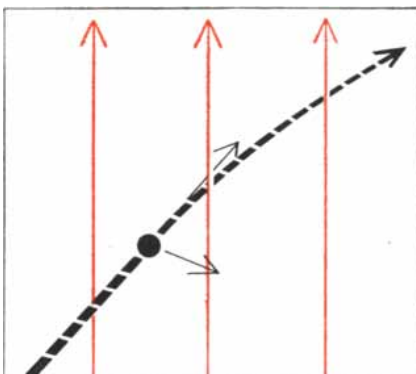
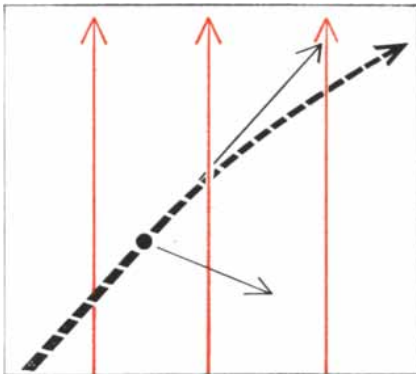
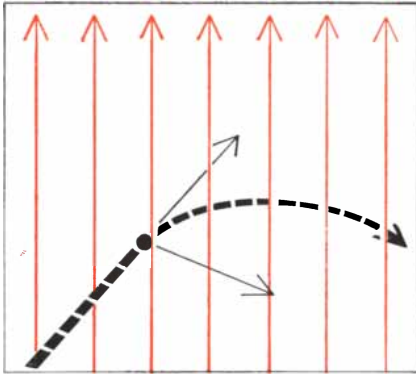
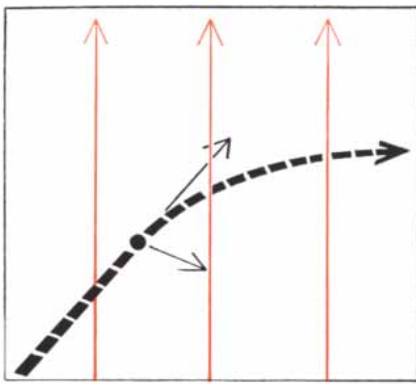
who help to build it, and fewer still are those who use it.

So the accelerator building boom goes on largely unnoticed, but at a quickening pace. Cyclotrons, the original “atom smashers,” are now dotted almost all over the globe. They have evolved into

synchro-cyclotrons, and have reached their culmination in three giant machines, one at the University of California in Berkeley, another at the European Organization for Nuclear Research (CERN) in Switzerland and another in the U.S.S.R. These machines accelerate



PROTON SYNCHROTRON IN GENEVA is designed to yield 25 bev. Shown here is a section of the interior of its ring building. This structure is approximately 660 feet in diameter.



MAGNETIC FORCE on moving charged particles (*black dots*) is indicated by arrows pointing down and to right. Upward arrows show the speed of the particles and colored arrows the direction of the field. Large dot at the bottom represents a heavier particle.

protons to energies of between 600 and 700 million electron volts (mev). Synchrotrons, another development, are even bigger and more powerful. The Cosmotron, a 2,200-ton monster at Brookhaven National Laboratory which emits 3-billion-electron-volt (bev) protons, is small compared to the 6-bev, 10,000-ton Bevatron at Berkeley. This in turn is topped by the 10-bev, 36,000-ton Phasotron in the U.S.S.R. Two even larger machines are under construction at Brookhaven and CERN; they are designed to produce protons of 25 to 30 bev. And still bigger accelerators are being planned.

Nuclear Microscopes

Why? What is the purpose behind this almost feverish effort to build more and bigger machines? Perhaps the simplest answer is that accelerators are the microscopes of nuclear physics. We usually think of an accelerator as a sort of gun, producing high-speed particles which bombard the nucleus of the atom. But since particles are known to have wave properties, it is equally appropriate to say that the accelerator shines "light" on the nuclei, enabling us to "see" them.

Now the resolving power of a microscope, *i.e.*, its ability to distinguish small objects, depends on the wavelength of the light it employs. The shortest wavelength of visible light is about four 100,000ths (4×10^{-5}) of a centimeter; with these waves one can perceive a microbe of about the same length.

To examine smaller things, biologists now use the electron microscope. The wavelength of a particle depends on its mass and its energy. At a few thousand electron volts—the energy at which electron microscopes operate—an electron has a wavelength some 10,000 times shorter than that of visible light (about 10^{-9} centimeter). With these waves one can begin to see the details of molecules.

The nucleus of an atom is about 10^{-12} centimeter in diameter. This is the wavelength of a proton with an energy of 1 mev. To "see" the nucleus we therefore need a 1-mev proton "microscope," and to make out some of its internal details we need some 10 to 20 times as much energy. Thus a laboratory interested in classical nuclear physics will invariably have a Van de Graaff accelerator or a cyclotron operating in the range of 1 to 20 mev.

But physics has pushed beyond this point. At present many of us are interested not in the nucleus as a whole but in the structure of the protons and neu-

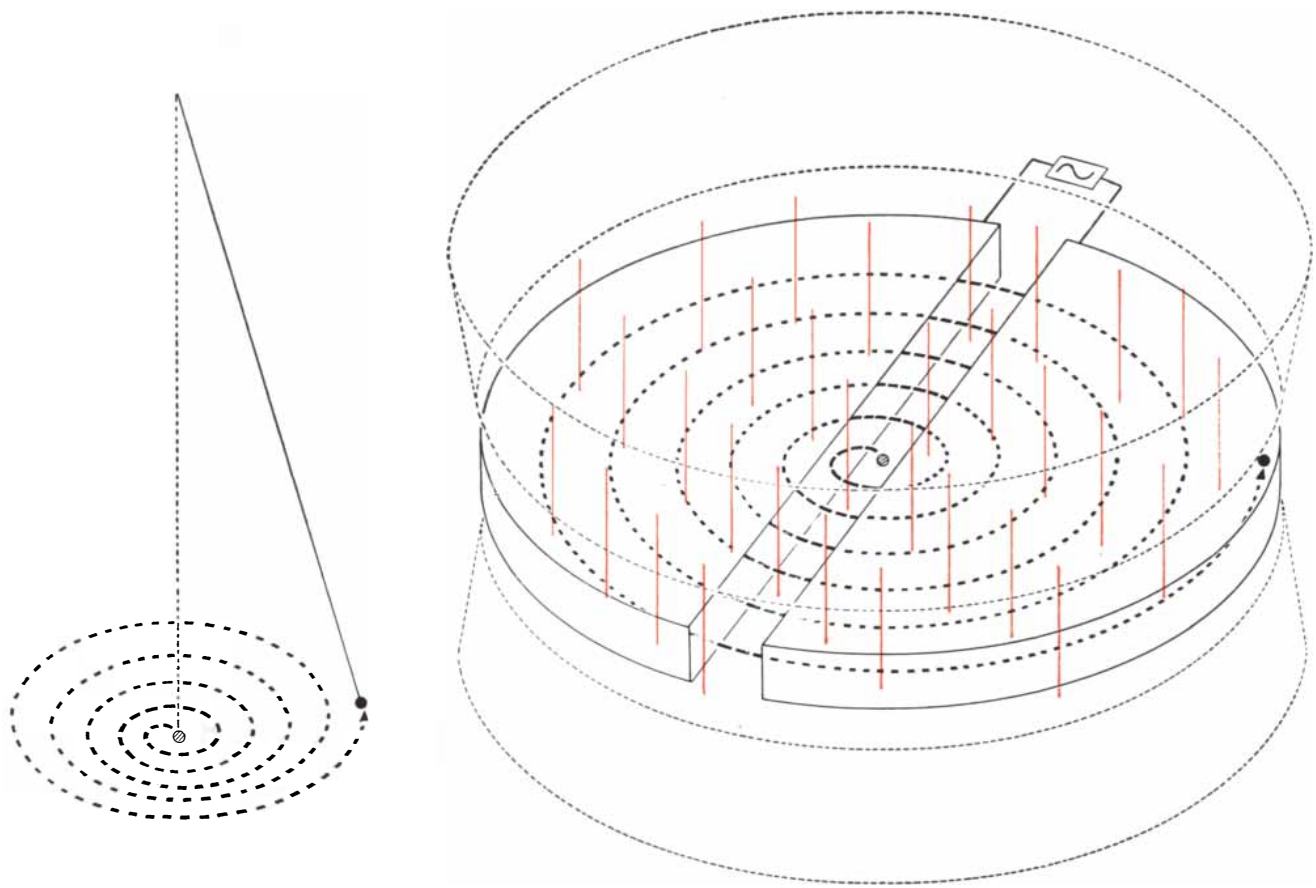
trons (nucleons) of which it is composed. It is the old problem of worlds within worlds, for the proton itself turns out to have a rich structure. It is perhaps 10^{-13} centimeter in diameter, and to resolve it requires an energy of several hundred mev. To see it in as fine detail as we can see the structure of the nucleus we must have still higher energy. It is for this reason that the 25- to 30-bev machines are under construction. If and when the structure of the proton is known, will its component parts turn out to have their own structure? Very possibly so, and if they do, machines of higher energy will be built to explore that structure.

The microscope analogy does not tell the whole story. When we get to sufficiently short wavelengths (*i.e.*, when the bombarding particles in our accelerators reach sufficiently high energy), we not only see particles, but we also make new ones. These new particles are created out of energy. At 1 mev an electron has enough energy to create a pair of particles—an electron and a positron. At 150 mev it makes pi mesons (pions) when it collides with a nucleon. Our 1-bev electron accelerator at Cornell University produces more massive particles: K and lambda mesons. The Bevatron, which produces 6-bev protons, is able to create antiprotons, antineutrons and still heavier particles such as xi and sigma mesons.

Thus as the energy of the machines has increased it has become possible to create more and heavier new particles. Obviously the exciting next step is to attain even higher energies, and then to see what sort of monster particles are created. One has the very strong feeling that new particles will indeed show up. It may well turn out that they will prove to be only complexes of particles which we already understand; however, it is exactly to answer such questions that we are building the machines.

Originally we constructed our accelerators in order to search for the ultimate in elementary particles. We expected these particles to be fragments and hence to be successively smaller; it was to improve our definition of them that we went to higher energies. Ironically the fragments now seem to get larger. One has the uneasy feeling that new machines make new particles which lead to the construction of new machines, and so on *ad infinitum*. In fact, there may be lurking here a new kind of indeterminacy principle which will inherently limit our knowledge of the very small.

So much for the reasons why accelera-



CYCLOTRON'S OPERATION is like that of a circular pendulum (*left*) in which the weight is pushed repeatedly to give an ever-widening swing. The schematic diagram at the right shows a particle (*dot*) spiraling within two D-shaped electrodes. The magnetic

pole pieces which provide the guiding field (*colored lines*) are outlined in light broken lines. The particles are accelerated by an oscillating electric field between the dees. The generator which produces the field is shown as a wavy line within a rectangle (*top*).

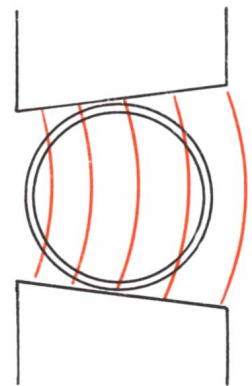
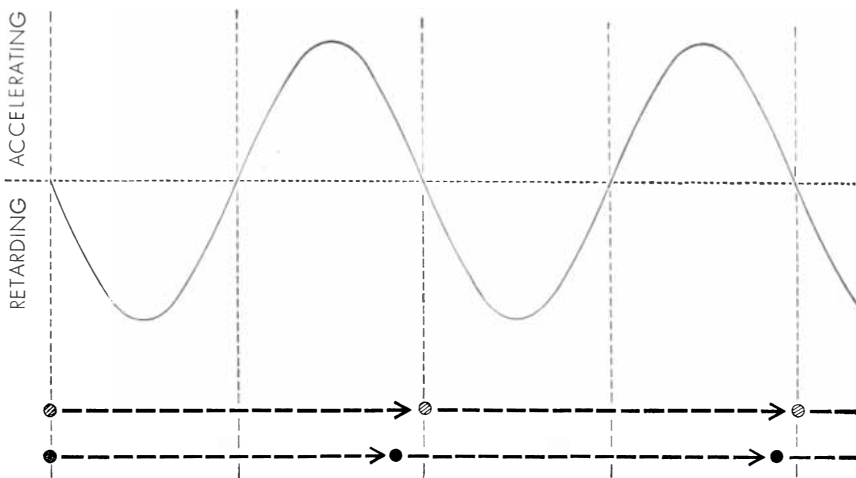
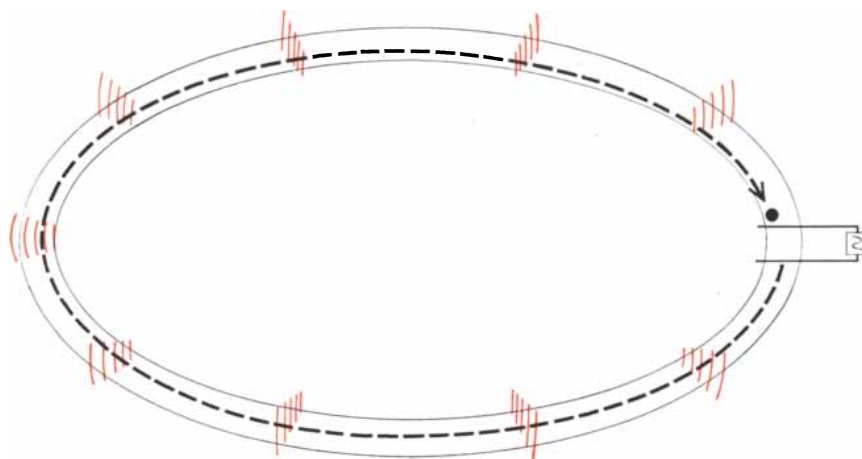
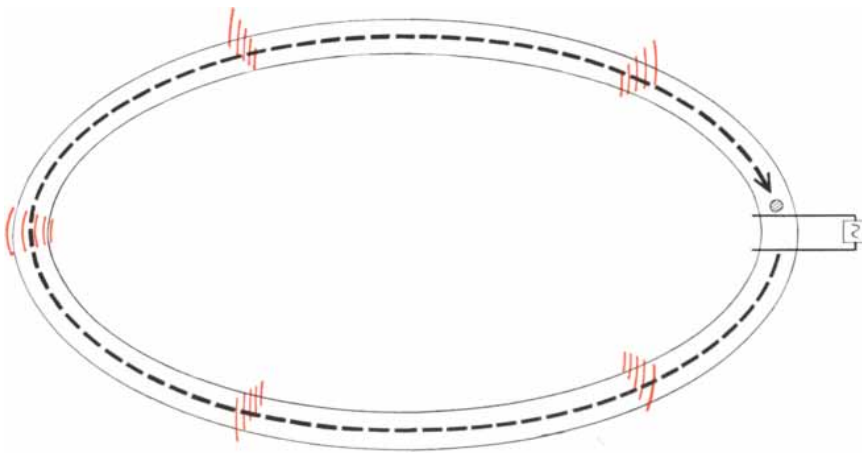
tors are built. Let us turn to the machines themselves. All of them operate on the same fundamental principle: charged particles (electrons or positive ions, usually protons) are put into an electric field which exerts a force on them, pushing them to high speeds and energies. (The electron volt, in which the energy is usually measured, is the energy acquired by a particle with one electronic unit of charge accelerated by a potential difference of one volt.) The simplest form of accelerator is a pipe along which a steady electric field accelerates the particles. This is the well-known Van de Graaff machine. To obtain higher energies a long pipe may be used with several accelerating electrodes which kick the particles to higher and higher speeds as they travel down the tube [see "The Linear Accelerator," by Wolfgang Panofsky; *SCIENTIFIC AMERICAN*, October, 1954]. But to attain a really high energy by this method would require an extremely long pipe. To get around this difficulty the particles can be made to travel in a circular or spiral

path which brings them back through the same electrodes where the accelerating voltage is applied again and again.

It is with such circular machines that we are chiefly concerned in this article. In these machines the circular motion is brought about by magnetic fields. A magnetic field exerts a force on all electric charges that move through it; the force is always at right angles to the direction of the charges' travel. It is the same kind of force that acts on a stone whirled at the end of a string. The magnetic field, like the string, forces the particles to move in a circular path. The stronger the field, the sharper the curvature of the path; on the other hand, the faster or heavier the particle, the less it is curved by a given field [see diagrams on opposite page].

The simplest and oldest type of accelerator to make use of magnetic bending is the cyclotron. The operation of this machine can be most easily visualized by imagining a weight suspended by a string and pushed so as to describe a circular motion. As with any pendulum the

time required to complete a full circular swing is the same whether the circle is small or large. Thus if the weight is pushed rhythmically it will move outward in an ever-widening circle, returning to the pushing point in the same time on each revolution [see diagram above]. So it is in the cyclotron: each ion whirls inside of two semicircular electrodes or "dees," getting an electrical push when it passes from one to the other. A vertical magnetic field provides a constant inward push and, like the string, holds the ion in a circular path and guides it back to the gap between the dees, where it is given another electrical push. The velocity of the ion then becomes greater and, as a result of its inertia, the curvature of the circular path caused by the magnetic field becomes larger. The time taken to traverse a full circle is the same no matter how big the radius, because the increase in speed just compensates for the increase in path-length per turn. Now if the voltage across the dees is made to oscillate rapidly, and if its period is adjusted so that it exactly matches



SYNCHROTRON restricts particles to a nearly circular path by means of a magnetic field (colored lines) which grows stronger as the particle energy increases. At top an electron (hatched circle) is in an orbit that brings it to the accelerating gap (right) just as the voltage changes from accelerating to retarding (curve at bot-

tom). In the center drawing the field is made stronger and the electron (black circle) is bent more strongly, following a shorter path and arriving at the gap in time to get a push. After a number of pushes it spirals out to the original path. The cross section at bottom right shows magnetic pole pieces around the doughnut.

the period of revolution of the ions, then the ions will be pushed in the right direction at the right time at each crossing of the gap between dees; the energy of the ions will build up until their path takes them to the edge of the magnetic field, where they can be used or extracted in the form of a beam.

If the cathedrals had great designers such as Suger of St. Denis and Sully of Notre Dame, the accelerators have their Cockcroft of Cambridge and Lawrence of Berkeley. In 1928 J. D. Cockcroft and E. T. S. Walton built a device in which a voltage generated between two electrodes accelerated ions to a high enough speed to cause the disintegration of a bombarded nucleus. They were still working in the magnificently simple tradition of Ernest Rutherford's laboratory at the University of Cambridge. A quite different tradition was established with the building of the first cyclotron by Ernest O. Lawrence in 1930. It has spread from his laboratory at the University of California and has come to dominate experimental nuclear physics in this country. Indeed, one can begin now to trace this spirit abroad, particularly to the U.S.S.R., where it may flourish even more vigorously than it does in the U. S.

This tradition, called "berkelitis" by its detractors, is a true departure in experimental physics. Previously experimental equipment had been constructed to test a particular surmise or idea. But building a large accelerator is more analogous to outfitting a ship for an expedition of exploration, or to the construction of a huge telescope to study a variety of astronomical objects. After several cyclotrons had been built at Berkeley, the

students and associates of Lawrence traveled far and wide to spread the gospel. By World War II they had helped to build cyclotrons not only at universities in the U. S., but also in several other countries. The biggest of these machines produced protons of about 10 mev. As we have seen, this is an appropriate energy for exploring the nucleus as a whole, but not for examining its parts. Just before the war Lawrence had begun to build a giant cyclotron, to enter the energy region above 100 mev, with which he could start to probe nucleons.

The Synchrotron

It was characteristic of Lawrence that he went ahead despite a prevalent conviction that the energy limit of the cyclotron was about 20 mev. This conviction was based on an effect predicted by Albert Einstein's theory of relativity: particles traveling at nearly the speed of light will increase in mass. At 20 mev a proton has entered this "relativistic" region, and further increases in energy will result not so much in greater speed as in greater mass. When this happens, the particle in a cyclotron begins to fall behind schedule as it spirals farther outward, and it no longer arrives between the dees at the right time to get a push from the oscillating voltage.

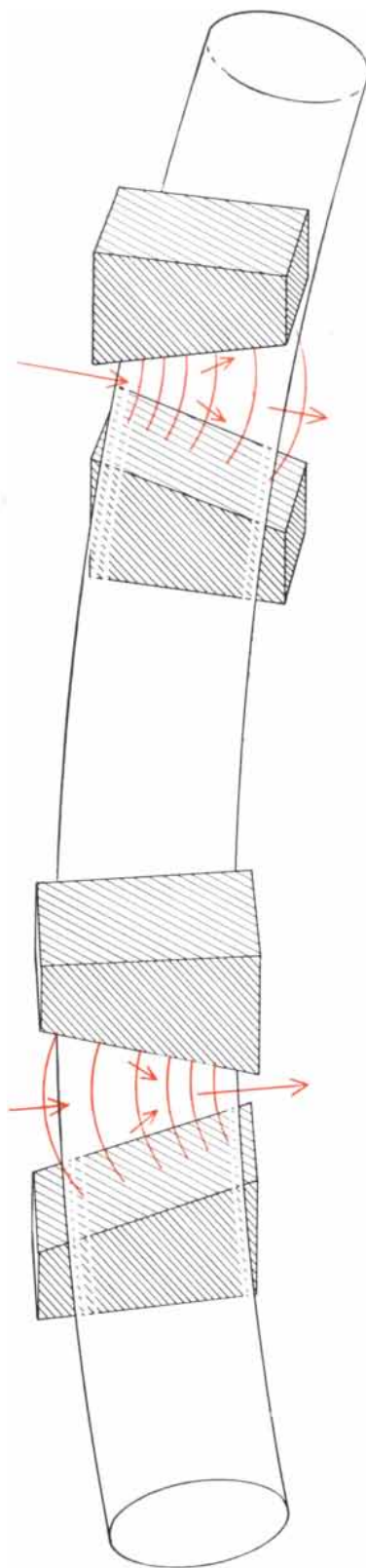
The war interrupted work on Lawrence's big machine. Its huge magnet was used to separate isotopes of uranium for the atomic-bomb program. At the end of the war V. I. Veksler of the U.S.S.R. and E. M. McMillan of the University of California independently and almost simultaneously enunciated the so-called synchrotron principle. This principle showed the way to accelerating particles into the completely relativistic region. It was exactly the sort of *deus ex machina* that Lawrence had envisioned when he gambled some \$1 million in starting his big cyclotron. The principle was immediately adopted. A successful synchro-cyclotron was built which produced protons in the region of 100 mev (eventually 730 mev). In the next few months a number of important features of the proton were discovered.

To understand the synchrotron principle, it is easier to consider its application in the electron synchrotron rather than in the more complicated synchro-cyclotron. Some half-dozen of these electron accelerators, with maximum energies of about 300 mev, were also built just after the war.

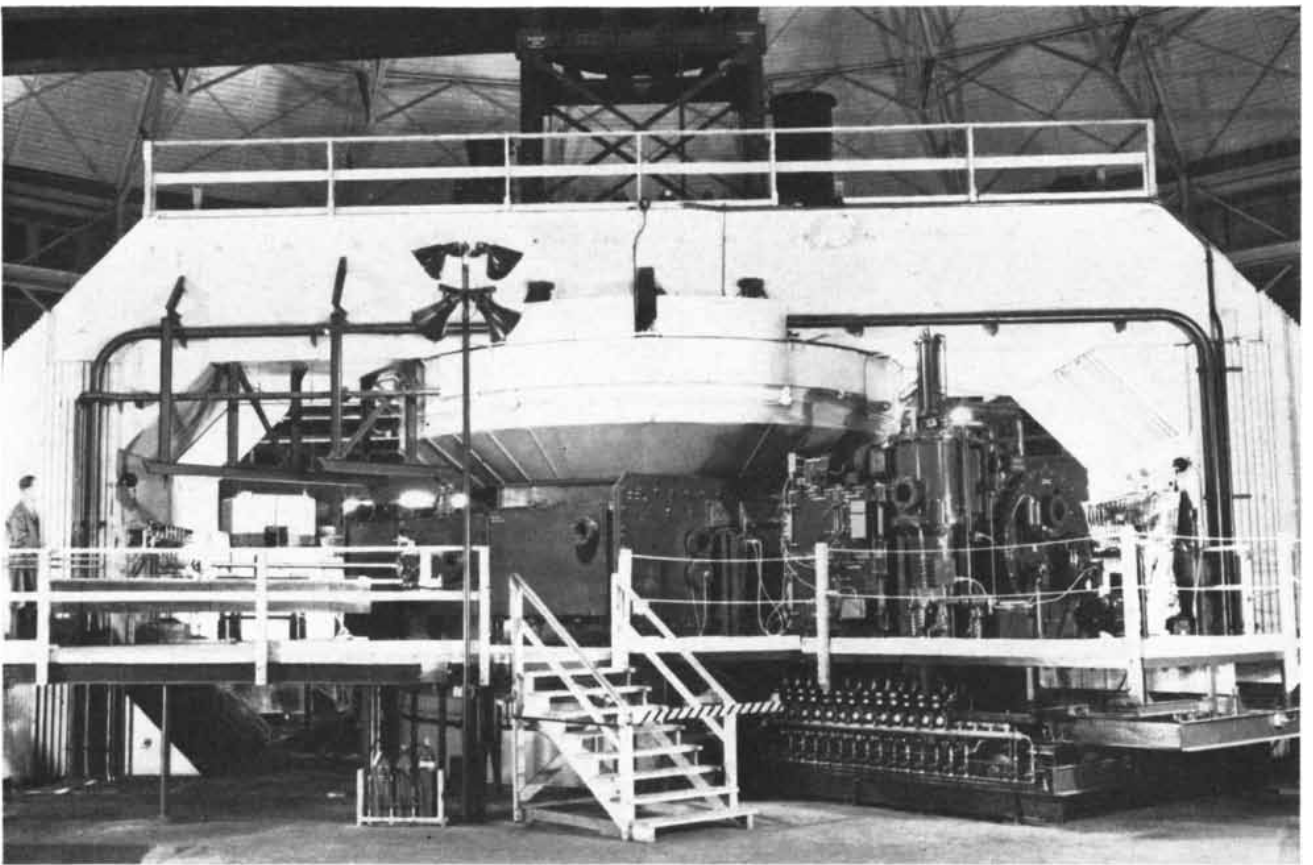
In a synchrotron electrons travel on a circular orbit inside a narrow doughnut-

shaped vacuum vessel. At one point in the doughnut is a pair of accelerating electrodes across which there is an oscillating voltage like that in the cyclotron. A ring-shaped magnet surrounding the doughnut produces a field which forces the particle to travel on orbits close to the center of the tube [see diagram on opposite page]. The electrons are injected into the doughnut from a small linear accelerator at an energy of about 2 mev. At this energy their speed is some 98 per cent of the speed of light; hence they cannot travel much faster. To make matters simpler let us assume that the speed is exactly the speed of light and that the whole increase in energy goes into mass. Now imagine an electron in a circular orbit at the center of the doughnut. The electron is held there by a constant magnetic field. Also imagine that our oscillating voltage is applied, but that the electron crosses the accelerating gap just at the time when the voltage falls through its zero value. The frequency of the voltage is made the same as that of the electron traveling around its orbit at the constant speed of light. The electron now passes the gap on all subsequent turns just as the voltage becomes zero. Thus nothing happens; the electron remains on its orbit and keeps the same energy. Now we increase the magnetic field slightly. Since the energy (mass) is still the same, the particle is forced into a sharper curve, *i.e.*, its orbit gets smaller. But because the orbit is smaller and the speed is constant, the time it takes the electron to return to the accelerating gap is shorter. Hence the electron arrives slightly before the voltage has fallen to zero; it is accelerated slightly. On the next turn, if the energy is still not large enough, the orbit will still be too small: the electron will arrive still earlier and be accelerated even more. Eventually the energy will increase enough (that is, the electron will get heavy enough) so that it is bent less sharply and edges out to its original orbit. If the energy should become too great, the orbit will be too big and the time it takes the electron to make each turn will be too long. This will cause the electron to drop behind the accelerating voltage and be pushed backward so that it will lose energy. Thus we have a beautiful automatic device for keeping the electron on the right orbit, or at least oscillating around the right orbit. That is all there is to the synchrotron principle or, as it is sometimes called, phase focusing.

Now we can see that, if the magnetic field of the synchrotron is increased continuously, the energy of the electrons

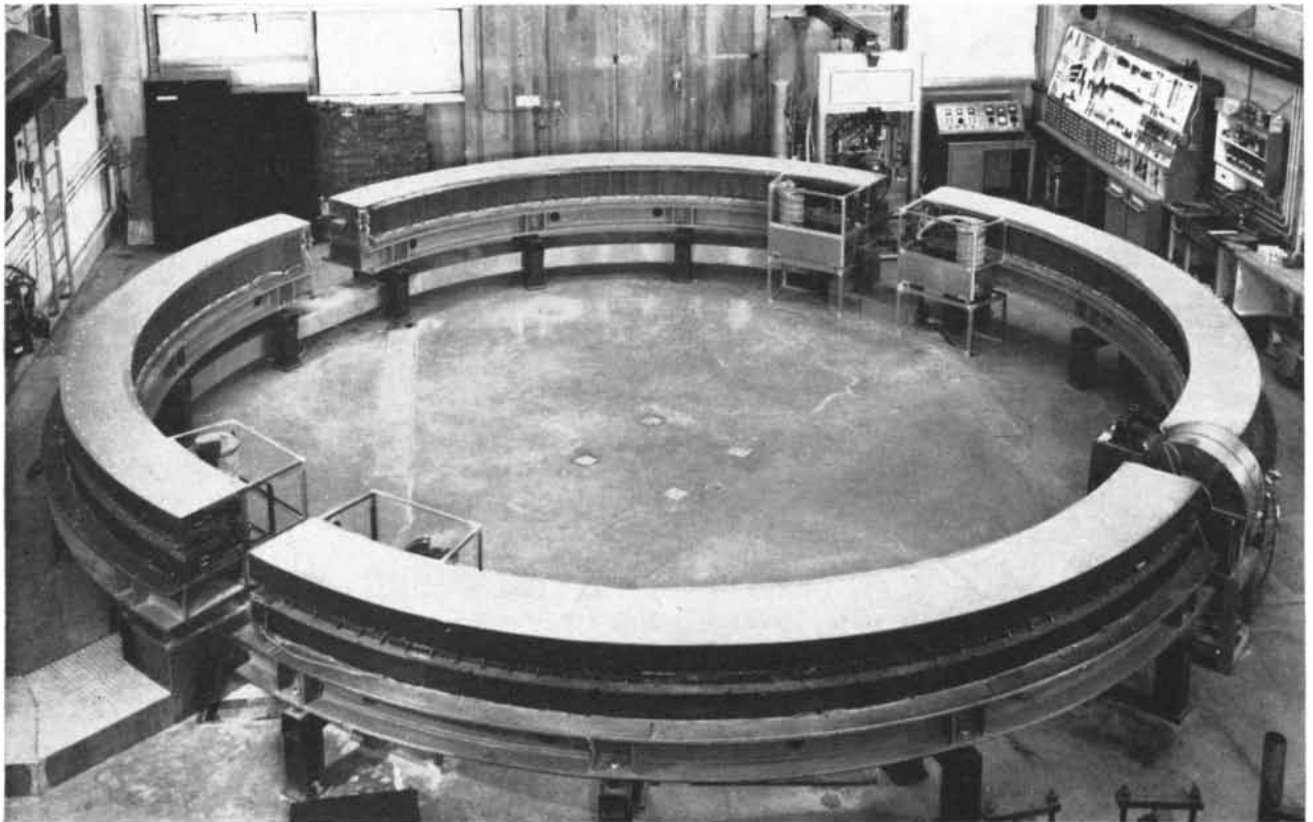


STRONG FOCUSING is produced by magnetic fields which are alternately bowed out and in. Horizontal arrows show radial forces on the particles at inner and outer edges of the field. Slanted arrows represent forces which focus or defocus particles vertically.



SYNCHRO-CYCLOTRON at the Berkeley Radiation Laboratory of the University of California is now the most powerful machine

of its kind. A modification of its design last year increased the energy of its proton beam to 730 million electron volts (mev).



ELECTRON SYNCHROTRON was photographed in the author's laboratory at Cornell University while its guiding magnet was un-

der construction. Machine, which produces an energy of 1 bev, is the first to use strong focusing. Accelerating electrodes are at right.

will also increase continuously; the electrons will receive energy at just the right rate to keep them on the central, or synchronous, orbit. In practice electrons can be injected into the doughnut when the magnetic field is rather weak (about 10 gauss) and ejected when the field is quite strong (more than 10,000 gauss). A synchrotron with a large enough radius can accelerate electrons up to energies of about 10 bev. There are now about six machines, built or being built, which are designed to yield electron energies between 1 and 1.5 bev. At Cambridge, Mass., a 6-bev electron synchrotron is being constructed by a joint Harvard University-Massachusetts Institute of Technology group.

Let us return to the synchro-cyclotron. It works in essentially the same way as a synchrotron but it is shaped like a cyclotron. Instead of a varying magnetic field it has a constant field, but the frequency of the accelerating voltage applied to the dees is varied. This means that the synchronous orbit of the protons is not a fixed circle but a growing spiral.

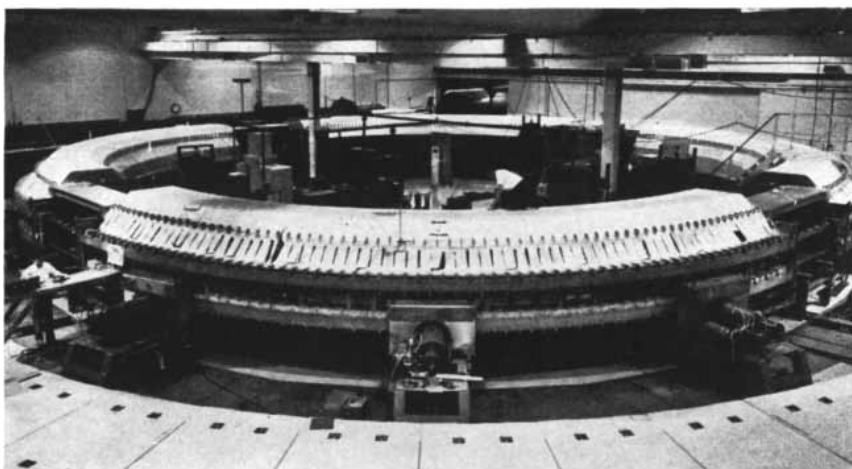
In another class of accelerators, the proton synchrotrons, both the magnetic field and the frequency of the accelerating voltage are varied. The increasing field counteracts the protons' tendency to spiral outward as they get up to relativistic energies, and the orbit is again a fixed circle. Above about 5 bev the protons are traveling practically at the speed of light, and from here on the proton synchrotron works just like an electron synchrotron.

If I may extend the figure of speech with which I began this article, each kind of accelerator has its own architectural style. To me synchro-cyclotrons are baroque. Proton synchrotrons are definitely Romanesque, although their rounded arches are horizontal. Electron synchrotrons have a lightness and grace that could only be Gothic.

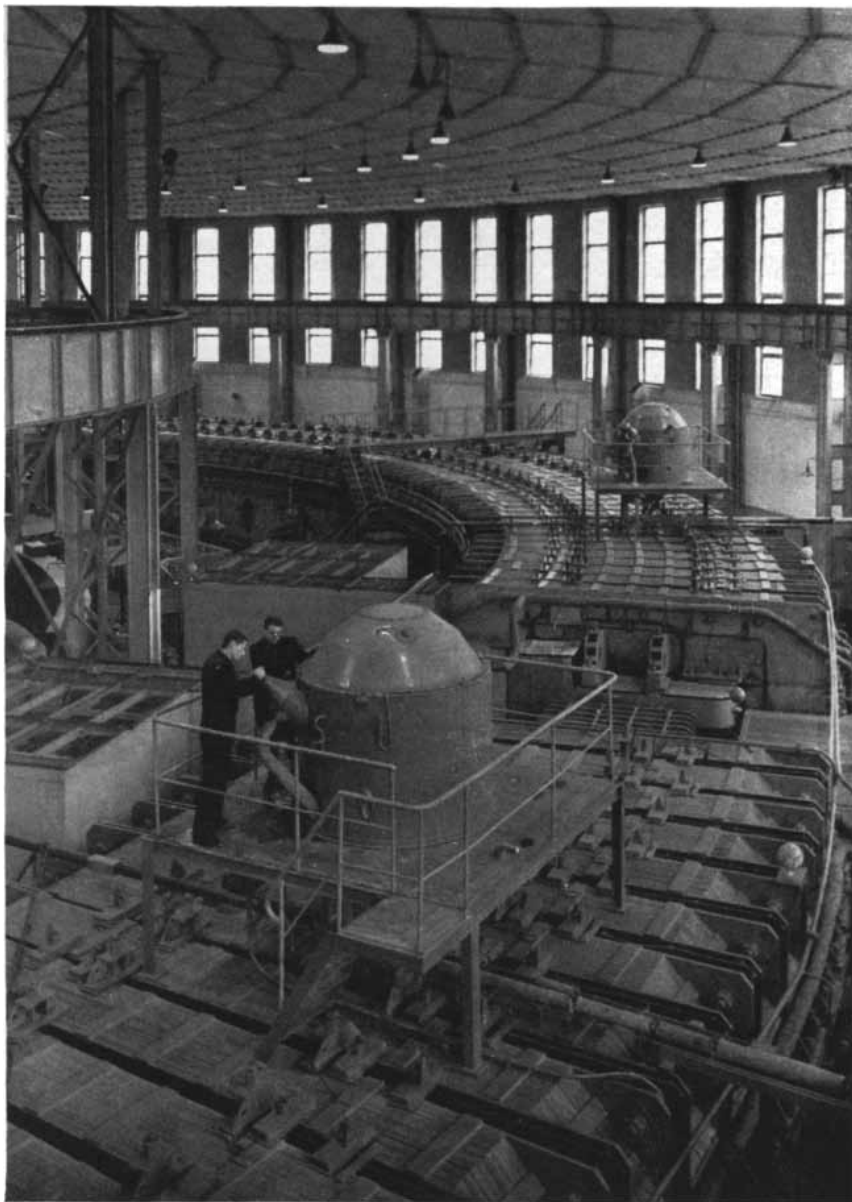
The Newer Machines

This brings us more or less up to date in the evolution of accelerators. We may now ask whether we are near the end of this movement in physics or still at its beginning. The field still has tremendous vigor, and it is my guess that we are at about the same stage as the cathedral builders were after they had completed Notre Dame of Paris. The significant innovations were behind them, but most of their masterpieces were yet to come.

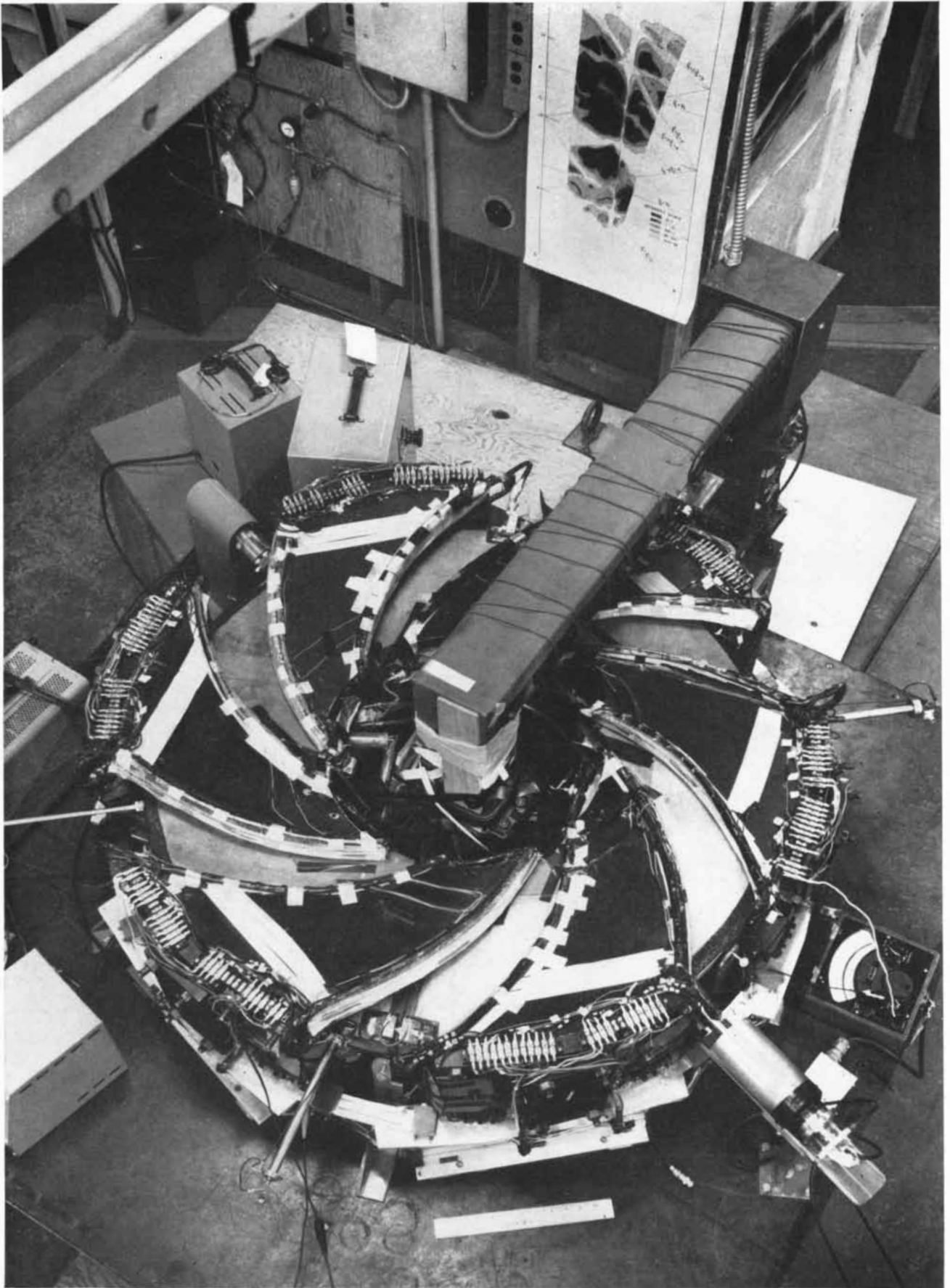
Early in this article I mentioned that two machines now under construction, one at Brookhaven National Laboratory



COSMOTRON, the 3-bev proton synchrotron at Brookhaven National Laboratory, was the first one of the multi-bev accelerators. Its 2,200-ton magnet has an inside diameter of 60 feet.



PHASOTRON is a 10-bev proton synchrotron in the U.S.S.R. Its magnet, of which a portion appears in this photograph, weighs 36,000 tons and is approximately 200 feet in diameter.



FFAG (fixed-field alternating-gradient) design is embodied in an electron accelerator built as a model for a larger proton machine

at the laboratory of the Midwestern Universities Research Association in Madison, Wis. The dark spiral sectors are the magnets.

and the other at CERN in Geneva, will produce protons of 25 to 30 bev. Both of these machines are proton synchrotrons; each will cost between \$20 million and \$30 million. The diameter of the orbit traveled by their protons will be nearly 1,000 feet!

These machines were made possible by the discovery at Brookhaven of a new principle called strong focusing [see "A 100-Billion-Volt Accelerator," by Ernest D. Courant; *SCIENTIFIC AMERICAN*, May, 1953]. This principle involves a reshaping of the guiding magnetic field so that the particles are held much closer to their ideal orbit. It means that the doughnut can be thinner, and the surrounding magnet smaller and lighter.

Until now we have considered only the radius of the orbit, *i.e.*, the size of the circle on which the particles travel. However, the particles can not only drift in and out but also up and down; thus they must be focused vertically as well as horizontally. In old-style synchrotrons the lines of force in the magnetic field are bowed slightly outward [see diagram on page 68]. This has the effect of forcing particles back toward the center line when they move above or below it. But the bowed field gets somewhat weaker with the distance from the center line. Hence a particle that wanders too far from the center line is not strongly pushed back toward it.

In strong focusing the field is broken into sectors which are alternately bowed outward and inward [see diagram on page 69]. The sectors bowed outward provide sharp vertical focusing, but are even worse than the old field-shape at bringing a particle in from an orbit that is too large. In other words, they do not focus radially. On the other hand, the sectors bowed inward increase in strength as the radius gets bigger, and provide strong radial focusing. Vertically, however, they have the wrong effect on the particles, tending to spread rather than to focus them. It turns out that each of the defocusing influences is overbalanced by the focusing effect of the other sector; the net result is a much more tightly restricted beam. This method of focusing was successfully used in the Cornell 1-bev electron synchrotron, and it will be applied in the 6-bev Harvard-M.I.T. electron synchrotron.

Not to be outdone by CERN and Brookhaven, the U.S.S.R. has announced that it will build a 50-bev strong-focusing proton synchrotron. The magnet will weigh about 22,000 tons and will have a diameter of 1,500 feet. It would seem that whatever we do, our Soviet friends

can do too—and with a factor of two in their favor.

"FFAG"

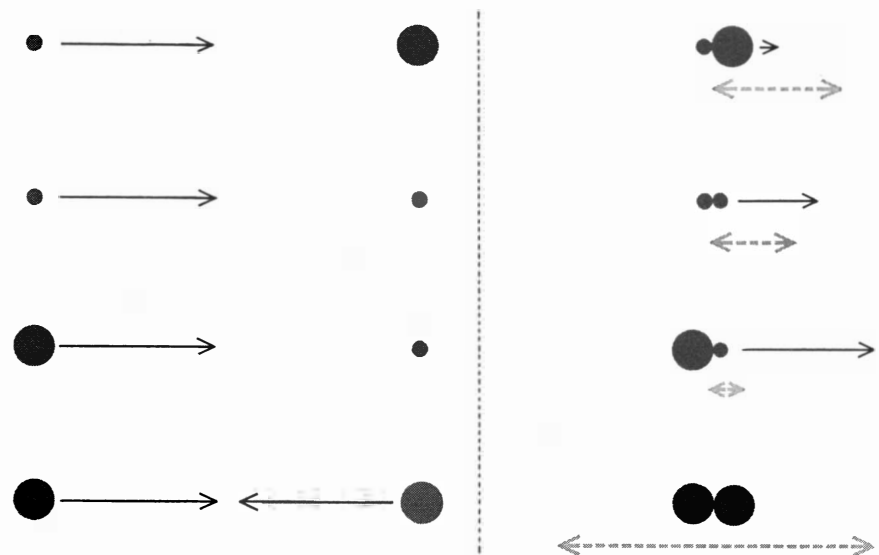
The most exciting recent development in this country has been the "fixed-field alternating-gradient" accelerator proposed by Keith R. Symon of the Midwestern Universities Research Association (MURA). The so-called FFAG machine is really a rococo cyclotron in which the magnetic field is shaped in such a way as to allow the cyclotron to work into the high-energy relativistic region. We have already seen how the ordinary cyclotron is limited to accelerating protons to about 20 mev. When this limitation was first pointed out in 1938, L. H. Thomas of the Ohio State University suggested a way to get around it. He proposed to scallop the pole tips of the cyclotron magnet so that the surfaces would consist of a series of ridges running out from the center, with valleys in between. Thomas showed that the strength of the resulting field would increase toward the outside, compensating for the protons' relativistic increase in mass, and would also focus the protons so that they would stay in the vacuum chamber. Thomas's scheme was far too complicated for the techniques of the time, and it was ignored. Now we realize that he had anticipated the strong-focusing principle. Two Thomas-type cyclotrons are now under construction, one at Oak Ridge National Labora-

tory, the other at Berkeley. Both of them will produce protons and deuterons in the range of several hundred mev.

We can now understand an FFAG type of accelerator if we imagine that the radial scallops of the Thomas magnet are twisted into spiral ribs. (Is this the flamboyant style that presaged the end of the Gothic period?) The twisting introduces an additional kind of strong focusing. In fact, the idea grew out of strong focusing; only later was its similarity to the Thomas cyclotron recognized. The idea of FFAG has been exploited to the full by the workers of the MURA laboratory at Madison, Wis. They have imagined and computed (using two high-speed computing machines) all sorts of variations of the FFAG geometry, and have built several models that have successfully demonstrated the practicality of the scheme.

The advantage of the fixed-field design is twofold. First, it is easier to control a constant field than a varying one. Second, the fixed-field machines can be operated continuously, whereas the synchrotrons and synchro-cyclotrons must operate cyclically, or in pulses, a new cycle starting each time the field reaches its maximum value. Continuous operation means that more accelerated ions are produced per unit time; in other words, the beam has a higher intensity.

According to the MURA workers, the increased intensity that can be obtained with FFAG machines will make it possible to circumvent a serious limitation



USEFUL ENERGY in a collision depends on the motion of the particles after impact. Solid arrows at left represent energy of motion of bombarding particles. Solid arrows at right show energy of motion of the system after impact. Broken arrows indicate fraction of total energy available for desired reactions. Small dots are light particles; large dots, heavy ones. When like particles are made to collide head-on (bottom), all of their energy is available.

on accelerators which I have not mentioned as yet. This limitation concerns the amount of energy that is actually available to produce the reactions we are looking for.

When a high-energy ion from an accelerator strikes a stationary target particle, part of the energy goes into moving the target, and is wasted. It is as if we were trying to break a stone by hitting it with a hammer. To the extent that the hammer blow simply moves the stone, the energy is not available for breaking it. Now if the hammer is very light and the stone very heavy, we can see that the target will not move very far; almost all the energy of the hammer will go into breaking or chipping the stone. If we use a heavy sledge on a light pebble, most of the energy goes into moving the stone, and very little of it is available for breaking the stone. If the hammer and stone weigh the same, they will tend to move off together with half the speed of the incoming hammer; exactly half the energy will be available for breaking the stone.

It is the same with atom-smashing. But here relativity plays a particularly dirty trick, robbing us of most of the advantage to be gained by increasing the energy of the bombarding particles. We have seen that really high energies mean an increase in mass. Thus as we go up in energy we increase the weight of our "hammer" and lose a larger and larger fraction of its energy. At 1 beV a proton is already noticeably heavier than when it is at rest; when it hits a stationary proton, 57 per cent of the energy is wasted and only .43 beV is available for useful purposes. At 3 beV (the energy of the Brookhaven Cosmotron), the available portion is 1.15 beV; at 6 beV (the Berkeley Bevatron) the available portion is 2 beV; at 10 beV, 2.9 beV are available; at 50 beV, 7.5; at 100 beV, 10.5. We see that increasing the energy 100 times from one to 100 beV results in only a 20-fold actual gain.

Suppose, however, that instead of firing a moving particle at a stationary one, we arrange a head-on collision between two high-energy particles. Then the mass increase is neutralized, and there is no tendency for the colliding particles to move one way or the other. All the energy of both of them is now available for the desired reactions. This is what the MURA designers propose.

They have envisaged a bold design, called "synchroclash," in which two 15-beV accelerators are placed so that their proton beams intersect and the particles collide with each other. This will yield an available energy of 30 beV, whereas

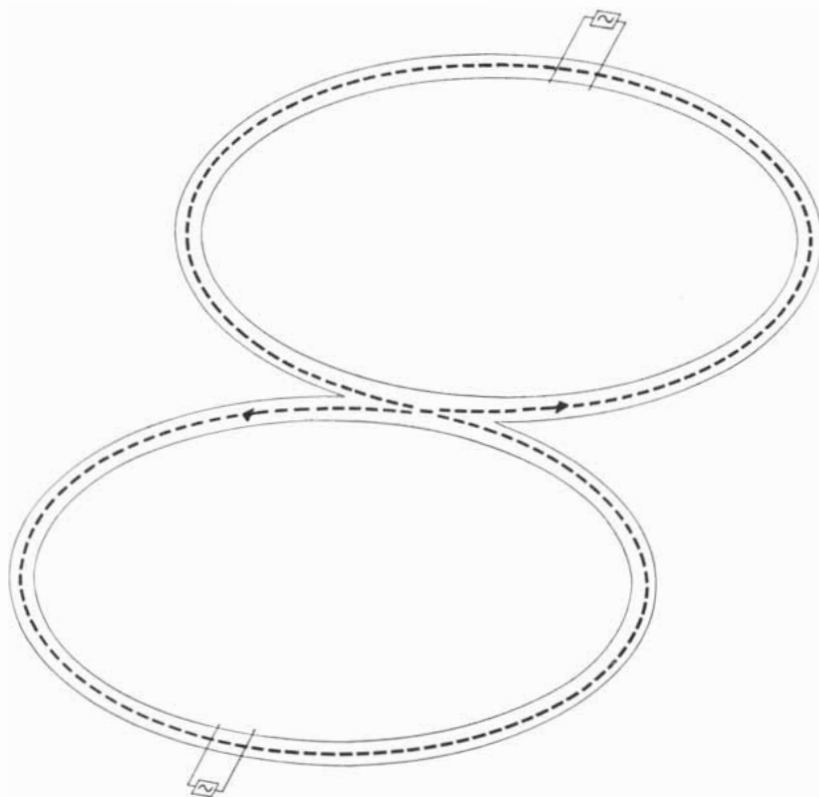
in the case of a 30-beV proton colliding with a proton at rest only 6 beV would be available. In fact, to attain a useful energy of 30 beV in the ordinary way would mean using at least 500 beV. The success of the synchroclash idea turns on the intensity of the accelerator beams: there must be enough protons to make collisions reasonably frequent. The MURA proposal languished for several years, but interest in it seems to have revived. Perhaps the complicated orbits of the artificial satellites have had something to do with the new willingness to consider attempting the complicated orbits of FFAG.

Soviet Ideas

The Soviet designers have gone off in different directions. Veksler has been thinking of a scheme in which one approaches the ideal accelerator, namely one in which the accelerating field appears exactly in the vicinity of the ions but nowhere else. He envisages a small bunch of ions in a plasma (a gas of ions) exciting oscillations or waves in an electron beam. These waves are to act together coherently to give an enormous push to the ions being accelerated. If this is not clear to the reader, it is

because it is not clear to me. The details have managed to escape most of us because of a linguistic ferrous curtain, but Veksler speaks of the theoretical possibility of attaining energies up to 1,000 beV. The proof of the idea must wait until it is put into practice. It should be remarked, however, that other wild schemes of Veksler, for example the synchrotron principle, are incorporated into most of our conventional accelerators today.

G. I. Budker of the U.S.S.R. has also presented some speculative ideas which have obviously been inspired by efforts to produce controlled thermonuclear reactions. Budker proposes an intense circular electron beam maintained by a weak magnetic guide field. The high current of the beam will cause it to "pinch" to a very small diameter because of its own magnetic field. The idea then is to use the very strong local magnetic field around the pinched beam as the guide field of a conventional accelerator [see diagram on page 76]. With an electron beam six meters in diameter one could expect to hold protons with an energy as high as 100 beV. Budker and his colleagues have constructed a special accelerator in which they have achieved a 10-ampere current of 3-meV



SYNCHROCLASH design would set two accelerators side by side so that their beams overlapped. Head-on collisions between particles would provide the maximum of useful energy.

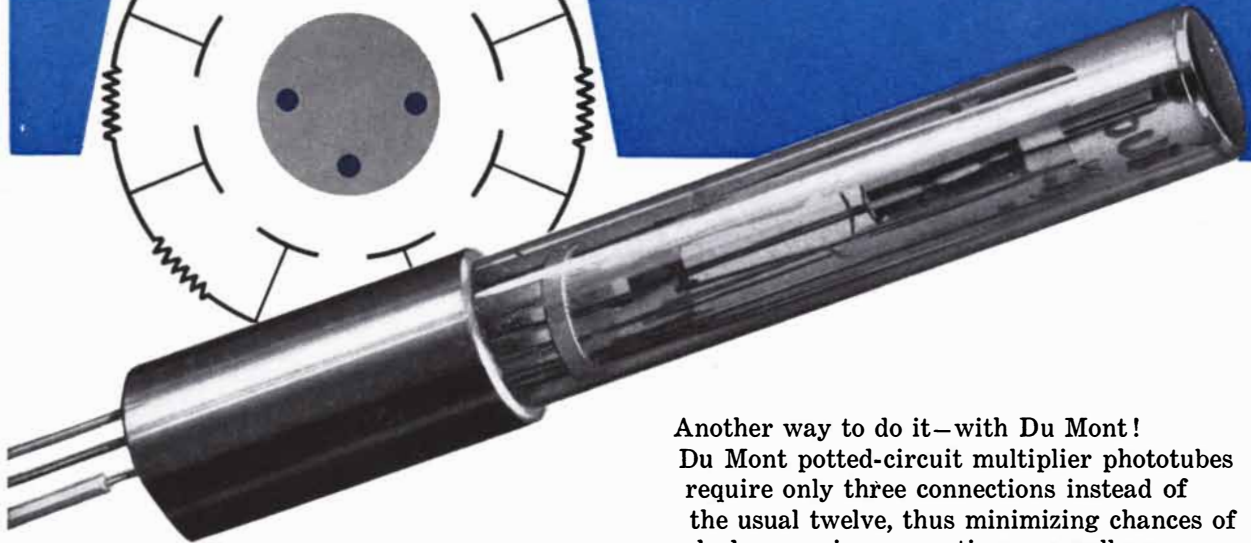
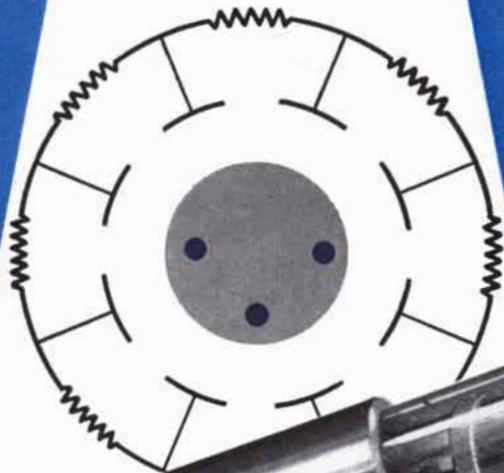
3

will
get
you

12!

—in the new
Du Mont
potted—
circuit

MULTIPLIER PHOTOTUBES



Another way to do it—with Du Mont! Du Mont potted-circuit multiplier phototubes require only three connections instead of the usual twelve, thus minimizing chances of leaky or noisy connections, as well as pickup between long leads. The resistor network for the bleeder system is *encapsulated within the base of the tube* eliminating the need for this associated circuitry in an external unit.

Do it the better way—do it with Du Mont. Send for complete details on Du Mont potted-circuit multiplier phototubes. Available in a wide range of sizes and characteristics...

DU MONT

Industrial Tube Sales
ALLEN B. DU MONT LABORATORIES, INC.

2 Main Ave., Passaic, N. J.

electrons, and they expect to attain much higher currents and energies before long. It could well be that something really revolutionary will come out of this energetic work.

Our own thermonuclear program has inspired research on very strong magnetic fields [see "Strong Magnetic Fields," by Harold P. Furth et al.; *SCIENTIFIC AMERICAN*, February]. It seems likely that this development will find an application to the guidance of particles in multi-bev accelerators.

Electron Accelerators

These new machines we have been discussing are proton accelerators, but there is vigorous activity in electron machines as well. We have already mentioned the Harvard-M.I.T. synchrotron which will attain 6 to 7.5 beV, and the half-dozen other smaller machines in the billion-volt range. The 220-foot linear electron accelerator at Stanford University has been on the scene for some time. Its energy has steadily increased so that it may now be used in experiments at 600 mev. We expect to welcome it to the 1-beV club before long.

The linear machine is significant because there is a special difficulty in reaching high energy with electron synchrotrons. When electrons are made to travel on a curved path at high speeds they give off strong electromagnetic radiation. The effect is easily visible to the

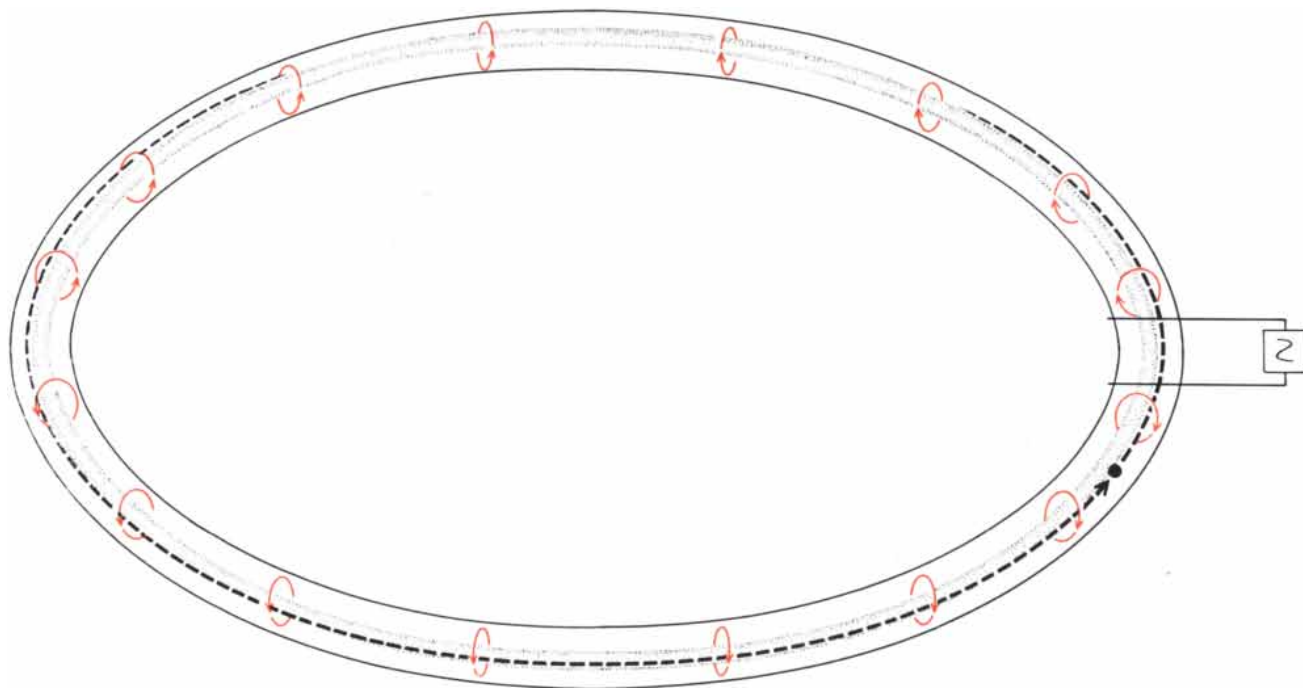
naked eye; the luminous horizontal beam on the cover of this issue of *SCIENTIFIC AMERICAN* is synchrotron radiation. The difficulty is that this radiation can represent a substantial loss of energy, and it increases rapidly as the energy of the machine goes up. In the Harvard-M.I.T. synchrotron the amount of energy radiated is almost prohibitive (about 10 mev per turn at 7.5 beV). To reach higher energies, say 20 beV, the Stanford group has been thinking in terms of a linear accelerator, which does not have this radiation difficulty because its particles do not move in a circle. Such a machine might be as much as three miles long.

I am not convinced that the limit of electron synchrotrons has been reached. Indeed, it is not difficult to imagine a 50-beV electron synchrotron. The radiation problem would be solved by reducing the curvature of the electron beam, that is, by increasing its radius to, say, half a mile. I believe that the upper limit of the electron synchrotron may be as high as 100 mev.

While we are "thinking big" we should not forget Enrico Fermi's proposal to ring the earth with a vacuum tube and, using the earth's magnetic field, obtain 100,000 beV. For that matter, now that artificial satellites are commonplace, we might put up a ring of satellites—each containing focusing magnets, accelerators, injectors and so on—around the earth. Something like a mil-

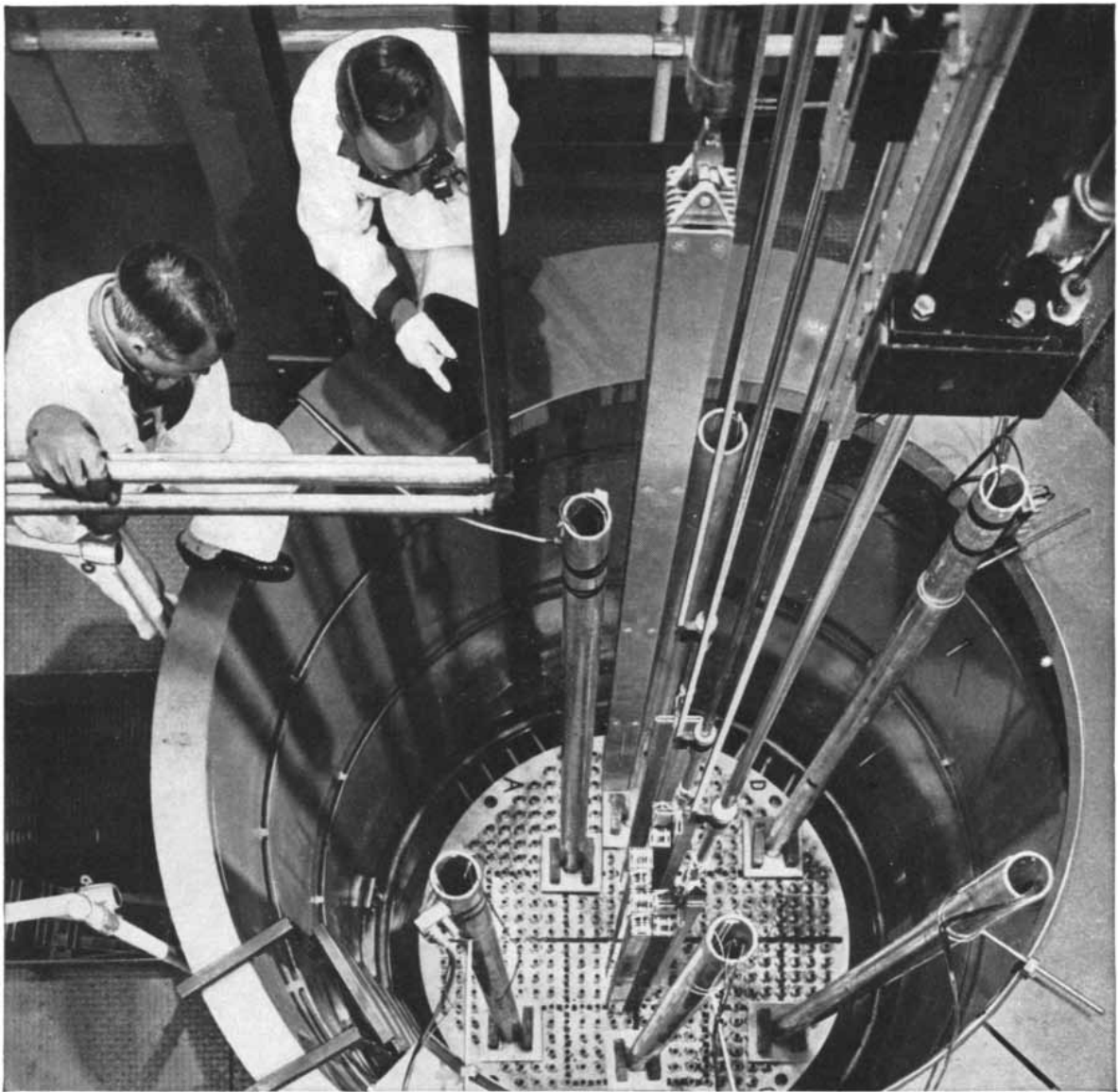
lion beV could be expected from this accelerator, which we might as well call the lunatron. At the very least such a device will eliminate the need for vacuum pumps, since it will be outside the atmosphere.

Villard de Honnecourt and later Viollet-le-Duc have left us detailed accounts of the builders of cathedrals and of their methods. It seems to be pretty much the same story then and now. The designer of the cathedral was not exactly an architect, nor is the designer of an accelerator exactly a physicist. Both jobs require a fusion of science, technology and art. The designers of cathedrals were well acquainted with each other; the homogeneity of their work in different countries is evidence of a considerable interchange of information. The homogeneity of accelerator design demonstrates the same interchange today. Our medieval predecessors were only human; one gets the definite impression that they were subject to petty jealousies, that occasionally there was thievery of ideas, that sometimes their motivation was simply to impress their colleagues or to humiliate their competitors. All these human traits are occasionally displayed by their modern counterparts. But one also gets a strong impression of the excitement of those mighty medieval creators as they exulted in their achievements. This sense of excitement is no less intense among modern nuclear physicists.



PINCH EFFECT might be used to provide a magnetic guiding field for an accelerator, thus eliminating the heavy magnet. The

dotted ring is a pinched plasma. Its magnetic field, which is shown by colored lines, would act to hold particles near its outer edge.



FORECASTING CORE PERFORMANCE

A nuclear power plant requires exact knowledge and control of the quantity and arrangement of the nuclear fuel. To determine precisely the operating nuclear characteristics and performance of B&W's full scale reactor cores, the company maintains a critical experiment laboratory at its specialized nuclear research facilities in Lynchburg, Va.

Critical experiments are conducted at virtually zero power, permitting economical, safe analysis of the proposed fuel cores and the gathering of nuclear data for their final design. Flux distributions in the reactor core are measured with foils of different elements which become radioactive under neutron bombardment.

In this way, the calculations of physicists and engineers can be confirmed or modified; optimum quantity and arrangement of fuel elements and control

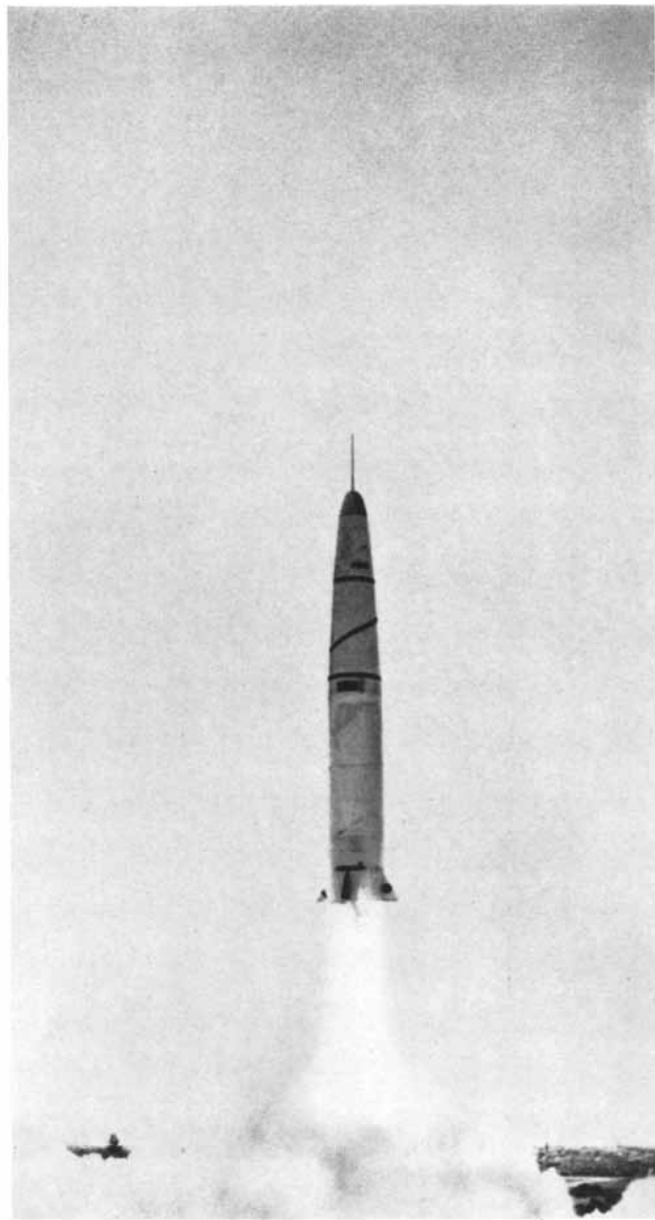
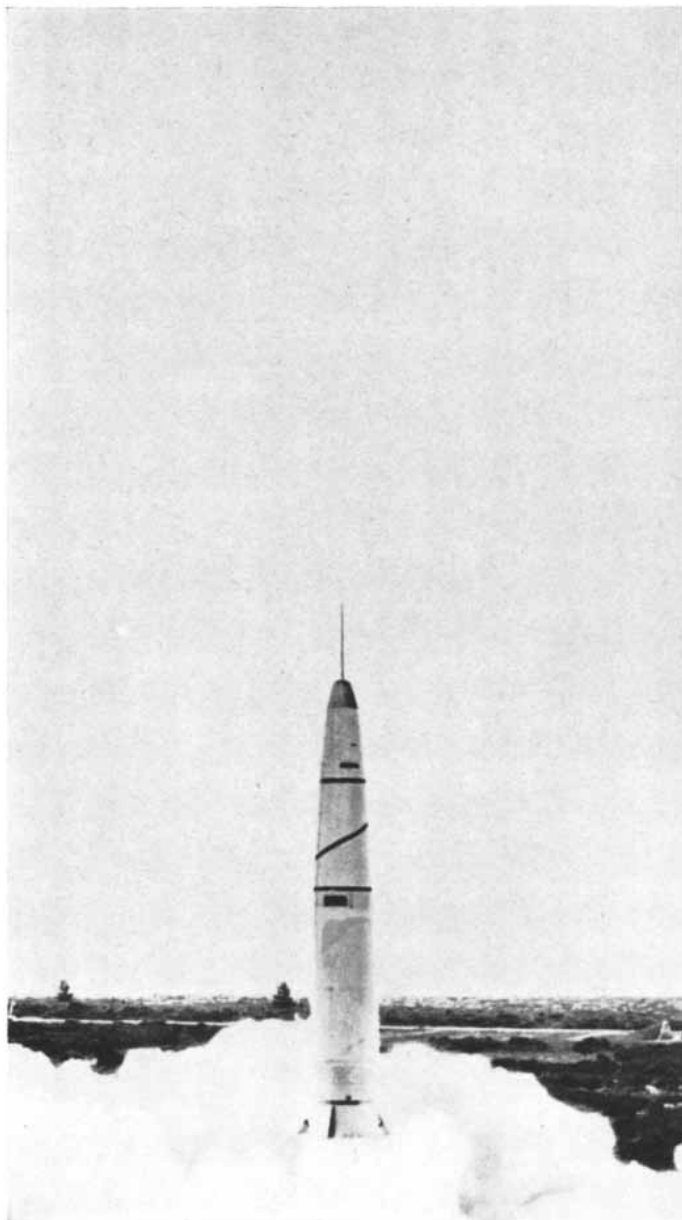
rods can be determined; the core's ultimate power distribution, safety and stability can be established; and a more accurate forecast of the conversion ratio and reactivity lifetime of the core is made possible.

This privately-financed critical test laboratory is just one example of B&W's investment in facilities, engineering, and research to put nuclear energy to work constructively and economically. The Babcock & Wilcox Company, Atomic Energy Division, 161 East 42nd Street, New York 17, N. Y.

AE-46



Today's air power in action:*



Thor starting one of its highly successful test flights from Cape Canaveral, Florida.

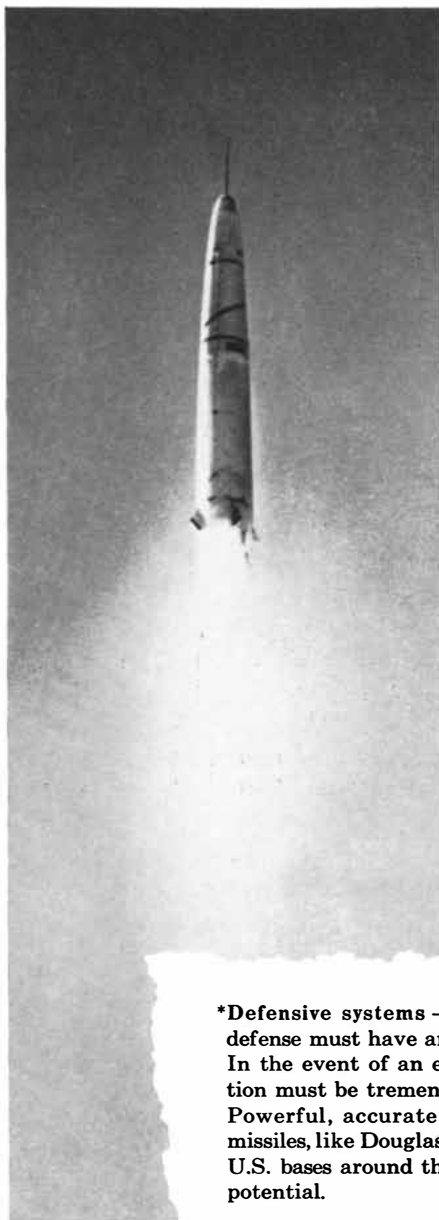
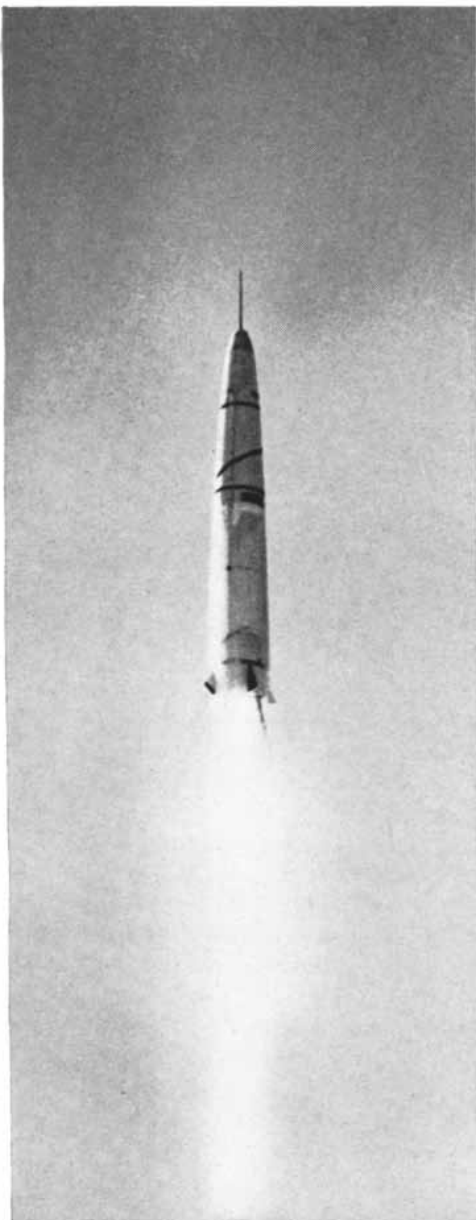
Giant Air Force THOR — *already in mass production*

Last November 27th the Defense Department announced that the Douglas *Thor* had been ordered into production as the Air Force's intermediate range ballistics missile.

America's defense is gaining more than just a highly successful missile. *Thor* comes completely equipped with a Douglas-engineered support system that is *immediately* ready for field operation.

No hand-tooled prototype, the *Thor* test models fired for Air Force acceptance are built with mass production tooling. As a result, manufacture of *Thor* on a volume basis began the minute Air Force approval was given.

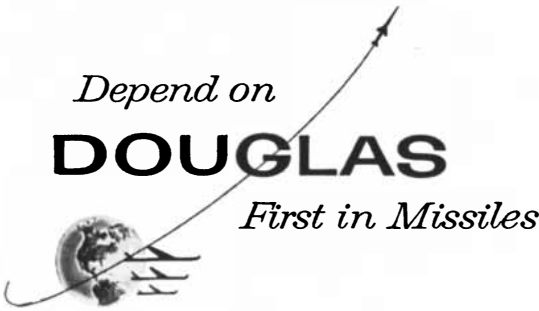
At the same time the science-industry-military team which cooperated in developing *Thor* readied the important systems required to make it operational... transportation, fuel-



***Defensive systems — The complete air defense must have an attacking arm, too. In the event of an enemy strike, retaliation must be tremendous, decisive, quick. Powerful, accurate intermediate range missiles, like Douglas Thor, launched from U.S. bases around the world, provide this potential.**

can strike anywhere in the world from U.S. bases !

ing, launching, training and parts replacement. Such thoroughness is typical of Douglas where 19,000 missiles of all types have been produced since 1941. In fact, Douglas is the *only* U.S. manufacturer to have developed missiles systems in all categories...air-to-air, air-to-surface, surface-to-air, and surface-to-surface. And Douglas has an accumulation of missile experience unequaled in the U.S.



F FOR

Y YOUR

I INFORMATION

BEAT BARNACLES

"Barnacle Bill" is not only the title of an old sea song—it's the price ship operators pay for inefficient operation due to barnacle-fouled hulls.

Although you can combat fouling with copper pigments, conventional copper bottom paints may create new problems by accelerating the corrosion of steel hulls.

MUTUAL sodium copper chromate to the rescue: research shows that it has both anti-fouling and anti-corrosive properties. No surprise either, because it is a member of the same pigment family as "zinc yellow," a chromate long used as a corrosion inhibitor

in metal priming paints. Anti-fouling of course, because it contains copper.

This useful combination of properties also has led us to test MUTUAL sodium copper chromate in preservative combinations for wood, cordage, fabrics and paper, and in agricultural fungicides.

OLEFIN OPPORTUNITIES

Did it ever occur to you that your product might be epoxidizable? Or even hydroxylatable?

What, never? All we mean is you can upgrade it with hydrogen peroxide, to put you in new markets with greater profits.

With H_2O_2 , you can upgrade such olefins as soya bean oil, cottonseed oil, tall oil, turpentine, linseed oil or unsaturated petroleum derivatives.

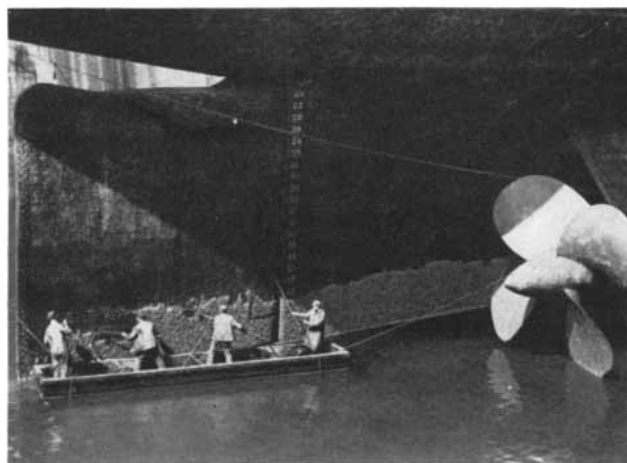
By upgrading, you find yourself making resin plasticizers, glycols, stabilizers, insecticides, monomers, lubricants, waxes, surfactants or brake fluids.

In the epoxidation and hydroxylation processes, hydrogen peroxide reacts with unsaturated olefins to form a completely different class of chemical compounds. Of course, hydrogen peroxide has been around for some time, but recent developments now permit broad commercial use of these processes.

Research people working in chemicals, plastics and pharmaceuticals will be interested in a new Solvay Process Division up-to-date review and bibliography on the subject.

WATER-RESISTANT COATINGS

Paper coaters know that if they want to keep a coating from coming off in water, they must insolubilize the binder after application. Starch, casein, protein and



"Barnacle Bills" can be cut...with MUTUAL sodium copper chromate

latex are the most widely used paper coating and sizing adhesives. The major advantage of starch is its ease of use, but this is offset by its lack of water resistance. On the other hand, although casein, protein and latex give good water resistance, they are more expensive.

May we suggest a starch coating modified with U.F. CONCENTRATE-85, for low-cost, water-resistant paper coatings. A product of our Nitrogen Division, U.F. CONCENTRATE-85 is a low-cost, non-resinous, high-concentration urea-formaldehyde product.

You can obtain different degrees of insolubility by adding 2 to 50% to the starch, though 20% generally makes an excellent coating. Other assets: a simple mixing operation, a useable pH range of 4 to 8.

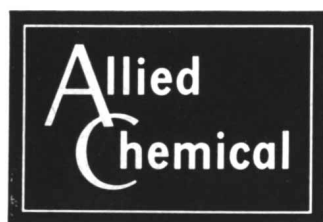
We have available a new technical paper on the subject, "A new product for the insolubilization of starch films."

NEW URETHANE BOOKLET

In these columns, we've talked about what the industry calls "the next great synthetic." Allied's interest in urethane materials lies with our National Aniline and Barrett Divisions, which produce the key chemicals—diisocyanates and polyester resins respectively—used in making these versatile plastics. Now we have a new booklet available on urethane materials, detailing their applications and their future.

FOR MORE INFORMATION about any of these developments, just write, on your company letterhead, to Allied Chemical, Dept. 38, 61 Broadway, New York 6, N. Y.

MUTUAL and U.F. CONCENTRATE-85 are Allied Chemical trademarks.



“Imprinting” in Animals

When ducklings are hatched, the first moving object they see is usually their mother. They proceed to follow her. If they see another moving object, however, they follow it instead

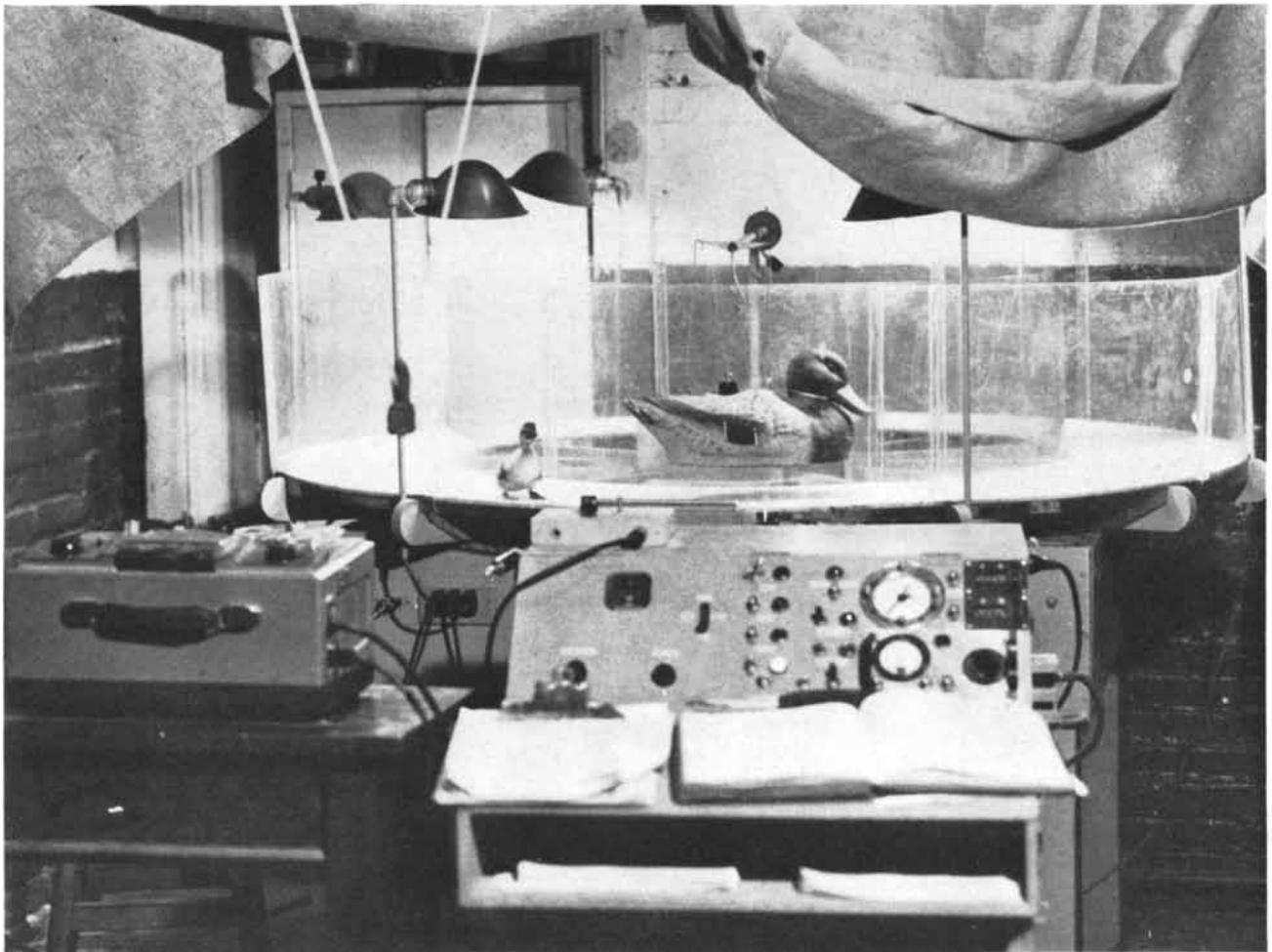
by Eckhard H. Hess

What is meant by “imprinting” in animals? The best answer is to describe an experiment performed on geese by the Austrian zoologist Konrad Lorenz. On an estate near Vienna Lorenz divided a clutch of eggs laid by a graylag goose into two groups.

One group was hatched by the goose; the other group was hatched in an incubator. The goslings hatched by the goose immediately followed their mother around the estate. The goslings hatched in the incubator, however, did not see their mother; the first living thing they

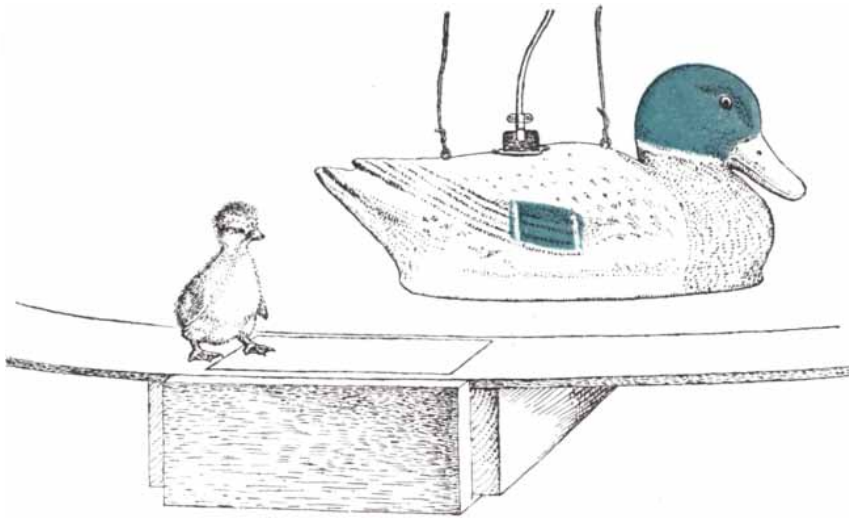
saw was Lorenz. They then followed Lorenz about the estate!

Lorenz now marked the two groups of goslings to distinguish them. He placed all the goslings under a large box, while the mother watched anxiously. When the box was lifted, the two groups of

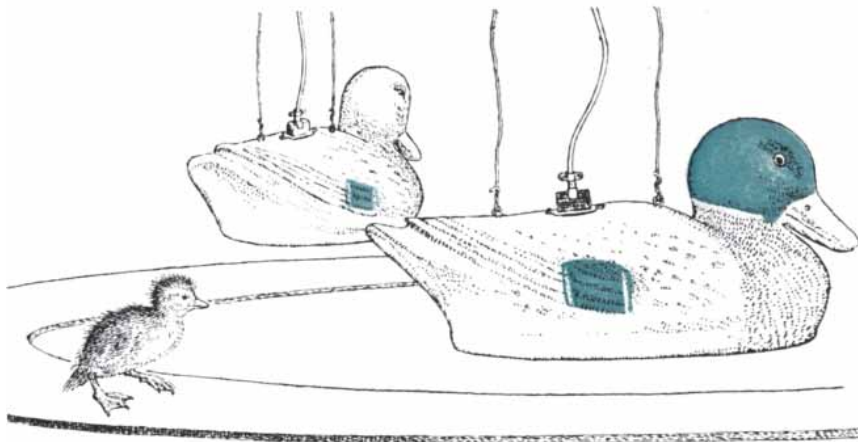


APPARATUS used by Hess and A. O. Ramsay in the study of imprinting consists primarily of a circular runway around which a decoy duck can be moved. In this photograph a duckling follows

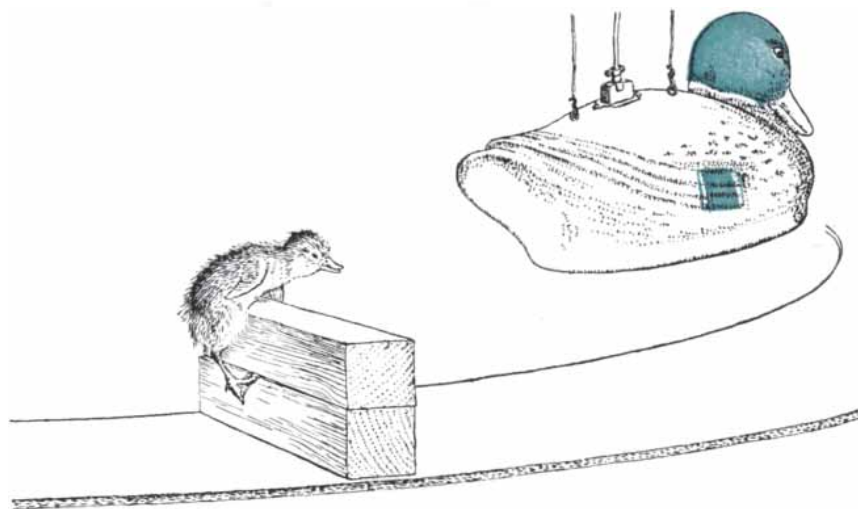
the decoy. In the foreground are the controls of the apparatus. At the top of the photograph is a cloth which is normally dropped so that movements of the experimenter will not distract the duckling.



DUCKLING IS IMPRINTED by placing it in the runway behind a model of a male duck which is wired for sound. Below the duckling is a trap door through which it is removed.



DUCKLING IS TESTED for imprinting by placing it between the male model and a female model which emits a different sound. If it follows the male, response is scored as positive.



DUCKLING SCALES AN OBSTACLE in the runway in an experiment to determine whether the effort it expends during imprinting is related to its score when it is tested.

goslings streamed to their respective "parents." Lorenz called this phenomenon, in which an early experience of the goslings determined their social behavior, "imprinting." Although earlier investigators had observed the effect, he was the first to name it and to point out that it appeared to occur at a critical period early in the life of an animal. He also postulated that the first object to elicit a social response later released not only that response but also related responses such as sexual behavior.

Students of behavior generally agree that the early experiences of animals (including man) have a profound effect on their adult behavior. D. O. Hebb of the University of Montreal goes so far as to state that the effect of early experience upon adult behavior is inversely correlated with age. This may be an oversimplification, but in general it appears to hold true. Thus the problem of the investigator is not so much to find out *whether* early experience determines adult behavior, but rather to discover *how* it determines adult behavior.

Three statements are usually made about the effects of early experience. The first is that early habits are very persistent and may prevent the formation of new ones. This, of course, refers not only to the study of experimental animals but also to the rearing of children. The second statement is that early perceptions deeply affect all future learning. This concept leads to the difficult question whether basic perceptions—the way we have of seeing the world around us—are inherited or acquired. The third statement is simply that early social contacts determine adult social behavior. This, of course, is imprinting.

Although imprinting has been studied mainly in birds, it also occurs in other animals. It has been observed in insects, in fishes and in some mammals. So far as mammals are concerned the phenomenon appears to be limited to those animals whose young are able to move about almost immediately after birth. For example, imprinting has been described in sheep, goats, deer and buffalo. For better or worse these observations have not been made under controlled laboratory conditions. One exception is a study begun in our laboratories at the University of Chicago. One of our students has observed that imprinting appears to occur in guinea pigs. Our work has dealt mainly, however, with imprinting in birds.

Lorenz and other European workers



RCA Electron Microscope helps build better cars at General Motors

Automotive masterpieces have virtues that are more than "skin deep," thanks to basic research with the RCA Electron Microscope. At General Motors Technical Center in Detroit, studies using the instrument range in scope from determining deformation in crystalline solids to quality control problems in connection with heat-treated metals. Recently, GM researchers correlated the score resistance properties of an alloy used in bearings with the precipitation of silicon.

Micrographs, such as shown, indicated that optimum performance resulted when the aluminum-silicon-cadmium-bearing material was heat treated to precipitate the thin crystallites of silicon throughout the matrix. Particle size and distribution were studied by means of electron microscopy and positively identified by electron diffraction.

RCA Electron Microscopes are providing valuable information regarding size, shape and structure of particles smaller than 20 angstrom units. With the ability to produce direct electron image magnifications up to 200,000X, the RCA Electron Microscope is advancing man's knowledge in many fields, as diversified as automobiles and cell structures . . . chemicals and viruses. Installation supervision and contract service are available through the RCA Service Company.



Undissolved silicon (large opaque particles) and thin silicon plates in an aluminum matrix, magnification 12,000 diameters. (Micrograph courtesy General Motors Research Staff.)



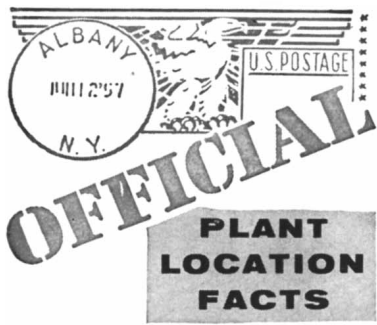
Tmk(s) ®

For full particulars, write to RCA, Dept. D-111, Building 15-1, Camden, N.J.

In Canada: RCA VICTOR Company Limited, Montreal.

RADIO CORPORATION of AMERICA

CAMDEN, N. J.



You'll be close to your **components** in New York State

Infinite Variety: New York State has an unequalled variety of component manufacturers, machine shops and sub-contractors qualified to turn out any components or semi-processed goods you need.

Ready Availability: In addition to local sources, supplies of materials from other parts of the country are promptly available through the nation's largest concentration of sales and distribution offices in New York City and upstate.



Before you decide on a new plant site, what data on components or other materials do you need?

- Specific sources of supply?
- Specification details?
- Costs?

The New York State Department of Commerce stands ready with a professional, long-experienced staff to give you a tailor-made analysis of the availability of materials at any New York State location.



But components are only one of your factors. What about

...labor... markets and transportation... sites and buildings... power... water... fuel... financing?

Let us answer your questions. Write for "Industrial Location Services," a free booklet that tells what we can do for you. Send your request to me at Room 674, 112 State Street, Albany 7.

Edward T. Dickinson

EDWARD T. DICKINSON
Commissioner of Commerce

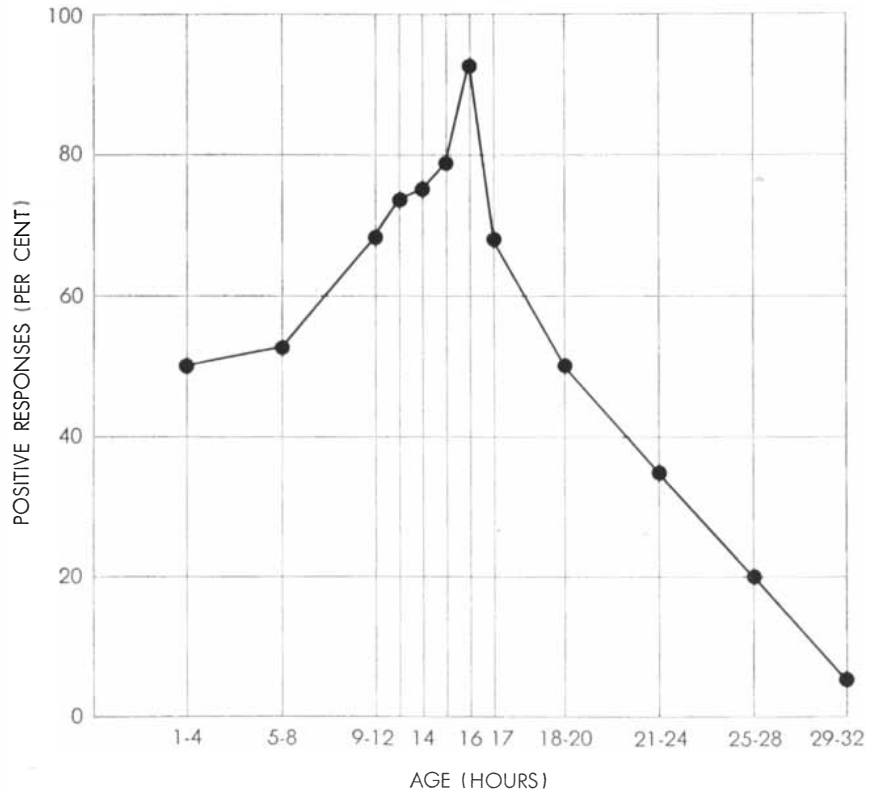
have shown that a variety of birds are most easily imprinted during the first day after they are hatched, and that the birds will follow not only other animals but also inanimate objects. In this country A. O. Ramsay of the McDonogh School in McDonogh, Md., succeeded in making young Canada geese and mallard ducklings follow a small green box containing an alarm clock. Some ducklings and goslings responded to a football. In the early 1950s I met Ramsay and we decided to begin a cooperative study of imprinting under laboratory conditions. Among our goals were the following. What is the critical age at which imprinting occurs? How long must young birds be exposed to the imprinting object in order for them to discriminate between it and similar objects?

The subjects used in the experiments described here were mallard ducklings. We were fortunate in that our laboratory in Maryland had access to a small duck pond in which we could keep relatively wild mallards. The birds laid their eggs in nesting boxes, so the eggs could be regularly collected and hatched in laboratory incubators. Our experimental apparatus consisted of a circular runway about five feet in diameter and 12 inches wide, the walls of which were

made of transparent plastic. Our imprinting object was a model of a male mallard duck, of the sort used by duck hunters as a decoy. The model was suspended from a motor-driven arm pivoted at the center of the apparatus; thus it could be moved around the runway at various speeds. Inside the model was a loudspeaker through which tape-recorded sounds could be played.

After the mallard eggs were collected, they were placed in a dark incubator. When the young birds were hatched, they were kept in individual cardboard boxes so that they would have no visual experience until they were put into the imprinting apparatus. The boxes were then kept in a brooder until we were ready to work with the birds. After each duckling was exposed to the imprinting object (the decoy duck) in the apparatus, it was automatically returned to its box by means of a trap door in the floor of the runway. The bird was then lodged in another brooder until it was to be tested for the imprinting effect.

The imprinting itself was accomplished first by placing the young mallard in the runway of the apparatus about a foot away from the decoy. As the bird was released, the loudspeaker inside the decoy was made to emit a human rendition of the sound "GOCK



CRITICAL AGE at which ducklings are most strongly imprinted is reflected by this curve. Each black dot on the curve is the average test score of ducklings imprinted at that age.



Mass Produced Aspherics Revolutionize Optical Design

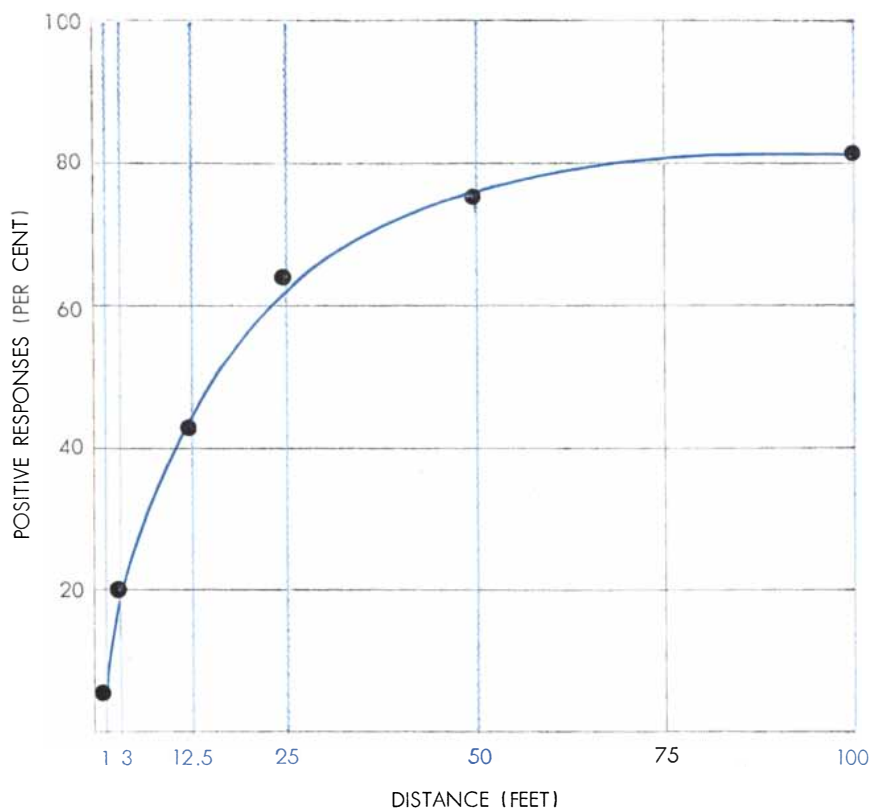
The science of optics dates back to the days of Galileo. In this modern age of electronics and atomic energy, optics is often passed over as a science in which there is really nothing new to be learned. Yet, in the past few years, a development has been quietly taking place which bids fair to revolutionize the optical industry and obsolete many standard optical designs. This development is the invention of production techniques by which lenses using aspheric surfaces can be quantity produced economically.

An aspheric lens, i.e., a lens whose surfaces conform to some curve other than a sphere, such as a hyperbola or a

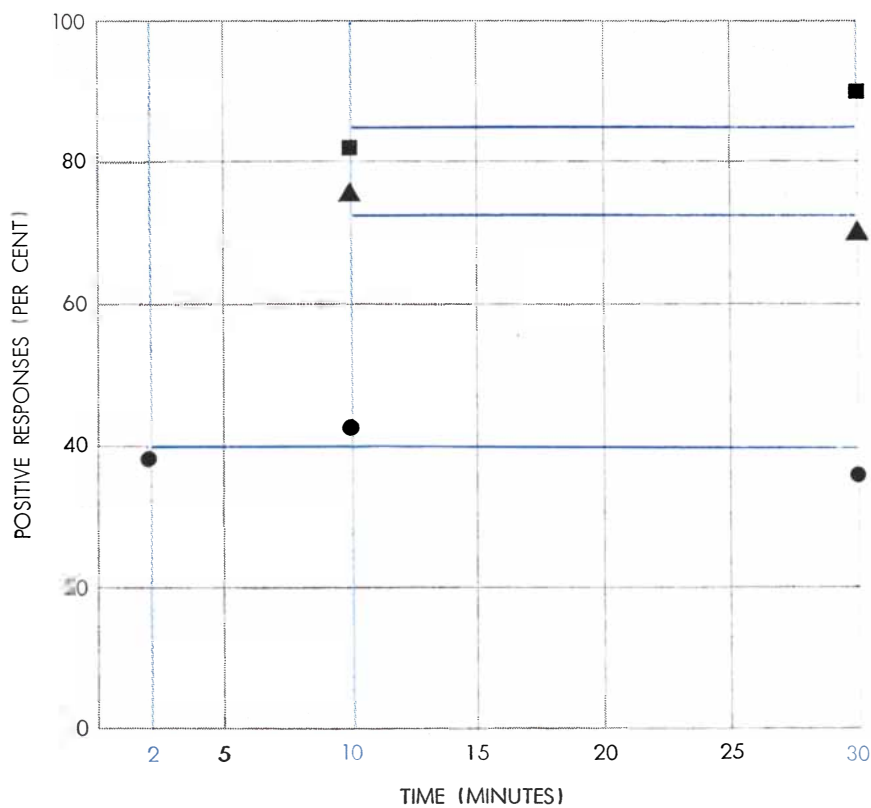
parabola, is often able to replace several conventional lenses and frequently permits performance unobtainable with spherical surfaces alone. Until recently aspherics could be generated only by laborious hand methods.

Perkin-Elmer has pioneered in both aspheric production techniques and the equally important development of computation methods for designing aspheric optical systems. Many Perkin-Elmer products for industry and the military are already utilizing aspheric optical elements. These new optics may soon appear in many common products, such as cameras, microscopes, and telescopes.

Perkin-Elmer *Corporation*
NORWALK, CONNECTICUT



DISTANCE TRAVELED during imprinting affected the scores of ducklings as indicated by this curve. The farther the ducklings had traveled, the more strongly they were imprinted.



TIME ELAPSED during imprinting had little effect on the scores. The squares represent ducklings which had traveled 100 feet during imprinting; triangles, 50 feet; dots, 12.5 feet.

gock gock gock gock,” and after a short interval the decoy was moved around the runway. The imprinting period, during which the duckling followed the decoy, usually lasted 10 minutes. We can also imprint ducklings with a silent object, or even with sound alone. In one experiment we tried to imprint ducklings with the “gock” sound while they were still in the egg. This effort was unsuccessful.

The bird was tested for imprinting by releasing it between two decoys four feet apart. One decoy was the male model with which the duckling had been imprinted; the other was a female model which differed from the male only in its coloration. One minute was allowed for the duckling to make a decisive response to the silent models. At the end of this time, regardless of the duckling’s response, sound was turned on in both models. The male model made the “gock” call; the female emitted the sound of a mallard duck calling her young. This latter sound was a recording of a real female. Four test situations were run off in sequence: (1) both models stationary and silent; (2) both models stationary and calling; (3) male stationary and female moving, both calling; (4) male stationary and silent, female moving and calling. Each bird was scored according to the percentage of its positive responses, *i.e.*, the number of times it moved toward the male model as opposed to doing something else.

To determine the age at which an imprinting experience was most effective we imprinted our ducklings at various ages after hatching. In this series of experiments the imprinting experience was standard: it consisted of having the duckling follow the model 150 to 200 feet around the runway during a period of 10 minutes. It appears that some imprinting occurs immediately after hatching; however, only those ducklings imprinted between 13 and 16 hours after hatching consistently made a maximum score [see chart on page 84].

To answer the question how long the imprinting experience must last in order to be most effective we varied not only the time during which the duckling was exposed to the model but also the distance traveled by the duckling as it followed the model around the runway of our apparatus. We exposed groups of ducklings to the model for the same length of time (10 minutes), but during that time moved the model at different speeds so that the ducklings in each group moved a different distance (1,

Solenoid MOTOR STARTER Design

**only one moving part assures
uniform closing and opening
of the circuit, reliable operation,
and long life**

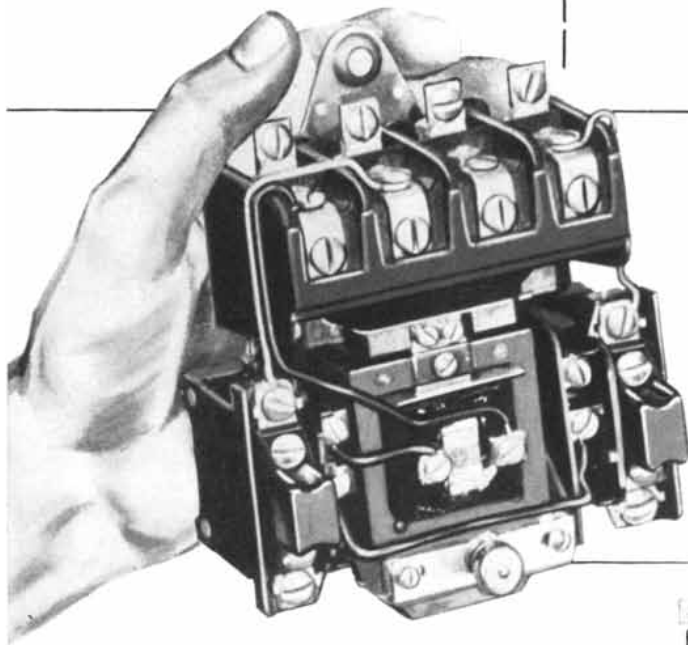
The solenoid mechanism, used in all A-B motor starters, contactors, and relays, is the *key* to the proven success of this control. With only *one* moving part, all pins, pivots, bearings, and flexible jumpers—each a potential source of trouble—are eliminated. That's why you are assured *millions* of trouble free operations.

Not only is operation trouble free—it is also *maintenance free*. The double break, silver alloy contacts never need cleaning, filing, or dressing . . . they are always in perfect operating condition. That's why you can install Allen-Bradley control . . . and forget it. Please write for the new 132-page Allen-Bradley Handy Catalog—your guide to *Quality* motor control.

Allen-Bradley Co.

134 W. Greenfield Ave., Milwaukee 4, Wis.

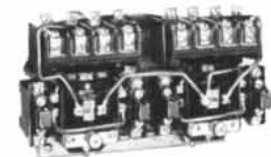
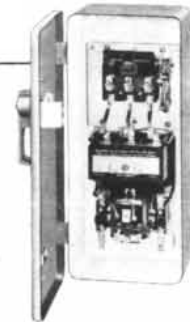
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.



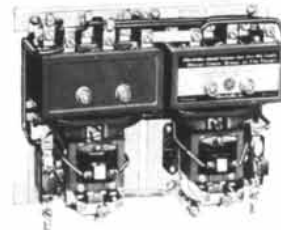
ACROSS-THE-LINE STARTERS—This Bulletin 709, Size 0, starter with overload relays illustrates the complete line. Maximum ratings 300 hp, 220 v; 600 hp, 440-550 v. Available in enclosures for all types of operating conditions.



SOLENOID CONTACTORS—Bulletin 702, Size 1, two pole magnetic switch. Available in various pole combinations and in ratings up to 300 amp, 110 v; 900 amp, 220-440-550 v.



MULTISPEED STARTERS—Bulletin 715, Size 1, two speed, separate winding starter. Also available in consequent winding types.



REVERSING SWITCHES—Bulletin 705, Size 2, across-the-line reversing switch. Ratings to 300 hp, 220 v; 600 hp, 440-550 v.

COMBINATION STARTERS—Bulletin 712, Size 1, with visible disconnect. Ratings to 100 hp, 220 v; 200 hp, 440-550 v.

Allen-Bradley also produces quality fixed and variable composition resistors, ceramic capacitors, and ferrite parts

ALLEN-BRADLEY MOTOR CONTROL



12½, 25, 50 and 100 feet). All the ducklings were imprinted between 12 and 17 hours after hatching. The results showed that at distances up to 50 feet the strength of imprinting increased with the distance traveled [see chart at top of page 86].

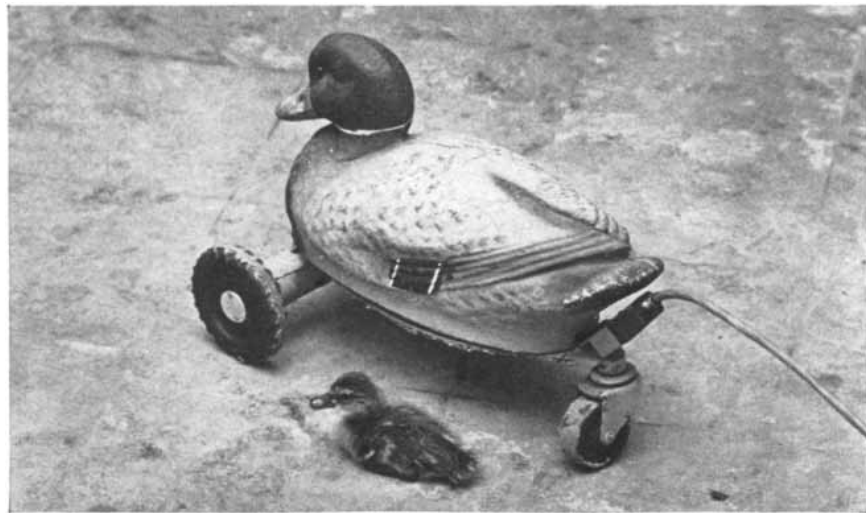
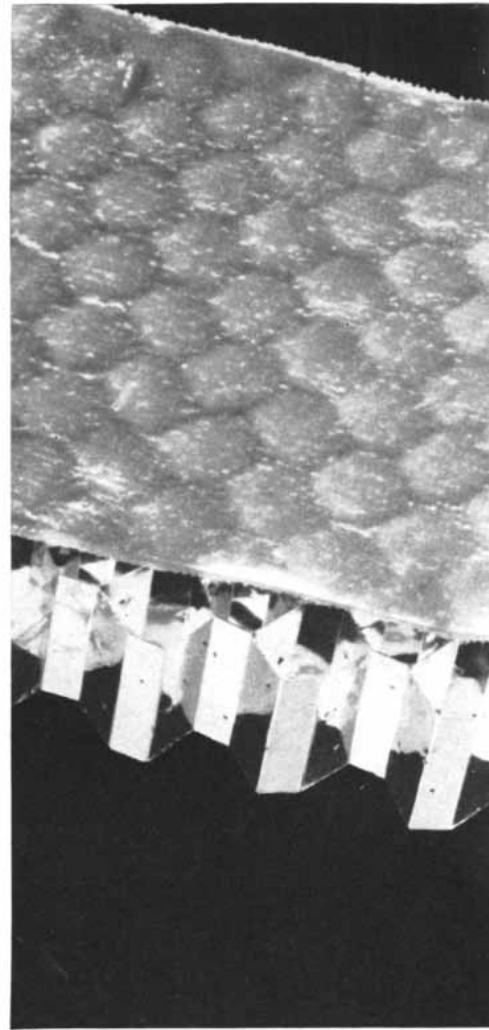
We now allowed other groups of ducklings to travel the same distance, but over different periods of time. One turn around our runway is 12½ feet; a duckling can walk this distance in something less than two minutes. We moved the decoy so that groups of ducklings made one turn around the runway in 2, 10 and 30 minutes. The scores of these animals were essentially identical [see chart at bottom of page 86]. Moreover, there was no significant difference between the scores of ducklings which followed the decoy 100 feet in 10 minutes and those which traveled the same distance in 30 minutes.

In other words, the strength of imprinting appeared to be dependent not on the duration of the imprinting period but on the effort exerted by the duckling in following the imprinting object. To confirm this notion we tried two supplementary experiments. In the first we placed four-inch hurdles in the runway so that the ducklings not only had to follow the model but also had to clear the obstacles. As we suspected, the birds which had to climb the hurdles, and thus expend more effort, made higher imprinting scores than those which traveled the same distance without obstacles. In the second experiment we allowed the duckling to follow the decoy up an inclined plane, with similar results. After further experiments we came to the conclusion that we could write a formula

for imprinting: the strength of imprinting equals the logarithm of the effort expended by the animal during the imprinting period.

Now that we had this basic information, we began to explore other aspects of imprinting. We had been puzzled by the fact that the imprintability of ducklings rapidly declines soon after they are 16 hours old. We had noticed, as had other workers, that ducklings develop their first emotional response when they are 16 to 20 hours old. This response is an avoidance or fear of moving objects. Twenty-four hours after hatching almost 80 per cent of the ducklings exhibit this fear; the proportion increases to 100 per cent at about 32 hours. Does this fear response knock out imprinting?

At the time we were reflecting on this question the tranquilizing drugs had just been introduced, and it occurred to us that these drugs which reduce fear and anxiety might solve our problem. We administered meprobamate (Miltown) to 24-hour-old ducklings; their fear response was indeed reduced. We then imprinted the drugged birds 26 hours after hatching. Ducklings 26 hours old are of course imprinted very weakly, but we were surprised that the imprinting scores of these animals were even lower than normal. In other words, eliminating fear did not improve imprintability. Later we found that the tranquilizer also interfered with the imprinting of young mallards at an age when they were normally most imprintable. So far our best conclusion is that meprobamate, being a muscle relaxant, nullifies the effectiveness of the imprinting experience by re-

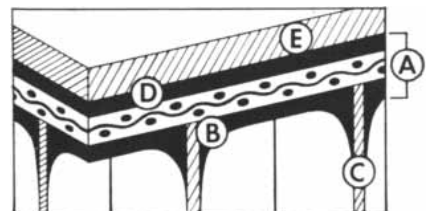


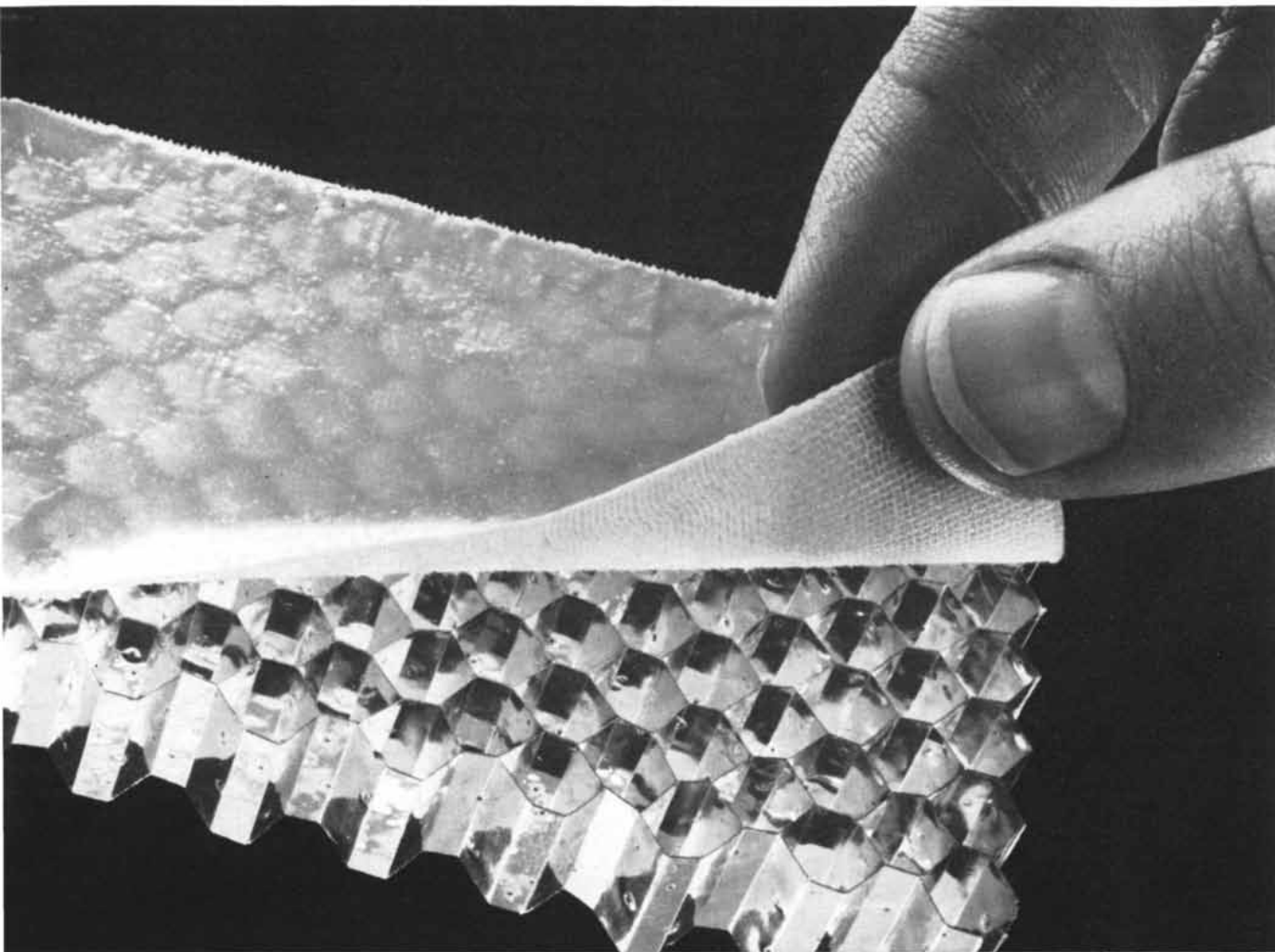
REMOTE-CONTROLLED DECOY was used by Hess and his colleagues in other imprinting experiments. Here both decoy and duckling move about freely rather than on a runway.

Dry/liquid

3M Research merges two technologies, creates new composite film adhesive

GREATER BOND AREA—One side of 3M Composite Adhesive Film (A) is coated with dry filleting epoxy (B). Under heat, this epoxy turns liquid, wets deep into the honeycomb (C), then cures chemically to a high-strength, solid fillet. Elastomeric adhesive (D), on the opposite side of the film, bonds firmly to skin material (E). You get a sandwich bond of controlled thickness, tougher and far less messy than previous sandwich construction adhesives.





THIS DRY ADHESIVE FILM will turn liquid when bonding heat is applied. A combination of epoxy resins and elastomeric components, it makes possible stronger honeycomb sandwich bonds for aircraft and many other industries, too.

adhesive helps jets fly faster

Today's jets fly faster, carry bigger payloads, thanks to a new 3M, dry/liquid adhesive film.

Thanks also to a daring leap of research imagination—from breweries to raincoats. Here's what happened:

The aircraft industry needed to bond honeycomb sandwich structures more strongly, more easily. 3M Research combined knowledge from two far distance sources. One, knowledge of deep filleting adhesives springing originally from glass-to-glass bonding in breweries. The other, knowledge of high peel strength adhesives stemming back to the apparel industry.

The result—a totally new adhesive family, 3M Composite Adhesive Films that turn liquid under bonding heat, avoid the messiness and handling difficulties of previous adhesives.

They combine *both* deep filleting and high peel strength, make possible far stronger, lighter, more fatigue-resistant aircraft wings, speed production, cut fabricating costs.

Incredible to consider jets, breweries, raincoats all at once? Not for 3M. This ability to combine research in many fields is the superiority of a fully diversified adhesive manufacturer like 3M. And of its products, too. Only 3M has such broad adhesive experience.

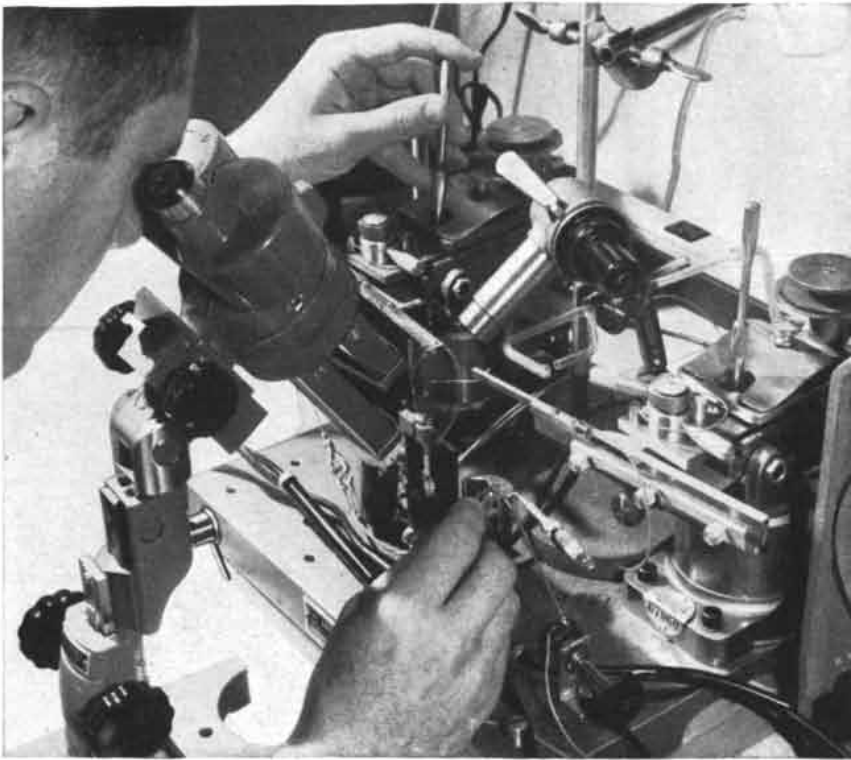


SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Call your 3M Field Engineer. Or for free literature write on your company letterhead to: 3M, Dept. B-3, 417 Piquette, Detroit 2, Michigan, stating your area of interest and adhesive need.

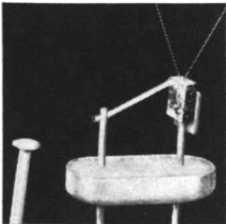
ADHESIVES, COATINGS AND SEALERS DIVISION
MINNESOTA MINING AND MANUFACTURING COMPANY
 ...WHERE RESEARCH IS THE KEY TO TOMORROW





3-D MICRO-VISION

helps RAYTHEON develop new SPACISTOR amplifier



Spacistor shown next to ordinary pinhead.

The Spacistor, Raytheon's new semiconductor amplifier, opens new horizons in missile and communications equipment design. Still in development, the Spacistor promises to combine many advantages of transistors and vacuum tubes.

Viewed through a Bausch & Lomb Stereomicroscope, contact points that are normally barely visible can be positioned with hairline accuracy. 3-D magnification shows all parts vividly, right side up. Long working distance permits free movement of hands and tools between eyepiece and stage. Dustproof, shockproof optical system, with sharp, flat images free from distortion, assures fatigue-free viewing throughout prolonged examination.

**SEE FOR YOURSELF!
MAIL COUPON FOR
FREE 15-DAY TRIAL**

BAUSCH & LOMB



BAUSCH & LOMB OPTICAL CO.
78127 ST. PAUL ST., ROCHESTER 2, N. Y.

- I'd like to borrow a B&L Stereomicroscope for a 15-day trial without cost or obligation.
- Send me B&L 3-D Micro-Vision Book (Cat. D-15), containing valuable data, showing actual stereo views.

NAME

TITLE

COMPANY

ADDRESS

CITY ZONE STATE

laxing muscular tension. It is also possible that in the imprinting process some degree of anxiety is necessary. This anxiety, from an admittedly human viewpoint, may merely be the fear of being left alone; the duckling might thus tend to follow the imprinting object as it moved away. We are continuing our study of these drugs because we feel that it may not only shed some light on the mechanism of imprinting but also may give us valuable information about the action of the drugs themselves.

We have also considered the genetic side of imprinting. We have kept ducklings which were highly imprintable and bred them separately from ducklings which showed very little imprinting response. Significant differences appeared even in the first generation: the offspring of imprintable parents were easily imprinted; those of less imprintable parents were difficult to imprint. We are also following up those animals which have had experimental imprinting experiences to determine what influence, if any, these experiences have on their adult behavior. So far the results are inconclusive, but they do suggest that experimental imprinting of mallards affects their adult behavior, particularly with respect to courtship patterns.

We have performed imprinting experiments not only with mallards and, as indicated earlier, guinea pigs, but also with other kinds of ducks, several varieties of geese, with sheep, turkeys, pheasants, quail and chickens. We have had some success in imprinting certain breeds of chicks (mainly Cochin bantams and Seabright bantams), but in general domestic fowl cannot be as clearly imprinted as wild birds.

What does all this have to do with human behavior? Of course it is not really necessary to relate our work to such behavior; it is interesting and important in its own right because it tells us something about the way an organism adapts itself to the world. We do feel, however, that the work has some implications which are relevant to humans. It has long been known, for example, that in order for a child to develop normally it must have a certain amount of attention and handling during a critical period of its infancy. This period is doubtless not as sharply defined as the imprinting period in birds, but it may lie within the first six months of life. Jere Wilson of our group is studying the smiling response of infants in an effort to get at some aspects of human behavior which may involve imprinting.

NEW DEPARTURE FACTS













TINY SIZE...

TREMENDOUS IMPORTANCE!

New Departure has many years of experience in the manufacture of ball bearings to the finest ultra-precision tolerances. And . . . New Departure uses the most advanced equipment for research, development and production in making a

full range of bearings of precision instrument classification. A new catalog, including miniature sizes, plus additional information helpful to you in design problems sent on request. Write New Departure, Division of General Motors, Bristol, Conn.

ASK FOR CATALOG P.I.B.

FULL SIZE	BORE B		DIAMETER D		WIDTH W		BALLS		CORNER RADIUS r (To Clear)
	FRAC- TION	DEC- IMAL	FRAC- TION	DEC- IMAL	FRAC- TION	DEC- IMAL	NO.	DIAM- ETER	
	3/4	.0469	5/32	.1562	1/16	.0625	5	1/32	.005
		.0550	3/16	.1875	5/64	.0781	6	1 mm	.005
	5/4					.0937	5	1/16	.006
	3/32					.0625	8	.025	.005
	3/32						6	1/16	.005
	1/8							1 mm	.005
	1/8								.005
	5/32	.1562							.005
	3/16	.1875							.005
	3/16	.1875	3/8						.006
	1/4	.2500	3/8	.3750					.006
	1/4	.2500	1/2	.5000	1/8	.1250	*12	*1 mm	.006



DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

THE STORY BEHIND THE STORY



GYROSCOPES:

Their Strange Properties Changed Our World



Surgically clean, dust-free laboratories are required to produce the highly accurate Sperry gyroscopes for advanced inertial navigation and guidance systems in missiles, aircraft, ships and submarines.

Nearly 50 years ago Elmer Sperry transformed a child's toy into a practical gyro-compass. In a major scientific break-through, man had harnessed the gyroscope's unique ability to maintain the direction of its rotational axis and also its strange behavior when this axis is disturbed.

This historic achievement touched off a series of Sperry developments in gyroscopics which revolutionized marine navigation, gave new horizons to the airplane, and opened the door to outer space. For the marine gyro-compass was soon followed by the first automatic pilot for aircraft and the first guided missile, both introduced by Sperry.

Through the years, new and improved gyro instruments, controls and systems by Sperry became essential equipment aboard ships and planes. By World War II, they

had also become essential to our defense. Guiding and stabilizing bombers, fighters, battleships, submarines, tanks and torpedoes, the gyroscope also made possible the first bombsight and the first automatic computing gunsight for ships and aircraft.

The gyroscopes of today—refined, modified and adapted past all resemblance to their ancestors—are widely employed as key elements of precision devices on land, at sea and in the air. In Sperry's modern laboratories unique new gyroscopes are now being developed and produced to meet the challenges of tomorrow.

SPERRY *GYROSCOPE COMPANY*
Great Neck, New York

DIVISION OF SPERRY RAND CORPORATION



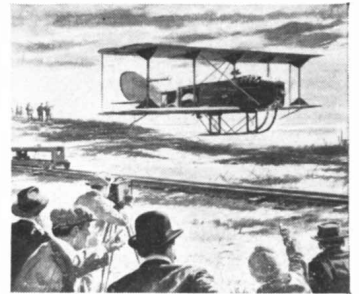
1911 Successful tests aboard U. S. S. DELAWARE proved worth of first Sperry Gyro-Compass in accurate navigation and gunfire control.



1912 Lawrence Sperry, son of the inventor, was first to fly automatically using the first gyroscope controlled Sperry Stabilizer.



1913 First vessel automatically stabilized by Sperry gyroscopes was U.S. destroyer WORDEN.



1915 First U. S. missile was Sperry "Aerial Torpedo", in which gyros held pre-established course.



1919 Gyroscopic Turn Indicator and Drift Set guided Navy's NC-4 Flying Boat on first transatlantic flight.



1924 Precise navigation for the first round-the-world flight by Army's Douglas planes was provided by Sperry Master Compasses.



1929 First "blind" flight in covered cockpit by Lt. Jimmy Doolittle using Sperry Gyro-Horizon and Directional Gyro.



1933 Wiley Post's dramatic solo around-the-world flight also won acclaim for Sperry's gyroscopic automatic pilot.



1942 In World War II, Sperry gyroscopes in bombsights and electronic automatic pilots enabled precision bombing.



1942 Ship defense against aircraft was greatly strengthened by introduction of Sperry's gyroscopic computing gunsight.



1946 Sperry began design of Sparrow I missile which later became first U. S. operational air-to-air missile.



1952 Improved gyroscopic gunsight helped pilots establish U. S. jet fighter superiority in Korea.



1952 S. S. United States keeps on course, on schedule with aid of Sperry Gyro-Compass and automatic steering system.



1953 Navy's Regulus missile, built by Chance-Vought for ship or submarine launching, is directed over great distance to target by Sperry gyroscopic controls.



1956 Sperry Gyrofin™ Stabilizers reduce ship roll up to 90% for passenger comfort and cargo protection.



1956 Advanced Sperry gyroscopes form core of electronic flight control and bombing system for B-52 bombers.



1957 B-58 Hustler, first supersonic jet bomber, has extremely accurate Sperry navigation and guidance system.



1957 Albacore, the sub that "flies" under water, has complete Sperry gyroscopic control system similar to an airplane's.



1958 Douglas DC-8 jetliner will have new Sperry automatic flight control system to relieve pilot fatigue and increase passenger comfort.



19?? Sperry gyroscopic devices are destined to guide space-piercing missiles and vehicles of the future.

Helmholtz

This 19th-century German was a deep and versatile investigator. Although he had been trained as a physician, he made important contributions to physics, physiology and the theory of knowledge

by A. C. Crombie

“My mind absorbed avidly, like a revelation, the first law I knew to possess absolute, universal validity, independently from all human agency: the principle of the conservation of energy.”

These words are from the *Scientific Autobiography* of the great German physicist Max Planck. The law to which they refer—which says essentially that energy, like matter, cannot be created or destroyed but only transformed—was indeed a revelation to scientists of the mid-19th century. Its implications and the problems it posed dominated physics in the period between the electromagnetic researches of Faraday and Maxwell and the introduction of the quantum theory by Planck in 1900. It is certainly one of the most important ideas in the history of physical science.

Like many great scientific discoveries, the law of the conservation of energy was arrived at independently by several men. Its broadest and most definitive formulation was given by the German physicist, physiologist and philosopher Hermann von Helmholtz. Yet at the time he published his account of energy conservation he was not a professional scientist but a young doctor practicing in the Prussian army.

Helmholtz's scientific accomplishments were extraordinarily wide in range. To physics he contributed not only his work on the conservation of energy but some of the most important germinal ideas on the electrical theory of matter and of light and radio waves. In physiology he carried out the first systematic experimental investigation of the sense organs, especially the eye and ear. These investigations in physiology led him to epistemology and the philosophy of science. Here his genius played a major part in turning German philoso-

phy from its resolute preoccupation with philology and history toward a concern with science.

The remarkable breadth of his achievements is a testimonial to the advantages of forcing a man of genius to consider problems outside his usual field of interest. By natural bent Helmholtz was a theoretical physicist and mathematician. His father, however, could not afford to give him a university education; to obtain a government scholarship Helmholtz had to take up the study of medicine. As a medical student and army surgeon he was forced to look at scientific problems from an unusual point of view and to enrich and discipline his unifying mathematical and physical intuitions by contact with concrete and particular facts.

Hermann Helmholtz (the “von” was added when he was ennobled many years later) was born at Potsdam in 1821. His father was a master at the Potsdam Gymnasium; his mother was the daughter of an army officer and a direct descendant of William Penn. As a young child Helmholtz was delicate and seems to have learned slowly; a relative, writing to reassure his ambitious parents, reminded them that the great Alexander von Humboldt had learned nothing before he was eight. Nonetheless when Helmholtz entered school at seven he is said to have astonished his teachers with his intuitive grasp of geometry, learned from playing with toy blocks.

Geometry appealed to the young Helmholtz because of its orderliness. He had a bad memory for disconnected facts and was hopeless at history. But geometry failed to satisfy him for long. As he said many years later: “It dealt exclusively with abstract forms of space, and I delighted in complete reality.” The

first fragments of physics which he learned at the Gymnasium revealed to him “the mighty fullness of Nature, to be brought under the dominion of a mentally apprehended law.” The prospect of winning “intellectual mastery over Nature” was to fascinate him for the rest of his life.

Helmholtz's first attempts to generalize reality had been cast in geometrical terms. The study of physics soon shifted his thinking to “a kind of mechanical mode of view.” He discovered with delight that he had an intuitive grasp of the distribution of strains and stresses in any mechanical arrangement. Experienced mechanics and machine-builders also have this sort of intuitive understanding, but, as Helmholtz later put it, “I had the advantage over them in being able to make complicated and specially important relations clear by means of theoretical analysis.”

In 1838, when he was 17, Helmholtz entered the Friedrich-Wilhelm Institute of Medicine and Surgery in Berlin. Its professor of physiology—the first man to hold that title in any country—was Johannes Müller. Through Müller's influence Helmholtz soon became interested in seeking out physicochemical explanations for biological processes. His first original contribution to science, published soon after his graduation, was in the field of anatomy; it showed that the nerve fibers of invertebrates originate in ganglion cells. For relaxation from his medical and physiological studies he read mathematical works by Euler, Bernoulli and d'Alembert, along with the poetry of Goethe and the philosophy of Kant.

As a scholarship student at the Institute Helmholtz had had to agree to serve 10 years as an army surgeon. Fortunately he was able to continue his physio-

logical researches in a laboratory fitted up in the Potsdam barracks where he was stationed. These researches, which were to lead him to the law of the conservation of energy, were inspired by the controversy over "vitalism" that stirred all workers in the life sciences in the first half of the 19th century.

As Helmholtz himself put it: "Most physiologists had at that time adopted G. E. Stahl's way out of the difficulty, that while it is the physical and chemical forces of organs and substances of the living body which act on it, there is an indwelling vital soul or force which could bind or loose the activity of these forces; that after death the free action of these forces produces decomposition, while during life their action is continually being controlled by the soul of life." He went on to say: "I had a misgiving that there was something against nature in this explanation; but it took me a good deal of trouble to state my misgiving in the form of a definite question."

It was the great German chemist Justus von Liebig who succeeded in formulating the question. Are the me-

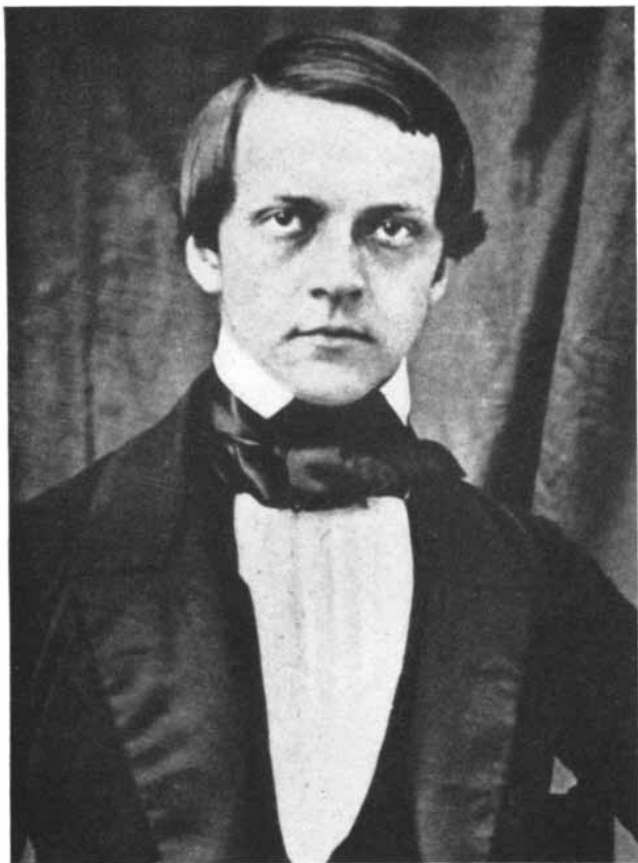
chanical energy and heat produced by an organism, he asked, entirely the product of its own metabolism? Helmholtz, in his barracks laboratory, set out to discover the answer. His first investigations into the metabolism of muscle showed that the heat of the body comes entirely from the foodstuff and oxygen supplied to it. The heat given off by an animal, he found, was equal to that produced by burning the animal's food in a calorimeter. There was none left over to indicate the operation of a vital force.

Now Bernoulli, d'Alembert and other 18th-century mathematicians had already developed Newton's law of the conservation of momentum to show that machines cannot originate energy, but can only convert the energy they receive from without into various forms of motion. Thus a man may give potential energy to a weight-powered clock by winding up the weight; as the weight falls this potential energy will be converted into the kinetic energy of the clock-mechanism. But when the weight reaches the bottom, the clock will stop. A perpetual-motion machine, which works without input of energy, is impossible. "Stahl's theory," Helmholtz later wrote,

"ascribed to every living body the nature of a *perpetuum mobile*." The concept of a vital force that could engender and direct physical forces without consuming energy struck Helmholtz as a paradox.

The resolution of this paradox stimulated Helmholtz, already able to move with ease in many different branches of science, to apply his powerful mathematical vision to a general solution of the whole problem of energy transformation. In 1847 he was able to present his theoretical solution to the Physical Society in Berlin, in his famous paper "On the Conservation of Energy."

Assuming that perpetual motion is impossible, he asked what the relations between the various known forces of nature must then be. His answer was that these forces cannot arise out of nothing. Mechanical energy cannot be generated in any natural process without a corresponding expenditure of energy. But neither can energy disappear. A quantity of energy may be lost to a particular machine (as in the clock when the weight reaches the bottom) but not to the universe as a whole (the kinetic energy of the clock's mechanism is converted into an equivalent quantity



HELMHOLTZ is shown as a young man and at the age of 60. The daguerreotype at left was made about 1842, the year he graduated



from medical school. The photograph at right was made in 1881, when he was professor of physics at the University of Berlin.

of heat). "Nature as a whole," Helmholtz wrote, "possesses a store of energy which cannot in any wise be added to or subtracted from. . . ." The quantity of energy is as eternal as the quantity of matter, the indestructibility of which had been established by Lavoisier.

Helmholtz went on to examine the implications of his thesis. The atomic and molecular theories, already well-secured as scientific principles, held that matter consists of elementary particles with unalterable properties, and that chemical changes involve merely the redistribution of these particles in space. To this conception Helmholtz added the postulate that all forces can be analyzed into mechanical forces acting between these elementary particles; even heat is due to atomic or molecular motion. All forms of energy are ultimately kinetic; the final aim of natural science must be to reduce itself to mechanics, with mass and energy as the fundamental, indestructible quantities.

Applying his principle in detail, Helmholtz showed how to compare the kinetic energy of a moving body, the electrical energy produced by a thermocouple, the energy of a magnet moved by electricity, and simple heat energy. This could be done by reducing each form of energy to the amount of mechanical work it could do. Chemical reactions, he pointed out, also conserved

energy: the German chemist G. H. Hess had proved only a few years before that the heat liberated when two or more elements united to form a given compound was the same no matter what intermediate stages preceded the final result. Whatever the mode of transformation of one into another, all forms of energy were an exactly measurable equivalent of the kinetic energy of matter in motion.

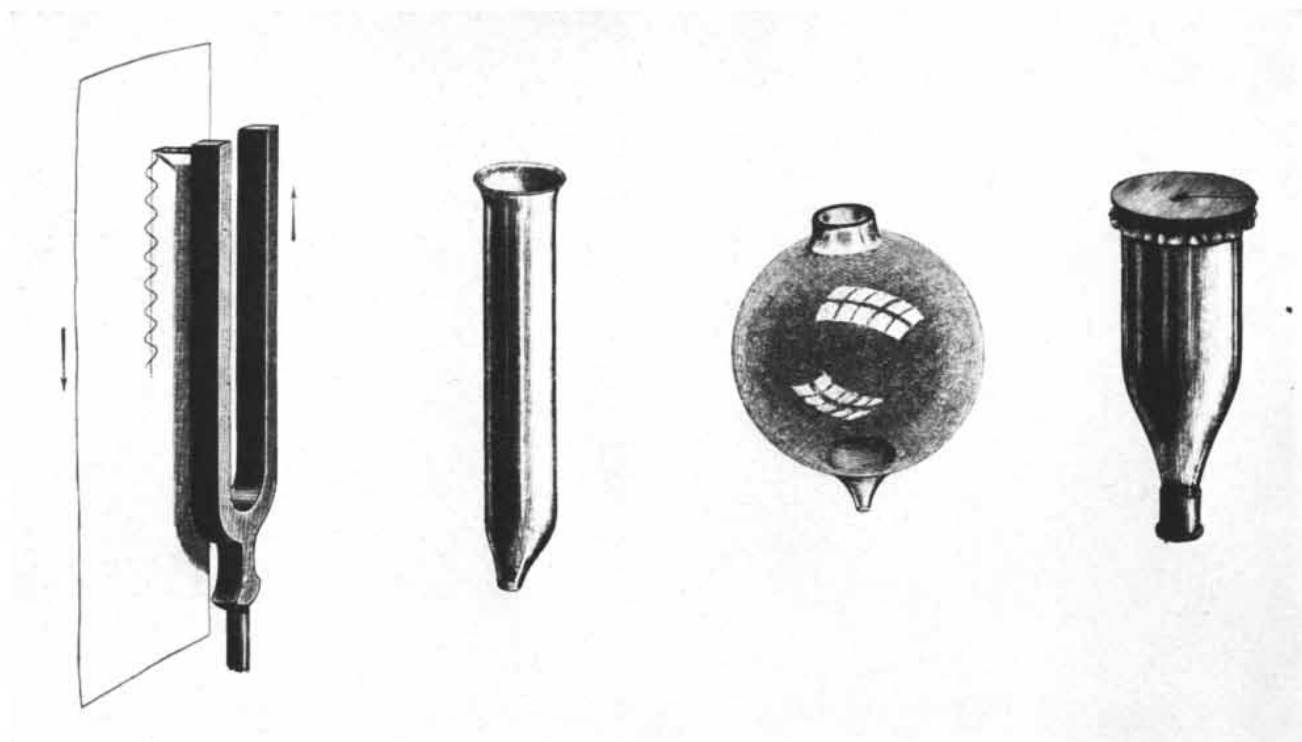
"I think that in the foregoing," he concluded, "I have proved that the above-mentioned law does not contradict any hitherto known facts of natural science, but is supported by them in a striking manner." Complete experimental confirmation of the law, he added prophetically, "must be regarded as one of the principal problems of the natural philosophy of the future."

Helmholtz was not the first to formulate the law of the conservation of energy; he soon found that Julius Robert von Mayer, another German physician, and the English physicist James Joule had both anticipated him. But it was undoubtedly Helmholtz who saw and presented mathematically the law's profound general implications.

The law of the conservation of energy revolutionized many branches of science. In physiology it helped to eliminate vitalism and opened up new areas

of research by regarding the body as a machine which converts food and oxygen into heat and work. It provided the main program for physics during the rest of the 19th century. From then on, as Helmholtz's most brilliant pupil Heinrich Hertz later wrote, the physicist's object was "to refer all phenomena . . . to the laws which govern the transformation of energy." From Helmholtz's original conception Clausius, Boltzmann, Kelvin and other physicists were able during the next 50 years to construct the imposing structure of modern thermodynamics. Helmholtz himself helped to clarify the concept of entropy, the basis of all subsequent cosmological systems. He even delivered a lecture on the ethical consequences of the assertion that the universe is tending toward a "heat death" of uniform temperature and eternal rest.

Helmholtz's paper, despite the incredulity which at first greeted it (the leading German journal of physics refused to print it), soon launched him on the academic career for which he had long hoped. Two years after its publication (as a pamphlet) Müller was able to extract him from the army and get him appointed lecturer in anatomy at the Berlin Academy of Arts. The following year he was appointed professor of physiology at Königsberg. Immediately on receiving this appointment he married

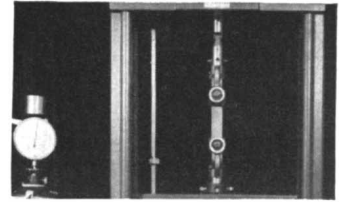


PHYSICS OF SOUND was studied by Helmholtz with the aid of a tuning fork (*left*), which traced its vibrations on a moving sheet

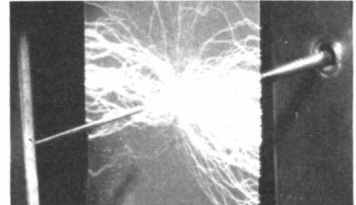
of paper. He devised glass resonators of various shapes as a means of analyzing complex musical tones into their constituent parts.



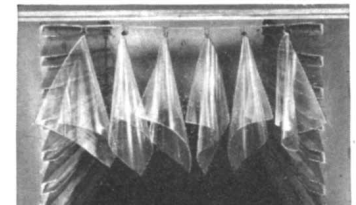
"MYLAR" offers a unique combination of properties valuable for electrical design



HIGH TENSILE STRENGTH. "Mylar" is the strongest plastic film. Instron tester shows an average strength of 20,000 lbs. psi.



HIGH DIELECTRIC STRENGTH. Average of 4,000 volts per mil . . . average power factor of 0.003 at 60 cycles . . . dielectric constant above 3.0 at 72°F., 1,000 cycles.



THERMAL STABILITY. Tests prove "Mylar" has an effective operating range, -80°F. to 300°F. . . won't brittle with age.

Here's why IBM introduced magnetic tape made with MYLAR for its data processing equipment

PROBLEM: International Business Machines Corporation wanted to increase the humidity and temperature range of magnetic tape used in its data-processing equipment. IBM was looking for a magnetic tape that maintained a relatively stable dimension through a wider range of atmospheric conditions.

SOLUTION: After conducting field tests over a period of 14 months, in conjunction with its own environmental test program on data-processing machines, IBM introduced magnetic tape using Du Pont "Mylar"* polyester film as the base.

RESULTS: Magnetic tape made with "Mylar", reports IBM, has good dimensional stability. This stability reduces the need for critically controlling temperature and humidity

in recording or storage areas.

HOW CAN "MYLAR" HELP YOU? No matter what product you make, it will pay you to investigate the unique opportunities offered by "Mylar" . . . opportunities to speed up production, improve performance or cut costs. For dramatic proof through successful applications of "Mylar", send today for a copy of our new booklet.



REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

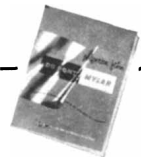
DU PONT
MYLAR®
POLYESTER FILM

*"MYLAR" is Du Pont's registered trademark for its brand of polyester film.

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room SA-3, Wilmington 98, Del.

- Please send your booklet outlining advantages of magnetic recording tape made with "Mylar".
- Please send your booklet listing properties, applications and types of "Mylar" available. (MB-11)

Application _____
Name _____ Title _____
Company _____
Address _____
City _____ State _____



Olga von Velten, whose father, an army surgeon, had been one of Helmholtz's superiors at Potsdam. In 1855 Helmholtz moved to Bonn as professor of anatomy; the young couple's home there, with its terrace overlooking the Rhine, became the center of a distinguished group of friends. In 1858 the Helmholtzes moved to Heidelberg, where Hermann was to spend 13 years as professor of physiology. In 1859 Olga died after a long illness; two years later Helmholtz married Anna von Mohl, whom he described with affectionate irony as having had the benefit of a "fashionable" education.

It was at Königsberg that Helmholtz began the investigations which were to lead him toward the other great question that guided his life's work: the origin of human knowledge. Again he began with the experimental study of a highly specific question and ended with broad, general conclusions. As his studies of vitalism had given birth to the law of the conservation of energy, so his theory of knowledge emerged from a lengthy and exact investigation of the nervous system and sense organs.

In 1850 little was known about what actually happens in the nervous system. Nervous activity was thought to be

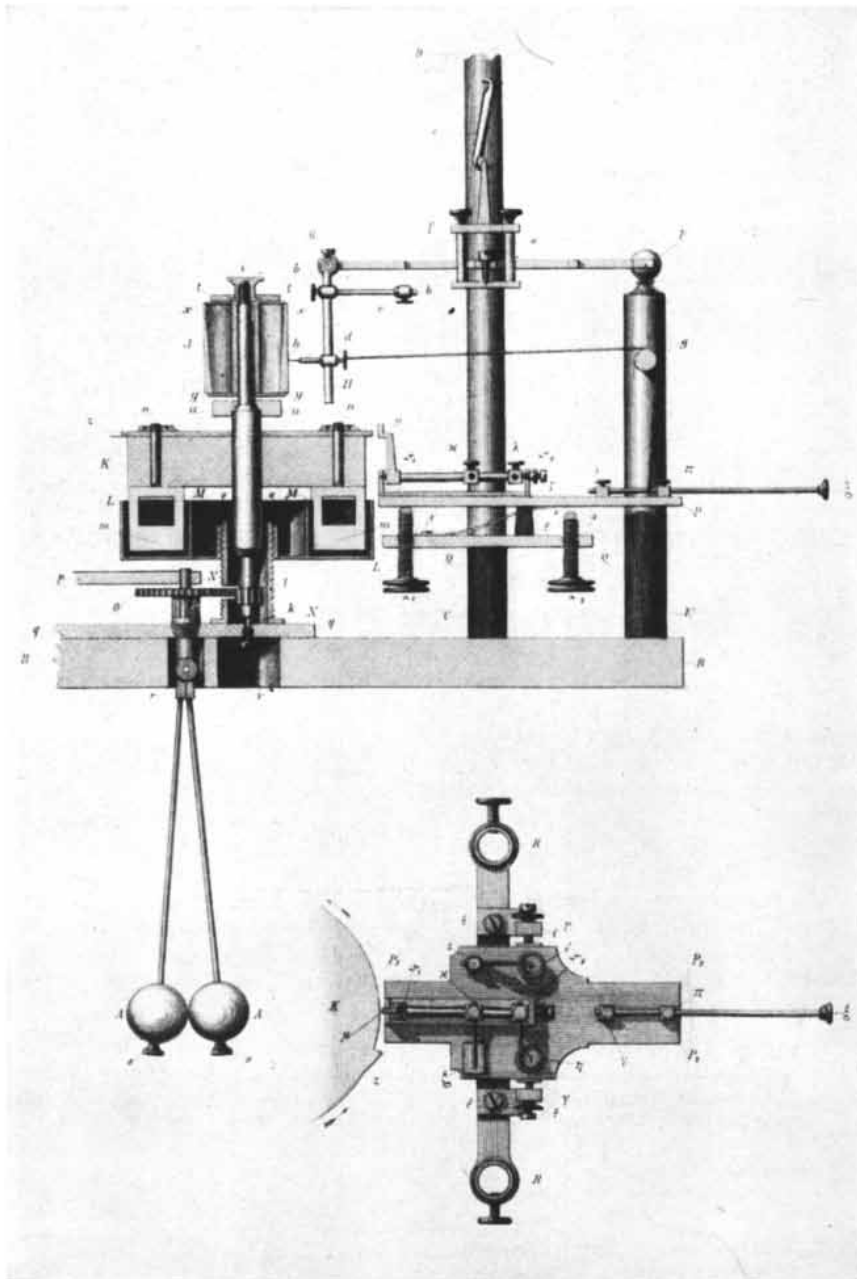
somehow related to electricity; Helmholtz's friend Emil Du Bois-Reymond had already described the electrical changes which accompany a nerve impulse. Helmholtz carried this work an important step further. By hitching a pointer to a frog's leg he was able to record on a smoked-glass plate its twitchings under electrical stimulation. By timing the interval between stimulus and twitch, he was able to make the first measurement of the speed of a nerve impulse. He made similar experiments on his own arms and those of his assistants. He was able to show that whatever passed along the nerves to deliver messages to the brain was a material change, moving with a definite speed; nerve fibers thus resembled the wires of an electric telegraph.

Turning to the special sense organs which receive impulses from the outside world, he made a thorough study of the eye, investigating the path of light in that organ, the resulting impulses in the optic nerve and their interpretation in the brain. While preparing an anatomical demonstration for one of his classes, he invented the ophthalmoscope. This instrument, which makes possible the examination of the living retina, quickly became essential equipment for every eye doctor.

He measured variations in the curvature of the lens in close and distant vision and explained the muscular mechanisms by which the eye focuses itself on near and far objects, as well as the way in which the two eyes secure a single image from two different stimuli. He re-established the theory of color vision advanced half a century earlier by Thomas Young, according to whom all colors are perceived by three primary sensations—red, green and violet—received by three different systems of optic nerves. Helmholtz used this theory to explain the different kinds of color blindness.

The result of these investigations, *Physiological Optics*, was published in three parts between 1856 and 1867. It is one of the great landmarks of 19th-century science.

Helmholtz next turned to the ear. Beginning with an investigation of the physics of sound, to which he made important original contributions, he looked into the way in which different sounds excite the cochlea. He studied differences in tone qualities (such as distinguish one musical instrument from another) and explained them in terms of the relative strength of overtones. His discussion of this point, involving de-

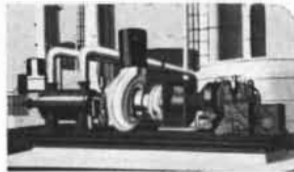


MUSCLE CONTRACTIONS under electrical stimulation were timed by Helmholtz with this apparatus. By means of it he was able to measure the speed of impulses in the nerves.

Four amazing advantages of Solar Gas Turbine Engines



Gasoline—any kind.



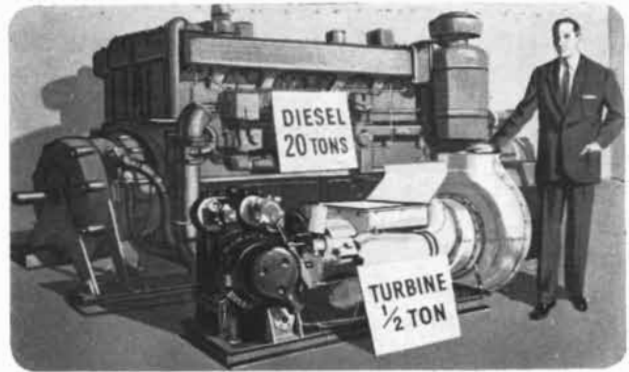
Diesel oil



Kerosene.



Natural gas.



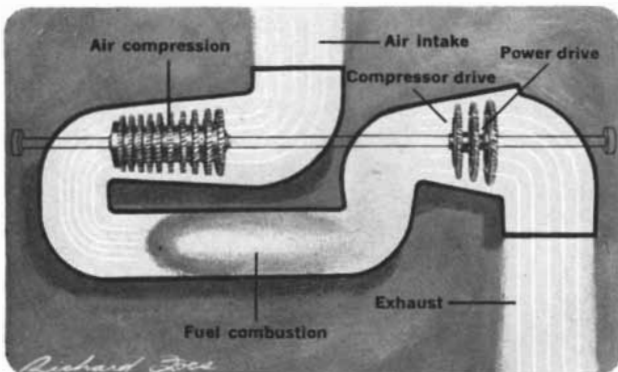
The Jupiter is completely portable—saves weight and space.

① Uses whatever fuel you've got!

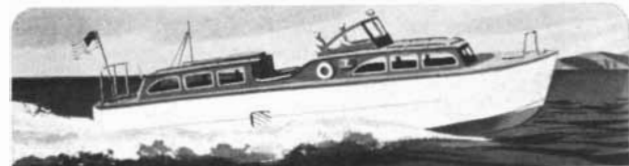
Solar gas turbines can operate on almost any available fuel—fuel that costs the least for *your* particular operation. Located in remote areas, for instance, self-sufficient Solar turbines can take fuel directly from a gas pipeline! This often results in lower total operating costs.

② Light—500 hp in 1/5 the space!

Solar's 500 hp Jupiter® engine is only one-fifth the size of a diesel of similar horsepower—and weighs *forty times less!* The entire unit is easily transported to remote locations. And it is especially suited to applications where space limitations create a troublesome installation problem.



Few moving parts, no reciprocation—longer life.



Instant acceleration—takes full load without laboring.



Instant emergency power.



Starts in any climate.

③ Simple design—low maintenance!

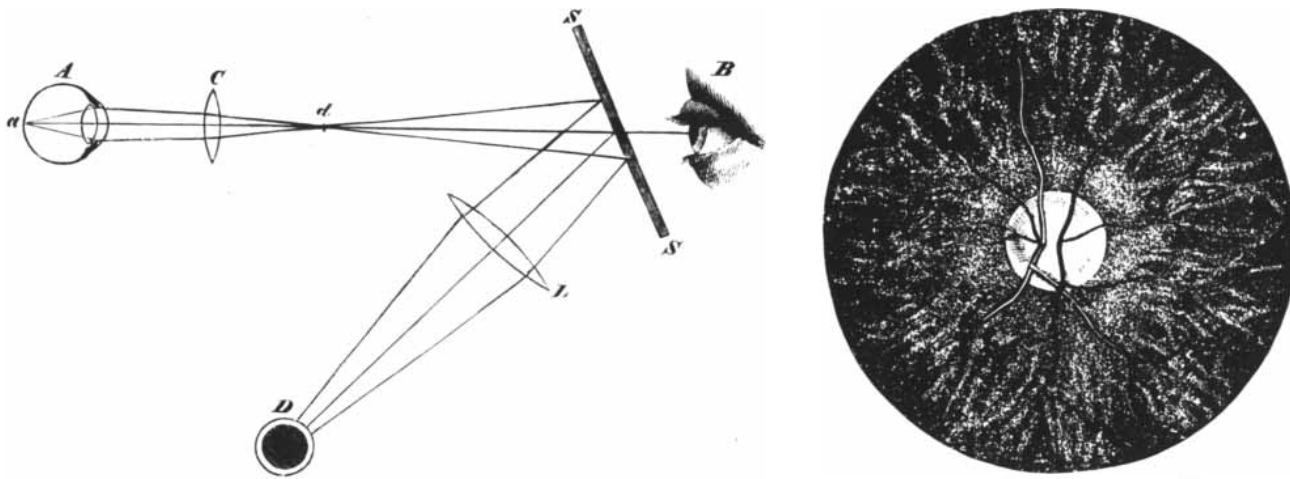
Gas turbines are the simplest of all heat engines. In operation, large volumes of air are drawn in by the compressor, mixed with fuel in the combustion chamber, greatly expanded, and delivered to a turbine which produces shaft power. Routine servicing can be completed in a few hours at most. Overhauls are infrequent. Simple design and low maintenance make gas turbines ideal for a wide range of important applications—including boat propulsion, portable power generation, air compression and chemical processing. And other applications for these versatile power plants of the future are limited only by the imagination.

④ Starts instantly—no warm-up!

Solar gas turbines can be turned on or shut down in seconds. And they require no warm-up—even after long periods of stand-by service. No matter what your business, no matter what your power needs, these amazing advantages can benefit you. Write to Dept. D-151 for free gas turbine brochure.



2200 PACIFIC HIGHWAY • SAN DIEGO 12, CALIFORNIA



THE OPHTHALMOSCOPE, invented by Helmholtz, uses lenses (C and L) and a mirror (S) to focus a beam of light and reflect it into the eye (A). The observer (B) can then examine retina (shown at right in drawing by Helmholtz) through hole in mirror.

tailed studies of scales in Eastern and Western music and a theory of vowel tones, is evidence of his own love of music; it is one of the most charming marriages of science and esthetics. Later he made an equally interesting study of the relation of optics to painting.

From these detailed physiological researches Helmholtz now began to evolve his theory of knowledge. Sense perception—the process by which we know external things—he had already analyzed into two stages. The first stage he held to encompass the physical processes through which stimuli are received by the sense organs and transmitted to the brain; the second concerned the interpretation of the messages of “knowledge” by the mind.

Müller, Helmholtz’s teacher, had already noted that there is no one-to-one correspondence between a sensory stimulus and the sensation it produces. A given nerve tends to produce the same type of sensation no matter how it is stimulated (for example, pressure on the eyeball in a dark room will stimulate the optic nerve to produce the sensation of light). Müller explained this fact by postulating physiological differences between the various sensory nerves.

Helmholtz further developed this principle in his studies of what is now called “color constancy.” He noted that the same subjective sensation of color can be produced by light of quite different physical composition (for example, this page would look green if it was illuminated either by pure green light or by a mixture of blue and yellow light). From this and similar facts Helmholtz concluded that “our sensations are, as regards their quality, only

signs of external objects, and in no sense images of any degree of resemblance.” The only connection between the sensation and the external object which produces it is the fact that both appear simultaneously.

Our sensations, then, do not resemble the objects they symbolize, any more than the letters on this page resemble the sounds they represent. Sensations are “signs that we have learned to decipher, . . . a language given us with our organization by which external objects discourse to us.” Our ability to understand this language, Helmholtz believed, is not inborn. Like any other language it is learned “by practice and experience.”

Thus Helmholtz’s theory of knowledge derived from his factual approach through empirical physiology. This approach, born of the fusion of medicine and mathematics that had formed his mind, is well illustrated by his analysis of the origin and significance of geometrical axioms.

Kant had supposed that these axioms were innate *a priori* determinants of all our conceptions of space. Helmholtz, approaching the problem quite differently, asked under what conditions we arrive at our knowledge of these axioms. He concluded that they were not innate but rather the result of our perceptions of space as mediated by the spatial extension of the retina. Since they were not intuitive but the fruit of observation, they could be tested by observation and replaced if they proved incorrect.

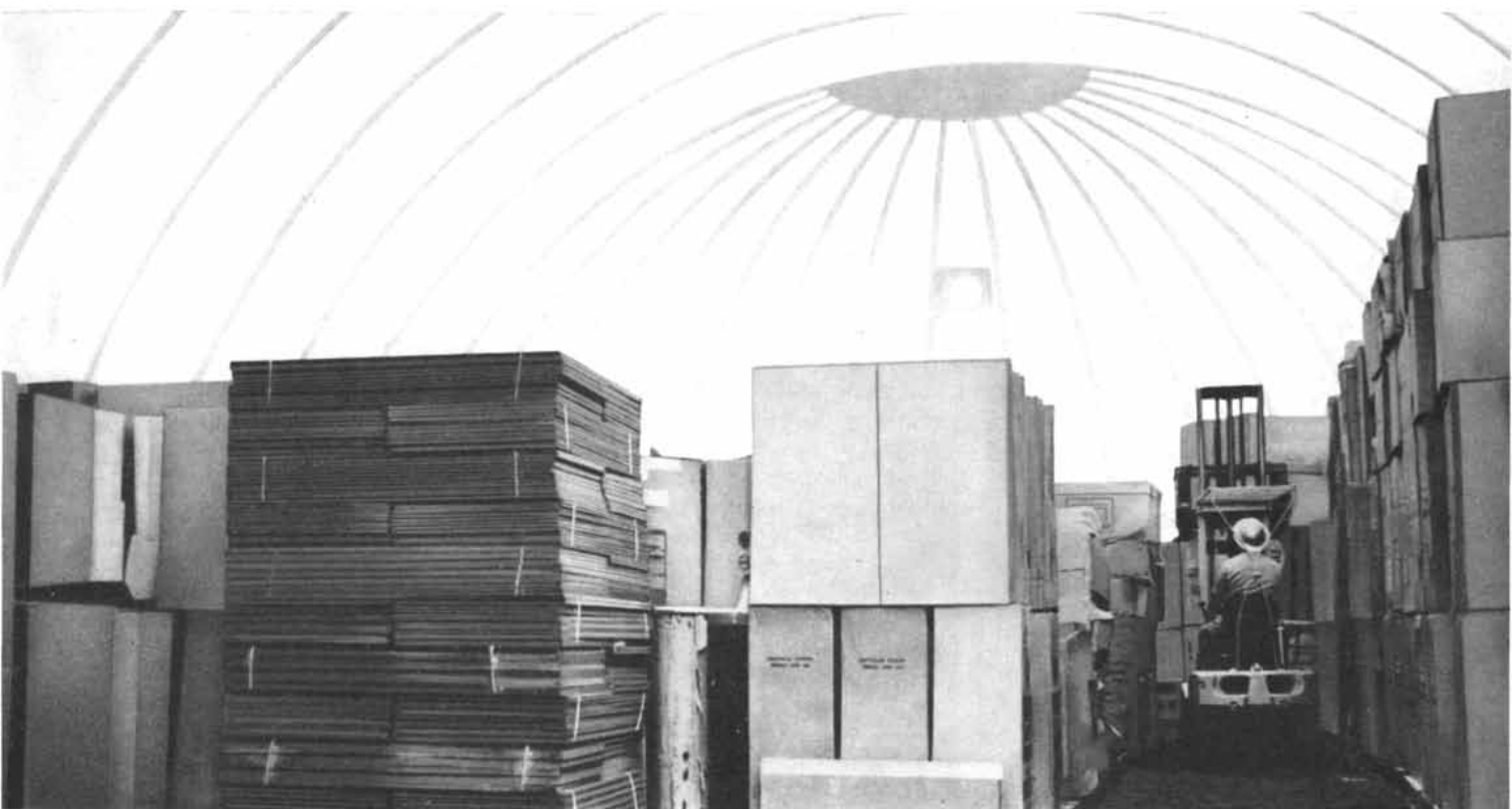
With this view of geometrical axioms, it is not surprising that Helmholtz—albeit with some initial hesitation—came to applaud the non-Euclidean geometries of Lobachevsky, Gauss and Riemann. His own work in geometry, dating from

1870, became, along with that of Riemann, the basis of the important developments in the field which took place toward the end of the century.

Helmholtz’s empirical investigations into philosophy made him increasingly dissatisfied with the school of metaphysical idealism which then dominated German philosophy. This school had been founded at the beginning of the 19th century by Hegel, who held that a purely speculative philosophy could replace all the other sciences. To Helmholtz, the experimentalist, this notion seemed absurd. As early as 1859 he wrote his father, from whom he had acquired his interest in philosophy, that Hegel “diverted philosophy from its proper scope and gave it problems it can never accomplish.” The task of philosophy, he held, was not to try to replace science but to supplement it by investigating the source and functions of knowledge, after the example of Kant and his disciple Johann Fichte.

“I believe,” Helmholtz declared, “that philosophy will only be reinstated when it turns with zeal and energy to the investigation of epistemological processes and of scientific methods. There it has a real and legitimate task. The construction of metaphysical hypotheses is vanity. Most essential of all in this critical investigation is the exact knowledge of the processes of sense perception.” He added: “I believe that any German university which had the courage to appoint a scientific man with an inclination to philosophy to its chair of philosophy would confer a lasting benefit on German science.”

Helmholtz’s crusade to reform philosophy along empirical lines entitles him



Structures without structural support

This temporary warehouse has no framework. It's supported by air from a small blower, but has such stability that even 70-mph winds won't collapse it. When its job is finished, it will be deflated and rolled up — possibly for use in sheltering a construction crew in foul weather.

Pneumatic buildings are one use of a new material: HYPALON® coated nylon fabric. HYPALON is a synthetic rubber with properties matched by no other. It weathers well, no matter what the color. It flexes without cracking and stands up to severe abra-

sion. It's ozone-proof and flame-resistant. And since it's an *elastomer*, there's no plasticizer to migrate and shorten its life. In addition, the fabric is lightweight and translucent enough to let daylight come through.

HYPALON coated fabric is the natural choice to assure long life for a pneumatic building. But look for it soon in convertible tops . . . outdoor furniture . . . raincoats . . . tents and awnings . . . luggage. And look for HYPALON now in molded and extruded products like spark-plug boots and acid hose and tank linings.

To see how HYPALON can improve the performance of your products, send for our 28-page booklet. Write Elastomer Chemicals Dept., SA-3, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.



HYPALON®

Better Things for Better Living
... through Chemistry

**NO LIGHTER LIKE IT...
NO GIFT LIKE IT!**



**BEATTIE —
the ONLY LIGHTER
with the
jet®
FLAME!**

The Strongest Jet Flame!

DOWNWARD—
right into pipe-bowl.
UPWARD—to cigar
and cigarette tip.
SIDEWAYS—into
fireplace or campfire.
ANYway—right into the wind.

*There is no substitute
for a Beattie Jet!*

at most TOBACCO, DRUG, JEWELRY, DEPT. STORES,
from **\$4.95** to **\$49.00**

or write to: DEPT. 5-3
BEATTIE JET PRODUCTS, INC.
19 EAST 48th STREET, NEW YORK 17, N. Y.

**SCIENTIFIC ENCLOSURES
QUICKLY ASSEMBLED!**

The **Widney-DORLEC**
**Cabinet Component
System**

of pre-fabricated dural
die-cast corners, extruded
sections and parts . . .
assembles into modern
fully-radiused
cabinets to any
dimensions, with
**NO SPECIAL
TOOLS, DIES
OR JIGS.**

Used in
Electronic
applications,
such as Control
and Analysis,
Computers, Mining,
Spraying, Refining,
Food Processing, etc.
Also in many Government-
approved installations.

For
prices
& data
sheets, write
Dept. YC-42E

British Industries Corporation
Port Washington, New York

to be numbered among the fathers of the modern philosophy of science. Though he himself was apt to declare that too much philosophy made one vague, his own writings on the philosophy of science have all the confident feel of reality that only a scientist can give.

Though Helmholtz during his later years became increasingly preoccupied with physiology and philosophy, his contributions to physics did not end. Indeed, the culmination of his academic career came with his appointment as professor of physics at Berlin in 1871, and his appointment as president of the State Institute of Physics and Technology in 1888.

During these years he pursued experimentally and theoretically ever more remote applications of the conception of matter in motion. He made a mathematical study of the analogy between the motion of fluids and the electromagnetic action of electrical currents in wires. The equations he produced inspired Kelvin to conceive of an atom as a vortex in the ether, in which different chemical properties were associated with different combinations of vortex rings.

Later he developed Faraday's conception that the bonds between chemical elements are electrical in character. From experiments on the electrolysis of substances in solution he was able to calculate the equivalence of electrical, chemical and mechanical forces. His work on this subject was a fundamental contribution to the theory that matter consists of electrically charged atoms and to the whole conception of valency on which modern chemistry is based.

The most far-reaching later manifestations of Helmholtz's mathematical insight were concerned with the nature of electrical and magnetic forces. Here we have the vision of the mathematician, strained to its utmost, combined with the practical logic of the experimenter to penetrate the structure of the physical world. Faced with three rival theories of electromagnetic forces, Helmholtz showed that all three were special cases of a more general mathematical theory, and devised theoretical and experimental tests to determine which special theory was to be adopted. Two of the three were eliminated, and Helmholtz was left with the theory of Faraday and Maxwell, according to which electrical and magnetic forces are propagated through an all-pervading ether. Helmholtz's mathematical interpretation of Maxwell's theory that light is another form of electromagnetic wave in the ether stimulated Hertz to make his famous ex-

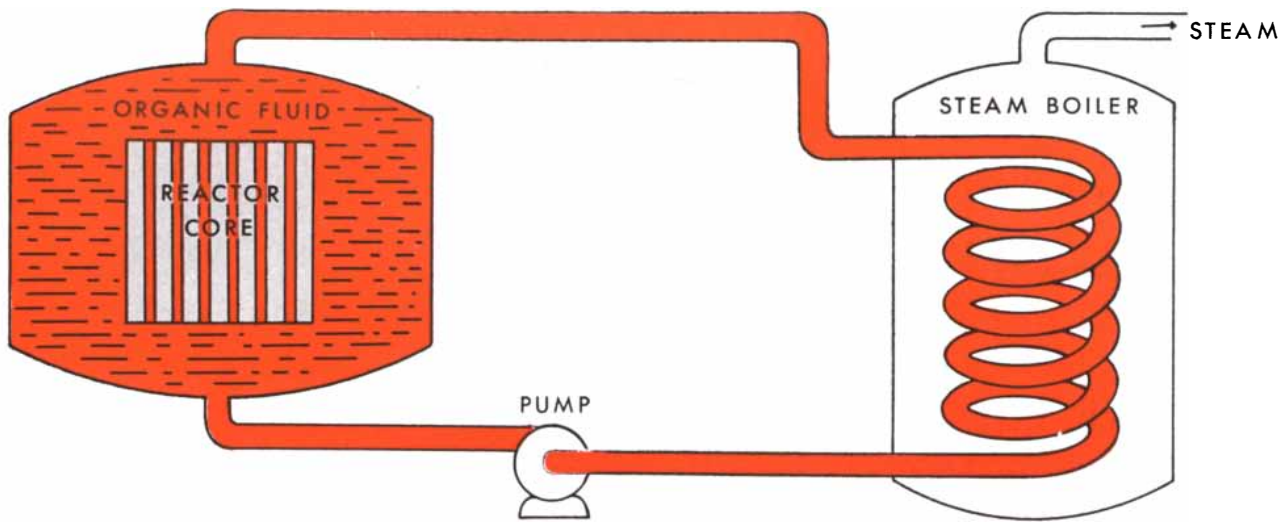
periments in electromagnetic radiation. These not only established Maxwell's theory of light, but made possible the development of radio communication.

Helmholtz's genius was remarkably original, versatile and productive. In this article I have tried to indicate the main lines of his thought and to relate them to the chief qualities of mind from which his discoveries seem to spring. He himself became deeply interested in the processes of scientific discovery; his essays on the subject, drawing heavily on his own experiences, are among the most interesting of his philosophical writings. Here is an example from a lecture, "On Thought in Medicine," which he delivered in 1877. If it leads some readers back to Helmholtz's own writings, the main purpose of this article will have been fulfilled:

"In speaking against the empty manufacture of hypotheses, do not by any means suppose that I wish to diminish the real value of original thoughts. The first discovery of a new law is the discovery of a similarity which has hitherto been concealed in the course of natural processes. It is a manifestation of that which our forefathers in a serious sense described as 'wit'; it is the same quality as the highest performances of artistic perception in the discovery of new types of expression. It is something which cannot be forced, and which cannot be acquired by any known method. . . .

"When we fancy that we have arrived at a law, the business of deduction commences. It is then our duty to develop the consequences of our laws as completely as may be, but in the first place only to apply to them the test of experience, so far as they can be tested, and then to decide by this test whether the law holds and to what extent. This is a test which never really ceases. The true natural philosopher reflects at each new phenomenon whether the best-established laws of the best-known forces may not experience a change; it can of course only be a question of a change which does not contradict the whole store of our previously collected experiences. It never thus attains unconditional truth, but such a high degree of probability that it is practically equal to certainty."

It is not as common as one could hope for creative minds, whether in science or in art, to be so conscious of their mental processes and so well equipped to criticize logically the results of these processes. The combination of these gifts makes Helmholtz all the more worthy of our study.



Simple, low-cost plants are the key to power from the atom at a competitive price. Sooner than you think, nuclear reactors may be as simple as a steam boiler. That's why the future of cheap atomic power looks more promising. Optimism is based on new test results with Monsanto functional fluids...

Blood for the veins of nuclear reactors

"Burning" fuel in the core of a nuclear reactor—theoretically—is as easy as firing coal in a furnace. The hard, practical problem has been to capture heat from the reactor and transfer it at low cost to a steam generator. Now, new test results with Monsanto synthetic fluids indicate that organic chemicals can transfer heat more economically than other materials.

Unique properties of these synthetics from Monsanto's storehouse of functional fluids break the barrier to lower costs in reactor construction. Their low vapor pressure at high temperatures eliminates the need for high-pressure equipment. Since they do not corrode common construction materials, such as mild steel and aluminum, costly metals are not required in equipment. And

because these organic fluids do not emit gamma radiation even while under neutron bombardment, thick secondary shielding is unnecessary for safety.

Work by Atomics International at the National Reactor Testing Station in Idaho has already spurred plans for a commercial power reactor with Monsanto terphenyl compounds as the "coolant-moderator." Meanwhile, researchers are studying other Monsanto organic fluids, such as isopropyl biphenyl and biphenyl, which may be more desirable in certain types of reactors. Some engineers believe a mixture of organic liquids may prove to be the best coolant of all. Whichever proves best, Monsanto organic fluids promise to help ease the cost pinch on atomic power.

YOUR FLUID PROBLEMS INVITED

For virtually any kind of equipment, including atomic reactors, Monsanto can supply or develop the special fluid needed. Monsanto has a stockpile of commercial chemical fluids plus a backlog of experience in developing the first fire-resistant hydraulic fluid, special lubricants, coolants and dielectrics. If your engineering calls for a fluid to absorb, dissipate or transmit heat, electrical or mechanical energy... ask Monsanto to help. Just call or write:

MONSANTO CHEMICAL COMPANY
Organic Chemicals Division
Department SA-3
St. Louis 24, Missouri

WHEN YOU NEED A SYNTHETIC FLUID, COME TO MONSANTO—
Creator of Fluids for the Future



®

HYPOTHERMIA

Artificial lowering of body temperature is becoming a useful medical technique. Already it has made possible unusual heart operations and has proved valuable in the treatment of shock

by Raymond J. Hock and Benjamin G. Covino

Every winter we read stories in the newspapers about people who have died from exposure to cold. In man, as in most warm-blooded animals, the reduction of body temperature much below normal causes death. Since cold-blooded animals and even warm-blooded hibernators can survive a far greater reduction of their body temperature for prolonged periods, we do not fully understand why human life should be so sensitive to cold. We do know, however, that life processes in general slow down as temperature falls. This knowledge, incomplete though it is, has recently proved a boon to surgery. In "freeze surgery," as it has been called, the patient's body is chilled 10 or 15 degrees below normal, usually by immersing it in ice water. With the body's demand on its circulatory system thereby sharply reduced, surgeons are able to perform heart operations that were unthinkable a few years ago. The technique is rapidly finding application in other branches of surgery, in the prevention of shock and in other medical problems. With practice advancing faster than understanding, lowered body temperature, or "hypothermia," is now of interest to many research groups.

Hypothermia has been likened to hibernation. The analogy is attractive, but it is helpful only if it provides an occasion for considering the significant differences between the two states. In the true hibernator, body temperature falls spontaneously to about the temperature of the environment; heart and respiratory rate and other bodily processes throttle down accordingly. With metabolism reduced to 2 per cent of normal and even less, the animal is enabled to survive the winter without eating. This adaptation is somehow built into the animal's physiological make-up, and it is a

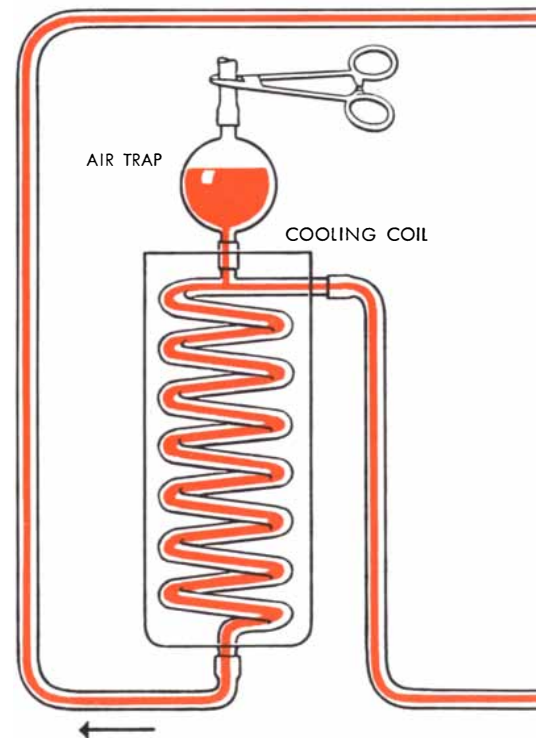
major feature of its existence. For example, the Arctic ground squirrel, studied by one of us (Hock), spends more than half the year in hibernation. In its winter lair this little creature's heart continues to beat with the temperature of its body reduced to three or four degrees above freezing. Upon awakening, the animal spends the rest of the year recovering and preparing for the next hibernation by increasing its body weight 20 to 40 per cent.

In a nonhibernator such as man there are no physiological mechanisms to reduce metabolism and body temperature in response to lower environmental temperature. In fact, the body is geared to the opposite response of stepping up its metabolism to maintain its normal temperature. A lowering of the body temperature, whether by accident or in preparation for surgery, is an event for which no provision is made in our physiological make-up.

The first observations of hypothermia in humans were recorded in Germany in the 1870s, in connection with the treatment of drunken persons suffering from exposure. These indicated that people could rarely survive reductions of body temperature to 75 degrees Fahrenheit, obviously a temperature well above freezing. Several cases recently reported in this country, however, show that some human constitutions can stand even severer trials. In 1951 a young woman was hospitalized in Chicago after an overnight exposure out-of-doors to below-zero weather. An hour and a half after her arrival in the hospital her temperature was still only 64.4 degrees F. She recovered, but was so badly frostbitten that both of her feet and most of her fingers had to be amputated. In 1956 a two-year-old child and its 50-year-old grandmother were found "frozen rigid,"

according to press accounts, in a slum apartment in Marshalltown, Ia. Both were revived, the grandmother from a temperature of 70 degrees and the child from a temperature of 60.8 degrees, the lowest recorded temperature from which a person has recovered. Except for the effects of frostbite, it seems, recovery in these cases was complete.

From the observation of patients under controlled hypothermia and from animal experiments, we are beginning to get a picture of what goes on inside the



HYPOTHERMIA can be produced by several methods. This drawing shows "extracorporeal cooling," in which blood is with-

body as its temperature is reduced. The most impressive finding is the close dependence of metabolism on temperature. Metabolism falls with temperature in linear fashion; at 68 degrees it is only 25 per cent of normal. This slowdown in the processes of life is accompanied by a corresponding decline in the performance of the circulatory system. The pulse rate drops off, apparently as a direct consequence of the effect of cold on the pacemaker, the system of neuromuscular tissue in the heart that times and coordinates its contractions. Concurrently the volume of blood in circulation falls, as the plasma is sequestered in the peripheral capillary beds. At 68 degrees, if this low temperature is reached without other untoward developments, the output of the heart is down to 15 per cent of normal.

This depression of the circulatory system can greatly facilitate the work of the heart surgeon. With the body at normal temperature, the surgeon is in the position of a mechanic attempting to repair a motor while it is running. As late as 1940 few operations inside the heart were even attempted; despite brilliant progress in technique since then, surgeons have rarely opened the heart to operate on its interior, and then have worked blindly through a narrow slit in

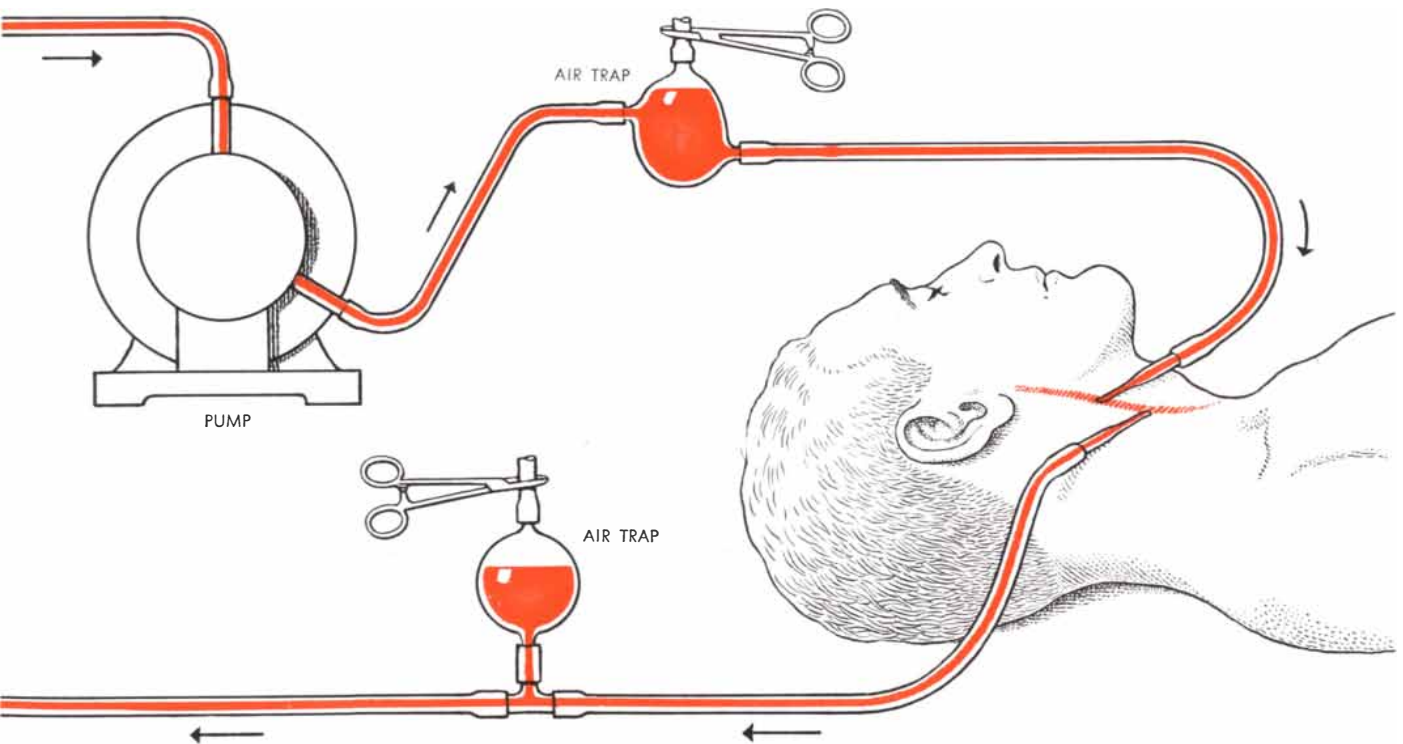
the heart wall. Now, with the patient in hypothermia, it is possible to shut off entirely the already reduced flow of blood through the heart. For a few minutes the surgeon can operate within a bloodless heart, with the site of operation under his direct vision.

Just how many minutes can be made available to the surgeon by this shutdown of circulation is determined by the hazard to the brain rather than to the heart. The brain is extremely vulnerable to oxygen deprivation. At the normal rate of metabolism it may suffer irreversible damage from an extremely short interruption of its blood supply. Hypothermia, however, depresses the brain's metabolism just as it does that of other organs. The effects of cold show up first in the centers located high in the cerebral tree, with impairment of the ability to coordinate mental processes and to perform intricate physical routines. At a body temperature of 86 degrees the cold narcosis familiar to readers of Jack London commences, and consciousness may be lost, though there are reports of individuals who maintain consciousness and even the faculty of speech at a temperature of 77 degrees. The lower cerebral centers which control such functions as respiration are the last to be inactivated; these centers continue to function, with

the depth and rate of respiration drastically reduced, at temperatures as low as 68 degrees.

From such deep depression of its activity the brain appears to recover completely. No mental impairment or abnormality is observed following an episode of properly controlled hypothermia. Even with its metabolism reduced by hypothermia, however, the brain is exposed to the hazard of oxygen deprivation during the period when its blood supply is shut off to permit heart surgery. At a body temperature of 86 degrees—the present limit of hypothermia in practice—the safe period is six to eight minutes. If hypothermia could be safely managed at a lower temperature and the brain's metabolism thereby reduced further, the time available to the surgeon could be prolonged. The limiting factor here is the effect of hypothermia on the heart.

Evidence from animal experiments indicates that the principal cause of death in hypothermia is an irreversible breakdown in the coordination of the heart action, a condition known as ventricular fibrillation. The rhythm of the heart first falters when the temperature goes below 80 degrees. In man it is the auricles, the entrance chambers of the



drawn from the body (right), passed through a chilled coil (left) and returned. Blood can be taken from the femoral artery (see next page) or from the carotid artery as shown here. By using the

carotid the brain can be made some 20 degrees cooler than the rest of the body. Circulation can then be stopped for up to 14 minutes, during which surgeon can open heart and operate on its interior.

ENGINEERS & SCIENTISTS

Electronics, Aerodynamics,
Mechanics

Information manual about APL and its programs now available

The Applied Physics Laboratory (APL) of The Johns Hopkins University is unique in that we are neither an industrial nor an academic organization, but rather a composite, having drawn freely from the methodologies of each.

For thirteen years APL has pioneered in guided missiles. Today we are engaged in a broad program of R & D for the Navy; in addition, we are responsible for technical direction of industrial and academic contractors in developing the Terrier, Talos and other major weapons and weapons systems. Our staff members enjoy not only the stimulus of association with their immediate colleagues at APL, but also with those in other organizations of considerable stature.

NEW 30-PAGE PUBLICATION

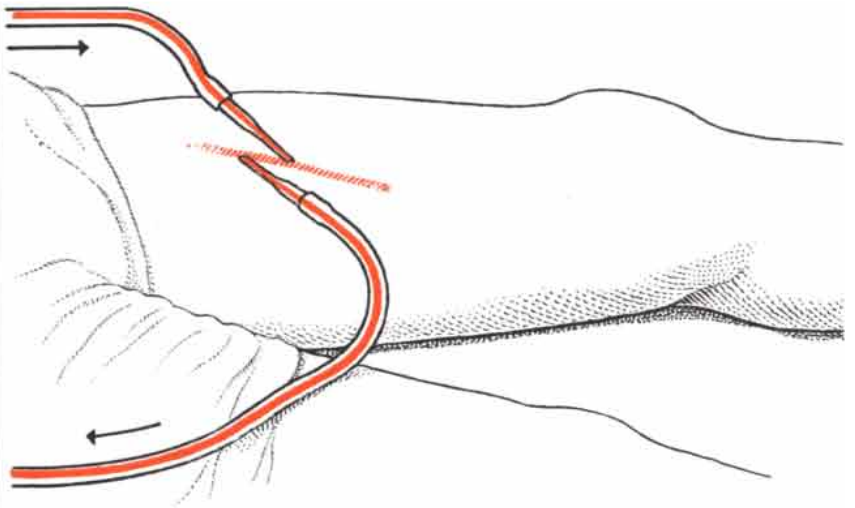
A few positions for senior engineers and scientists are now open. Information on our accomplishments and goals is available in a new 30-page publication, just off the press.

In it staff leaders representing each of the various disciplines and fields outline the nature of their programs. Information on our new laboratory in Howard County, Md. (equidistant between Baltimore and Washington) is also included, together with facts on the outstanding communities in which our staff members live.

*Quantity is somewhat limited.
May we suggest you send now to:
Professional Staff Appointments,*

The Johns Hopkins University Applied Physics Laboratory

8641 Georgia Avenue, Silver Spring, Md.



EXTRA-CORPOREAL COOLING of blood from the femoral artery produces a general lowering of body temperature rather than local brain cooling shown on preceding two pages.

heart, that are initially affected. Thereafter the ventricles begin to develop extra beats, then bursts of rapid contractions and finally the uncoordinated contractions of ventricular fibrillation that engage the entire musculature of the heart and terminate in heart failure. This pattern of activity is usually not spontaneously reversible and has been observed in 70 per cent of the experimental animals. Probably most people who are found "frozen to death" have died in this manner.

Experimental animals which do not succumb to ventricular fibrillation continue to exhibit a progressive slowing down in their heartbeat as their body temperature is brought lower. The heart finally stops beating between 60 and 50 degrees. From this condition, however, animals have been revived after varying periods of cardiac standstill. At the Arctic Aeromedical Laboratory in Fairbanks, Alaska, we have successfully rewarmed two dogs after keeping them an hour and 15 minutes with no heartbeat at a temperature below 60 degrees.

Why so many animals develop ventricular fibrillation is a question that has attracted the interest of many investigators. The susceptibility of the heart to fibrillation can be demonstrated by applying electrical stimuli of various strengths to the ventricle before and during hypothermia. Such tests have shown that there is one threshold for the stimulus that induces a normal heart contraction and another for the stimulus that brings on fibrillation. During hypothermia the normal threshold remains constant. The fibrillary threshold, however, is markedly reduced by hypothermia. At 86 degrees an electrical

stimulus of 15 milliamperes is insufficient to start fibrillation; at 75 degrees, fibrillation may be triggered by a stimulus of only 3.4 milliamperes.

Several factors seem to be implicated in the production of this lethal abnormality. The blood of experimental animals subjected to hypothermia exhibits increased acidity. This can be offset, and the chances of fibrillation reduced, by increasing the rate of breathing. Other evidence suggests that cold affects the activity of nerves which are external to the heart, but which are involved in its action. The level of calcium and potassium in the blood also seems to be affected in ways which tend to produce fibrillation. But we do not yet know how all these factors interact.

In surgery the risk of ventricular fibrillation is increased by the shock of the operation itself. Deep hypothermia cannot truly take its place in the armamentarium of surgery until additional information is gained by the various research groups working on the problem. Meanwhile the risk can be minimized by reducing body temperatures to no lower than 86 degrees. At this temperature the heart rhythm remains undisturbed, yet metabolism is slowed sufficiently to allow blood circulation to be halted for several minutes.

Hypothermia was first reported as a medical procedure in 1941 by Temple Fay and L. W. Smith, then at Temple University in Philadelphia. They had noticed that cancers rarely spread to the extremities of the body, where temperatures are six to 20 degrees lower than in the trunk. In contrast, the breast, a common site of cancer, has a high temperature. It occurred to Fay and Smith that

Your business is in the Age of Electronics

Your engineers

productive giants—or shackled Lilliputs?

You employ the finest development engineers to help your Company progress. But do you equip them with modern technical tools? Or must they waste priceless time tediously deriving engineering data in old-fashioned ways.

Electronic instruments free engineers' time by speeding and simplifying the ordinary—and extra-ordinary—measurements today's engineering requires. Hours, even days, are saved for creativity.

Hewlett-Packard makes 300 different electronic measuring instruments answering

a vast range of needs. One -hp- instrument saves time for many men, yet most -hp- instruments cost far less than just the recruiting of one new engineer.

A letter from you will bring a Hewlett-Packard field engineer to help your technical people simplify and make more productive your Company's engineering effort.

● Hewlett-Packard vacuum tube voltmeters, standard throughout industry, provide new simplicity and extreme accuracy for electrical measurements. -hp- 400H (shown) measures 1/10 millivolts to 300 volts at frequencies 10 to 4,000,000 cycles per second. -hp- voltmeters, \$200 to \$325.

 *world leader in electronic measuring instruments*



HEWLETT-PACKARD COMPANY

PALO ALTO, CALIFORNIA

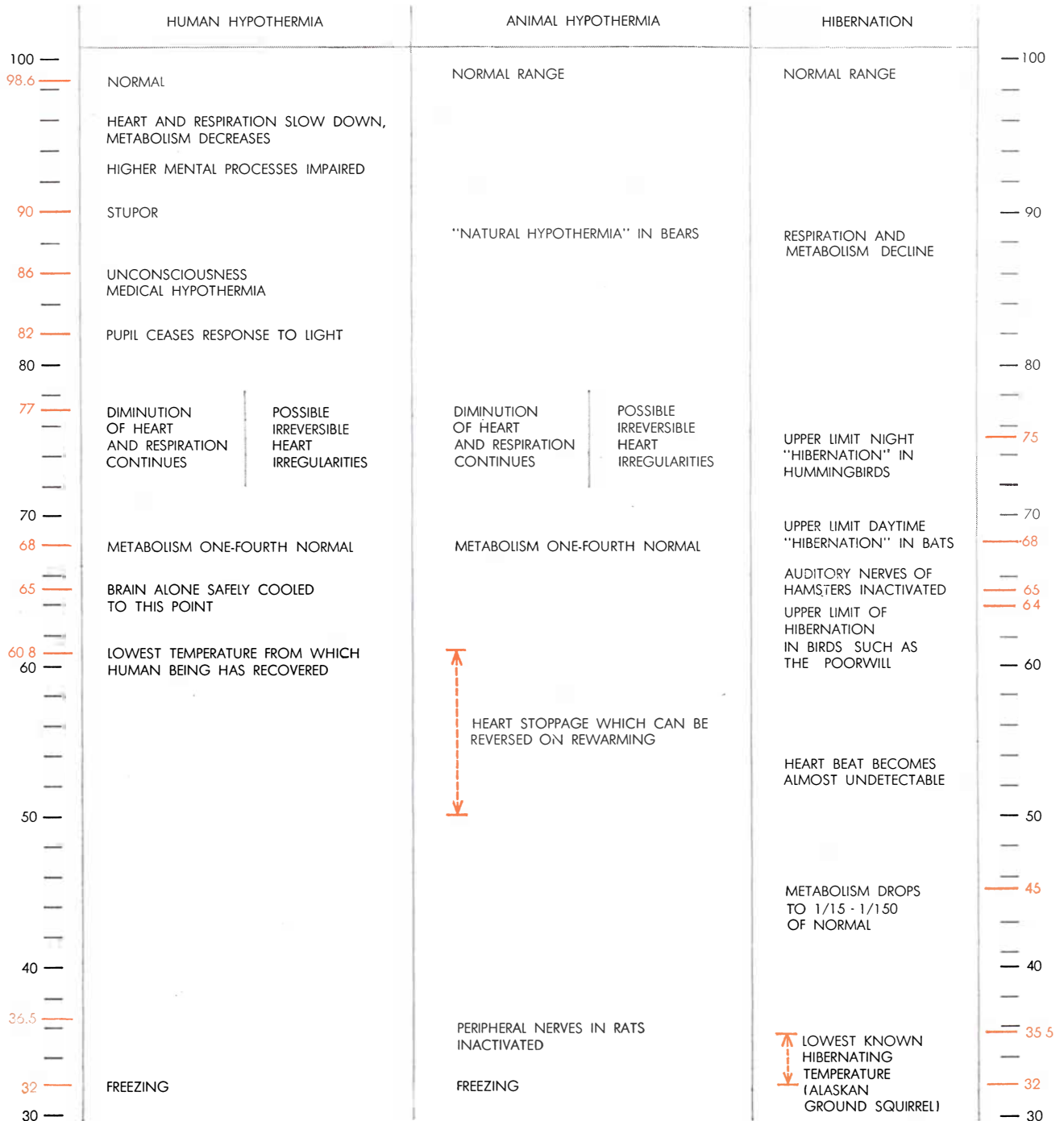
Field application engineers throughout the world

reduction of body temperatures might slow or halt the growth of cancer tissue. In a number of hopeless terminal cases the patients' temperatures were reduced to 80 degrees and held there up to eight days. Though the treatment did not affect the cancer, it achieved relief from pain for as long as five months and lessened or eliminated the need for opiates. Further work along these lines was soon undertaken at Lenox Hill Hospital in New York, and similar results were re-

ported in a number of cases of cancer, leukemia and even drug addiction.

In France after World War II Henri Laborit was looking for a method of treating shock, the principal immediate cause of death in severely wounded war casualties. Since the autonomic nervous system appears to play a central role in the onset of shock, Laborit reasoned that blocking of the autonomic nervous system might diminish shock and allow patients to survive its crisis. None of the

standard nerve-blocking drugs, however, achieved the general depression he was seeking. The concurrent discovery of chlorpromazine, a powerful depressant now widely used as a tranquilizer, solved the problem. Combined with several of the nerve-blocking drugs in a "lytic cocktail," it induced the desired autonomic block, evidenced in a slower heart and pulse rate and a lower body temperature. The mild hypothermic effect of the drugs suggested that the auto-



EFFECTS OF HYPOTHERMIA on men and experimental animals are contrasted with those of hibernation. Hibernators can survive

temperatures which would be fatal to other animals. Hummingbirds and bats show a sharp temperature drop during sleeping hours.

THIS IS GLASS

a report to men who make decisions



“Priceless” 1600-year-old antique sells for only 2 dollars. Why?

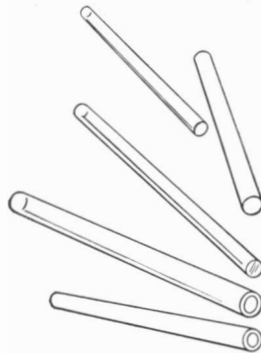
Legend has it that in grieving their departed, ancient Romans collected their tears in vases and buried the vases with the deceased. Such vases go back to the Rome of about 300 A.D. Yet, today a tourist can buy one of these “priceless” bits of antiquity for an outlay of two dollars. How come? Because untold numbers of these vases are still intact. Time, weather, heat, cold, dust, dampness—*nothing* has bothered these tiny vessels made of *glass*. Glass *lasts*. And glass

has a compelling beauty matched by no material known to ancient or modern man. Glass wipes clean with a damp cloth. Glass doesn't rust, tarnish, or fade. It stays new looking almost forever. Some of the ways in which the myriad forms of today's glass are being used are spelled out in a well-illustrated booklet called “This Is Glass.” The short time it will take you to become acquainted with its contents will be repaid many times over. Send for a copy.



New, neat way to heat

The heater you see here is so new you can't buy it yet. In fact, it's just a preliminary sketch from the designer's board. What makes it so exciting, aside from its modern look, is a heating unit that's completely *enclosed* in a glass tube about $\frac{5}{8}$ inch in diameter. Colored red, the glass is one of the VYCOR brand glasses, able to stand up to extreme heat . . . and *not* be bothered by ice water hitting it when it's operating at top temperature. One foot of this new heating tube will put out 500 watts. It will heat up in 5 seconds, last for at least 5,000 hours of operation. It's safe because the wire-heating unit is completely enclosed. It's attractive, too, glowing with a *cheery* red. Use it in portable heaters, broilers, coffee tables with built-in warmers, air conditioners, clothes dryers. Interested? Write for details on HEAT SHEATH®.



Even when temperatures go to 1000°F. PYROCERAM shows no loss of strength. Here heat has melted copper bar, caused steel to sag; but bar of a PYROCERAM is still rigid.



Basic, New Material ...now available as rod and tubing

It's PYROCERAM®, Corning's trademark for a new group of crystalline materials made from glass. Generally referred to as glass-ceramics, they are unlike *any* glass, ceramic, or other material you've *ever* worked with. And now you can get *one* variant in the form of rod and tubing. This PYROCERAM material is Code 9608—white, opaque, gas-tight—with a thermal shock resistance normally found only in fused silica. It's lighter than aluminum, and available in quite a size range. Summing up *all* the observable properties from the many different forms of PYROCERAM material you get this: Harder than carbon steel; immune to most corrosives; light in weight; unbothered by high heat; and possessed of electrical properties equal to the better ceramics. You can get the complete word on rod and tubing by writing for the “spec” sheet. For an up-to-date summary of the whole PYROCERAM story, ask for the just-released Progress Report No. 2. Why not do it now?

Facts at your fingertips: 64 pages of charts, drawings, photographs and facts—that's what you'll have with a copy of “This is Glass.” A note on your letterhead will bring you a copy.

CORNING GLASS WORKS

49-3 CRYSTAL STREET, CORNING, NEW YORK

Corning means research in Glass



$$1.008^{3.1} \times \sqrt[3]{63 \times 4000} = 0.2495$$

$$6 \times \sqrt[3]{260000} \times 42^{1.22}$$

A 66-inch Slide-rule for your pocket



Slide Rule Open

The GENIAC® Calculator carries 66-inch spiral scales yet measures only ten inches fully extended and six inches when closed. **Four to five figure accuracy can be relied on. It is indispensable to the scientist, research worker and student. A administrative staff and business men will find it of tremendous value for a host of estimating and checking calculations, and quite simple to use.** Of non-warping metal construction, with plastic coated scales, it will give years of service.

The GENIAC® Slide Rule solves multiplication, division, percentage calculations and gives 5 place logarithms as well.

You may use it for 30 days and if you are not satisfied repack and mail it back.

What our users say:

"May I congratulate you on such an instrument at so modest a price, combining engineering and mathematical skill, simplicity of operation in such a small space. **It does all you claim—four or five figure accuracy without eyestrain or magnifiers.** Half an hour's study is ample for its use." A.E.B.
... M.Sc.

"I have tested the GENIAC® Slide Rule in my office and find it much superior in **clearness and accuracy to ordinary slide rules.**" F.H.G.B.

"I use the GENIAC® Calculator for all my slide rule work and need the **extra digit which normal slide rules cannot give.** I had to get one of my customers a GENIAC® Slide Rule last month after using mine in his office." E. & G.H. Textile Manufacturers.



Slide Rule Closed

Send for yours now only \$19.95 postpaid.

ATOMOTRON

- **MINIATURE ATOM SMASHER**
- **PRODUCES 75,000 VOLTS**
- **ABSOLUTELY SAFE**



In no sense of the word a toy or gadget. The ATOMOTRON is a scientific instrument capable of producing 75,000 volts—makes sparks up to 2" long—yet it is absolutely safe because the current is infinitesimal. The science teacher—science lover—or hobbyist can perform experiments to astound students—friends—family. Makes smoke disappear—defy gravity—turns propellers at a distance—transforms atomic energy into light—makes artificial lightning—smashes atoms—demonstrates ionic space ship drive—and many other experiments. Constructed of the finest materials. Will do exactly—for instruction purposes—what generators that cost 3 to 10 times more will do. The perfect device to teach the secrets of atomic physics and electricity. Will hold an audience spell-bound as it performs trick after amazing trick. Includes an experiment kit and illustrated experiment manual. Manual explains the "how" and "why." You will invent many new experiments of your own. A fine research tool that will give years of beneficial service to the institution or individual who owns one. Available in kit form or assembled.

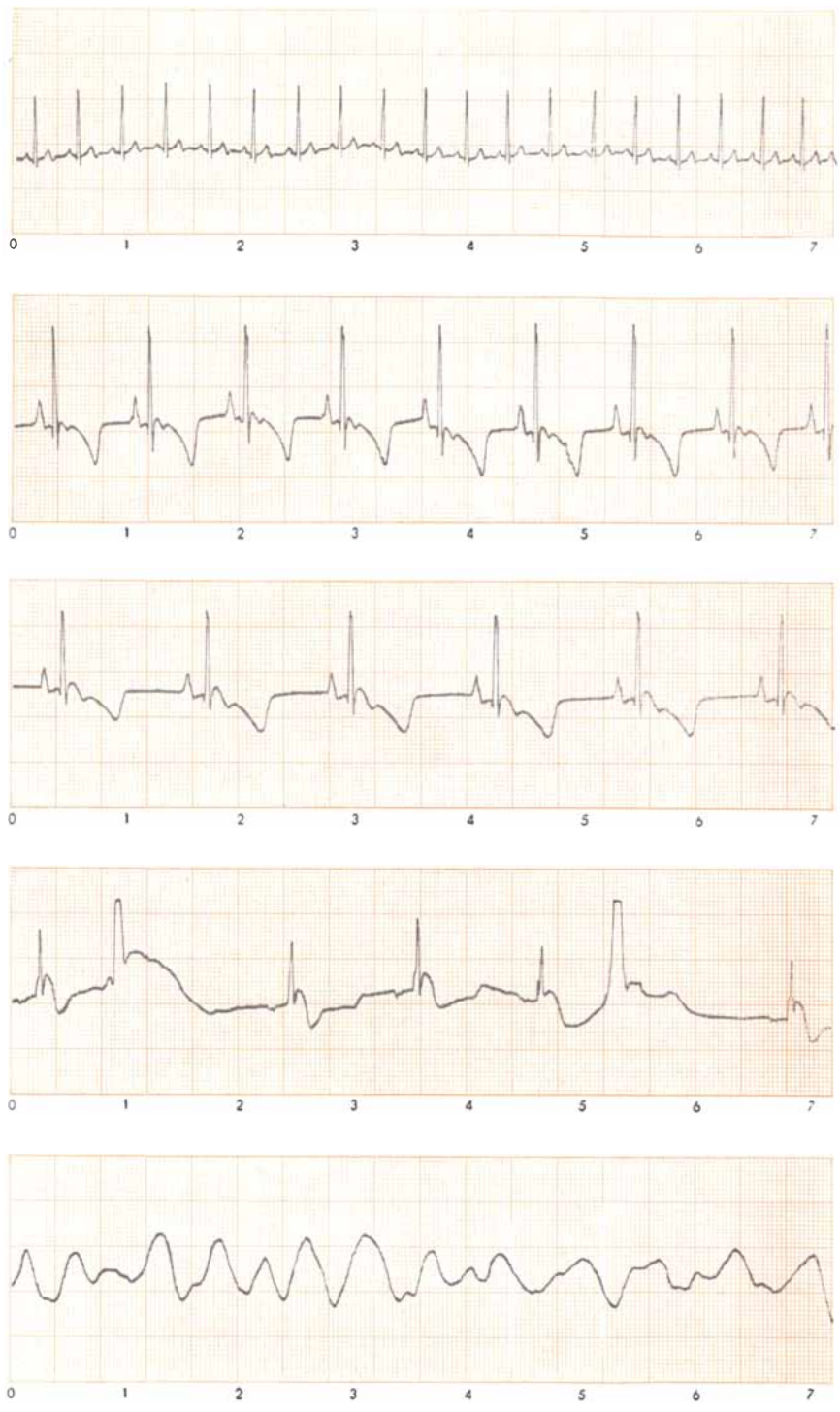
Kit form Net 14.95
Assembled Net 19.95
 Add 80c for postage and handling U.S.
 \$1.50 abroad

OLIVER GARFIELD CO., INC., DEPT. SA-38
 126 Lexington Avenue, New York 16, N. Y.

nomie block might be reinforced by further cooling of the patient's body with ice water. This treatment, it was observed, had the additional effect of lowering oxygen demand and inducing a mild general anesthesia. In the Indo-China campaign hypothermia by the drug-and-ice-water method became

something of a standard practice in French military medicine, and its users reported a reduction of about a third in the death rate of the severely wounded.

In 1950 W. G. Bigelow of the University of Toronto reported observations on the oxygen consumption of hypothermic dogs. Bigelow was the first to sug-



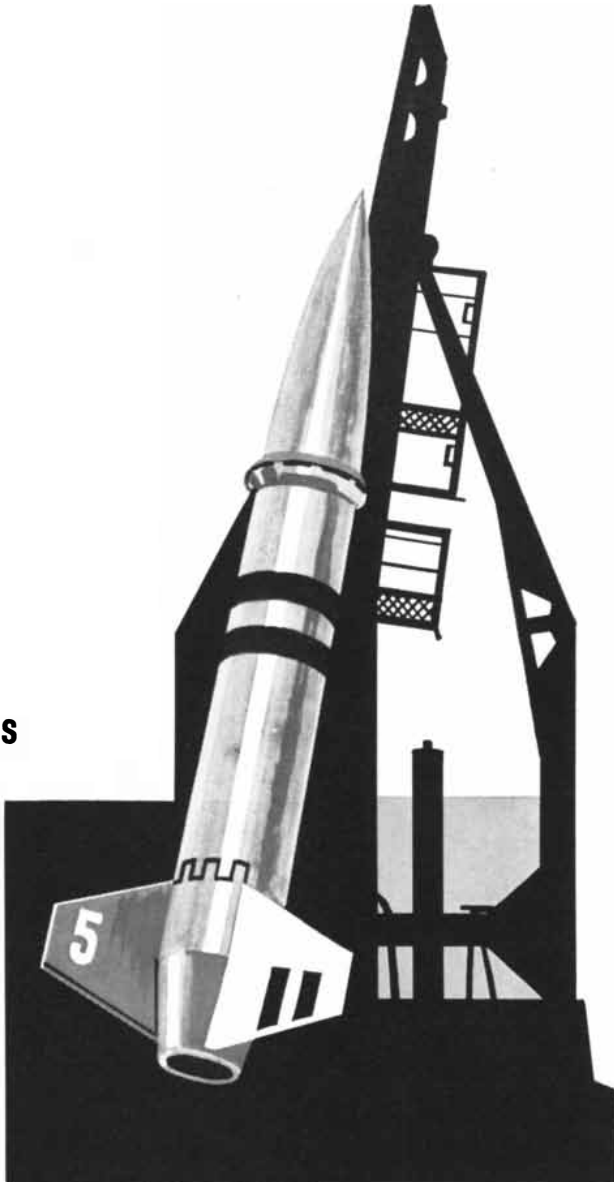
HEART ACTION during hypothermia is shown in electrocardiograms of a dog. Normal rate of 180 beats a minute slows as temperature drops from 98.4 to 77 degrees (top, second and third). At 68 degrees abnormalities develop (fourth); at 62.5 degrees total disorganization (ventricular fibrillation) sets in (bottom). This condition is fatal if it continues.

medicine and missiles

Because it represents a totally new idea, Decker's T-42 ionization transducer has evinced interest from men engaged in both the taking of life and the saving of life.

It has brought a hitherto unknown degree of accuracy to the study of the heart, of cancer, and the measurement of blood pressures . . . as well as the measurement of RAM and ambient atmospheric pressure.

But like nuclear energy, the T-42 has no soul. It can deal death or defy it as *you* wish.



THE DECKER CORPORATION

Bala Cynwyd, Pa.

whenever a new development takes place, it is based on ionization and electrical gas discharge

How To Get Things Done Better And Faster



BOARDMASTER VISUAL CONTROL

- ☆ Gives Graphic Picture—Saves Time, Saves Money, Prevents Errors
- ☆ Simple to operate—Type or Write on Cards, Snap in Grooves
- ☆ Ideal for Production, Traffic, Inventory, Scheduling, Sales, Etc.
- ☆ Made of Metal. Compact and Attractive. Over 250,000 in Use

Full price **\$49⁵⁰** with cards

FREE 24-PAGE BOOKLET NO. C-400
Without Obligation

Write for Your Copy Today

GRAPHIC SYSTEMS

55 West 42nd Street • New York 36, N. Y.

New "Mechanical Educator" to IMPROVE MEMORY

Inability to recall names, places, facts quickly is a common, often costly, shortcoming that can now be easily overcome with the aid of a new device for self-instruction, memory and concentration training. This versatile new educational tool can also be used effectively in language learning, speech correction and improvement, in mastering tables, formulae—anything to be memorized—faster than ever.

DORMIPHONE Memory Trainer

- Speeds up learning processes
- Aids Concentration

Using a new recording principle, the Memory Trainer records, instantly plays back, and automatically repeats speech, music, or any spoken or broadcast material through a built-in speaker. No reels of tape to wind and rewind. Completely portable. Ideal for home, school, industrial safety training use. So simple, children benefit—so helpful and practical, it is used by educators, psychologists, people of all ages and professions.



SELF-CONTAINED RECORDING CARTRIDGES
from 30 seconds to 50 minutes

Easily removed. Can be stored or "erased" instantly and re-used repeatedly. Just record, flip a switch for play-back and listen!

Write TODAY for FREE folder with complete information.

Modernophone, Inc.
220-038 Radio City
New York 20, N. Y.

MODERNOPHONE, INC. Circle 7-0830
220-038 Radio City, New York 20, N. Y.

Gentlemen: Please send me your FREE Booklet. I am interested in learning more about the Dormiphone Memory Trainer and what it can do for me. No obligation—no salesman will call.

Name

Address

City Zone State

My main interest in the Memory Trainer is for:

- Language Learning Speech Improvement
 Memorization School or College Work

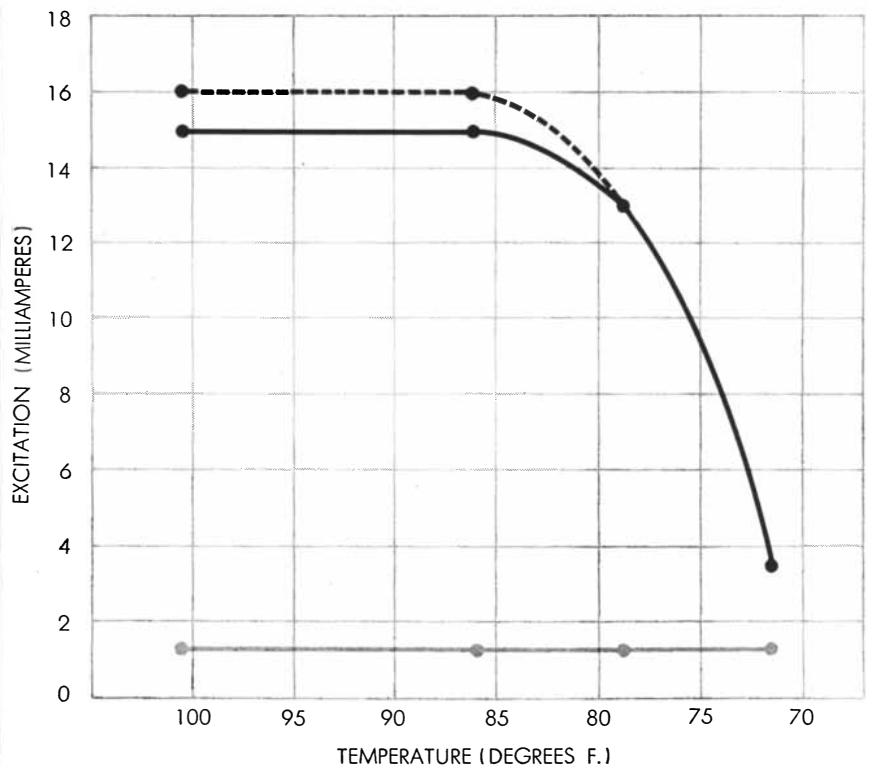
gest that this aspect of the hypothermic state gave great promise in situations where open-heart surgery was indicated.

In the U. S. today the accustomed procedure for inducing hypothermia is immersion of the patient in a bath of ice water with a temperature of from 35 to 40 degrees. The patient is usually anesthetized with pentothal or ether (chlorpromazine is not used); shivering, which tends to maintain body heat, is prevented by muscle relaxants such as curare or succinyl choline. The patient's body may also be cooled by wrapping it in a rubber blanket through which a refrigerant is circulated. After two or three hours in the bath or the blanket, the patient has been cooled to 86 degrees and is ready for surgery. Restoration of normal temperature after the operation, by means of a warm bath or by circulating warm water through the rubber blanket, takes another two or three hours.

Another method, "extra-corporeal cooling," has recently come into use: the blood from an artery is passed through refrigerated coils and returned to the circulatory system via the same artery or a vein [see illustrations on pages 104, 105 and 106]. A modification of this technique, developed by Kazumi Ta-

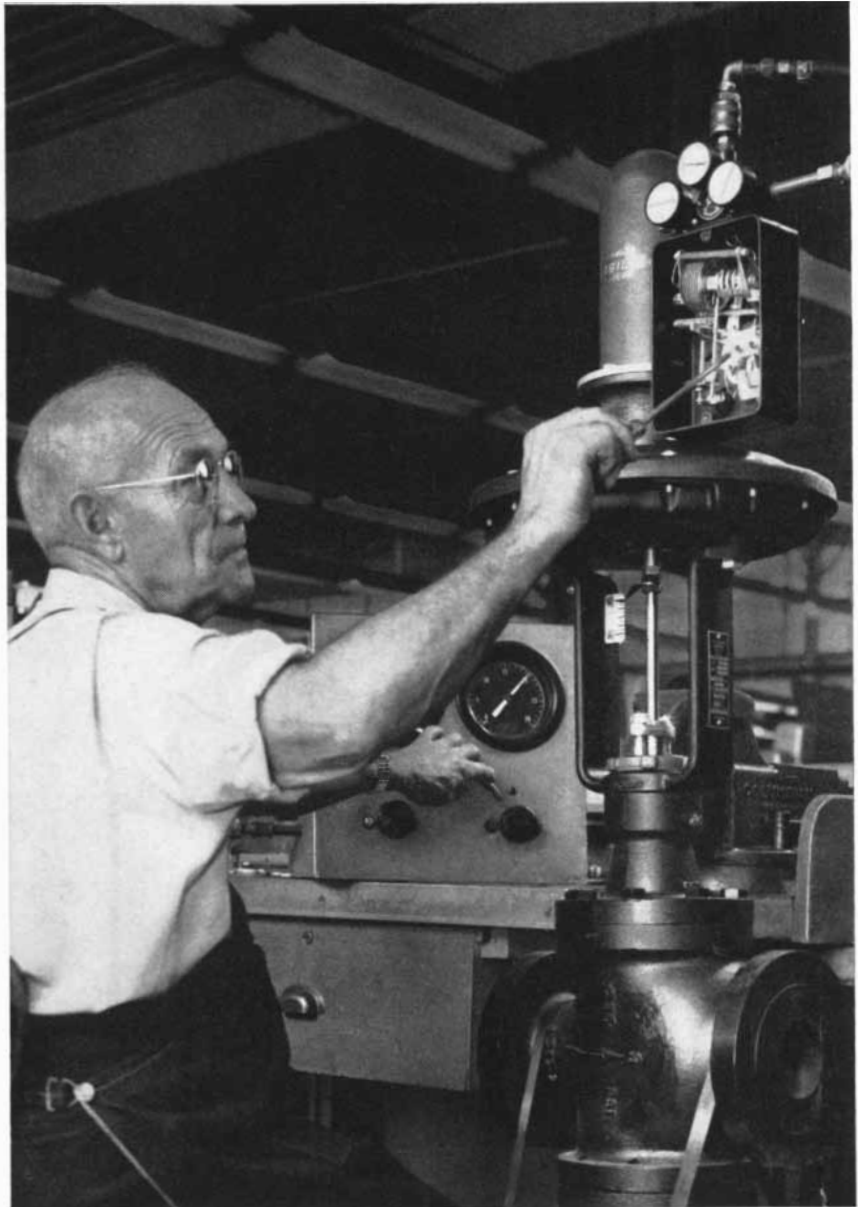
guchi of the University of Okayama in Japan, may help solve the problem of cooling the brain for more prolonged shutdown of circulation without overcooling the heart. By cooling blood from the carotid artery, which furnishes the principal blood supply of the brain, Taguchi has cooled the patient's brain down to 65 degrees, while maintaining the rest of the body in a safe range of hypothermia. As a result he has been able to extend the duration of heart operations to as long as 14 minutes.

While hypothermia has been a special help to the heart surgeon, it has proved valuable in other departments of medicine. French physicians in particular, encouraged by the experience in Indo-China, are using it extensively, and the current issues of their journals regularly carry one or more papers on the technique. One dramatic case suggests the wide range of application. This was a Caesarean section undertaken to terminate a pregnancy in a patient suffering from acute convulsive eclampsia. Such operations are performed to save the mother's life and with no expectation of delivering a live infant. In this case, however, the baby survived, having been rendered hypothermic along



SOME HEART ABNORMALITIES are more easily induced at low temperatures. The electrical stimulus needed to produce ventricular fibrillation (black line) decreases as body temperature falls; stimulus needed to produce an extra beat (gray line) remains the same. Broken line above black line indicates uncertainty in measurements at those temperatures.

Foxboro
makes
a better
instrument
... or
Foxboro
doesn't
make it!



Final calibration of a Stabilflo control valve. Development of this Foxboro product, with its wide-range V-port design, contributed new exactness to automatic process control.

FOXBORO
REG. U.S. PAT. OFF.

Creative Design and Manufacture of Instruments and Instrument Systems for Measurement and Control of Process Variables. The Foxboro Company, Foxboro, Mass., U. S. A.

PRECISION CAMS

PACK *Automation*
INTO INCHES!

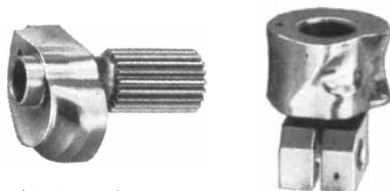


to perform superhuman control functions, Parker 2 and 3 Dimensional Cams are used in Jet Aircraft, Missiles, Rockets, Instrumentation, wherever environmental extremes make precision mechanical control a functional asset.

2 DIMENSIONAL *Precision* CAMS



3 DIMENSIONAL *Precision* CAMS



The heart of a compact,
automatic analog computer.

THE
PARKER-

HARTFORD CORPORATION

Dept. S, Cam Division

Franklin Avenue, Hartford, Connecticut

Please send "3 DIMENSIONAL CAMS"
by return mail

Please send "Design & Development"
Bulletins on 2 and 3 Dimensional Cams

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

CITY.....ZONE.....STATE.....



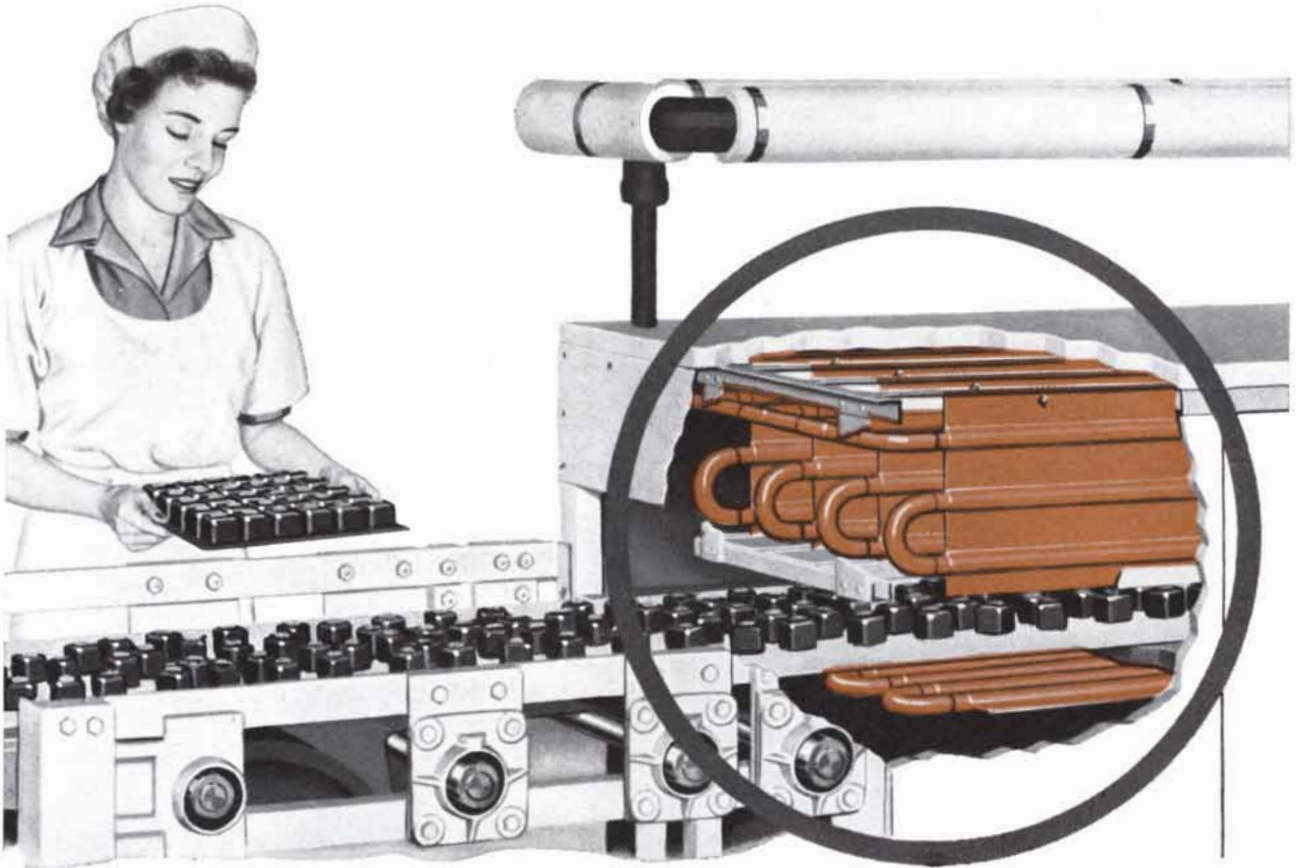
REFRIGERATED BLANKET through which a chilled water-alcohol mixture is pumped can be used to induce hypothermia. Warming the mixture restores normal temperature.

with its mother! Hypothermia is now being used to diminish shock and the effects of oxygen deprivation in infants delivered from prolonged labors, and to help pull infants born of Rh-negative mothers through the rigors of having their blood removed and replaced by transfusion. French physicians are also using hypothermia in contending with severe infections in the newborn; in effect the infant is refrigerated while the antibiotics work on the organisms.

Mild hypothermia may find wide use

in general surgery as a way of reducing the amount of anesthetic needed to ready the patient for operation. This is an important consideration in surgery on "poor risk" patients, especially the aged. For surgery of the brain, hypothermia offers several specific advantages. Most brain operations are complicated by excessive bleeding; with the patient in hypothermia, the flow of blood is reduced and may even, if necessary, be shut off entirely during the critical moments of the operation.

Copper, painted black to increase heat absorption, cuts cooling-time 40%, increases production 66%, in Barricini's Long Island City factory.



Use **COPPER** ... and cut cooling-time!

One thing a candy manufacturer worries about is the shelf-life of his chocolates. And he knows that the difference between stability and discoloration may be a question of the *rate* at which his product *cools*.

The Barricini candy makers found *radiant* cooling . . . with *Copper* . . . an ideal answer.

Former methods kept candy in the cooling tunnel for 12.2 minutes. Now, cooled with Copper, it goes through in 7.3 minutes.


That's 40% faster . . . and cutting cooling-

time increased production 66%. Copper saved floor space, the cost of additional machines, and *time . . . where time is money!*

Copper stands alone in its efficiency wherever heat transference is involved. That's why manufacturers of heating . . . or cooling . . . products prefer Copper! And they find Copper or any of its alloys easy to work . . . easy to machine, form, draw, stamp, plate and join. They can count on an ample supply of Copper, too!

COPPER • BRASS • BRONZE
in over 40 Standard Alloys!

Address your inquiry about cooling and heating and other applications of Copper to the Copper & Brass Research Ass'n., 420 Lexington Ave., New York 17, N.Y.



Shaping the future with Du Pont's
Engineered Fibers . . . nylon, "Dacron",
"Orlon", "Teflon" and "Super Cordura"

TOMORROW'S DATA FROM OUTER SPACE

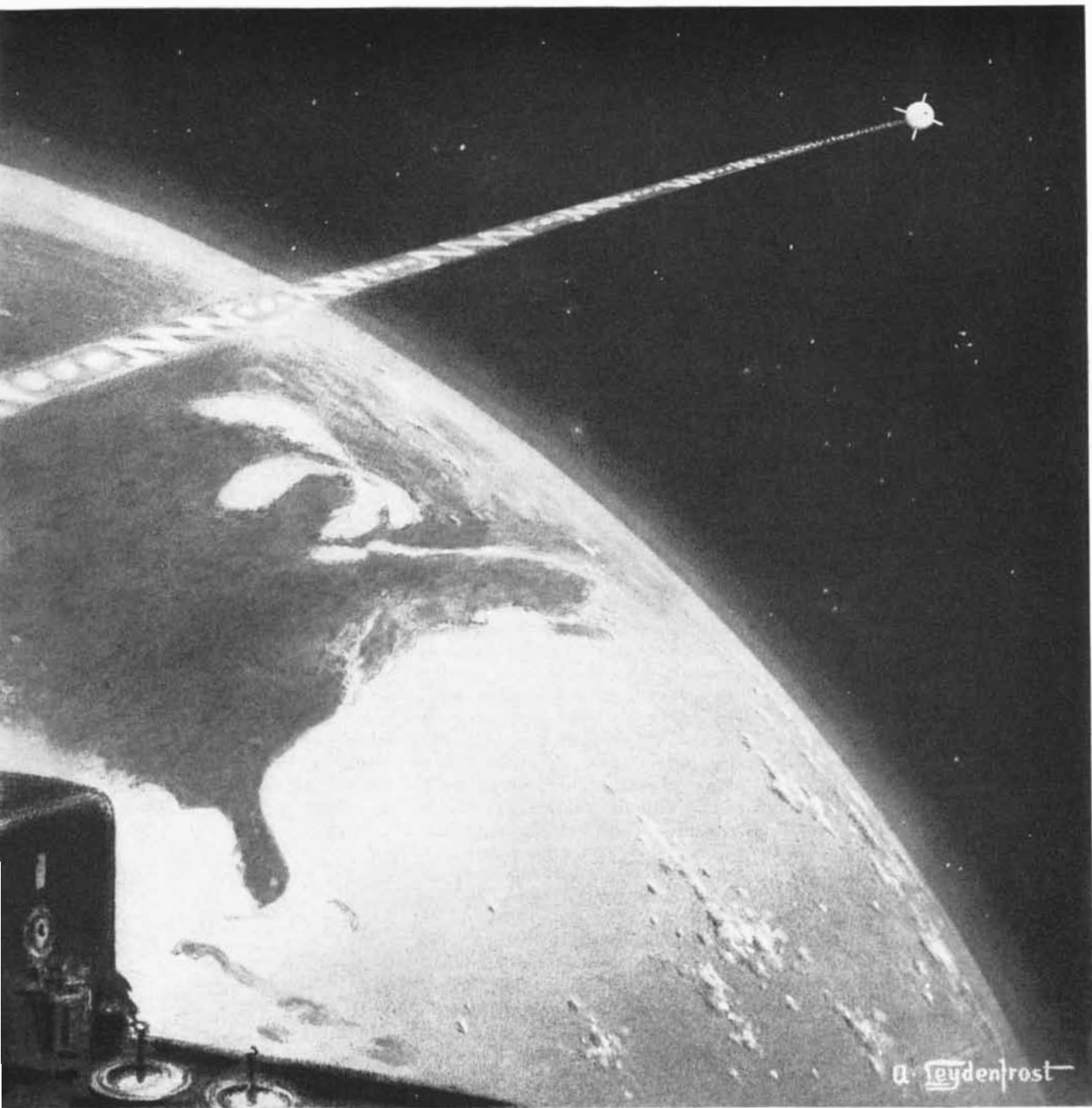
. . . precisely recorded on paper made from Du Pont fibers

Paper is one of the newest uses for Du Pont synthetic fibers. Its high dimensional stability can make recording of data more reliable . . . more precise. One future application may be recording paper—as indicated above—to receive data from test instruments in a satellite.

The properties of synthetic-fiber papers may be precisely engineered and varied, depending upon the fibers used—Du Pont nylon, Dacron* polyester fiber or Orlon* acrylic fiber. Papers can be made to have outstanding tensile strength, tear strength, chemical resistance, fold endurance, dielectric properties, stability—or any combination of these properties. Synthetic-fiber papers are good candidates for use in stencil

tissues, bookbindings, maps, backing for vinyl coatings, electrical insulation, etc. In fact, potential uses for these new papers are so broad that they are being classed as entirely new engineering materials.

In other forms, too, the family of five Du Pont fibers offers you many outstanding design opportunities. For example, in one test a fire hose jacketed with "Dacron" had 7 times the *abrasion resistance* of a natural-fiber jacket. Because of its *acid resistance*, "Orlon" is used as a filter medium. In a typical case it outlasted the original fiber 26 to 1. The *strength* and *flex resistance* of Du Pont nylon make possible tires with great blowout protection and durability. Fabric of Teflon*



tetrafluoroethylene fiber is being used in non-lubricated bearings because of its *low coefficient of friction*.

Chances are that Du Pont fibers can make an important contribution to one of your products. Du Pont's experience, testing and research activities offer you an authoritative source of assistance. Let us help you with your next materials problem.

*Registered Du Pont trademarks.



BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

WRITE FOR YOUR COPY

The 80 pages of "Du Pont Fibers in Industry" are edited especially for the engineer and designer. The properties of Du Pont nylon, "Dacron", "Orlon", "Teflon" and Super Cordura* high tenacity rayon are described in detail. Technical and performance data are presented for most present-day industrial-fiber applications. Write: E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., 5518-B Nemours Bldg., Wilmington 98, Delaware.



**DU PONT FIBERS
FOR INDUSTRY**

The Microsome

This small particle is found in a fraction of living cells which have been broken up for biochemical investigation. It now seems to be a fragment of an intracellular system which makes proteins

by Paul C. Zamecnik

The biochemist traditionally studies living cells by smashing them to bits and trying to analyze the function of their parts. This rough treatment reduces much of the cell to minuscule fragments, but some of its constituents survive as relatively large particles. One kind of particle is the mitochondrion, in which the chemical reactions that supply energy to the rest of the cell are conducted [see "Powerhouse of the Cell," by Philip Siekevitz; SCIENTIFIC AMERICAN, July, 1957]. Another is the microsome, which appears to be associated with the manufacture of the most elaborate molecules of living matter: the proteins.

But of course cells are not only studied by chemical means. They can also be examined under the microscope, in recent years at the huge magnifications of the electron microscope. Improvements in the preparation of cells for the electron microscope now reveal many details of cellular structure that were hitherto invisible. Today we see the cell not as a little bag of freely interacting molecules in solution, but as a highly organized microcosm.

Among the striking features of this microcosm is a system of membranes called by electron microscopists the "endoplasmic reticulum" [see *illustrations on this and the opposite page*]. Studied principally by George E. Palade of the Rockefeller Institute for Medical Research and by Fritiof Sjöstrand of Sweden these membranes are lined with tiny, dense particles. The membranes may form a system of interconnected canals resembling those of an automobile radiator, but this is not yet certain.

The electron microscopists observed that certain cells, notably those of the pancreas, were particularly rich in the membranes and particles of the endo-

plasmic reticulum. These cells specialize in the manufacture and secretion of enzymes, the protein molecules which catalyze the chemical reactions of life. This suggested that the endoplasmic reticulum might play a role in the synthesis of proteins.

A significant discovery was now made by Palade and in our laboratory at Harvard University and the Massachusetts General Hospital. When the biochemist breaks up his cells, he has a homogenized mixture of, among other things, red blood cells (which resist disruption because of their small size), cell nuclei, mitochondria and microsomes. These various constituents can be separated by placing them in a small vessel and spinning them at high speed in an ultracentrifuge. When the mixture is first spun, the relatively heavy red blood cells and cell nuclei settle out and form a pellet at the bottom of the vessel. When the remaining fluid is removed and spun, the mitochondria settle out and form a second pellet. The fluid can then be spun again to yield a pellet of microsomes. What Palade and we showed was that the microsome pellet of the biochemist was made up of fragments of the shattered endoplasmic reticulum.

Meanwhile biochemists had begun to suspect from other lines of work that microsomes played a significant part in protein synthesis. As readers of this magazine are well aware, proteins are huge molecules that are constructed from the much smaller molecules of 20-odd amino acids. By labeling the amino acids with radioactive atoms we can follow to some extent their incorporation into protein. In several laboratories (including our own) animal cells were broken up and radioactive amino acids were added to the mixture. When the

protein in the mixture was later analyzed, it was found that roughly two parts per 1,000 were radioactive. Presumably the labeled amino acids had been built into new proteins. The amino acids were taken up only for about 10 minutes after the cells had been disrupted, which suggested that this was the last flicker of protein synthesis in the cell.

The mixture was now fractionated in the ultracentrifuge. It was found that not all the fractions contained radioactive protein. The protein of the microsome fraction was, however, nicely labeled with radioactivity. (This observation was first made by Henry Borsook at the California Institute of Technology.) Particularly radioactive were the

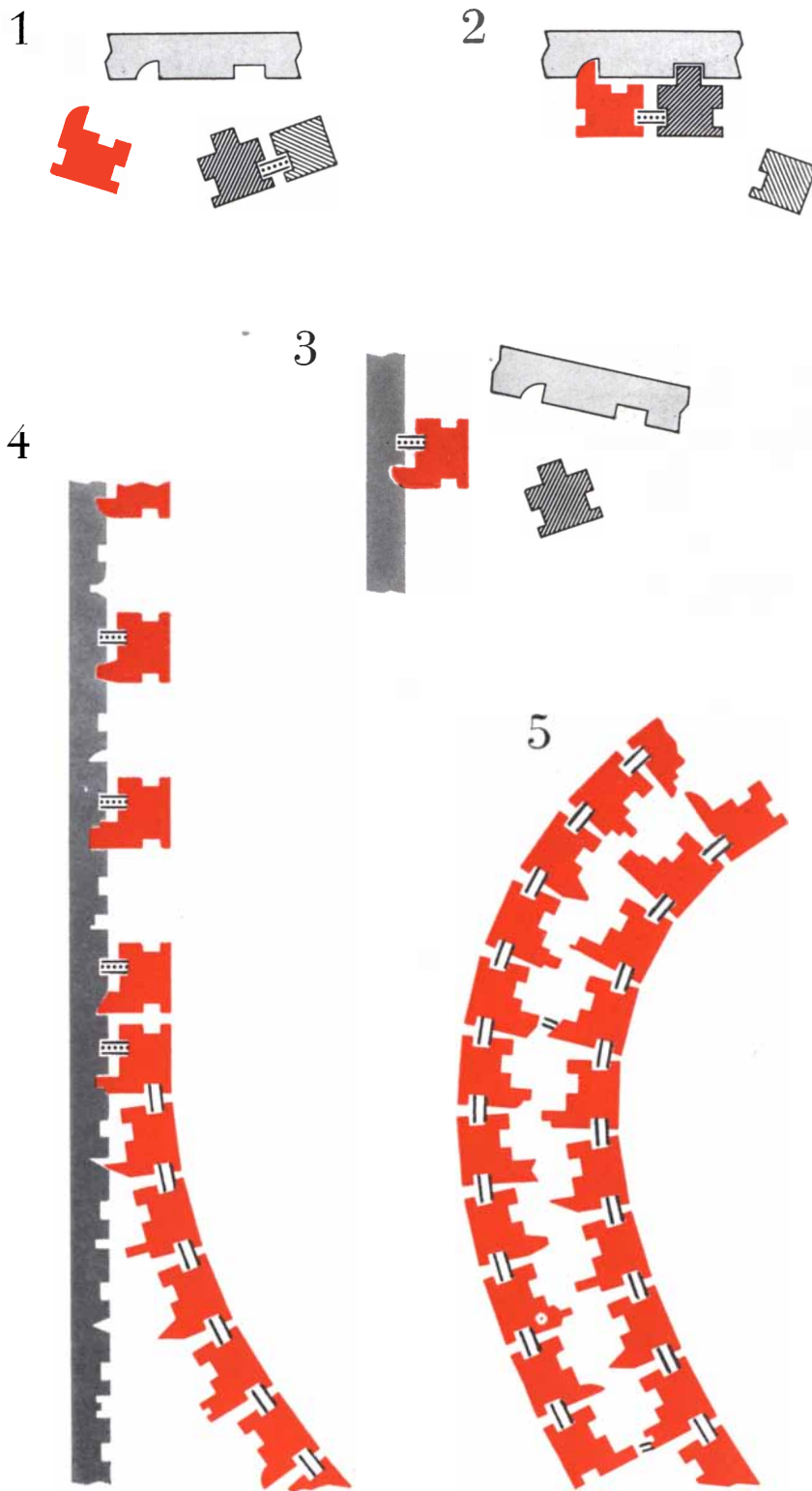


ELECTRON MICROGRAPH at right, made by George E. Palade of the Rockefeller Institute for Medical Research, enlarges part



of a cell from the pancreas of a guinea pig 56,000 diameters. The structures labeled 1 in the outline drawing at left are mitochondria. The structure labeled 2 is the nucleus of the cell. In the

area between them labeled 3 is an extensive system of membranes and small dark particles called the "endoplasmic reticulum." It is now known that the microsomes are fragments of this system.



PROPOSED SCHEME for the synthesis of a protein molecule is outlined in this drawing. First, an enzyme (*light gray*) combines with an amino acid (*color*) and the energy-rich substance adenosine triphosphate, or ATP (*hatching*). Second, the high-energy chemical bond (*dotted line*) of the ATP is transferred to join the phosphate group of the ATP (*dark hatching*) and the carbonyl group of the amino acid. Third, the "activated" amino acid combines with ribonucleic acid, or RNA (*dark gray*), by transferring the high-energy bond to a phosphate group of the RNA. Fourth, various amino acids line up along the RNA at specific sites. A "zipper" reaction now takes place in which the carbonyl group of the end amino acid is transferred from the phosphate group of the RNA to the amino group of the adjacent amino acid. Fifth, chains of amino acids are cross-linked, coiled or folded.

small, dense particles associated with the microsomes.

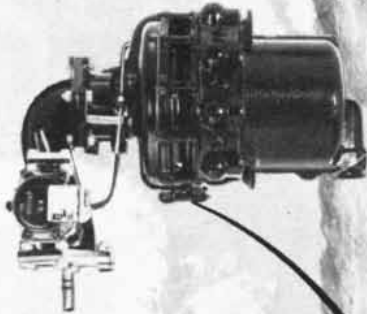
Here was a finding of especial interest. The small particles of the microsomes consist of roughly equal parts of protein and ribonucleic acid, or RNA. As far back as 1941 it had been independently suggested by Torbjörn Caspersson of Sweden and Jean Brachet of Belgium that RNA is associated with protein synthesis. It is now believed that a molecule of RNA may act as a kind of template for the manufacture of a molecule of protein.

This idea has received support from recent studies of the nature of proteins and similar substances. The trail-blazing work of Frederick Sanger at the University of Cambridge has shown that the protein insulin consists of a very precise sequence of amino acids. Other workers have found that the amino acids in the proteins ribonuclease and papain are equally well ordered. The same is true of oxytocin and vasopressin, hormones which are not proteins but smaller structures built up from amino acids. The latest of these smaller molecules to surrender to complete analysis are the two melanocyte-stimulating hormones (MSH) of the pituitary gland.

We also have the exciting observation that a change in a single amino acid unit can alter the character of an entire protein molecule. Vernon M. Ingram of the University of Cambridge finds that the abnormal hemoglobin which causes sickle cell anemia differs from normal hemoglobin only in that one amino acid is substituted for another at a specific point in a molecular structure made of some 300 amino acid units. It appears that the mutation of a single gene is responsible for this change [see "How Do Genes Act?," by Vernon M. Ingram; *SCIENTIFIC AMERICAN*, January].

In short, each protein seems to have a molecule of unique construction. It is difficult to see how amino acids could be so precisely lined up in solution. This would be like trying to load cargo into a ship in a heavy sea. Moreover, every living thing makes many molecules of each of its proteins every day. One can hardly avoid the conclusion that proteins are made by some biological equivalent of a printing press. The analogy is imperfect, but if such a press or template exists, it is very likely RNA. It also seems likely that the small particles of the microsome or endoplasmic reticulum are the site at which amino acids are linked. Several schemes have been proposed to explain the action of RNA in protein synthesis. One has been offered by V. V.

AIR CONDITIONING

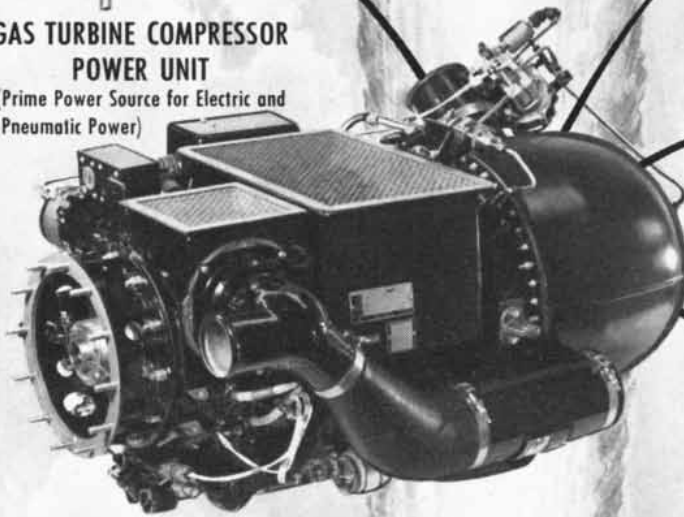


AIR TURBINES



**GAS TURBINE COMPRESSOR
POWER UNIT**

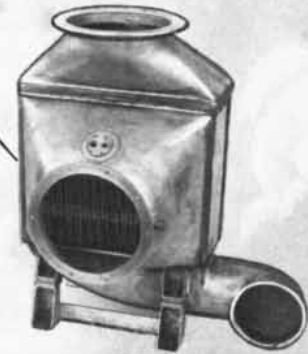
(Prime Power Source for Electric and
Pneumatic Power)



**AIR MOTOR
ACTUATORS**



HEAT EXCHANGERS



LIGHTWEIGHT COMPONENTS...

for HIGHLY MOBILE missile support systems

The AiResearch units shown answer the need for high-output, lightweight and compact components to be incorporated in mobile ground support systems for tactical missiles. The Gas Turbine Compressor Power Unit, proved in service, supplies shaft and pneumatic power simultaneously. DC or AC electrical current for 60, 400 or 1200 cycles can be generated for missile checkout. Gas turbine power units can be started immediately and operated under all extremes of weather.

Among the additional functions which can be accomplished with AiResearch components and systems are: main engine starting; heating and cooling for equipment and personnel; air supply for pneumatic systems including missile pre-flight de-icing, vehicle wheel drives and other linear and rotational actuation; and energizing of hydraulic systems. Reliability and compatibility are assured by components and systems now in the field. Contact the nearest Airsupply or Aero Engineering office for further information.



THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

AERO ENGINEERING OFFICES:

MINEOLA • ATLANTA • BALTIMORE • BOSTON • CHICAGO • CINCINNATI • COLUMBUS
DETROIT • INDIANAPOLIS • PHILADELPHIA • ST. LOUIS • SYRACUSE • ORLANDO

AIRSUPPLY OFFICES:

BEVERLY HILLS • DENVER • FT. WORTH • KANSAS CITY • SAN DIEGO • SAN FRANCISCO
SEATTLE • TULSA • WICHITA



THE ELEMENT OF ENVIRONMENT and the System Designer

To one looking beyond the four walls of his office, environment might be defined as the sum of (1) work responsibilities and (2) colleague personalities.

The System Designers we seek could not fail to be stimulated by (1) assignments of a most advanced nature and by (2) colleagues with considerable attainments in systems engineering, behavioral science and computing.

The advanced nature of the assignments requires at least four years' experience, including circuit design or development, equipment construction and a knowledge of logical design for computers. Moreover, the position also calls for a sound background in computer programming, the ability to write programs and familiarity with the IBM 700 series or similar single address parallel machines.

You are invited to write for more information or phone collect. Address R. W. Frost, System Development Corporation, 2420 Colorado Avenue, Santa Monica, Calif.; phone EXbrook 3-9411.

SYSTEM DEVELOPMENT CORPORATION

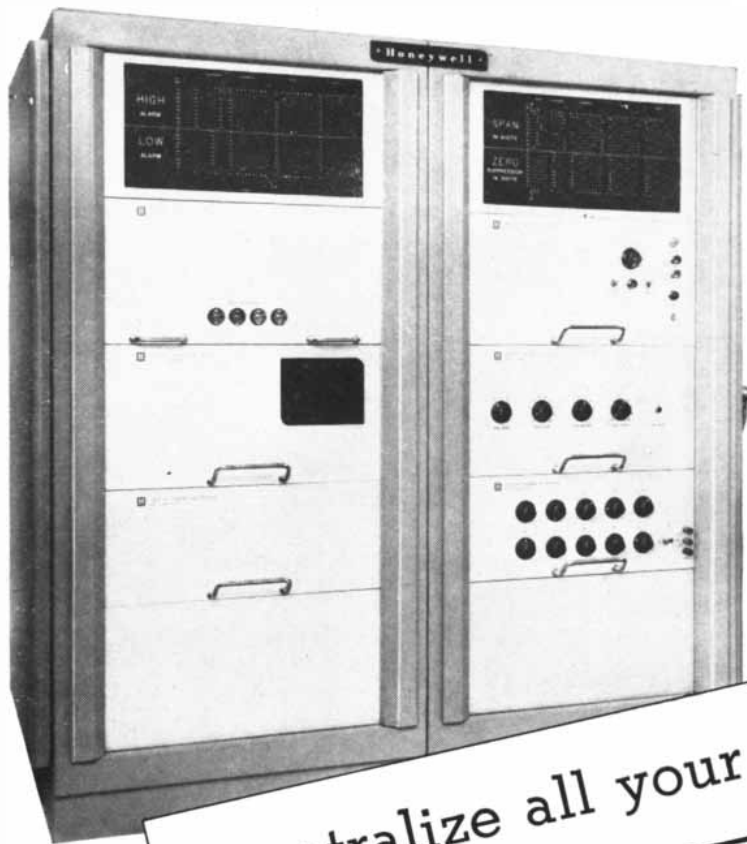
An independent nonprofit organization, formerly a division of the Rand Corporation

11-35

Konigsberger and J. T. G. Overbeek of the Netherlands; its main features are as follows. "Activated" amino acids line up along the RNA in a specific order determined by the structure of the RNA molecule; the carbonyl group (CO) of each amino acid is bound to a phosphate group (PO₄) of the RNA [see illustration on page 120]. By a "zipper" reaction the carbonyl group of an amino acid at one end of the chain is transferred from the phosphate group to the amino group (NH₂) of the adjacent amino acid. This causes the same transfer in the next amino acid, and so on down the line. The chain of amino acids separates from the RNA molecule as it grows.

How does the RNA determine the sequence of amino acids before the zipper reaction? The question has given rise to much thought and speculation. RNA is one of two types of nucleic acid found in the living cell; the other type is deoxyribonucleic acid, or DNA. Where a protein molecule is a chain of amino acids, both DNA and RNA are chains of sugars linked by phosphate groups; to each sugar, however, is attached a base. Chemically the two nucleic acids are quite similar; architecturally they may differ. J. D. Watson and F. H. C. Crick have worked out a now-famous model of DNA in which two nucleic-acid chains wind around each other like a double spiral-staircase [see "Nucleic Acids," by F. H. C. Crick; *SCIENTIFIC AMERICAN*, September, 1957]. The bases form the "treads" of the staircase; a base on one chain is joined to the adjacent base on the other chain by a weak chemical bond. The structure of RNA is not so clearly understood, but it is probably a two-chain helix also. Crick has suggested that for the RNA molecule to distinguish each amino acid from all the others requires the proper arrangement in space of three bases. That is about as far as we can go at present. We are much in need of an accurate three-dimensional model of RNA.

Goethe once said that genius was the ability to perceive analogies. When biologists are blocked in an investigation based on one kind of organism, they often turn to another kind. The small particles of the microsome are composed of protein and RNA; so are the viruses which cause the mosaic disease of tobacco. Various investigations of the tobacco mosaic virus show that it is made up of smaller units which resemble lock washers; in the intact virus the "washers" are stacked like coins. By inference the small particles of the microsome are also made up of smaller units, and several labora-



centralize all your process data

with Honeywell's new Data Handling System

SIMPLIFY DATA PROCESSING . . . eliminate the complexities you associate with gathering and correlating data.

GAIN NEW DATA PROCESSING FLEXIBILITY . . . change logging sequence at will . . . easily switch types or ranges of inputs . . . add inputs quickly . . . move smoothly from one process to another. Here is a system that defies obsolescence.

GAIN GREATER ACCURACY . . . process data with accuracy of 1/10 of 1% of reading—accuracy that's *barely approached* by other data processing equipment.

GAIN DEPENDABILITY . . . all components of Honeywell's new Data Handling System are designed for remarkably long life and utmost operating efficiency . . . maintenance needs are pared to a minimum.

SIMPLIFY OPERATION . . . span, range, zero and alarm points are set to the actual digital value by merely placing a few pins in a board.

CUT MAINTENANCE TIME . . . the Honeywell Data Handling System can be serviced while in operation—an exclusive advantage.

Write or call for details.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Products Group*, Brown Instruments, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell



First in Controls



Preserve your copies of **SCIENTIFIC AMERICAN**

☞ A handsome and durable library file or binder in which to keep your copies of **SCIENTIFIC AMERICAN**.

☞ Both styles bound in dark green library fabric and stamped in gold leaf.

FILE (shown at right): Holds 12 issues. Single copies easily accessible. Price: \$2.35 (U.S.A. only).

BINDER (shown at left): Holds 6 issues. Copies open flat. Price: \$2.50 (U.S.A. only).

Address your order,
enclosing check or
money order, to:

Department F (File) or A (Binder)
SCIENTIFIC AMERICAN
415 Madison Avenue
New York 17, N. Y.

(New York City residents please add 3% Sales Tax)

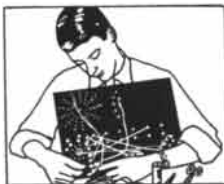
MAKE TINY GENIUS COMPUTERS WITH **BRAINIAIC**

a new and better

ELECTRIC BRAIN CONSTRUCTION KIT

Makes 106 computing, reasoning, arithmetical, logical, puzzle-solving and game-playing machines . . . all 33 **GENIAICS** (1955), 13 **TYNIAICS** (1956), and 60 All New **BRAINIAICS**® (1957)

- **Scientific**
 - **Fun**
 - **Instructive**
 - **Safe**
- with reusable
solderless parts
and
complete plans



THIS IS BRAINIAIC! With our Brainiaic Kit (K 15), you can build over 100 small electric brain machines and toys which "think", compute, reason and display intelligent behavior. Each one works on a single flashlight battery. . . . is FUN to make, FUN to use and play with, and TEACHES you something new about electrical computing and reasoning circuits. Originated and produced exclusively by Berkeley Enterprises. Brainiaic is the result of 7 years' development work with miniature mechanical brains, including Geniaic, Tyniaic, Tit-Tat-Toe Machine pictured in LIFE Magazine, Simon (baby automatic computer), Squee (electronic robot squirrel), etc.

WHAT CAN YOU MAKE WITH BRAINIAIC KIT K 15? 106 small machines including—*Logic Machines*: Logical Truth Calculator, Syllogism Prover, Intelligence Test, Boolean Algebra Circuits . . . *Game-Playing Machines*: Tit-Tat-Toe, Nim, Black Match, Wheelie Bandit, etc. . . . *Computers*: To add, subtract, multiply or divide, using decimal or binary numbers; Forty-Year Calendar, etc. . . . *Cryptographic Machines*: Coders, Decoders, Combination Lock with 15,000,000 combinations, etc. . . . *Puzzle-Solving Machines and Quiz Machines*: Over 30 intriguing puzzles and quizzes—with fascinating variations.

WHAT COMES WITH YOUR BRAINIAIC? Complete plans and instructions • Manual by E. C. Berkeley on small electric brain machines. • Over 120 circuit diagrams including 46 exact wiring templates • Introduction to Boolean Algebra for designing circuits. • Every part needed to build Geniaics, Tyniaics, Brainiaics—over 400 pieces including control panel, multiple switch discs, jumpers, improved wipers, bulbs, sockets, washers, wire, battery, special tools—everything needed. Price: \$17.95. (For shipment West of Mississippi, add 80¢, outside U.S., add \$1.50.)

7-DAY FULL REFUND GUARANTEE IF NOT SATISFACTORY
—MAIL THIS COUPON—

Berkeley Enterprises, Inc.
815 Washington St., R124, Newtonville 60, Mass.
Please send me Brainiaic Kit K 15. (Returnable in 7 days for full refund if not satisfactory—if in good condition.) I enclose \$..... in full payment.
My name and address are attached.

ASSISTANT GROUP MANAGER— MILITARY TV

The man we're looking for is currently working in this type of position, MEE—between 30 and 35 years of age with 5 years general electronics background plus 5 years R & D working experience in Military TV. He should have specific knowledge in the fields of tactical TV chains, kinescope recorders and color TV; he should have allied knowledge in the field of infra-red devices and subminiaturization.

Must be able administrator and coordinator, ability to delegate responsibility and solve technical problems essential.

Send your resume to Mr. Joseph W. Skelly, Technical Recruiter, R & D Division, Allen B. Du Mont Laboratories, 35 Market Street, East Paterson, New Jersey,

or phone MU 4-7400, Ext. 0434

DU MONT

tories are presently looking into the matter.

Despite the slow pace of this work we have succeeded in dissecting out three steps of protein synthesis. The first is the "activation" of the amino acids before they are joined. Amino acids will not link spontaneously; energy must somehow be funneled into the process. In 1941 Fritz Lipmann (now at the Rockefeller Institute) suggested that amino acids might be raised to a higher energy level by combining with an energy-rich phosphate group. The activated amino acids could then coast downhill, in the energetic sense, to combine with each other. For years biochemists sought this reaction, without success. Now my colleague Mahlon B. Hoagland has found a similar reaction which appears to supply the long-missing activation step.

In the second step the amino acids are lined up in association with RNA and linked. This does not complete the process; a protein is not a simple chain of amino acids. It may consist of two or more chains joined by secondary chemical bonds, and the chains may be coiled or folded by weaker bonds.

The third step is the establishment of this complex structure. At least part of it seems to take place in association with the membranes of the endoplasmic reticulum, as distinct from its small particles. The membranes are logically located in juxtaposition to the particles. The two components of the endoplasmic reticulum or microsome thus appear to be mutually dependent in protein synthesis.

Between the first and second step lies an active area of research. Evidence from our laboratory and others points toward the possibility that, between the activation of the amino acids and the completion of the amino acid chain, there may be an intermediate amino-acid-RNA compound. There is little doubt that the actual sequence of events is rather more complex than I have outlined it here.

The functions of the microsome are not restricted to protein synthesis. My colleague Nancy Bucher has shown that the membrane of the endoplasmic reticulum is essential to the formation of cholesterol, the steroid found in all cells. Curiously the small particles of the microsome play no part in cholesterol synthesis. Other important substances such as steroid hormones and drugs are oxidized or altered in the membrane; the list of its functions is rapidly growing.

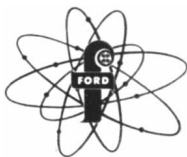


Ford Instrument Co. Engineer checks air-bearing gyro for angular drift on equatorial test stand. Test can show up drift rates as low as one revolution in 40 years. Tests like this . . .

helped Army put "Explorer" into orbit

Some of Ford Instrument's current or recent programs include:

- Inertial guidance systems . . . including Redstone and Jupiter
- Missile launching and control order computers
- Navigational and mission control systems and computers
- Analog and digital computer systems
- Fuzing, arming and other warhead control equipment
- Plotting equipment
- Nuclear systems and controls
- Gunfire controls
- Drone controls



A special guidance system for the Jupiter C, developed by the Army Ballistic Missile Agency, was used to launch the first U. S. artificial satellite into space.

Many components of this system were provided by Ford Instrument Co., prime contractor for both the "standard" U. S. Army Redstone and Jupiter guidance systems.

The fabulously-equipped, fantastically-clean gyro lab (above) is only a small part of the advanced research and

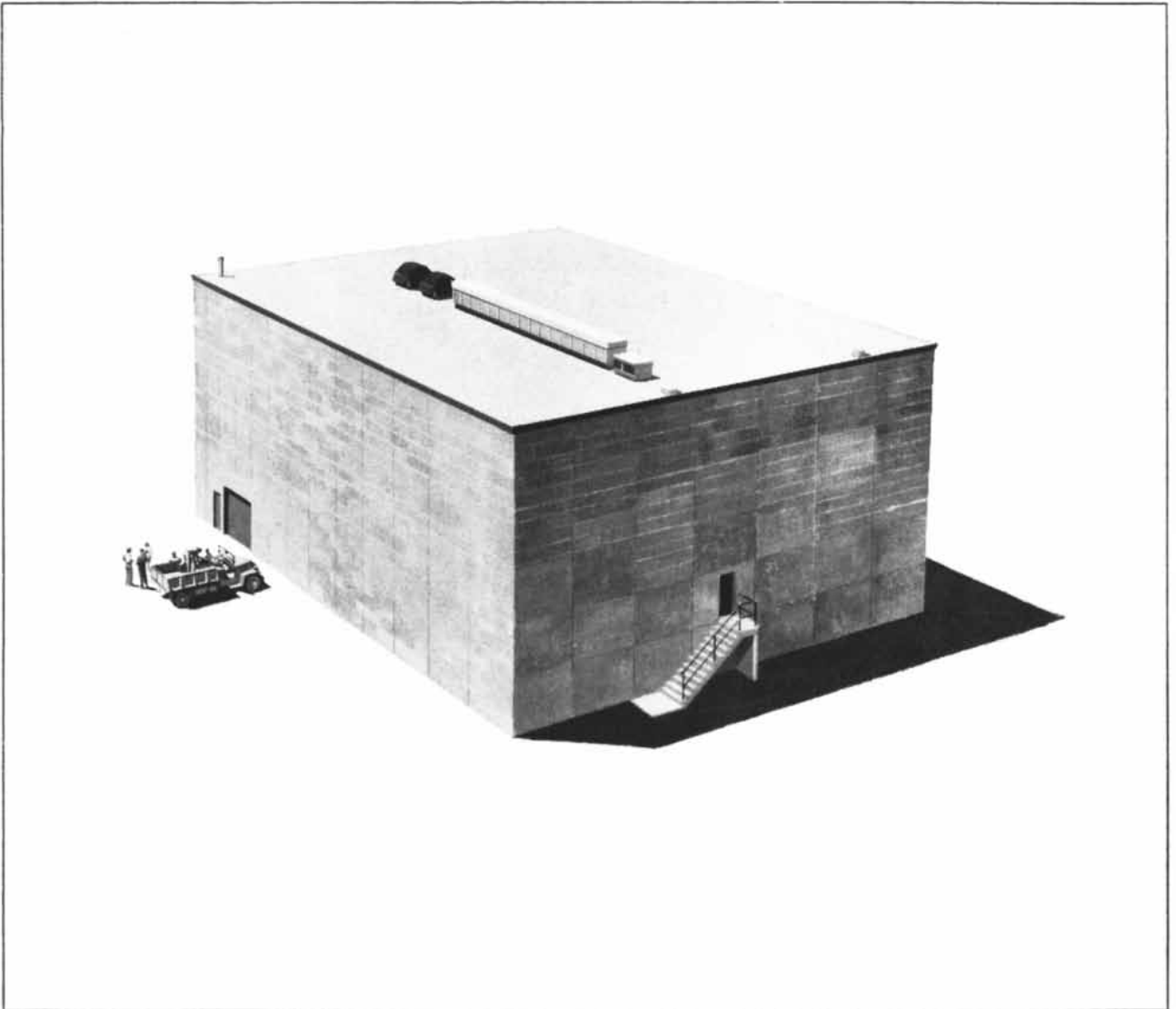
development facilities available at Ford Instrument Co. They're used to create and produce the incredibly accurate control systems called for by modern technology in both government and industry.

And Ford Instrument's large-scale precision manufacturing facilities can turn even the most critical system requirements into working "hardware" on a quantity-production basis. Our Liaison Engineers are at your service to discuss your system requirements. e. 6

FORD INSTRUMENT CO.

DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, New York
 Field Sales Offices: Beverly Hills, Calif.; Dayton, Ohio

This windowless building sees all, knows all



This four-story concrete blockhouse contains a unit of the SAGE system. SAGE—short for Semi-Automatic Ground Environment—is a master weapons control system. It is our nation's best insurance against surprise attack by air.

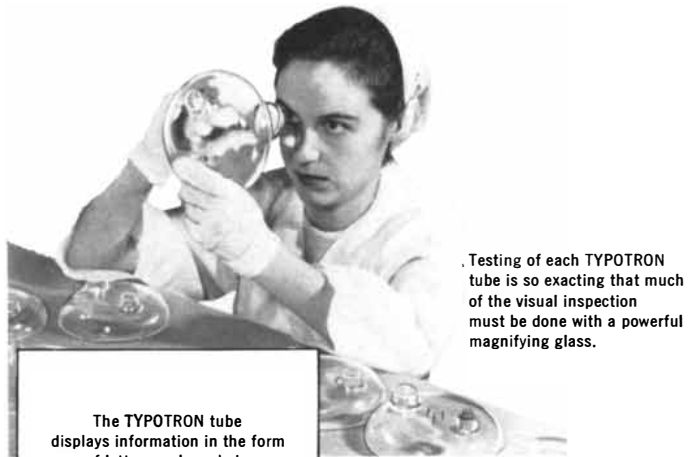


At each SAGE Direction Center officers can evaluate all action within their defense area and can quickly plan the strategy of counterattack.

In each windowless SAGE blockhouse is a huge electronic computer. Receiving information from a far-flung network of sources, the computer assembles reports—on as many as 30,000 separate air flights per day—and commits these facts to memory. In the event of enemy aggression, SAGE can identify the enemy planes, calculate their speed, range and direction—and then select measures of defense or counterattack. This blockhouse, and others like it, feeds information to the Combat Operations Center in Colorado Springs where all U.S. and Canadian military might is co-ordinated.



Flying radar stations patrol inaccessible land and sea areas to help in keeping an electronic vigil over the North American Continent.



Testing of each TYPOTRON tube is so exacting that much of the visual inspection must be done with a powerful magnifying glass.

The TYPOTRON tube displays information in the form of letters and symbols.



One important component in the SAGE system is the Hughes TYPOTRON® tube. Its function: to display and store information gathered by radar and fed through a digital computer. Developed by Hughes at the request of the U.S. Air Force, the TYPOTRON tube is basically a high-speed read-out device (25,000 characters per second) which can also present data for extended periods of time. The TYPOTRON tube, in its critical SAGE role, has established an outstanding record of reliability.

Other Hughes components are also used in the SAGE system. In each SAGE computer, for example, there are thousands of Hughes diodes. These diodes act as traffic controls in directing a myriad of computations through the computers.

These display tubes and diodes have not only military but also commercial applications. We at Hughes produce a wide range of electronic systems and components. Drawing on our extensive experience, we may be able to help with your problems.

Creating a new world with **ELECTRONICS**

HUGHES PRODUCTS

© 1958, HUGHES AIRCRAFT COMPANY
International Airport Station, Los Angeles 45, California

MATHEMATICAL GAMES

About left- and right-handedness, mirror images and kindred matters

by Martin Gardner

The recent discovery that fundamental particles of physics have a left-and-right "handedness" [see "The Overthrow of Parity," by Philip Morrison; *SCIENTIFIC AMERICAN*, April, 1957] opens new continents of thought. Do all the fundamental particles in the universe have the same handedness? Will nature's ambidexterity someday be restored by the discovery that some galaxies are composed of antimatter—matter made up of particles that "go the other way," as Alice described the objects in her looking glass? Perhaps we can better understand these speculations if we approach them in a playful spirit.

Mirror reflections are so much a part of daily life that we feel we understand them thoroughly. Most people are nonetheless at a loss for words when they are asked: "Why does a mirror reverse left and right and not up and down?" The question is made more confusing by the fact that it is easy to construct mirrors that do not reverse left and right at all. Plato in his *Timaeus* and Lucretius in *On the Nature of Things* describe one

such mirror, made by bending a rectangle of polished metal into the slightly concave form shown in the middle illustration below. If you look into such a mirror you will see your face as others see it. The reflection of a page of type may similarly be read without difficulty.

An even simpler way to make a mirror that does not reverse images is to place two mirrors, preferably without frames, at right angles to each other as shown in the illustration at right below. If you rotate this mirror (as well as the one described earlier) through 90 degrees, what happens to the image of your face? It turns upside down.

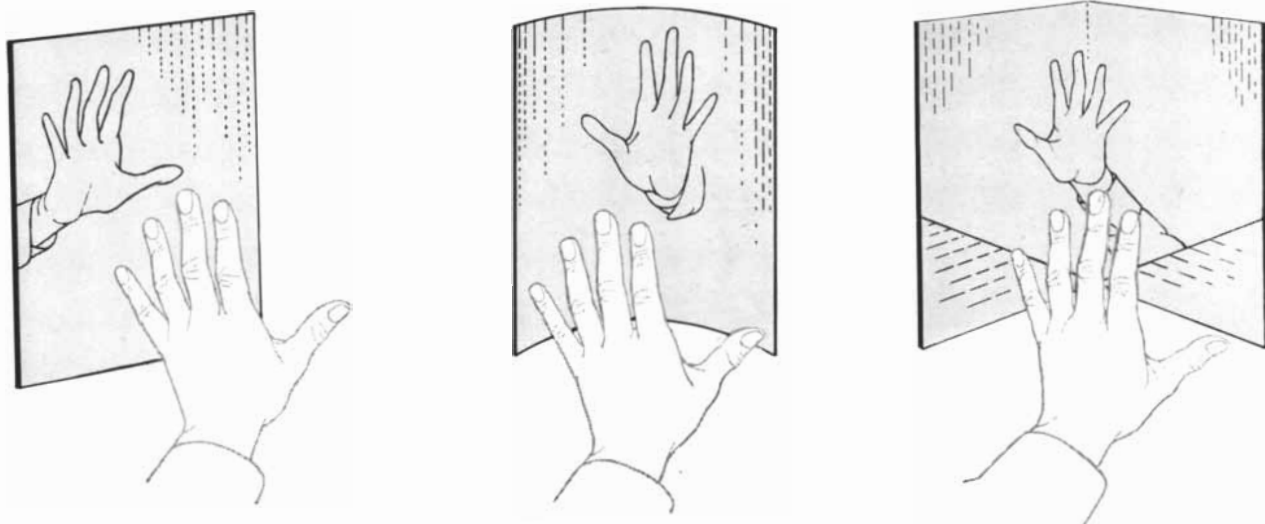
A symmetrical structure is one which remains unchanged when it is reflected in an ordinary mirror. It can be superposed on its mirror-image, where asymmetric structures cannot. The twin forms of all asymmetric objects are often distinguished by calling one "right" and the other "left." No amount of inspection or measurement of one will disclose a property not possessed by the other, yet the two are quite different. This sorely puzzled Immanuel Kant. "What can more resemble my hand," he wrote, "and be in all points more like, than its image in the looking glass? And yet I cannot

put such a hand as I see in the glass in the place of its original."

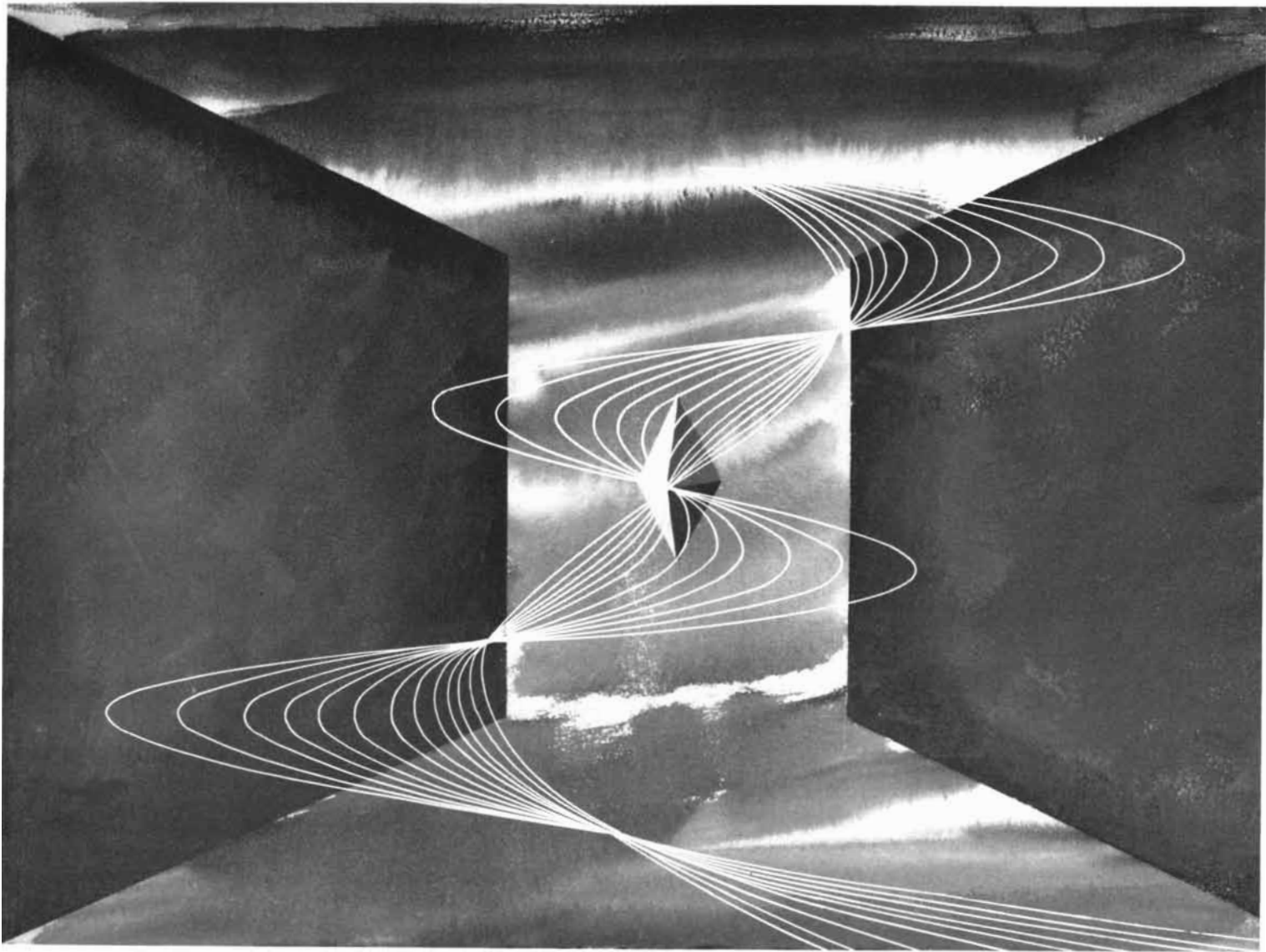
This curious duality is found in structures with any number of dimensions, including those with more than three. A segment of a straight line, for example, is symmetrical along its one dimension; but if we consider a long segment followed by a short one, the pattern is asymmetric. Mirrored by a point on the linear dimension it becomes a short segment followed by a long one. If we think of printed words as symbols ordered in one dimension, then most words are asymmetric, though there are palindromic words like "radar" which read the same both ways. There are even palindromic sentences: "Draw pupil's lip upward"; Napoleon's fancied statement, "Able was I ere I saw Elba"; and Adam's first remark, "Madam, I'm Adam" (to which Eve appropriately replied, "Eve").

Melodies may similarly be regarded as tones ordered along the single dimension of time. During the 15th century it was fashionable to construct palindromic canons in which the imitating melody was the other melody backward. Many composers (including Haydn, Bach, Beethoven, Hindemith and Schönberg) have used the device for contrapuntal effects. Most melodies, however, grate on the ear in retrograde form.

Many amusing experiments in musical reflection can be performed with a tape recorder. Piano music played backward sounds like organ music because each tone begins faintly and swells in volume. Particularly weird effects may be obtained by playing music backward inside an echo chamber while recording it on another tape. When the second



An ordinary mirror and its image (left) and two mirrors whose images are not reversed (center and right)



An inquiry into anisotropy

Magnetocrystalline anisotropy or the variation of magnetic energy as a function of the direction of magnetization in a crystal, is the subject of careful study at IBM Yorktown Research Center. Currently, the investigation of this property of magnetic crystals has been greatly furthered by an apparatus developed at IBM.

In crystals of ferrites and garnets there are certain directions in the crystal along which magnetization prefers to point. When the crystal is magnetized in other directions, it experiences a torque tending to align the preferred direction with the magnetizing field. The new

apparatus automatically records this torque as the magnetizing field direction changes. By analyzing these "torque curves" it is possible to learn how the anisotropy varies with chemical composition, temperature, and the previous thermal treatment of the crystals.

This research is pursued because the magnetic materials used in computers consist of millions of tiny crystals oriented at random. By studying single crystals, IBM hopes to unlock secrets that may help lead the way toward improved computers to relieve the world from computational drudgery.

Investigate the many career opportunities available in exciting new fields at IBM.

IBM**RESEARCH**

International Business Machines Corporation, 590 Madison Avenue, New York 22, New York

WESTINGHOUSE COMMERCIAL ATOMIC POWER COMES OF AGE

Where would you work on an atomic power plant?

Physicists and Nuclear Engineers

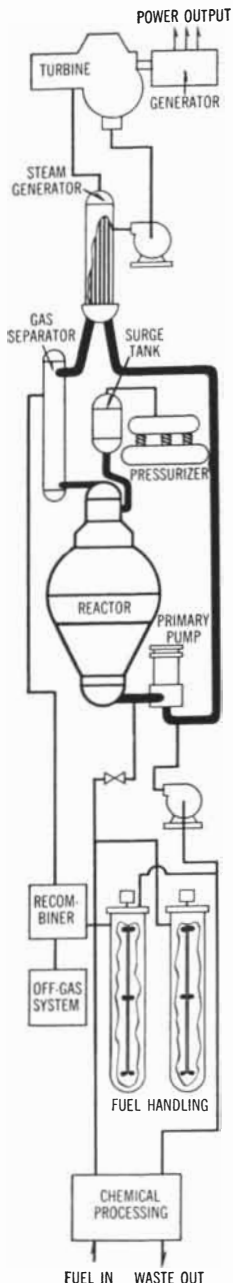
Criticality and lifetime studies, secondary loop water activation, component gamma heating, stability and transient response, critical experiment design, fissionable and fertile material concentration, neutron flux distributions, radiation analysis, thermal and biological shielding, conceptual and detail design of reactor and components.

Chemists and Chemical Engineers

Systems, process, vessel, and piping design and development; extraction, ion exchange, calcination, drying, adsorption, dissolving; physical, inorganic, and water chemistry; fine particle technology, heat transfer, corrosion, erosion, fluid dynamics, liquid phase catalysis, reaction kinetics, instrumentation, transient analysis, boundary layer flow, rheology, and sedimentation.

Mechanical Engineers

Design high pressure piping and vessels, heat exchangers, remote repair equipment and tools, gas handling equipment, mixer mechanisms; analyze problems in fluid flow, heat transfer, erosion, corrosion, gamma heating, stress analysis, hydraulic design, valve development, fluid dynamics, instrumentation and control.



This diagram shows the main parts of the world's first homogeneous power plant being developed by Westinghouse Atomic Power Department in conjunction with Pennsylvania Power and Light Company . . . and just where you would work. This pioneering plant, unlike the heterogeneous reactor, will use a liquid or "slurry" nuclear fuel, capable of continuous reprocessing.

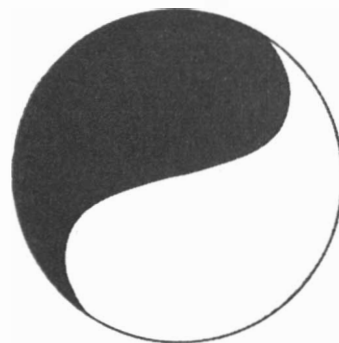
5 Commercial Atomic Power Programs Now Under Way

1. A 150-megawatt homogeneous reactor for Pennsylvania Power & Light Co.
2. The first industry-owned testing reactor for nuclear-materials study (Owned by Westinghouse).
3. A 134-megawatt reactor for Yankee Atomic Electric Co.
4. A 134-megawatt atomic plant for Edison-Volta, Italy.
5. An 11.5-megawatt pressurized water reactor for Belgium.

Also research, analysis, and development of advanced reactor types . . . and more programs, national and international, are coming in.

Immediate openings in the Pittsburgh area for: Metallurgists. Physicists. Ceramists. Mechanical Engineers. Chemists. Chemical Engineers. Nuclear Engineers. Instrumentation & Control Engineers. Atomic experience desirable but not necessary . . . we're not dependent on government subsidy . . . opportunities for advanced study on company fellowships.

Send your résumé to: C. S. Southard, Westinghouse Atomic Power Department, Box 355, Dept. 1017, Pittsburgh 30, Pa.



The Chinese monad

tape is reversed, the notes regain their original order but the echoes precede the sounds.

Another type of musical reflection is produced by turning a player-piano roll around so that it plays forward but with high and low notes reversed—the inverted music a pianist would produce if he played in the normal manner on a looking-glass piano. The melody becomes unrecognizable, and there is an unexpected transposition of minor and major keys. This device was also used in Renaissance canons and in the counterpoint of later composers. The classic example is in Bach's *Die Kunst der Fuge*, in which the 12th and 13th fugues may be inverted. Mozart once wrote a canon with a second melody that was the first one both backward and upside down, so that two players could read the same notes from opposite sides of the sheet!

A configuration such as the Christian cross is of course symmetrical in two dimensions. The monad, an ancient Chinese religious symbol [see illustration above], is not. The dark and light areas, called Yin and Yang, symbolize all the fundamental dualities, including left-right and its combinatorial basis in even and odd numbers. The monad's pleasing asymmetry makes singularly appropriate the fact that it was two Chinese physicists (one of them named Yang!) who received the Nobel prize last year for their theoretical work which led to the overthrow of parity. Unlike music, all asymmetrical designs and pictures can be "fopped" (to use the graphic-arts term for "reflected") without losing esthetic value. In fact, Rembrandt once made a fopped etching of his famous *Descent from the Cross*.

Because most printed words form asymmetric patterns, reflections of printed matter are usually unreadable, but not always. If you look at a mirror reflection of the words "CHOICE QUALITY" on the side of a Camel-cigarette package, holding the pack so that its top points to your right, you will be startled

Westinghouse

FIRST IN ATOMIC POWER



SLEEVE BEARING of Du Pont ZYTEL used in rotor hub of helicopter eliminates field maintenance of blade-retention system. (Made by Doman Helicopters, Inc., Danbury, Conn.)

Here's how you, too, may

cut maintenance costs by using tough components of ZYTEL[®] nylon resin

ZYTEL nylon resin is widely used for making strong bearings and gears, because the parts wear so well and need little or no lubrication. A real benefit is the savings in maintenance costs.

A typical experience is that of the Rotor Group Engineer at Doman Helicopters, where a bearing of ZYTEL is used to support the helicopter spar tube. In his own words: "This appli-

cation has solved all spar-tube galling problems. By eliminating galling problems in the Doman Rotor, there is no longer a need for field maintenance of the blade-retention system."

While the load-carrying ability and temperature range of bearings of ZYTEL are much like those of babbitt, the components fabricated from ZYTEL have considerably better abra-

sion resistance. Even thin-walled parts of ZYTEL are found to be very strong. Since ZYTEL is a resilient material, this property provides a tendency to damp harmful vibrations.

Be sure to evaluate the many advantages of ZYTEL nylon resin. The coupon will bring you facts on numerous successful uses, plus detailed property data.



BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department
Room 383, Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

Please send me more information on Du Pont ZYTEL. I am interested in evaluating this material for _____

Name _____
Firm Name _____
Position _____
Type of Business _____
Street Address _____
City _____ State _____



— technological bumbershoot

Covering the advanced needs of industry and defense is today's biggest technological job.

GPE has brought together, under one umbrella, broad physical resources plus a remarkably creative group of scientists, engineers and technicians. Its co-ordinated skills,

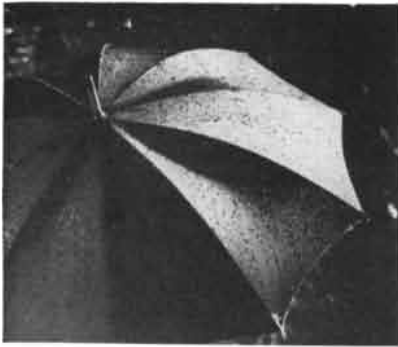
knowledge, experience and producing facilities cover more than a dozen industries.

Each company in General Precision Equipment Corporation works close to the frontiers of science in its specific fields. Working together, they have rolled up an impressive record

of achievement in new and often uncharted technological areas.

If your needs are in controls, systems engineering or automation, you'll find some eye-opening answers in this highly integrated research, design, engineering and manufacturing group.

GENERAL PRECISION EQUIPMENT CORPORATION



The principal GPE companies cover needs of defense and industry in these areas: Audio-Visual, Automatic Controls and Automation, Aviation, Chemical Processing, Electronic and Electrical, Graphic Arts, Instrumentation, Marine, Motion Picture, Packaging, Paper, Petroleum, Photo Technology, Power Generation and Conversion, Printing, Steel, Television, Textile.

ASKANIA	GPE
GPL	GPE
GRAFLEX	GPE
<i>Griscom-Russell</i>	GPE
Hertner	GPE
Kearfott	GPE
<i>LIBRASCOPE</i>	GPE
LINK	GPE
NATIONAL THEATRE SUPPLY	GPE
SHAND AND JURS	GPE
<i>Strong</i>	GPE

Address inquiries to:
General Precision Equipment Corporation
 92 GOLD STREET, NEW YORK 38, N. Y.

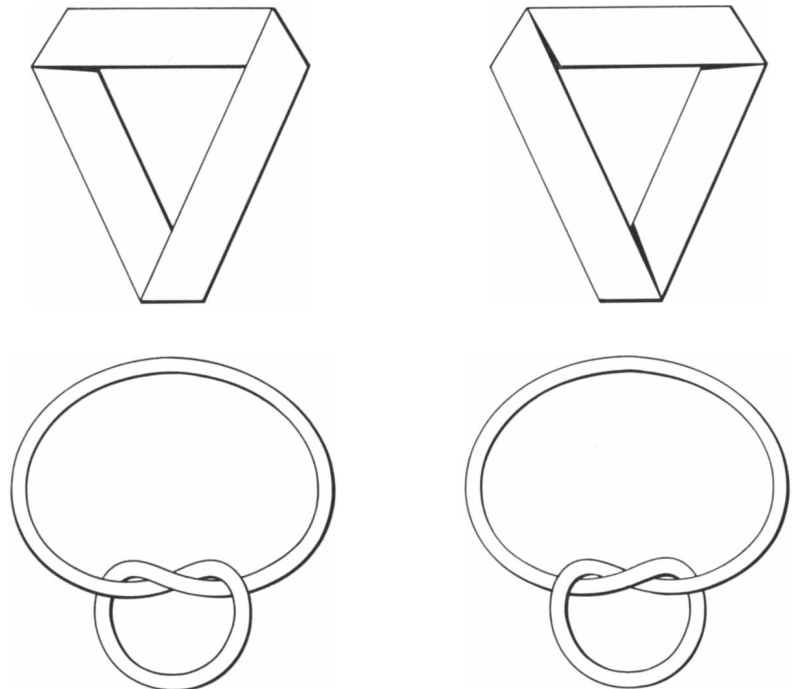
by what you see. "QUALITY" is unreadable, but "CHOICE" is entirely unchanged!

When we consider familiar structures of three dimensions, we find that they are a pleasing mixture of symmetry and asymmetry. Most living forms are symmetrical in their outward appearance, with such notable exceptions as spiral shells, the pincers of the lobster, the crossed bills of the crossbill and the unilateral eyes of flatfish. Even behavior patterns are sometimes asymmetric; for example, the counter-clockwise gyrations of bats swarming out of Carlsbad Caverns. Most man-made objects are likewise symmetrical, though some that seem to be so prove to be asymmetric when inspected more closely—for instance, scissors, Moebius strips, hexaflexagons and simple overhand knots. The two knots in the illustration below have identical topological properties, yet one cannot be deformed into the other. Dice also have two distinct forms. There are two ways of placing spots on a die's faces so that the spots on opposite sides always total seven; one way is a mirror image of the other.

Since folding your arms is the same as tying them in an overhand knot, it follows that there are two distinct ways to fold arms, though we are all so conditioned to one method that it is annoyingly difficult to execute its mirror twin. Fold your arms as you normally do, grasp the two ends of a string, unfold

your arms, and you will transfer the knot from your arms to the string. Repeat the experiment with your arms folded the other way and you get a knot that is a reflection of the first one. A fascinating (and unsolved) topological problem is to prove that a pair of mirror-image knots in a closed curve cannot be made to cancel each other by deforming the curve. No one has succeeded in doing it, though it is easy to push one knot into the other and form a square knot, which is symmetrical. If you do this with two knots of the same handedness, you get an asymmetric granny.

These are not trivial matters. Now that certain particles are known to be asymmetric in some as-yet-unknown spatial sense, physical theory will have to account for the fact that when a particle meets its antiparticle, the two annihilate each other and create symmetrical energy. Alice looked into her mirror and wondered if looking-glass milk was good to drink. For some time it has been known that such milk would not be digested, because the enzymes of the body, designed to act on left-handed molecules, could not cope with right-handed ones. Now it would seem that the situation might be a good deal worse. If Alice tried to drink the mirror-image milk, there might be a violent explosion as left- and right-handed particles annihilated each other. It is safe to predict that we will be speculating right and left for a long time to come.



Left- and right-handed knots (bottom) and their equivalents in Moebius strips (top)



THE AMATEUR SCIENTIST

How to cultivate harmless bacteria and perform experiments with them

Conducted by C. L. Stong

One of the most active fields of experimental biology deals with organisms that are too small to see. Yet microbiology attracts few amateur experimenters. The reasons are doubtless that experiments with microorganisms seem to require advanced techniques and elaborate apparatus, and even to involve the risk of dangerous infection. Actually the amateur can perform rewarding microbiological experiments with modest equipment and, given simple precautions, with a high degree of safety.

The cultivation of microorganisms resembles farming in miniature. The soil in which the organisms are grown consists of nutrient solutions or jellies; the climate is provided by artificial means. By manipulating this environment the characteristics of a microorganism can be sharply defined. The experiment described here demonstrates how certain bacteria are affected by bacteriostatic agents. It is presented by Robert Lawrence and Henry Soloway, students in the College of Medicine of the State University of New York.

"The experiment," they write, "is designed to demonstrate how certain drugs retard the growth of selected bacteria. Such drugs are called bacteriostatic.

"In testing such substances one first cultivates a selected bacterium in an environment which encourages its growth, subjects it to the bacteriostatic agent and then measures the result. Bacteria, like other forms of life, have preferences in foods, temperature, moisture and so on. Hence no universal culture medium, in which all organisms thrive equally, has been developed. Media must be compounded according to the preferences of the bacteria under study. However, one medium in which some thousands of or-

ganisms thrive consists of beef broth, the familiar consommé of the dinner table, which has been refined and specially treated. It is used both in liquid form and, when thickened by the addition of agar, as a stiff jelly.

"As in ordinary farming, 'weeds' must be kept down. One is often interested in the characteristics of a single species of bacterium, and since the size of the organism makes 'weeding' impractical, intruders must be prevented from gaining a foothold in the first place. This is accomplished by killing all microscopic life in the environment of the experiment except the desired organism. The culture medium and all equipment is sterilized, exposed only to sterilized air and otherwise kept scrupulously aseptic during the experiment.

"These conditions can be maintained if the amateur provides himself with an aseptic transfer chamber in which all critical operations are performed. This can be a simple wooden box two feet high, two feet wide and three feet long. It is fitted with a glass top, a small door and a pair of holes in one side large enough to admit the hands and forearms comfortably. The cracks should be calked with cotton or sealing compound. A short pair of muslin sleeves may be tacked around the holes to serve as barriers against the outside air. Inside the box one should place, among other things, an alcohol lamp or Bunsen burner, and a small atomizer of the nose-spray type containing Lysol or Chlorox.

"Glassware should include two dozen Petri dishes, which have flat bottoms about four inches in diameter, sides about half an inch high, and are fitted with covers. The experimenter will also need three Erlenmeyer flasks of one-liter capacity and half a dozen of the quarter-liter size, a half-dozen test tubes of 20-milliliter capacity and a rack for supporting them, a dozen one-milliliter pipettes and a special rubber bulb or syringe for filling them, a 50-milliliter graduated cylinder, a wax pencil for marking the glassware, a dissecting needle fitted to a pencil-sized wooden hold-

er, a small loop of thin wire fitted to a similar handle, a glass stirring rod about eight inches long, and a pair of tweezers. All these things should be assembled, together with the special wooden box or transfer chamber, on a substantial bench located where the materials will not be disturbed.

"All the materials are then sterilized. Petri dishes and pipettes are tightly wrapped in lots of six in brown paper. Larger items are wrapped individually. Test tubes and Erlenmeyer flasks may be plugged with wads of absorbent cotton instead of being wrapped in brown paper. The glassware is then placed in an oven and heated to 325 degrees Fahrenheit for at least two hours. None of the packages should be opened nor the cotton removed until the glassware is used.

"Dehydrated culture medium, both plain and in the form of an agar infusion, may be purchased from the Difco Laboratories, Detroit, Mich., or from the Baltimore Biological Laboratory, Baltimore, Md. A principal object of the experiment, however, is to provide the amateur with experience in the basic techniques of culturing bacteria. The beginner is therefore urged to prepare his own culture medium.

"Stir a pound of freshly ground hamburger into a liter of distilled water and put it in the icebox (at about 40 degrees F.) for 10 hours. Then skim off the fat which rises to the top and filter the remaining liquor through a single thickness of clean muslin. Add distilled water to bring the liquor back to a full liter, then add five grams of peptone and five grams of ordinary table salt and stir until the salt is dissolved. Pour 50 milliliters into a second flask and set it aside. Then add 15 grams of agar to the 950-milliliter portion.

"Bacteria, like other organisms, are sensitive to the acid-base balance of the medium in which they grow. Those grown in this experiment prefer a neutral medium. The two solutions just prepared will be slightly acid; they must accordingly be adjusted to neutrality (pH 7) by adding precisely enough so-

dium hydroxide to counteract the acid. Mix 10 grams of sodium hydroxide in a liter of distilled water. Test the beef broth with a piece of blue litmus paper. An acid broth will turn the blue paper red. The sodium-hydroxide solution will turn red litmus blue. Add a drop or two of sodium hydroxide to the liquor, stir, and with the glass rod put a drop of the solution on a piece of blue litmus. The paper in contact with the drop will probably turn pink. Add more sodium hydroxide to the liquor and test again. Continue this until the test drop causes no change in the color of either red or blue litmus.

"Each container of liquor is then heated almost to 212 degrees F. for half an hour. This will precipitate the proteins in the liquor. The proteins are removed by passing the hot liquor through coarse filter paper. Each filtrate is again brought up to volume by adding distilled water.

"One hundred milliliters of the hot agar medium are poured into each of six Erlenmeyer flasks, which are then stoppered with wads of absorbent cotton. Five milliliters of the liquor containing no agar are poured into each of 10 test tubes, which are similarly stoppered.

"The media are now sterilized. The containers may be placed in boiling water for half an hour on each of three successive days. They may alternatively be sterilized in a pressure cooker. Put the containers inside the cooker, add two inches of water and pressure-cook for 20 minutes. Be sure to cool the cooker slowly. Rushing the job by quenching the cooker with cold water will cause the internal pressure to drop suddenly and the vessels of hot medium to boil over. Stoppered tubes of tap water and other solutions may be sterilized by either of these methods.

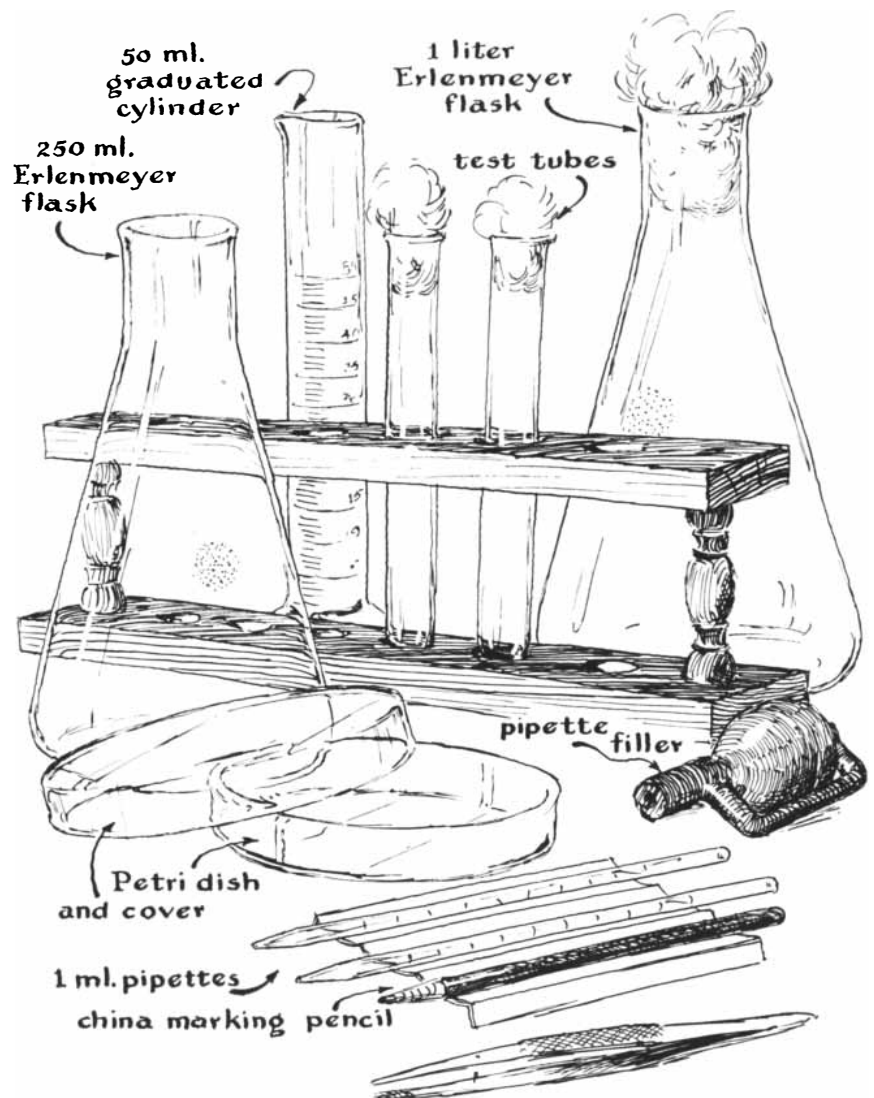
"Any nonpathogenic strain of bacteria may be employed for the demonstration of bacteriostasis. *Micrococcus pyogenes* var. *albus*, *Proteus vulgaris* or *Alcaligenes faecalis* can be used in the experiment and may be purchased at low cost from the American Type Culture Collection, 2112 M Street, N.W., Washington 6, D.C. Amateurs may wonder why one should go to the expense of buying bacteria if they are plentiful in the air. You can, of course, grow your own simply by exposing a quantity of the culture medium to the air and incubating it for 24 hours. Let us emphasize that this is both pointless and extremely dangerous. It is pointless because the average amateur has no means of identifying the microbes he has caught. It is dangerous because

he is likely to capture and cultivate deadly disease organisms. Incidentally, media that have been used should be sterilized and discarded immediately. Otherwise the experimenter runs a serious health risk. The strains recommended are inoffensive and have the further advantage of being accessible to all workers. Results of experiments may accordingly be compared. Purchased cultures can be perpetuated indefinitely by keeping them in beef broth at room temperature and inoculating a fresh tube of medium (by putting a drop of the old culture into it) every other day. If the culture can be stored at 40 degrees F., the growth of the bacteria is slowed and new media need be inoculated only once every six days.

"To perform the bacteriostasis experiment, first place a test tube of sterile beef broth, the tube containing the flourishing culture, and the wire loop inside

the transfer chamber. The chamber is sprayed thoroughly with germicide and the droplets are allowed to settle for five minutes. The alcohol lamp or Bunsen burner is lit and the wire loop heated to redness as far as the handle. Hold both test tubes obliquely in the left hand and the sterile wire loop in the right. Remove both cotton plugs from the tubes with the last two fingers of the right hand. The mouths of both tubes are passed slowly through the flame. The wire loop is then dipped into the flourishing culture for about a second, withdrawn and inserted into the tube containing the sterile broth. Both cotton plugs are replaced and the wire loop is again sterilized by heating to redness. To avoid contaminating the pure culture the beginner should run through these operations with empty tubes a few times for practice.

"The freshly inoculated tube is per-



Glassware and other materials required for experiments with bacteria



TEENAGER DESIGNS A NEW COMPUTER!

Using his Geniac® Electric Brain Construction Kit young John S., 16 years old, of Pittsburgh, Pennsylvania designed and built a machine that composes music, a circuit that is now included with every kit.

An exception? Not at all—

Ronald W. of Denver, Colorado used his Geniac® to design machines giving geometric area formulas, position of the planets in the solar system, control system in an atomic reactor, comparative weights on Mars and Earth and seems to find new uses each week in addition to those in the experimental manual.

Peter H. of River Edge, N.J. created an averaging machine.

Thousands of other people have used Geniac®, the Electrical Brain Construction Kit, to explore the fascinating new world of computing machinery. Schools, colleges, industrial training programs, engineering scientists and executives who have to keep abreast of new developments find in Geniac® the answer to their search for information and material to advance their knowledge of computers.

WHICH GROUP ARE YOU IN?

- Engineer or Research Scientist, who wants to learn more about the application of computers to his problems.
- Executive, with an interest in computing machinery.
- Teacher, in high school or college who needs laboratory or demonstration material on computers.
- Student, impatient for teachers to begin.
- Scientific Amateur, who wants to learn about computers but doesn't know how to begin.
- Parent of a scientific-minded youngster, who is looking for a present that will provide hours of entertainment and instructive value.

Thousands of people from these groups have bought and enjoyed Geniac®, the Electrical Brain Construction Kit.

Every Geniac® Kit contains 7 books and manuals including a Beginner's Manual and Study Guide to help the teenager whose knowledge of electrical circuitry may be limited. From these you can go step by step into more advanced circuit designs and finally through the theory needed to design your own machines.

This is why we don't think the designs we receive are exceptional. We planned it that way.

So if you have a boy—from 11 years up, who is an electrical bug, or if you yourself want to understand more of the theory behind circuit designs, order your complete kit now.

Geniacs are fun too. Exciting puzzle-solving circuits—the Uranium Shipment and the Space Pilots, code-making machines, game-playing machines for Tic-Tac-Toe, Nim, intelligence-testing devices will give you and your children hours of amusement. Over forty machines can be built from your Geniac® Kit with more than 400 pieces and parts, seven books and manuals.

GENIAC® KIT with special discs, 7 manuals and texts, parts tray, tool kit and display rack.....\$19.95 (Add 80¢ west of Mississippi, \$2.00 outside U.S.) Seven day return guarantee.

Name.....

Address.....

City.....Zone.....State.....

Send check, cash or money order to:

DEPT. SA-38

OLIVER GARFIELD CO., INC.

126 Lexington Avenue, New York 16, N. Y.

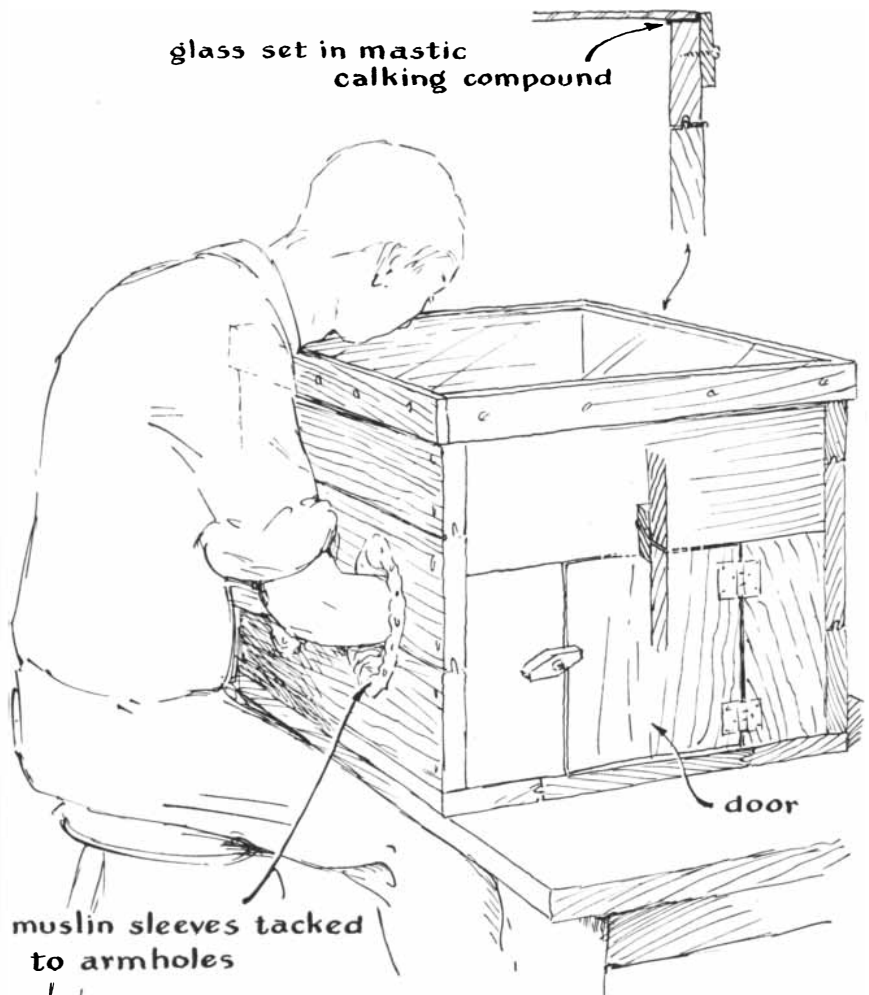
mitted to incubate for two hours at room temperature and is then stored at 40 degrees F. At the end of 24 hours the tube is swirled in front of a light. The presence of sediment indicates that the inoculation has 'taken.' The purchased culture may then be sterilized and discarded. If at the end of 24 hours there is no sediment, the procedure should be repeated. It is useless to wait another 24 hours.

"Antibiotics for diagnostic purposes may be procured in sterile containers with the trade name of Dia-Discs. They are manufactured by Reed and Carnrick of Jersey City, N.J. The assortment includes pellets of penicillin, bacitracin, streptomycin, Chloromycetin, Aureomycin and Terramycin in two strengths, the stronger having 10 times the potency of the weaker.

"The bacteriostasis test consists in exposing a series of increasingly concentrated cultures of bacteria growing on

plates of agar medium to the action of the drugs. A duplicate set of plates is used as a control for detecting contamination. Begin the experiment by placing the following materials in the sterile transfer chamber: (1) a liter of sterilized tap water, (2) two packages of sterile Petri dishes, (3) a dozen sterilized one-milliliter pipettes and the sterilized rubber squeeze bulb, (4) a water bath heated to 112 degrees F. in which has been placed six Erlenmeyer flasks of agar medium, (5) a test-tube rack containing six test tubes, (6), the wax pencil and (7) an open bowl of germicide.

"The packaged glassware is opened and the cotton stoppers removed from the culture and test tubes. A small tuft of sterilized cotton is placed in the neck of each pipette. Nine milliliters of sterile tap water are poured into each of the six test tubes. The following operations are then carefully performed, each piece of



muslin sleeves tacked to armholes

seal all joints with cotton or calking compound

An aseptic transfer chamber which can be built by the amateur

UNUSUAL OPTICAL BARGAINS



SATELLITE TELESCOPE

Especially made for members of MOONWATCH. Gives you the greatest possible field with the ability to observe faint objects with only slight magnification. Wide (51 mm) diameter, low reflection, coated objective lens. A 6 element extremely wide field, coated Erle eyepiece, which in combination with the objective, gives 5.5 power with a big 12° field and over 7 mm exit pupil. This scope also makes a perfect wide field finder—a wonderful comet seeker; see complete asterisms.

Stock No. 70,074-S.....\$49.50 Postpaid

See the Satellites NEW, LOW PRICE "SATELLITER" TELESCOPE



Get ready for a terrific sky show as more Satellites are vaulted into space. See thrilling sights with our amazing Satellite Scope at unheard of low cost. Also view comets—use as a Rich-field Scope for viewing star clusters. 5 power—wide 12° field. Use of high quality war surplus optics makes possible this bargain.

Stock No. 70,150-S.....\$9.95 Postpaid



Take Telephoto Shots Thru 7 x 50 MONOCULAR

This is fine quality, American made instrument—war surplus! Actually ½ of U.S. Govt. 7 x 50 Binocular. Used for general observation both day and night and to take fascinating telephoto shots with your camera. Brand new. \$95 value. Due to Japanese competition we close these out at a bargain price. Directions and mounting hints included.

Stock No. 50,003-S.....\$15.00 Postpd.

4" REFRACTOR TELESCOPE 240-POWER



Complete with Finder, Equatorial Mounting, Tripod, Eyepiece Extension, Star Diagonal, and Three Eyepieces giving you 48X, 120X and 240X. Special Barlow lens also gives up to 500X. Big 4" objective is an air-spaced achromat, each element coated on both sides for low reflection. Rack-and-pinion focusing. A \$400 value.

Stock No. 85,038-S.....\$247.00 f.o.b.
(Shipping wt. 5.5 lbs.) Barrington, N. J.

NEW! STATIC ELECTRICITY GENERATOR



See a thrilling spark display as you set off a miniature bolt of lightning. Absolutely safe and harmless. Sturdily made—stands 13" high. Turn the handle and two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. Countless tricks and experiments. 24 page instruction booklet included.

Stock No. 70,070-S.....\$10.95 Postpaid

BUILD A SOLAR ENERGY FURNACE



Good Geophysical Year Project
A fascinating new field. You can build your own Solar Furnace for experimentation—many practical uses. It's easy—inexpensive—use your scrap wood. We furnish instruction booklet. This sun powered furnace will generate terrific heat 2000 to 3000°. Fuses enamel to metal—produces many unusual fusing effects. Sets paper aflame in seconds. Use our Fresnel Lens—14 3/4" diameter. . . f.1. 14".

Stock No. 70,130-S package of 1.....\$ 6.00 Postpaid
Stock No. 70,131-S package of 2..... 11.00 Postpaid



4 1/4" ASTRONOMICAL TELESCOPE MT. PALOMAR TYPE ONLY UP TO 270 POWER \$7450

A REAL REFLECTOR TELESCOPE COMPLETE
Complete with Equatorial Mount, Tripod

With this scope you can see the craters on the moon, rings of Saturn, double stars, or a newspaper headline at a mile! Mirror guaranteed to give theoretical limit of resolution. 6X Finder. Rack and pinion focusing, removable mirror mount, real equatorial mounting—only one adjustment follows stars! Aluminum tube—takes standard eyepieces. You get 40X Kellner, 1/2" F. L. eyepiece, one Barlow lens to give you up to 270 Power. F/11 mirror corrected to better than 1/4" wavelength.

Stock #85,006-S.....\$74.50 f.o.b. Barrington, N. J.



ASSEMBLED
AND
READY TO USE!

See the Stars, Moon, Planets Close Up! 3" ASTRONOMICAL REFLECTING TELESCOPE 60 & 120 Power—An Unusual Buy!

Famous Mt. Palomar Type

You'll see the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Star Clusters, Moons of Jupiter in detail. Galileist Equatorial mount with lock on both axes. Aluminumized and overcoated 3" diameter high-speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens, giving you 60 & 120 power. An Optical Finder Telescope, always so essential, is also included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272 page "Astronomy Book."

Stock No. 85,050-S.....\$29.50 f.o.b.
(Shipping wt. 10 lbs.) Barrington, N. J.

Fine, American-Made Instrument at Over 50% Saving STEREO MICROSCOPE For Industrial or Hobby Use



Up to 3" Working Distance—Erect Image—Wide 3 Dimensional Field

Now, ready after years in development—this instrument answers the long standing need for a sturdy, efficient STEREO MICROSCOPE at low cost. Used in production—in research—in the lab, shop, factory, or at home; for inspections, examinations, counting, checking, assembling, dissecting—speeding up and improving quality control. 2 sets of objectives on rotating turret. Standard pair of wide field 10X Kellner Eyepieces give you 23 power and 40 power. Additional eyepieces available for greater or lesser magnification. Helical rack and pinion focusing. Precision, American-made! WE WILL SHIP ON 10-DAY FREE TRIAL . . . complete satisfaction or your money back.

Order Stock No. 85,056-S.....\$99.50 f.o.b. Barrington, N. J.

(Shipping wt. approx. 11 lbs.)

Send check or M.O.

MAKE YOUR OWN POWERFUL ASTRONOMICAL TELESCOPE

GRIND YOUR OWN ASTRONOMICAL MIRROR
Complete Kits Including Blank, Tool and Abrasives

All over America amateurs are grinding their own mirrors and making expensive Telescopes cheaply. You can do the same using our Kits. These contain mirror blank, tool, abrasives, diagonal mirror and eyepiece lenses. You build instruments ranging in value from \$245 to thousands of dollars.



Stock No.	Dia. Mirror	Thickness	Price
70,003-S	4 1/4"	3/4"	\$ 7.50 postpaid
70,004-S	6"	1"	11.95 postpaid
70,005-S	8"	1 3/8"	19.50 postpaid
70,006-S	10"	1 3/4"	30.75 postpaid
70,007-S	12"	2 1/8"	54.75 postpaid

NEW! STATIC ELECTRICITY GENERATOR



See a thrilling spark display as you set off a miniature bolt of lightning. Absolutely safe and harmless. Sturdily made—stands 13" high. Turn the handle and two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. Countless tricks and experiments. 24 page instruction booklet included.

Stock No. 70,070-S.....\$10.95 Postpaid



INFRARED SNIPERSCOPE TELESCOPE & PARTS

See in the dark—without being observed. War surplus Sniperscope M-2. Gov't cost about \$1200. Used for industrial plant security; research lab experiments; infrared photography; spectroscopy, etc. Instrument complete, ready to use. Includes Power Pack, infrared light source. Will operate from 6V auto battery. Battery or transformer available.

Stock No. 85,053-S.....\$150.00 f.o.b.
Shpg. wt. approx. 12 lbs. Barrington, N. J.

Save still more money! Build your own Sniperscope! We will furnish instructions—parts, including: Power Packs, 1P25A image tubes, light units, filters, etc. For details—request FREE catalog "S".

AMERICA NEEDS SCIENTISTS!
Stimulate your son's interest—request for him our FREE CATALOG-S featuring hundreds of scientific and astronomical items. No better time than in this GEO-PHYSICAL YEAR!

New! 2 in 1 Combination! Pocket-Size 50 POWER MICROSCOPE and 10 POWER TELESCOPE



ONLY
\$4.50

Useful Telescope and Microscope combined in one amazing, precision instrument. Important! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects, just plain sniping.
Order Stock # 30,059-S.....\$4.50 ppd.
Send Check or M.O.
Satisfaction Guaranteed!

WRITE FOR FREE CATALOG-S

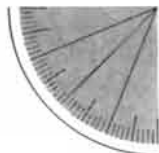
Huge selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, microscopes, satellite telescopes, binoculars. Infrared Sniperscopes & parts, reticles, mirrors, Ronchi rulings, dozens of other hard-to-get optical items. America's No. 1 source of supply for Photographers, Hobbyists, Telescope Makers, etc. Ask for catalog S.



ORDER BY STOCK NUMBER . SEND CHECK OR MONEY ORDER . SATISFACTION GUARANTEED!

EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY

Angle Measuring Interferometers



An Interferometer which measures accurately the divisions of a circle to a precision of one-tenth second of arc without cumulative or periodic errors has been satisfactorily produced by Ferson in collaboration with Eichner. Pictures and a description of the functioning of the instrument are available upon request.



"BIG" LENSES Our selection of diameters and focal lengths is the largest in the United States available for immediate delivery. Perfect magnesium fluoride coated and cemented achromatic telescope objectives. Aluminum tubing and cells available for lenses listed below. Send for complete list of other diameters and focal lengths.

Dia.	F.L.	EACH	Dia.	F.L.	EACH
2 1/8"	10"	\$12.50	3 1/2"	15"	\$21.00
2 3/8"	15"	\$ 9.75	3 3/4"	24 1/2"	\$22.50
2 1/2"	24 1/2"	\$12.50	4"	40"	\$30.00
2 3/4"	40"	\$12.50	4 3/8"	42 1/2"	\$67.00
2 5/8"	50"	\$12.50	5 1/8"	24 1/2"	\$85.00

MOUNTED AIR SPACED OBJECTIVES

We offer the finest hand-corrected air spaced American made astronomical objectives. Mounted in Black Anodized Aluminum Cells.

DIA.	F.L.	PRICE	PRICE
3 1/4"	48"	Coated \$32.00	Not Coated \$28.00
4 1/8"	62"	Coated \$69.00	Not Coated \$60.00

We can supply ALUMINUM TUBING for the above lenses.

MOUNTED 1 1/4" O.D. EYEPIECES

12.5 mm F.L.	Symmetrical	\$6.00
16 mm F.L.	Erfler (Wide Angle)	12.50
16 mm F.L.	Triplet	12.50
18 mm F.L.	Symmetrical	6.00
22 mm F.L.	Kellner	6.00
32 mm F.L.	Orthoscopic	12.50
35 mm F.L.	Symmetrical	8.00
55 mm F.L.	Kellner	6.00

COATING 75c extra

WIDE ANGLE ERFLER (68° Field)
EYEPiece Brand new coated 1 1/4" E.F.L. Focusing mount, 3 perfect achromats, 1 3/16" aperture.....\$18.50

WIDE ANGLE ERFLER 1 1/2" E.F.L.
Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field.....\$18.50
1 1/4" DIA. ADAPTOR for above eyepieces.. \$ 3.95

MONOCULARS (COATED)

Fine quality imported monoculars. Leather case and straps included.

6 x 30	\$10.00	7 x 50	\$15.00
8 x 30	11.25	16 x 50	17.50
7 x 35	12.50	20 x 50	20.00

ASTRONOMICAL TELESCOPE MIRRORS

Polished to 1/4 Wave and Aluminized

	Dia.	F.L.	Postpaid
1 1/2" Pyrex	3 3/8"	42"	\$ 9.75
1 3/8" Pyrex	4 1/4"	45"	\$13.50
	6"	60"	\$25.00

Free Catalogue "MILLIONS" of Lenses, etc.

We pay the POSTAGE—C.O.D.'s you pay postage—Satisfaction guaranteed or money refunded if returned within 10 days.

A. JAEGER'S 601A Merrick Road
LYNBROOK, N.Y.

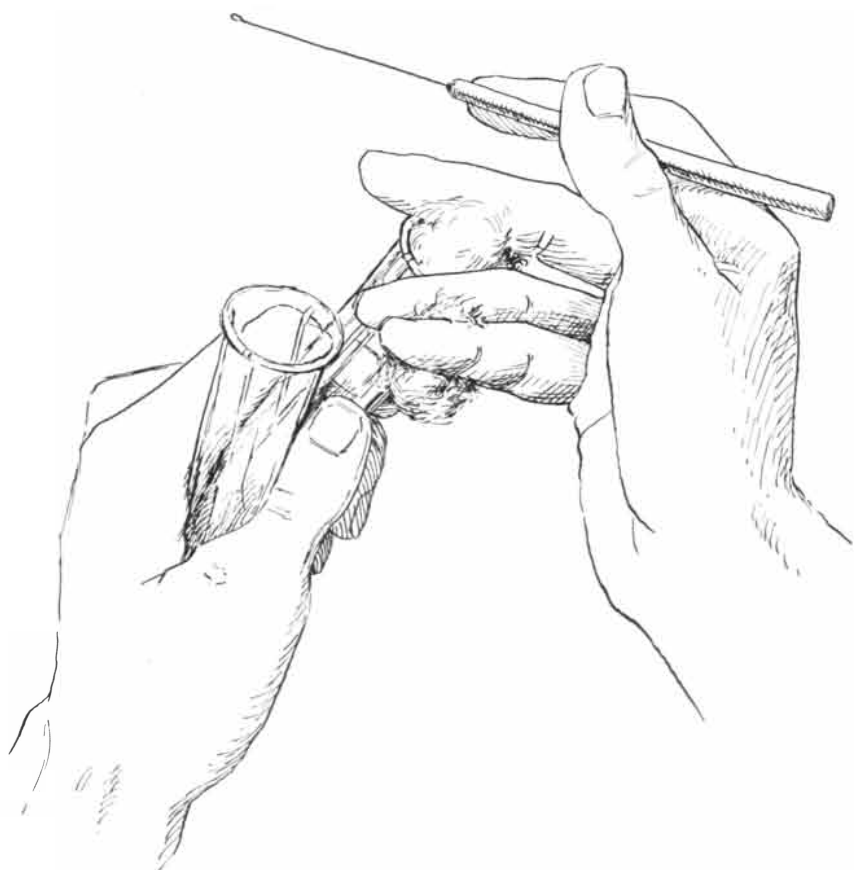
glassware being labeled or coded as it is used. Fit the squeeze bulb to a pipette and with it transfer one milliliter of the culture to a test tube of tap water. This tube is labeled 1:10, indicating that it contains one part of culture in 10 by volume. The tube is swirled for 30 seconds to assure thorough mixing. Remove the squeeze bulb from the pipette and drop the used pipette in the bowl of germicide. Select another sterile pipette and transfer one milliliter of the 1:10 mixture to a tube of tap water. Mark this tube 1:100. Again swirl the 1:100 mixture for 30 seconds, drop the used pipette into the germicide and with another sterile pipette transfer one milliliter of the 1:100 mixture to the third tube of tap water. Mark this tube 1:1,000 and proceed in the same way with the remaining tubes, labeling them 1:10,000, 1:100,000 and 1:1,000,000.

A specimen of melted agar medium is now poured from each of the six Erlenmeyer flasks into six Petri dishes, each dish being labeled to correspond with the flask from which it is poured. The dishes are then covered with their glass tops and set aside to harden. After these control plates have been poured, each batch of melted medium remaining

in the flasks is inoculated with one of the dilutions in the test tubes. Pipette one milliliter of the dilution into the appropriately labeled flask. Drop the used pipette into the bowl of germicide. The flasks are stoppered with cotton and swirled gently for 30 seconds to mix their contents. The water dilutions are sterilized and discarded.

The control plates are incubated two days at 80 degrees F. The transfer box can be made to double as an incubator by fitting it with a 100-watt bulb controlled by a thermostat of the type used in tropical-fish aquariums.

Twelve Petri dishes, the Dia-Discs and a pair of forceps are next introduced into the transfer chamber. The chamber is sterilized as before. Two Petri dishes are then filled from each of the six inoculated flasks, each pair being labeled to show the culture dilution. The dishes are permitted to stand for about 20 minutes until the agar solidifies. The forceps are then passed through the flame, the box of Dia-Discs opened and the discs placed carefully on the agar medium by means of the forceps. The weaker discs are placed on one plate of the pair and the stronger on the other. One way to keep track of the discs is to draw a radius



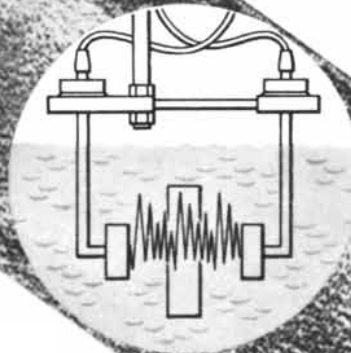
How to hold test tubes while transferring bacterial cultures with a wire loop

Progress In Leadership...

Ultrasonic Nondestructive Testing

**NUCLEAR REACTOR
TECHNOLOGY**
demands precise, reliable
procedures for testing fuel
elements. The ultrasonic
system developed at Argonne
is typical of the advancements
being made in this field.

In the ultrasonic scanning and recording system developed at Argonne, pulsed energy in the megacycle range is transmitted through reactor fuel elements to reveal bond defects and other internal faults. Two piezoelectric transducers mounted on an automatic scanner traverse across and along each fuel plate. An electrosensitive paper recorder is used to make a permanent two-dimensional record of changes in the transmitted ultrasonic energy. At Argonne, over a thousand fuel plates for the Experimental Boiling Water Reactor were tested by this method in an average time of 12 minutes each. Some firms that manufacture fuel elements commercially now use this system to insure quality.



Argonne
NATIONAL LABORATORY

Operated by the University of Chicago under
contract with the United States Atomic Energy Commission

**Professional Personnel Office
P. O. Box 299, Lemont, Illinois**

*Inquiries are invited from highly
qualified engineers, physicists,
mathematicians and metallurgists.*

AMATEUR TELESCOPE MAKING

Edited by Albert G. Ingalls

Book One

497 pages, 300 illustrations
\$5.00 postpaid. \$5.35 foreign

Book Two

650 pages, 361 illustrations
\$6.00 postpaid. \$6.35 foreign

Book Three

644 pages, 320 illustrations
\$7.00 postpaid. \$7.35 foreign

Send postcard
for descriptive circular

**SCIENTIFIC
AMERICAN**

415 Madison Avenue, New York 17, N. Y.
(Residents of New York City please add 3% sales tax)

Get UNITRON's FREE
Observer's Guide and Catalog on
ASTRONOMICAL TELESCOPES

This valuable 38-page book
is yours for the asking!

With artificial satellites already launched and space travel almost a reality, astronomy has become today's fastest growing hobby. Exploring the skies with a telescope is a relaxing diversion for father and son alike. UNITRON's handbook contains full-page illustrated articles on astronomy, observing, telescopes and accessories. It is of interest to both beginners and advanced amateurs.

Contents include—

- Observing the sun, moon, planets and wonders of the sky
- Constellation map
- Hints for observers
- Glossary of telescope terms
- How to choose a telescope
- Amateur clubs and research programs



UNITRON

INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASS.

Please rush to me, free of charge, UNITRON's new Observer's Guide and Telescope Catalog.

Name _____

Street _____

City _____

State _____

SA-3

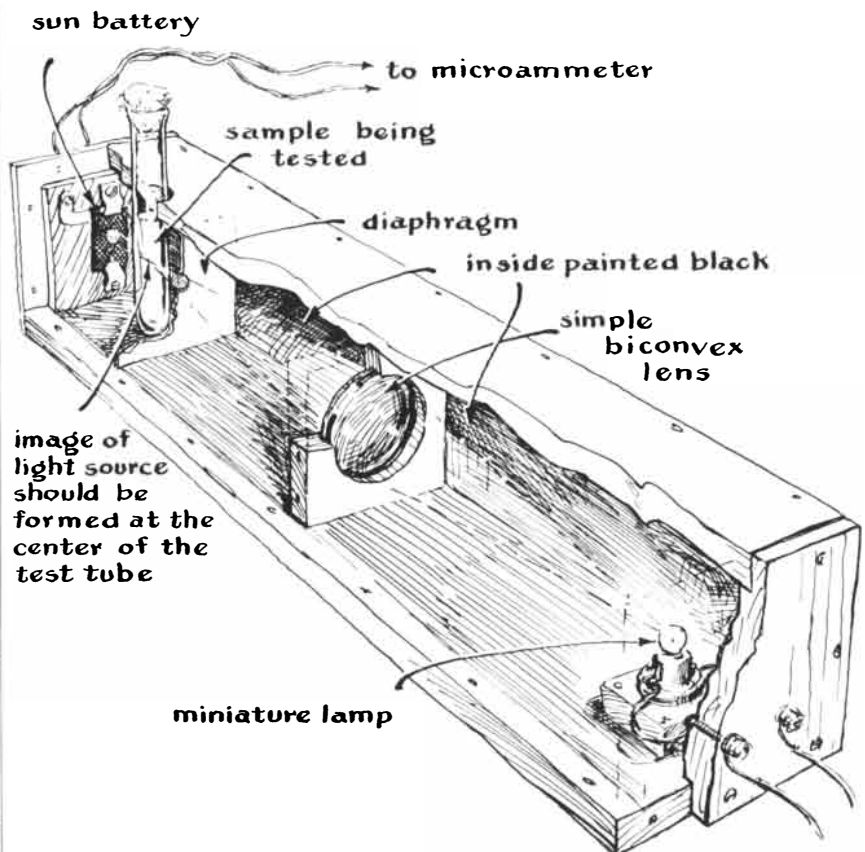
on the back of each Petri dish with the wax pencil. The disc of Aureomycin is then placed on this line. All other discs are placed alphabetically, according to the name of the drug, in a clockwise circle. Crowding should be avoided; if space is limited, the last disc can be placed in the center of the plate. Covers are then placed on the dishes, and the culture is left to incubate for two days at 80 degrees F.

"The effects of the several drugs on the various concentrations of bacteria are then evaluated by observing the growth on the plates and the diameter of the rings around each drug where growth has been inhibited. The larger the ring, the greater the bacteriostasis. The results may be tabulated by using a minus sign to indicate no growth, a plus-and-minus sign for minimum inhibition, a plus sign for marked inhibition and two plus signs for extreme inhibition. Any growth on the control plates indicates contamination and invalidates the experiment. The test plates should be re-read after four days of incubation, then sterilized and discarded.

"An interesting modification of the test permits the experimenter to chart the effect of the drugs with respect to time. Thus he can study the interval fol-

lowing inoculation at which each antibiotic exerts its greatest action, and the rate, if any, at which it loses its effect. This requires the construction of a relatively simple light-meter capable of reading the relative transmission of light through a test tube. Bacterial growth in beef broth increases the turbidity of the broth and reduces its transparency. When the broth is placed in a test tube its turbidity—and hence its population of bacteria—can be measured by the light-meter. The device consists of a lamp and lens for focusing a beam on the side of a test tube, a photocell on the other side of the tube for receiving the transmitted light, and a microammeter for reading the output of the cell. The light source, lens assembly, test tube and photocell are mounted in an appropriately compartmented and light-tight box [see illustration below].

"Here the operations are conducted in test tubes rather than agar. A tablet of antibiotic is dissolved in 10 milliliters of sterile tap water (in the aseptic transfer chamber). Dilutions of this solution are prepared as before, so that six dilutions span the range from 1:10 to 1:1,000,000. Observe that in this case it is the drugs, not the cultures, which are diluted. One milliliter of each of the dilu-



A homemade light-meter for measuring the density of a bacterial culture

Our References



C O N V A I R



users of 1 or more of these types of

Hamilton Standard Electronics Department products



Aircraft Temperature Controller



Propeller Synchrohaser



Turbo-jet Temperature Limiter



• electronic engineers
• microwave engineers
• radar circuit designers
today ... contact Robert C. Main,
Manager of our Electronics Dept.,
at the address below.

The enormous scope of our Electronics Department's activities in this challenging field manifests a variety of unique career opportunities for the creative scientist. Proof of our ability is underscored by our successful association with the proud companies listed on this page — and by our increasing emphasis on the development of important missile systems.

Electronics Department, Hamilton Standard

DIVISION OF UNITED AIRCRAFT CORPORATION

28 Main Street, Broad Brook, Connecticut

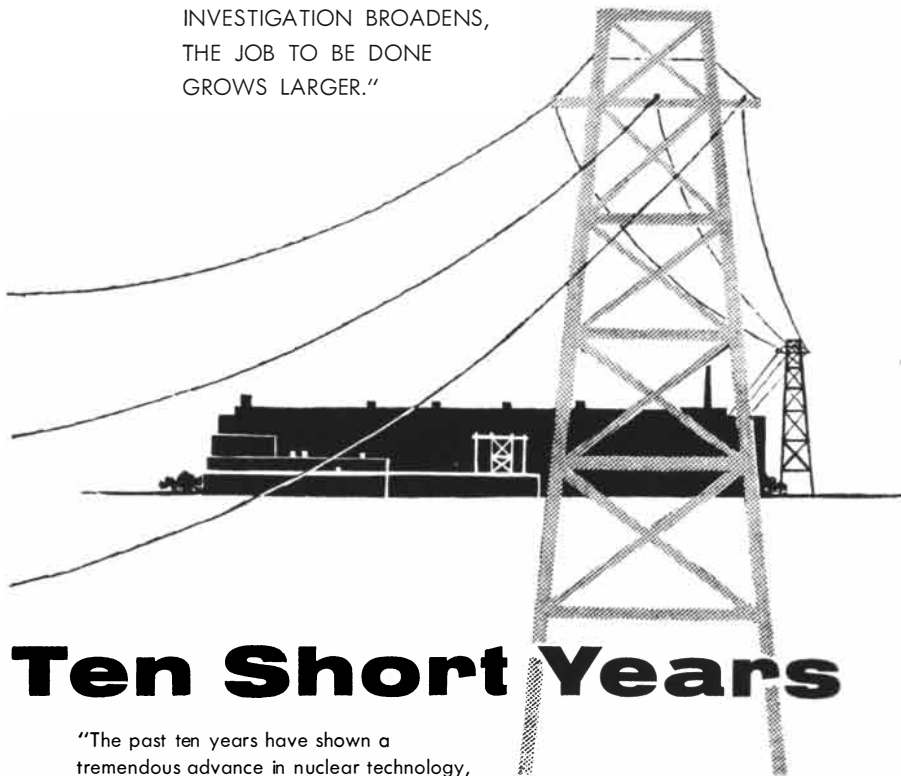
1948 — ORGANIZATION OF BETTIS ATOMIC POWER DIVISION

1953 — DEVELOPED: FIRST NUCLEAR PROPULSION UNIT

1955 — BUILT: REACTOR FOR FIRST NUCLEAR SUBMARINE

1957 — COMPLETED: FIRST FULL SCALE COMMERCIAL
NUCLEAR POWER PLANT

TODAY—“AS WE LOOK TO THE FUTURE OF NUCLEAR POWER IT IS EVIDENT THAT WE ARE STILL FAR FROM OUR ULTIMATE GOAL OF TOTAL DEVELOPMENT. . . AND WITH EACH NEW DISCOVERY OUR AREA OF INVESTIGATION BROADENS, THE JOB TO BE DONE GROWS LARGER.”



Ten Short Years

“The past ten years have shown a tremendous advance in nuclear technology, yet every step forward reveals a still broader view of the future and one realizes that the next ten years will show an even greater acceleration in the development of this new power source. In short, to date we have done little more than make a good beginning.

The young men who enter this field today will have the responsibility of creating a solid structure of knowledge and accomplishment from this beginning. Yet, even they, ten years from now, will look ahead and know they are still far from fully realizing the ultimate potential of nuclear energy.”

You can participate in the continuing development of this expanding field of activity. A field whose only limits are the creativity of man's mind and the extent of his desire to learn. If you are a U.S. Citizen with an advanced degree in Physics, Mathematics, Metallurgy, or Engineering, and would like to apply your knowledge to the field of nuclear power, send your resume to: Mr. M. J. Downey, Dept. #A-29, Bettis Atomic Power Division, Westinghouse Electric Corp., P.O. Box 1468, Pittsburgh 30, Pa.

BETTIS ATOMIC POWER DIVISION

Westinghouse

BETTER YOUR FUTURE AT BETTIS

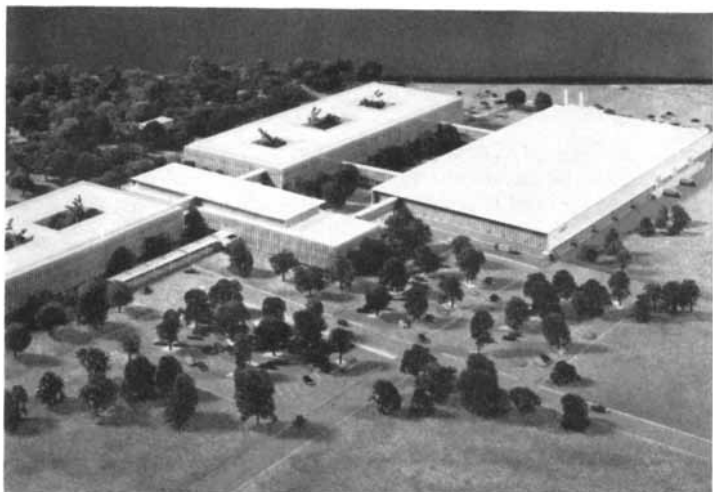
tions is added to a sterile test tube which contains four milliliters of beef broth. The tubes are then inoculated with one loop of bacteria from a two-day-old beef-broth culture and left to incubate at 80 degrees F. At equal intervals during the incubation, say every three hours, the tubes are gently swirled and their turbidity is measured by means of the light-meter. Turbidity is then plotted against time. The result is a set of graphs showing bacteriostatic activity. The test tubes should be inspected for optical uniformity by means of the light-meter before they are used. Professional light-measuring instruments used for this test are usually calibrated in accordance with Beer's law, which states that, for solutions of a given substance in a given solvent, light will be absorbed in proportion to the thickness of the solutions. Graphs made with instruments calibrated arbitrarily will show accurate rates of bacteriostatic effect, although the curves will not necessarily conform to those drawn with the aid of professional instruments. Tests which employ light-measuring devices can have great practical value because they show which antibiotic can be employed most effectively against a bacterium about which no data has been collected. They also disclose whether a known bacterial strain has mutated to become more resistant to a given drug.

“In the course of experiments employing plates of agar medium one may occasionally observe a small colony flourishing within the circle of inhibition. The chances are that this is a contaminant. There is always the possibility, however, that the organism is a mutant, a new strain which has been naturally selected over the original strain susceptible to the drug. All such unusual colonies should be isolated and cultured. (A portion of the colony is lifted from the plate with the tip of the dissection needle and transferred to fresh medium for incubation.) Tests can then be performed to learn if it is in fact a mutant or merely a contaminant.

“Radiation is known to increase the mutation rate of all living organisms; thus it is possible to develop new strains by exposing cultures to X-rays. The homemade X-ray machine described in this department by Harry Simons [“The Amateur Scientist,” July, 1956] is capable of inducing such mutations. The experimenter is cautioned, however, to avoid exposure to the X-rays. The culture should be placed in front of the tube and the machine operated by remote control from behind a shield, as suggested by Simons.”



Dennis W. Holdsworth



Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion this year, the ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers.

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

IDEALS AND PRACTICALITY

"Science and Philosophy mutually criticize each other and provide imaginative material for each other."... Alfred North Whitehead.

In the increasing preoccupation of science with material things and progress, the truth of this statement by one of our greatest philosophers is often overlooked and forgotten. The scientific philosopher is a rare being and is becoming rarer still, nor can he be adequately replaced by the group technique or the 'brainstorm' session.

It should be one of the noblest aspirations of all our sciences to provide for the true contemplation of the inner meaning of facts and to stimulate that interplay of mind on mind by which alone we may progress.

In all these things, however, we cannot forget the problems peculiar to research and development in private industry. The obligation to work to otherwise-determined time-scales poses a nice problem in balancing ideals against the practicalities of everyday life.

It is in this field that the test of management comes. Its success at meeting such continuously conflicting requirements determines the character and ultimate success of the organization.

With such thoughts as these in mind, we here at Research and Advanced Development Division of AVCO are seeking unique people. We wish to foster the creative minds and fundamental thinkers, while preserving an atmosphere of self-discipline, free from a rigid hierarchy of command and organization.

Dennis W. Holdsworth,
Manager, Computer and Electronic Systems Department

AVCO
Research & Advanced Development

The Library of Science

INVITES YOU TO ACCEPT
THE MOST VALUABLE MEMBERSHIP GIFT

EVER TO BE OFFERED:



1629 PAGES
1349
ILLUSTRATIONS
80 HALF-TONE
PLATES

The two magnificent, richly-illustrated volumes of

A HISTORY OF TECHNOLOGY

Edited by Charles Singer, E. J. Holmyard and
A. R. Hall and Associates

Published at \$53.80

Vol. I: From Early Times to Fall of Ancient Empires
Vol. II: The Mediterranean Civilization and the Middle Ages

This
Two-Volume Set
YOURS AS A GIFT
with membership

Edited by the foremost British historians of science, these profusely illustrated volumes are, according to *Scientific American*, a "monumental project . . . which will appeal to any one interested in the . . . marvelous development of man's ability to manipulate nature."

1629 pages long, containing over 1400 illustrations and half-tone plates, with contributions by 43 leading scholars and scientists, these volumes take the reader on a fascinating journey through an enormous field of knowledge. The development of virtually all the scientific skills is brought vividly alive and lavishly illustrated on almost every page.

"Written and edited by the best equipped authors in the world, to me the appeal of this work is tremendous. Its scope is far wider than the misleading word 'technology' suggests. It embraces all of science and shows it in a setting that will interest the working scientist."

Henry Margenau, Yale University

These two truly monumental volumes, already hailed as providing an encyclopedic picture of all the scientific skills and arts by which man has mastered environment, are offered to you—free upon joining—as a remarkable demonstration of the benefits of membership in THE LIBRARY OF SCIENCE.

Here you will find the impressive record of the development of chemistry, engineering, mathematics, astronomy, architecture, mining, transport, ship-building, metallurgy—viewed against the perspective of 2500 years of man's progress.

Organized to bring to working scientists and related professionals the finest scientific literature available, THE LIBRARY OF SCIENCE helps to keep its more than 40,000 members abreast of the thinking and research of those who work on the frontiers of knowledge today.

As a member, you will join in receiving—at substantial savings—the authoritative volumes from all fields of inquiry, books pointing up the unity of science, and works illuminating the personalities who shape the scientific world.

To start your membership, choose any one of six significant Selections described below. With it, you will receive as a gift the two volumes of A HISTORY OF TECHNOLOGY. Thereafter, you need take as few as 5 more Selections during the next 24 months, out of at least 40 volumes available at the reduced Member's Price. After every fourth Selection you take, you get a Free Bonus Book of your own choosing—this *in addition to* your Membership Gift on joining.

Choose Your First Membership Selection from these Outstanding Volumes

SCIENTIFIC AMERICAN BOOKS (2nd series)

By the Editors of *Scientific American*.
1104 pages, 73 contributors.
Contents: *New Chemistry; Plant Life; The Universe; The Planet Earth; Lives in Science*. 5 volumes, paper bound, boxed.
List price \$7.25 Member's price \$5.75

MATHEMATICS AND PLAUSIBLE REASONING

TWO VOLUMES By *George Polya*.
Analyzes the methods of scientific problem solving, showing their origins in mathematical reasoning and their applications in other fields of inquiry.
List price \$9.00 Member's price \$6.50

GAMES AND DECISIONS

By *R. D. Luce and Howard Raiffa*.
A comprehensive new analysis of recent conceptual developments in game theory and related decision-making models.
List price \$8.75 Member's price \$5.95

ROCKETS, MISSILES & SPACE TRAVEL

By *Willy Ley*. New, revised edition.
"The definitive book about the subject [by] the best known exponent of . . . rocketry and space travel in the world today."
Scientific Monthly.
List price \$6.75 Member's price \$5.25

ATOMS & THE UNIVERSE

By *Jones, Rotblat, Whitrow*. The structure of matter—with contents including: Smashing the Atom; Cosmic Radiation; Quantum Theory; Relativity; The Solid State; Inter-Atomic Forces.
List price \$4.50 Member's price \$3.95

THEORIES OF THE UNIVERSE

Edited by *Milton K. Munitz*. Space, Time and the Creation of the Universe—the first one-volume presentation of the development of cosmology from Plato until the present day.
List price \$6.50 Member's price \$4.95

The Library of Science 436

59 Fourth Avenue, New York 3, N. Y.

Enroll me as a member and send me the two volumes of A HISTORY OF TECHNOLOGY as my Membership Gift, and the book indicated below as my first Selection, at the reduced Member's Price. I need take as few as 5 more Selections during the next 24 months; after every fourth Selection taken, I will receive a free Bonus Book of my choice.

First Selection _____

Additional Selection Desired _____

Name _____

Address _____

City _____

Zone _____

State _____



BOOKS

An Australian symposium on war as a disease of societies

by James R. Newman

PATHS TO PEACE: A STUDY OF WAR, ITS CAUSES AND PREVENTION, edited by Victor H. Wallace. Cambridge University Press (\$3.75).

War is much too serious a thing to be left to the human race. Talleyrand was against leaving war to the military, which was sensible, but he could not have been expected to foresee the evil day when it might have to be renounced altogether. The globe is now too small; the weapons are too large; man is too frail. And reason itself, as George Santayana once wrote, has abdicated in a world which is "the sport of cruder powers."

It is often said that men desire peace but don't know how to get it. If they expended a modest effort on studying the causes of war they might learn. The preamble to the United Nations Charter opens with the words: "We the peoples of the United Nations determined to save succeeding generations from the scourge of war," but in the last dozen years no notable progress has been made in furthering this determination. Future generations may be spared simply by not arising. The fact is that people do not always believe what they profess to believe. It is not true that a great majority of people "passionately believe that war is the worst of all alternatives." When one is not suffering it is hard to imagine suffering, especially if one has never suffered. Men are apt to be entranced by heroic images and caught by phrases. "Better death than dishonor" is a cry of the living; the dead have no opportunity to reconsider. A passage of G. K. Chesterton (in his book *The Flying Inn*) refers to "one of the worst tricks of modern journalism; the trick of dismissing the important part of the question as if it could wait, and appearing to get to business on the unimportant part of it." His illustration is: "Whatever we may think of the rights and wrongs of the vivisection

tion of pauper children, we shall all agree that it should only be done, in any event, by fully qualified practitioners." The same trick is today practiced in discussing war and peace: Whether or not it is true that another war would mean world suicide, we must be prepared to win if war breaks out.

This book presents a different outlook. A symposium edited by the distinguished Australian physician Victor Wallace, it attempts a dispassionate analysis of the causes of war. The assumption is that if we desire peace we must do more than sigh for it; we must gain an understanding of the forces and circumstances which thwart peace. War is a social and economic problem. It is appropriate therefore to solicit the views of those who study the ways of society—historians, investigators of economic conflict, students of cultural patterns and social tensions, of frustration and aggression, of ideologies, of propaganda, of power politics, of population. Wallace has gathered a notable company of many specialists. His contributors are Australian leaders of thought: in law, social studies, diplomacy and politics. Jawaharlal Nehru has written a foreword. It is often a fault of symposia that they are diffuse and repetitious. This work is both, yet it has great value. It contains an impressive set of civilized affirmations. It makes clear as few other books have done the main causes of war, and it exposes misconceptions, misleading analogies, false dogmas and prejudices.

Some ages have obviously been more warlike than others. Our own, says the University of Melbourne historian R. M. Crawford in his introductory essay on the problem of recurrent wars, "bears marked resemblances to the long and troubled age which is commonly taken as the threshold of the modern era, the age which began with Charles VIII's invasion of Italy in 1494 and culminated in the disastrous Thirty Years' War, 1618-1648." In some respects it is also like the much shorter age which saw the wars of the French Revolution and Napoleon. What is to be learned from ex-

amining these periods and the intervals between, during which, while the world was not altogether peaceful, warfare was comparatively limited and "considerations of war did not dominate all else"? The Thirty Years' War was exceptionally ferocious. Whole cities were sacked and destroyed, starvation was widespread and there was even cannibalism. A long night of barbarism and misery descended upon a large area of Central Europe. After a time Europeans began to sicken of the slaughter, and slowly established a tradition of limited warfare which no longer required armies to resist to the point of death. But the tradition could be established, says Crawford, only when men came to value peace more than what they had fought for.

In the 18th and 19th centuries it was assumed that, since war was an instrument of policy, annihilation need not be the objective. The foe was not sub-human, some meaning attached to the notion of a community of Europe, and war did not have to invade all spheres of human activity. Thus, for example, intellectual intercourse continued between nations at war. Without hesitation Napoleon granted to Humphry Davy, the distinguished English chemist, a travel permit for himself and his party so that they could visit France and other European countries in 1813, though other Englishmen in France were held prisoner. And when Captain Ross set out in 1839 to explore the Antarctic he carried instructions from the Lord Commissioners of the Admiralty stating that if England should become involved in war during his absence he was "not to commit any hostile act whatever." The Commissioners wrote: "The expedition under your command [is] fitted out for the sole purpose of scientific discoveries, and it [is] the established practice of all civilized nations to consider vessels so employed as exempt from the operations of war."

In ages of unlimited warfare the sense of community has, as Crawford points out, been broken. Deep ideological divisions have led to the abandonment of moderation and the collapse of

PHILOSOPHICAL LIBRARY BOOKS

□ **THE ENCYCLOPAEDIA OF RADIO AND TELEVISION** edited by J. H. Reyner. Revised new edition covering transmitting and receiving theory and practice including V.H.F., color, radar, measuring instruments, equipment, circuits and power supplies. Over 3,000 entries and 750 illustrations. Immediately applicable data for engineers, service mechanics and students. \$12.00

□ **SPACE TRAVEL** by K. W. Gatland and A. M. Kunesch. Two of England's outstanding technical experts have pooled their knowledge in this comprehensive survey of the progress to date on man's newest frontier. The records of experiments, rocket societies, satellites, interplanetary vehicles and fuels are described in detail. Almost 100 illustrations by an eminent specialist in the field. \$6.00

□ **DEVELOPMENT OF THE GUIDED MISSILE** by Kenneth W. Gatland. This is the new and revised edition of an important book which presents factually all the main information available on the contemporary development of guided weapons and rockets for military and peaceful purposes. By England's foremost missile expert. Illustrated. \$4.75

□ **ROCKET** by Sir Philip Joubert. This book by Air Marshal Sir Philip Joubert, who was A.O.C.-in-C. Coastal Command from 1941 to 1943, is a brilliant and detailed study of rocketry from its early beginnings in Germany. \$6.00

□ **ENCYCLOPEDIA OF ATOMIC ENERGY** by Frank Gaylor. More than 2,000 entries defining and explaining concepts and terms in nuclear physics and atomic energy make this volume a vital handbook for all those concerned with atomic science. Illustrations, charts, tables. \$7.50

□ **AN ENCYCLOPEDIA OF THE IRON & STEEL INDUSTRY** by A. K. Osborne. Provides a concise description of the materials, plant, tools and processes used in the Iron and Steel Industry, and in those industries closely allied to it, from the preparation of the ore down to the finished product; and to define the technical terms employed. \$25.00

□ **OUT OF MY LATER YEARS** by Albert Einstein. The distinguished physicist, always an independent and uncompromising thinker, deals with the most urgent questions of modern society: Social, religious, educational and racial relationships. \$4.75

□ **REASON AND CHANCE IN SCIENTIFIC DISCOVERY** by R. Tatton. Dr. Tatton examines the relative role of active purpose and chance in the processes of scientific discovery. Steering clear of theory, he illustrates his thesis by practical examples drawn from the lives and works of distinguished scientists. Illustrated. \$10.00

□ **PROGRESS IN PLASTICS**. The latest scientific discoveries and developments in the all-important field of plastics engineering are presented in this symposium of reports by research specialists associated with American universities and leading American, British, and German producers of commercial plastics. \$22.50

□ **PHYSICAL METHODS IN PHYSIOLOGY** by W. T. Cotton. A presentation of the wide variety of physical experimental techniques and theoretical treatments which have been applied to physiological investigations. \$10.00

□ **THE ATOMIC AGE AND OUR BIOLOGICAL FUTURE** by H. V. Bronsted. The aim of this book is to describe the biological and genetical effects that may ensue from the increasing use of atomic energy. \$2.75

□ **MYSTERIES OF SCIENCE** by John Rowland. The author attempts to ask certain questions, and to see if it be possible to state satisfactory answers. And where, in his opinion, no answer will ever be available, he does not attempt to hide that fact, for he feels that it is necessary for present-day men to face facts, even when the facts are unpalatable or uncomfortable. \$6.00

□ **DICTIONARY OF MECHANICS AND GEOLOGY** by S. A. Cooper. English, French, German, Spanish nomenclature of machine parts, mechanical and mathematical terms, mining and geology, iron and steel, chemical reagents, color and cycle mechanisms. Invaluable to the engineer, geologist, business man. \$6.00

□ **OUR NUCLEAR ADVENTURE** by D. G. Arnott. A lucid appraisal of the good and evil potentials in nuclear energy. \$6.00

□ **RADIOISOTOPES** by Sidney Jefferson. The industrial applications of radioisotopes from marking devices, leak detection, thickness measuring, uniformity of batch mixing to static discharges and ionization. Written by a prominent staff member of the British Atomics Center at Harwell. \$4.75

□ **MODERN COMPUTING METHODS**. Designed to teach the basic principles of the use of analogue machines, high-speed digital computers and the techniques of numerical mathematics involved in the solution of problems in electrical engineering. \$8.75

□ **DIRECTION OF RESEARCH ESTABLISHMENTS**. 20 internationally famous scientists cover all phases of research direction from the one man experimenter to the multi-million dollar endowed operations. Details included are budgets, controls, organization, cost accounting methods both for private and governmental projects. \$12.00

MAIL THIS COUPON TODAY

Mail to your favorite bookseller or directly to
PHILOSOPHICAL LIBRARY, Publishers
 15 East 40th Street, Dept. A-154, New York 16, N. Y.
 Send books checked. To expedite shipment I enclose remittance \$.....
 NAME.....
 ADDRESS.....

moral restraints. In the Thirty Years' War the embittering element was religion; in the age of the French Revolution and Napoleon, it was politics; in our own age, it is politics and economics. Two points, however, should be noted. Ideologies have rarely, if ever, ruled the outlook of leaders of government; and an ideology, whatever its form—religious, political or economic—has always in “these ages of savagery” been held as a religious faith by its adherents, and has been able “to inspire a devotion that has frequently extended into fanaticism.”

It is easy to find historical examples of strongly held ideological convictions outweighed by self-interest and expediency. Political considerations have usually had more effect on relations between governments than religious faiths, even fighting faiths. It is true that in our age popular education, the multiple channels of communication and the prodigal use of new techniques of propaganda have been singularly successful in whipping up mass feeling. Sometimes they have created waves of passion which restricted the movements of the very governments that set the waves in motion. Nevertheless, even constitutional governments have found it possible to turn popular fears and hatred on and off as the occasion required. Soviet Russia and Nazi Germany suddenly fell into each other's arms and just as suddenly went to war; a common loathing of communism did not make friends of the British Tory Government and Germany, and a bitter ideological cleavage did not prevent the alliance of the Western powers with the U.S.S.R.

The well-butressed argument that ideological antipathies are brushed aside when national interest seems to require it bears directly upon U. S.-Soviet relations. For political and economic reasons each of these powers considers the other a threat to its security. In discussing the conflict of ideologies P. H. Partridge, professor of social philosophy at the Australian National University, deflates a good deal of nonsense. Between Russia and the U. S. there would be suspicion and tension even if a Czar ruled Russia, the churches were thriving and capitalism were sacred. To be sure, communist ideology differs, as Partridge states, from any other ideology that has been important historically, in embracing doctrines of permanent world revolution and of an inevitable struggle between communism and capitalism. These doctrines are the basis of an ideological split which is a prime source of unrest. But this split is subsidiary to the real clash of interests in many parts of the world.

Why is communism popular in Asia? Not, by any means, because of ideology alone. It is the existence of Russia as a formidable power, as well as the protagonist of world revolution, that attracts adherents. Is it reasonable to consider all communist countries as forming a single bloc? Evidently not, Partridge argues, even though for the time being Russia and China appear to be bound together in what they conceive a common struggle against the West and “capitalism-imperialism.” Yet this common ideology is not necessarily a strong or lasting cement, since Russian and Chinese interests do not always run parallel and in time may diverge even more. “It follows from this that if the Western democracies take communism as such to be their enemy, if they base their foreign policies on the postulate that wherever communism is, it is to be resisted or attacked, they will reinforce the binding properties of a common communist ideology.”

In Partridge's view it is a mistake to imagine that democracy as an ideology has much appeal in Asian countries and other parts of the world where communism has become a major force. This is not to question the values of democratic institutions and practices, but simply to recognize that there are large areas where the economic and social conditions are unfavorable to democracy, and where its liberal methods and institutions are not adapted for the sort of “revolutionary social surgery” which the masses of people are willing to support to remake their economy and raise their standards of life. Undoubtedly the U. S. has great influence because of her economic resources, and can play a significant part in the transformation of backward and largely peasant societies; but this depends on the actual assistance given rather than on the advocacy of a gradualist democratic model of social change. The Asian countries, Partridge is convinced, will follow the Soviet pattern of revolution.

A psychiatrist, the late Reginald S. Ellery, and a psychologist, O. A. Oeser of the University of Melbourne, examine the relation between human drives and cultural patterns and war. Ellery tackles the “complementary fallacies” that war is rooted in a “human nature” which cannot be changed, and the “soothing notion that so long as a nation remains adequately defended no other nation is likely to make war upon it.” The danger in these beliefs, he says, is that they contain beguiling half-truths. Men have been quarreling for a long time, and it is not easy to imagine the elimination of their combative instincts. Moreover, in

SCHAUM'S OUTLINE SERIES

each title includes *THEORY* and *HUNDREDS* of *SOLVED PROBLEMS*

MATHEMATICS SCIENCE ENGINEERING



These books are designed to illustrate and amplify the theory by the presentation of numerous completely solved problems.

They are being used with great success at hundreds of colleges and technical schools as supplementary texts. Engineers, scientists, and technical men have also found them invaluable for reference and review of fundamental theory and problem work.

adopted by leading COLLEGES and UNIVERSITIES

COLLEGE ALGEBRA . . . \$2.50

including 1940 SOLVED PROBLEMS
By MURRAY R. SPIEGEL, Ph.D.,
Professor of Math., Rensselaer Polytech. Inst.

TRIGONOMETRY \$1.95

including 680 SOLVED PROBLEMS
By FRANK AYRES, Jr., Ph.D.,
Professor of Mathematics, Dickinson College

ANALYTIC GEOMETRY . . \$1.75

including 345 SOLVED PROBLEMS
By JOSEPH H. KINDLE, Ph.D.,
Professor of Mathematics, University of Cincinnati

CALCULUS \$2.50

including 974 SOLVED PROBLEMS
By FRANK AYRES, Jr., Ph.D.,
Professor of Mathematics, Dickinson College

DIFFERENTIAL EQUATIONS \$2.95

including 560 SOLVED PROBLEMS
By FRANK AYRES, Jr., Ph.D.,
Professor of Mathematics, Dickinson College

COLLEGE PHYSICS . . . \$1.95

including 425 SOLVED PROBLEMS
Edited by CAREL W. van der MERWE, Ph.D.,
Professor of Physics, New York University

COLLEGE CHEMISTRY . . . \$1.95

including 276 SOLVED PROBLEMS
Edited by CHARLES O. BECKMANN, Ph.D.,
Professor of Chemistry, Columbia University
and JEROME L. ROSENBERG, Ph.D.,
Assoc. Prof. of Chemistry, University of Pittsburgh

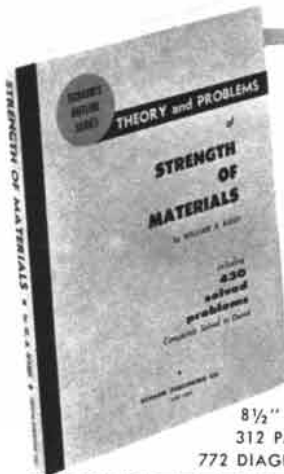
ENGINEERING MECHANICS \$2.95

including 400 SOLVED PROBLEMS
By W. G. McLEAN, B.S. in E.E., M.S.,
Professor of Mechanics, Lafayette College
and E. W. NELSON, B.S. in M.E., M. Adm. E.,
Engineering Supervisor, Western Electric Co.

HYDRAULICS and FLUID MECHANICS \$3.25

including 450 SOLVED PROBLEMS
By RANALD V. GILES, B.S. in C.E.,
Prof. of Civil Engineering, Drexel Inst. of Tech.

Just Published



STRENGTH OF MATERIALS . . \$3.25

including 430 SOLVED PROBLEMS
By WILLIAM A. NASH, PH.D.,
Professor of Eng. Mechanics, University of Florida
Contents: Tension and Compression; Statically Indeterminate Force Systems; Thin-Walled Cylinders and Spheres; Direct Shear Stresses; Torsion; Shearing Force and Bending Moment; Centroids and Moments of Inertia of Plane Areas; Stresses in Beams; Deflection of Beams, Double-Integration Method; Deflection of Beams, Moment-Area Method; Statically Indeterminate Beams; Columns; Riveted Joints; Welded Connections; Combined Stresses; Eccentrically Loaded Members and Members Subject to Combined Loadings; Reinforced Concrete.

Clip and send to your bookseller or to **SCHAUM PUBLISHING COMPANY, Dept. 838**
611 Broadway, New York 12, N. Y.

Send books checked below. I enclose \$.....

NAME..... (PLEASE PRINT)

ADDRESS.....

CITY..... STATE.....

- | | |
|--|--|
| <input type="checkbox"/> COLLEGE ALGEBRA.....\$2.50 | <input type="checkbox"/> COLLEGE PHYSICS.....\$1.95 |
| <input type="checkbox"/> TRIGONOMETRY.....\$1.95 | <input type="checkbox"/> COLLEGE CHEMISTRY.....\$1.95 |
| <input type="checkbox"/> ANALYTIC GEOMETRY.....\$1.75 | <input type="checkbox"/> ENGINEERING MECHANICS.....\$2.95 |
| <input type="checkbox"/> CALCULUS.....\$2.50 | <input type="checkbox"/> HYDRAULICS & FLUID MECHANICS.....\$3.25 |
| <input type="checkbox"/> DIFFERENTIAL EQUATIONS.....\$2.95 | <input type="checkbox"/> STRENGTH OF MATERIALS.....\$3.25 |

FULL REFUND PROVISION

Books purchased may be returned within 15 days for full refund.

WHY DOUGLAS ENGINEERS AND SCIENTISTS GO FURTHER . . .

At **DOUGLAS**, you'll work to expand the frontiers of knowledge in today's most advanced missiles program



1. Nike 2. Honest John 3. Sparrow 4. Thor IRBM 5. Secret 6. Secret 7. Secret 8. Secret

It's no secret that we're in the "missile business" to stay . . . with seventeen years behind us and an ever-expanding future ahead

There can be no mightier challenge than to be assigned to any one of the major projects now under way in the Douglas Missiles Division.

Some — like Nike and Honest John — have pioneered missile development. Others on which Douglas engineers are engaged are extending the horizons of present-day development. . . cannot be mentioned for reasons of national security.

These are the projects that require engineers who are looking far beyond tomorrow. You will use all of your talents at Douglas and have the opportunity to expand them. Your only limitations will be of your own making. Douglas is an engineer's company . . . run by engineers. Make it your working home and build an important and rewarding future in your field.

GO FURTHER
WITH

DOUGLAS



FIRST IN MISSILES

For complete information, write:

E. C. KALIHER
MISSILES ENGINEERING PERSONNEL MANAGER
DOUGLAS AIRCRAFT COMPANY, BOX 620-N
SANTA MONICA, CALIFORNIA

most societies a high value is placed on warriorship and soldierly virtues. It is true that a good supply of ammunition and rifles discouraged marauding Cheyennes, and that a large policeman is a wonderfully effective scarecrow against burglars and footpads. But a man's willingness to fight for a woman or a bone is not the same as a willingness to fight over issues of principle against men with whom he has no personal quarrel, whom he has never seen and will not see even in combat; and keeping one's powder dry is not quite the same as assembling stocks of nuclear weapons. The deterrent may not deter, and once it is used all is lost. The deterrents of our day are somewhat overgrown for their purpose; the hydrogen bomb, as Nehru remarks, is not an instrument of persuasion.

Ellery points to the frustrations and aggressions of society as one of the main causes of war. These twins (resembling action and reaction in physics) are among the fundamental components of behavior. Frustration produces aggression. The reaction may occur on a conscious level, or it may take strange forms in the complicated interchange of psychological forces. Aggression, though it has an ugly sound, is when properly controlled a "serviceable implement" of behavior; without it a man is a noodle. Ellery shows how social and economic circumstances often turn men into sick, hostile, belligerent individuals, burdens to themselves and to society, subversive of the natural inclination toward peace.

Do we know enough about social tensions within a group and between groups to bring under control "the violent manifestations of group hostility"? Oeser says we do, however difficult it may be to apply what we know. Hens peck at each other to establish a hierarchical order in the barnyard, and many animals will fight for food or to protect their young; but there is no evidence to support a biological theory of war. (W. C. Allee and others have shown that cooperation is far more common and necessary in the animal world than competition, let alone organized warfare.) War is a culture trait; the propensity to practice it has nothing to do with genes. In some societies women hold economic or political power; in some, competitiveness is regarded as antisocial; in others, men have to be forced to assume leadership positions. (Oeser gives two amusing examples: Arnhem Land children, who cannot be tested individually in tests which contain problems because all problems are discussed only in groups; and the Zuñi Indian, who never wins a race twice because "that would be indelicate, if not

immoral.") Certain societies regard war as an ennobling opportunity, but others hold it "literally unthinkable that men should band themselves together to kill people of another tribe, whether for glory or for gain."

War is a disease of societies. People see social reality "through the more or less ready-made spectacles of group experience and group ideologies." It is the rare man who can put these spectacles aside and escape the group myopia which determines likes and dislikes, prejudices and stereotypes, appraisals of self-interest and class interest. How one sees the world and its social tensions affects one's willingness to choose war as the solution of international crises. By combining what is understood about group tensions and hatreds with what is known about the distortions of personality that drive men to seek power and to vent their destructive impulses on society, one is in position to make sound diagnoses of the causes of war.

Of course diagnosis is a long way from prevention or cure. Much that men have been taught to believe is glorious has to be thrown on the rubbish heap. New heroes are needed. Bertrand Russell recently suggested that if one compared the height of the Nelson monument in Trafalgar Square with the height of statues of Shakespeare, Newton or Darwin, one got a pretty good idea of the heroes the English most admire. The study of social interaction demands the intensive cultivation of many disciplines, from psychology to economics. Training in these is at least as important as training in physics or biology or engineering. If the welfare of mankind is the first goal, education in the ways of society is the first requirement. Not everyone needs to be a nuclear physicist, but everyone is obliged to be a human being.

Among other articles in Wallace's book which deserve mention is W. Macmahon Ball's discussion of nationalism as a cause of war. One of his acute observations relates to the real meaning of self-government: for example, when the British work for Malaya's self-determination, where is this "self" to be found in a plural society of Chinese, Malays and Indians? Does it consist of the majority of the people, who are mostly illiterate? Or is the "self" to be identified with "Chinese big business" or Malay sultans? Self-determinism is easier in Europe, but even there plebiscites and elections do not always express the popular will; and when they do, they achieve it at the expense of minorities. W. G. K. Duncan, a historian and political scientist at the University of Adelaide, presents a very

7 IMPORTANT NEW BOOKS from Van Nostrand

SOURCEBOOK ON ATOMIC ENERGY

New Second Edition by Samuel Glasstone,
Consultant to USAEC

Enlarged and completely up-to-date, this book covers the amazing accomplishments of recent years in nuclear research and development—the identification of hitherto unknown particles, advances in the use of isotopes, and vastly improved experimental techniques and equipment. **641 Pages, \$4.40**

MISSILE ENGINEERING HANDBOOK

By C. W. Besserer, Technical Staff,
Ramo-Wooldridge Corporation

This fourth volume in the series PRINCIPLES OF GUIDED MISSILE DESIGN brings together important handbook data and a glossary of guided missile and space flight terms—useful for reference and for preliminary design; parametric studies and student instruction. **608 Pages, About \$12.50**

EXTERIOR BALLISTICS OF ROCKETS

By Leverett Davis, Jr.,
James W. Follin, Jr., and Leon Blitzler

The basic theory of exterior ballistics of rockets without moving control surfaces, emphasizing both the physical understanding of rocket behavior and its mathematical description. **458 Pages, About \$8.00**

SPOT TESTS IN INORGANIC ANALYSIS

By Fritz Feigl, Professor of Chemistry,
University of Brazil; Translated by Ralph
Oesper, Professor Emeritus of Analytical
Chemistry, University of Cincinnati

This new fifth edition is enlarged to reflect the tremendous strides made in the past three years. More than 100 new tests are included for the first time, with full description in this standard work.

Over 550 Pages, About \$12.50

TRANSISTOR TECHNOLOGY, Vol. II

Edited by F. J. Biondi, Member of the
Technical Staff, Bell Telephone Laboratories

Discusses the technology of materials, with special emphasis on silicon, and treats the principles of transistor design, with special information on diode design principles, junction diodes, switching devices, junction transistor tetraodes, radiation sensitive devices, field effect devices and the design implications of surface phenomena.

600 Pages, About \$15.00

TRANSISTOR TECHNOLOGY, Vol. III

Edited by F. J. Biondi, Member of the
Technical Staff, Bell Telephone Laboratories

Separated into four major divisions, the book deals with the preparation of junction structures; fabrication technology of transistors; the measurements and characterization of materials properties; and the reliability of transistors. An appendix of terms and symbols and an index aid in ready reference.

550 Pages, About \$15.00

NUCLEAR REACTOR EXPERIMENTS

By the Staff of the Argonne
National Laboratory, J. Barton Hoag,
Editor and Contributor

Ranging over the entire nuclear reactor field, this new book will give engineers and scientists a comprehensive view of the work performed by each member of a reactor team. The forty-four experiments were written, for the most part, by the A.N.L. staff members who created, or helped create, the work they describe. **600 Pages, \$6.45**

D. Van Nostrand COMPANY, INC.

Publishers of Van Nostrand's
SCIENTIFIC ENCYCLOPEDIA

120 Alexander Street
PRINCETON, N. J.

**New OXFORD
Scientific Texts**

**A History of
Technology**

Volume III: From the Renaissance to the Industrial Revolution, c. 1500 to c. 1750

Edited by CHARLES SINGER, E. J. HOLMYARD, A. R. HALL, and TREVOR I. WILLIAMS. Many subjects are carried forward from Volume II and new topics include: coal mining; town planning; land drainage and reclamation; printing, cartography, survey, etc. 696 text figures. \$26.90

**The Spectrum of
Atomic Hydrogen**

By G. W. SERIES. This book describes the successive formulations of quantum theory, the quantum electrodynamics theory, measurements of Lamb shifts and hyperfine structures in hydrogen, ionised helium, etc. Formulae for numerical computation have been extracted from the recent literature.

\$2.00

**An Introduction
to Chemical
Thermodynamics**

By EDWARD F. CALDIN. The first and second laws of thermodynamics are fully treated as the foundation for the definition and use of the free energy entropy, and other thermodynamic functions. These are applied to pure substances, solutions, chemical reactions, etc. The third law is carefully considered. 86 text figures.

\$8.00

**The Chemical Industry
During the
Nineteenth Century**

A Study of the Economic Aspects of Applied Chemistry in Europe and North America

By LUDWIG F. HABER. This history traces the chemical industry from its 18th century forerunners down to 1900. It emphasizes products critical in the development of the industry, such as: dyestuffs, soda ash, caustic soda, and bleaching powder. Text figures.

\$7.20

At all bookstores

OXFORD UNIVERSITY PRESS, Inc.

New York 11

sensible analysis of the much-misunderstood and overused concept of balance of power. The idea behind the principle is expressed in the old phrase that "one sword holds another in its sheath." In practice, balance of power turns out to be "a chimera, a myth, an ideology, a cloak to disguise the realities of foreign policy from critics, at home as well as abroad." If it works at all, even temporarily, it depends on an outside power holding the balance between opposed groups of nations, and tilting it against a potential aggressor. But with the world divided between two giants there is no outside balancer, and the slightest move by either giant can produce an immediate, dangerous tilt. Frederick E. Emery and James F. Cairns consider economics and war; the noted agriculturist Sir Samuel Wadham, population and food production in relation to world peace; the physicist M. L. E. Oliphant, the threat to civilization from atomic warfare (he makes it devastatingly clear that there is no effective defense, and none in prospect, against atomic weapons, and that shelters are useless unless men are prepared to shift life permanently underground). Sir Frederic Eggleston's essay considers the U.N. as an instrument for preserving peace. Most thoughtful persons would agree with Sir Frederic that the U.N. deserves the strongest possible support. It has failed often but it has probably averted irretrievable disaster.

Whether one is hopeful or despairing of the future is at bottom a matter of temperament. For even if we assumed we could know all about the causes of war, we might discover that situations arise which "are intractable in themselves." The University of Cambridge historian Herbert Butterfield has spoken of the "tragic element in modern conflict, . . . the absolute predicament and the irreducible dilemma." The greatest war in history, said Butterfield, could be set off between two powers "both of which were moderately virtuous and desperately anxious to prevent a conflict." Such a struggle "would be embittered by the heat of moral indignation on both sides, just because each was so conscious of its own rectitude, so enraged with the other for leaving it without any alternative to war. It is the peculiar characteristic of the situation I am describing . . . that you yourself may vividly feel the terrible fear that you have of the other party, but you cannot enter into the other man's counterfear, or even understand why he should be particularly nervous. For you know that you yourself mean him no harm and that you want nothing from him save guaran-

tees for your own safety; and it is never possible for you to realize or remember properly that since he cannot see the inside of your mind, he can never have the same assurance of your intentions that you have."

As a companion to this penetrating observation I mention a memorable paragraph from an address given to the American Legion in 1955 by General of the Army Douglas MacArthur. (The quotation appears in W. Glanville Cook's essay on propaganda in the present volume.) MacArthur said that present tensions were "kept alive by two great illusions. The one, a complete belief on the part of the Soviet world that the capitalist powers are preparing to attack it; that sooner or later we intend to strike. And the other, a complete belief on the part of the capitalist countries that the Soviets are preparing to attack us. Both are wrong. Each side, so far as the masses are concerned, is equally desirous of peace. For either side, war with the other would mean nothing but disaster. Both equally dread it. But the constant acceleration of preparation may well, without specific intent, ultimately produce a spontaneous combustion."

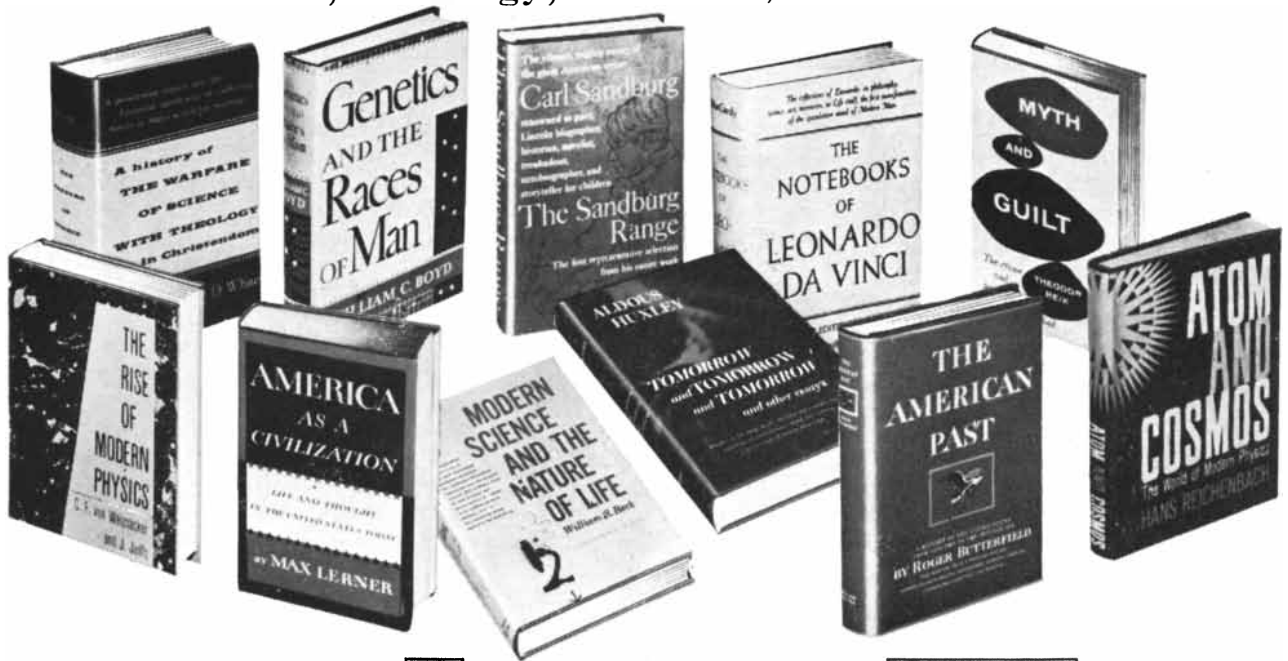
Wallace's symposium is patchy and uneven. Certain critical political and economic issues are scantily treated, the majority of the essays dealing with the uses of diplomacy and the prevention of war are unimpressive. But the book as a whole must have great impact on open minds. It often speaks directly and incisively. It is not unfriendly to the U. S., but it says many things we do not like to hear. Australians do not wear our kind of glasses. They see things we do not see, although they are well aware that they are tied to our fate. It is an omen not to be disregarded that these expressions come to us from the Pacific. And the spirit of the undertaking recalls some words of Gilbert Murray: "Man has in the last issue only one weapon for dealing with the innumerable problems which bewilder and which may destroy him, the weapon of thought. Thought may go wrong; but it is the best guide we have, if it is patient, if it is based on study, if unwarping by personal interests and moved by the spirit of goodwill."

Short Reviews

THE LIFE AND WORK OF SIGMUND FREUD: VOL. III, by Ernest Jones. Basic Books, Inc. (\$7.50). Ernest Jones's final volume carries this biography of a great and lovable man through the last 20 years of his life, from 1919 to 1939. There are two parts to the book: the

Outstanding...

In Science, Sociology, Literature, and World Affairs



ANY 3 FOR ONLY \$3.95

WITH MEMBERSHIP IN THE BOOK FIND CLUB

The books pictured here are representative of the outstanding works in science, sociology, literature and world affairs, regularly offered to BOOK FIND CLUB members at savings of up to 50%. These are among the most stimulating and informative books by the outstanding writers of today. They are intended for people who want to keep abreast of the most significant ideas, discoveries and adventures in every important area of human experience.

Membership in THE BOOK FIND CLUB is easy and rewarding. Each month you receive FREE our literary magazine, The

Book Find News, which contains an authoritative review of the forthcoming selection. If you like it, you need do nothing, it will arrive automatically; if not, you simply return a form saying, "Send me nothing." Or you may choose from a list of over 100 current books, all available at special membership savings. And—under the Book Find Club Bonus Plan, you receive one free book for each four selections purchased.

Begin your membership now by accepting any 3 of these provocative books—all 3 for only \$3.95.

AMERICA AS A CIVILIZATION. By Max Lerner. A brilliant insight into the workings of America. An examination of the automatic factory, public relations, steady dating, the split-level home, and many more aspects of the growing pains of a nation. Pub. at \$10.00.

MODERN SCIENCE AND THE NATURE OF LIFE. By William S. Beck. Probing into the vital question "What is the nature of Life?" this work dissects the very guts of science and scientists. Pub. at \$5.75.

THE AMERICAN PAST. By Roger Butterfield. A panorama in pictures and words of the entire history of the United States, newly revised and updated with additional text and plates. Pub. at \$6.95.

A HISTORY OF THE WARFARE OF SCIENCE WITH THEOLOGY IN CHRISTENDOM. By Andrew D. White. A monumental study of conflicting influences in Human history. Pub. at \$7.50.

THE NOTEBOOKS OF LEONARDO DA VINCI. The most comprehensive approach to the thought and character of Leonardo in the English language. A definitive edition, edited by Edward MacCurdy. Pub. at \$7.50.

GENETICS AND THE RACES OF MAN. By William C. Boyd. An important study of physical anthropology from a viewpoint adequate to this modern age. Pub. at \$6.00.

TOMORROW AND TOMORROW AND TOMORROW. By Aldous Huxley. Huxley at his most varied, startling and readable best, his unrivalled erudition and intellectual virtuosity touching on a great range of human knowledge. Pub. at \$4.00.

THE RISE OF MODERN PHYSICS. By C. F. von Weizsacker and J. Juilfs. A brilliant integration of classical and modern physics including discussion of historical origins and the practical problems of physics' future development. Pub. at \$3.75.

ATOM AND COSMOS. By Hans Reichenbach. An introduction to the basic concepts of modern physics that makes intelligible recent spectacular advances in terms of the research and theory preceding them. Pub. at \$5.00.

THE SANDBURG RANGE. By Carl Sandburg. 496 pages, 16 pages of photographs, portraits and caricatures, 6 1/8" x 9 1/4". A single volume that presents every aspect of a notable literary career, including Sandburg as poet, biographer, historian, novelist and storyteller for children. Pub. at \$6.00.

MYTH AND GUILT. By Theodor Reik. A foremost psychoanalyst explores the crime and punishment of mankind and probes human guilt feelings. Pub. at \$5.75.

THE BOOK FIND CLUB
215 Fourth Ave., New York 3

Please enroll me as a member and send me, for only \$3.95 plus 24¢ postage and handling, the 3 books I have chosen. I am to receive free the monthly Book Find News. I agree to purchase at least 4 additional books during my first year of membership, and I am to receive a free Bonus Book for each 4 purchases. I may cancel my membership without obligation at any time after accepting 4 selections.

- Genetics and The Races Of Man
- Atom and Cosmos
- Myth and Guilt
- Tomorrow and Tomorrow and Tomorrow
- The Rise of Modern Physics

- The Sandburg Range
- Notebooks of Leonardo Da Vinci
- America As A Civilization
- Modern Science And The Nature Of Life
- The American Past
- The Warfare of Science with Theology

Name..... Please Print

Address.....

City..... Zone..... State.....

(Same price in Canada: 105 Bond St., Toronto 2, Canada)

SA-3-88

MAIL THIS COUPON TODAY

published in February

THE WORLD OF THE ELECTRON MICROSCOPE

by Ralph W. G. Wyckoff

The inaugural volume in a new series—Trends in Science. Dr. Wyckoff explains the developments that have made the electron microscope possible, and he describes the hitherto hidden world that emerges from under its lens as the scientist looks at living matter and at inorganic substances as well.

Illustrated. \$4.00

to be published in April

THE COMPUTER AND THE BRAIN

by John von Neumann

The last writing to come from one of the greatest mathematicians of the twentieth century presents his views on the analogies between computing machines and the living human brain. He concludes that the brain operates in part digitally, in part analogically, but uses a peculiar statistical language unlike that employed in the operation of man-made computers. \$3.00

to be published in May

LISTENING IN THE DARK

by Donald R. Griffin

Bats, birds, and other creatures that "hear their way" fascinatingly revealed by the man who has made echolocation his life work. This milestone publication describes and explains the mechanism of bats' "sonar," the acoustic property of their sounds, and the specialized nature of their brains and hearing—and looks to the future when the blind may use echoes to guide themselves.

Illustrated. \$7.50

THE INNER METAGALAXY

by Harlow Shapley

A summary of three decades of trail-blazing work. \$6.75

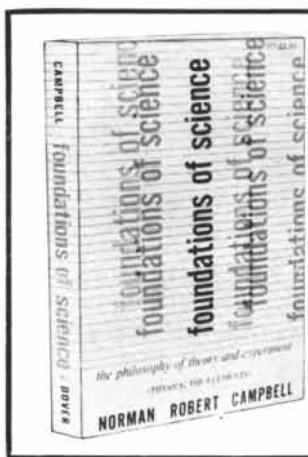
at your bookseller



first a chronicle; the second a historical review of Freud's contributions to medicine, psychology, anthropology and sociology, and his attitudes on lay analysis, art, literature, religion and occultism. The concluding chapter is a brief general assessment of his influence on the world. It cannot be said that the last phase of Freud's long life was a quiet tapering off, a change from vigor, creativeness and conflict to peacefulness and decay. At the end of World War I Freud was 63. He was penniless, his country was ruined, his practice was shattered, his friends were scattered. Everything had to be rebuilt. Fortunately he had the energy for rebuilding and a spirit which could not be broken. Psychoanalysis won increasing recognition. His consulting hours soon were filled, many with patients from foreign lands who could pay their fees in hard currency. In Vienna a separate publishing house was founded for psychoanalytic literature. Freud's own output was astonishing. *Group Psychology, The Ego and the Id, Beyond the Pleasure Principle, Moses and Monotheism* were among his books of the period; also numberless technical essays, and writings on war, religion and civilization. With Ambassador William C. Bullitt he collaborated on a life of Woodrow Wilson, which will be published "at a suitable time." Freud's fame spread: distinguished visitors, pupils, letters, honors came from all parts of the world. Vienna made him a professor; the Royal Society, a corresponding member. But together with the triumphs and satisfactions grief and suffering fell upon him in full measure. Dissension plagued the psychoanalytic movement. His closest collaborator, Sándor Ferenczi, gradually turned from him, as did Otto Rank. Old friends died. He had to bear the loss of his beautiful daughter Sophie, whom he called his "Sunday child," and of his beloved little grandson Heinz—a blow which brought Freud to tears (the only known occasion of this kind in his life, according to Jones) and from which he never recovered. In 1923 Freud underwent a major operation for cancer of the jaw. Thereafter he had to wear a huge prosthesis—called "the monster"—which at best was uncomfortable and for long periods miserably painful. Over the next 16 years 30 other operations were performed on him until finally the malignancy could not be contained. All this he bore with exemplary stoicism. He rarely complained. His work in all departments went on steadily. He would take no drugs, preferring, as he said, to think in torment than not to be able to think

clearly. It is a terrible and an inspiring story. Jones handles the final installment of his biography with the skill and devotion we have learned to expect from him. He imposes graceful order on a prodigious amount of material. The narrative, the delicate and difficult analysis of professional relationships, the exposition of the theories—all come off very well and are a tribute to his own largeness of spirit. There are many revealing anecdotes. Freud had a patient who almost converted him to bolshevism. Under the new order, the patient said, there would be some years of misery and chaos but these would be followed by universal peace, prosperity and happiness. Freud said: "I told him I believed the first half." On refusing to attend a festival in his honor, he remarked: "When someone abuses me I can defend myself, but against praise I am defenseless." After his first meeting with Einstein in 1926 he wrote: "He is cheerful, sure of himself and agreeable. He understands as much about psychology as I do about physics, so we had a very pleasant talk." As the years passed the admiration each man had for the other increased; in 1939 Einstein wrote Freud a superb letter saying that, while he could not always follow the older man's ideas, he was glad at least "to be able to grasp the structure of the thoughts expressed." It is perhaps ungrateful to complain about what this book does not give, when it gives so much. Yet it must be said that for all its riches the Jones biography is a work of grandeur which only rarely penetrates to the deeper levels of its hero. What he said or did is carefully reported, but somehow, whether because of the biographer's veneration and reticence or because Freud shielded himself too well, the inner man of tears, qualms, doubts and passions eludes our understanding.

THE EARLY ARCHITECTURE OF GEORGIA, by Frederick Doveton Nichols and Frances Benjamin Johnston. University of North Carolina Press (\$15). Savannah, the first town in Georgia, was settled in 1733. The town was under the benign and paternalistic control of James Oglethorpe, who had sailed from England the year before with 116 colonists—a few "gentlemen," but mostly men "on the charity"—and "10 tons of Alderman Parsons' best beer." Oglethorpe decreed there were to be no representative assembly, no slaves, no "rum punch" and no large plantations. Things went well until Oglethorpe had to return to England in 1742. Then Savannah's prosperity dwindled and its



A fundamental work on basic research, scientific method, philosophy of science—A372. FOUNDATIONS OF SCIENCE, THE PHILOSOPHY OF THEORY & EXPERIMENT by N. R. Campbell, only \$2.95

In this monumental 225,000 word study, formerly published by Cambridge, a foremost British physicist investigates fundamental concepts in science, scientific method, and theory of science. His work undertakes for science what Whitehead and Russell attempted for mathematics.

Dr. Campbell covers such topics as: the validity of hypothesis and theory, the relation of scientific creativity to artistic, the nature of a law of science, criteria for scientific judgments, definition of properties, logic & science, nature of induction, the meaning of explanation, differentiating laws from numerical properties, number, order, relation of order, conditions for measurement, determining units of measurement, arbitrary or true units, interpolation and extrapolation, theory of measurement, and scores of other topics.

While the physical sciences are used as the basic departure point, continual reference is made to biology, chemistry,

astronomy, and other sciences. The scientific logic of such men as Planck, Poincare, Hertz, Mach, Bohr, Maxwell, and scores of others is discussed throughout. Treatment is mostly nontechnical, only in one or two places is calculus needed to follow the presentation.

It is difficult to imagine any person interested in science—whether a physicist, biologist, sociologist, psychologist, philosopher, or intelligent layman—who would not benefit by reading this monumental work.

"It is a great feat to have assembled so much interesting matter, and to have put together a book containing so much fresh thought on a subject of fundamental interest," E. Andrade, in NATURE.

Formerly entitled PHYSICS: THE ELEMENTS. 578 pp. A372 Paperbound \$2.95

NEW DOVER SCIENTIFIC BOOKS

Inexpensive reprints, originals—for beginners & experts, \$1 to \$3

A374. FUNDAMENTALS OF HYDRO- & AEROMECHANICS. L. Prandtl & O. Tietjens. Unabridged Engineering Soc. Monograph. Covers statics of liquids & gases, kinematics, dynamics of non-viscous fluids; emphasis upon phenomena distinguishing motion of a free fluid from classic theory; boundary layers, vortices, etc. Relatively rigorous proofs, using vector analysis, but fundamentally physical. 186 figures. xvi + 270 pp. Paperbound \$1.85

A375. APPLIED HYDRO- & AEROMECHANICS. L. Prandtl, O. Tietjens. Best introduction, with hundreds of situations worked out; wide coverage, examining conflicting aspects of hydrodynamics & hydraulics. Covers elements of hydrodynamics, laws of similarity, flow in pipes & channels, boundary layers, drag of bodies in fluids, airfoil theory, experimental methods. "Will be welcomed by all." NATURE. 226 figures. 327 pp. Paperbound \$1.85

A387-8. THEORY OF FUNCTIONS OF A REAL VARIABLE & THE THEORY OF FOURIER'S SERIES. E. W. Hobson. Perhaps the best introduction to sets, aspects of functions, Fourier series, as source, study text, refresher. Much more thorough than most more recent studies, more easily followed. Only calculus needed. Practical, rigorous, & precise. Covers: numbers, sets of points, transfinite numbers, order types, functions of a real variable, Riemann integral, Lebesgue integral, non-absolutely convergent integrals, sequences & series, functions so defined, power series, functions representable by series of sequences or continuous functions, sequences of integrals, construction of functions with assigned singularities, representation of functions as limits of integrals, trig. series, Fourier's integrals, orthogonal functions, etc. "A great contribution to the best possible guide to anyone who encounters mathematical analysis." NATURE. "Most important exposition yet given." R. D. Carmichael. 23 figures. Total of 1591 pp. 2 vol. set. The set, Paperbound \$6.00

A391. THE TAYLOR SERIES: AN INTRODUCTION TO THEORY OF FUNCTIONS OF A COMPLEX VARIABLE. P. Dienes. Full, detailed, thorough; only calculus needed to use this shortcut. "Very useful." Ditch. Mathem. Ver. 136 examples. 67 figures. 567 pp. Paperbound \$2.75

A437. TABLES FOR DESIGN OF FACTORIAL EXPERIMENTS. T. Kitagawa, M. Mitome. Latin squares, factorial design, fractional replication, etc. Only 300 copies available. vii + 253 pp. 7 1/2 x 10. Clothbound \$8.00

A353. TREATISE ON PLANE & ADVANCED TRIGONOMETRY. E. W. Hobson. Goes far beyond usual material to advanced trigonometry. Remarkably clear exposition. "Irregular functions, complex numbers, theory of infinite series, exponential functions, hyperbolic series, etc." "Will retain its place as standard textbook for many years to come." NATURE. 689 problems. 66 figures. xvi + 383 pp. Paperbound \$1.95

A428. SCIENCE, THEORY & MAN. Erwin Schroedinger. Nobel Laureate covers problems, implications of new physics. Role of play function; chance; indeterminism; causality; science & cultural zeitgeist; Dirac, Fermi, Heisenberg, Einstein, etc. No math. needed. "Most readable, lively, provocative." NATURE. 223 pp. Paperbound \$1.35

A431. BRIDGES & THEIR BUILDERS, David Steinman & S. R. Watson

Written by the world's foremost bridge engineer & architect, this book covers bridge-science from earliest times to present; ideas behind bridge engineering, great men who built bridges, special difficulties. Why Eads packed the St. Louis Bridge in ice; why the Quebec Bridge collapsed twice during building; why the Brooklyn Bridge has more cables on one side than the other; why the Puget Sound Bridge was called Galloping Gertie, until it collapsed... hundreds of other facts. Covers primitive, oriental, Rome, Middle Ages, Renaissance, Stephenson, Roebeling; explanation of types of bridges, stresses, aerodynamic flows, rocker towers, eyebar chains, etc. "Authoritative & comprehensive." N.Y. TIMES. New revised edition. 49 illustrations. 418 pp. A431 Paperbound \$1.95

A395. TREES OF EASTERN & CENTRAL U.S.A. AND CANADA. W. Harlow. Serious easily followed study identifying native trees & important escapes. Full text on folklore of trees, uses, identification; over 600 illustrations. 301 pp. Paperbound \$1.35

A367. 101 PUZZLES IN THOUGHT & LOGIC. C. Wylie, Jr. ENTIRELY NEW! No knowledge of math needed to solve these entertaining puzzles; only ability to reason clearly. Weeks of spare-time fun here. 128 pp. Paperbound \$1.00

A413. INTRO. TO STUDY OF STELLAR STRUCTURES. S. Chandrasekhar. Unabridged republication of modern classic by foremost astrophysicist. 509 pp. Paperbound \$2.75

A366. APPLIED OPTICS AND OPTICAL DESIGN. A. Conrady. Only modern practical step-by-step text on design of optical equipment, theory. "As a practical guide, has no rival." TRANS. OPTICAL SOC. 150 illustrations. 528 pp. Paperbound \$2.95

BEST INEXPENSIVE LANGUAGE RECORD COURSE ON THE MARKET!

Here is the only language record set planned to help you in foreign travel. Giving practical language in a form you can use immediately. It will fill hundreds of your travel needs. Check these features: (1.) Modern, no trivia, no technicalities. (2.) 800 foreign sentences. 1 1/2 hours recording. (3.) English and foreign language recorded, with pause for you to repeat. (4.) 128-page manual, with complete text, only fully indexed set on the market. (5.) High fidelity recording. GUARANTEED. Return it within 10 days if you do not like it. Wonderful for review, refresher, supplement for any course. In each set you get 3 10" 33 1/3 records, manual, album.

- A875. LISTEN AND LEARN FRENCH per set, \$4.95
- A876. LISTEN AND LEARN SPANISH per set, \$4.95
- A877. LISTEN AND LEARN GERMAN per set, \$4.95
- A878. LISTEN AND LEARN ITALIAN per set, \$4.95

A27. NON-EUCLIDEAN GEOMETRY. R. Bonola. Standard history, exposition, with texts by Bolyai & Lobachevski. 180 diagrams. 431 pp. Paperbound \$1.95

A41. PRINCIPLE OF RELATIVITY. Einstein, Lorentz, Weyl, Minkowski. 11 papers founding relativity, translated. "Indispensable." NATURE. 224 pp. Paperbound \$1.75

A349. ORDINARY DIFFERENTIAL EQUATIONS. E. L. Ince. Real & complex domains. "Highest praise." BULL. AM. MATH. SOC. 564 pp. Paperbound \$2.55

A377. FOUNDATIONS OF PHYSICS. R. Lindsay, H. Margenau. 1st-rate coverage of ideas and methodology of physics. Theory, logic of science, similar topics. Not a text, but mature work for reader with background. "Unreservedly recommended." NATURE. 577 pp. Paperbound \$2.45

A109. VECTOR AND TENSOR ANALYSIS. G. E. Hay. Start with simple definitions, finish understanding vectors and tensors. 201 pp. Paperbound \$1.75

A361. THERMODYNAMICS. Enrico Fermi. "May be recommended as clear, very accurate introduction." JOURNAL OF PHYSICAL CHEMISTRY. 170 pp. Paperbound \$1.75

A193. HIGHER MATHEMATICS FOR STUDENTS OF CHEMISTRY AND PHYSICS. J. Mellor. Practical rather than theoretical, bases situations on lab situations; integral, differential calculus, theory of error, etc. 662 pp. Paperbound \$2.00

A370. CALCULUS REFRESHER FOR TECHNICAL MEN. A. Klaf. 756 detailed questions, answers provide brush-up for students, technical men, etc. Also 566 problems, odd-numbered answered. 436 pp. Paperbound \$2.00

A371. TRIGONOMETRY REFRESHER FOR TECHNICAL MEN. A. Klaf. 913 questions and answers, complete text or brush-up, plane & spherical trig; also 1738 problems, odd numbers answered. 436 pp. Paperbound \$2.00

A10. LANGUAGE, TRUTH & LOGIC. A. Ayer. Clear intro. to logical positivism. "Should like to have written it myself." Bertrand Russell. 160 pp. Paperbound \$1.25

A440. MATHEMATICS IN ACTION. O. G. Sutton. In an exposition any intelligent person can follow, noted British mathematician tells how advanced math is applied to meteorology, airfoil theory, electronics, calculating machines, wave motion, statistics, etc. 88 figures. 244 pp. Clothbound \$3.50

A107. PSYCHOLOGY OF INVENTION IN THE MATHEMATICAL FIELD. F. Hadamard. Where ideas come from, role of unconscious, how Einstein, others, developed new ideas. 138 pp. Paperbound \$1.25

A97. CRYPTANALYSIS. H. F. Gaines. Best text for serious reader: modern techniques, easy to follow; much not generally known save to experts. 168 fascinating crypts, also, for solution. Solutions. 236 pp. Paperbound \$1.95

A162. MATHEMATICAL RECREATIONS. M. Kraitchik. 250 puzzles based upon: arithmetic without numbers, topology, geometry, Fermat numbers, probability, etc. The best book for picking up easily understood insights into difficult math. 330 pp. Paperbound \$1.75

A295. HOW TO CALCULATE QUICKLY. H. Sticker. Tried, true method, over 9000 problems, solutions, enable you to develop number sense; techniques not taught in schools. Left to right multiplication, division at sight, etc. 256 pp. Paperbound \$1.00

A335. MATHEMATICS, MAGIC & MYSTERY. Martin Gardner. Delightful acct. of ideas behind topology tricks, card tricks, Moebius strips, Curry squares (which "prove" that sum of parts is greater than whole), etc. How Sam Loyd could make a Chinaman disappear. 135 illus. 186 pp. Paperbound \$1.00

A359. MATHEMATICAL EXCURSIONS. H. Merrill. 90 puzzles, hundreds of shortcuts not taught in schools; factoring at sight, mnemonic systems for numbers, etc. 145 pp. Paperbound \$1.00

A198. MATHEMATICAL PUZZLES FOR BEGINNERS AND ENTHUSIASTS. G. Mott-Smith. 188 puzzles of most interesting sort, detailed solutions. 248 pp. Paperbound \$1.00

A394. FADS AND FALLACIES IN THE NAME OF SCIENCE. Martin Gardner. Enlarged revised edition of the standard coverage of cults, fallacies, fads masquerading as science: Atlantis, Reich's orgone energy, flying saucers, General Semantics, Bridley Murphy, psionics, etc. Covers astronomy, physics, medicine, geology, philosophy, etc. Not only most fascinating reading, but a real eye-opener. "Should be read by everyone, scientist and non-scientist alike." R. T. Birge, Prof. Emeritus, U. of California, Former President, AMERICAN PHYSICAL SOCIETY. 375 pp. Paperbound \$1.50

All books standard 5 3/8 x 8 unless otherwise specified.

Dept. 142A, Dover Publications, Inc.
920 Broadway, N. Y. 10, N. Y.

Please send me the books circled below:

A10	A27	A41	A97	A107	A109
A162	A193	A198	A295	A335	A349
A353	A359	A361	A366	A367	A370
A371	A372	A374	A375	A377	A387-8
A391	A394	A395	A413	A428	A431
A437	A440	A875	A876	A877	A878

I am enclosing \$..... in full payment. Payment in full must accompany all orders except those from libraries or public institutions, who may be billed. Please add 10¢ per book to your remittance (for postage and handling charges) on orders less than \$5. On orders of \$5 or over, Dover pays postage & handling charges. Please Print

Name.....
Address.....
City..... Zone..... State.....

GUARANTEE: Your satisfaction is guaranteed. Any Dover books may be returned within 10 days of receipt for full and immediate cash refund. No questions asked.

I. M. LEVITT, Director, The Fels Planetarium, Franklin Institute, says: "A well written book with good imagery and examples, and done in a style which has a feeling for the layman."



EXPLORING THE DISTANT STARS

By CLYDE B. CLASON

Ranging over the whole subject of astronomy from the Babylonian star-gazers to the most recent developments, this book shows the reader the reasons why astronomers believe they have the right picture of the universe. While our solar system is discussed in detail, there is special emphasis on the distant stars and galaxies, with informative material on the internal composition, orbital behavior, and galactic roles of the stars; and on the origin, structure, and fate of the universe. Throughout, it is both fascinating and lucid, its mathematics virtually painless, the prose witty and colloquial. Line drawings; charts.

\$5.00 at all bookstores

G. P. PUTNAM'S SONS, N. Y. 16

LEFAX

Pocket Size—Loose Leaf

ENGINEERING FORMULAS & TABLES



Civil, Mechanical and Electrical Engineers will find Lefax, newly revised "Engineering Formulas & Tables" an indispensable tool. Contains 250 pages of basic formulas, design data, and tables for the three branches of engineering. Condensed, indexed and mathematically accurate. 12 division sheets with printed tabs furnish immediate access to the particular information desired. Handy, on-the-spot pocket size. Sections include Mathematics, Measures, Materials, Gauges, Screws, Mechanics, Electricity and Magnetism, Hydraulics, Structural Data, Reinforced Concrete, Pipe and Fittings, Steam Tables, and Mathematical Tables. This new data book is the result of 40 years of compilation, condensation and revision. 396 pages—Celluloid Tabbed Index.

No. 783 with cover \$4.75

TECHNICAL DATA BOOKS POCKET SIZE—LOOSE LEAF

Printed on loose leaf, 6 hole, 6 3/4" x 3 3/4" bond paper, each book contains about 130 pages of technical data, condensed, accurate, essential for engineer, technical worker, student, business man. **\$1.25** each

Architecture
Electrician's Data
Builder's Data
Air Conditioning
Building Constr.
Surveying
Surveying Tables
Highway Eng'g
General Math
Math Tables
Physics
Trig-Log Tables
Gen'l Chemistry
Chemical Tables
Analytic Chem.

Mech'l Drawing
Machine Design
Mech. of Materials
Pwr. Trans. Mach.
Thermo. Tbls. & Charts
Phys. & Thermo. Data
Metals
Metallurgy
Hydraulics
Radio
Television & FM
AC Motors & Gen'trs
Transformers,
Relays & Meters

Write for FREE catalog (2000 listings). See how helpful LEFAX can be to you. Send \$1.25 book, or \$6 for any five books to

LEFAX PUBLISHERS
DEPT. SA-38, PHILADELPHIA 7, PA.

population shrank from 5,000 to 500. Oglethorpe's rules were abandoned: slavery was introduced, liquor was imported and lands were held in fee simple. Rice and indigo fields were worked by numerous slaves; exports rose from 15,000 pounds in 1755 to almost half a million dollars in 1791. The rise of a prosperous class was accompanied by the construction of many splendid homes and other architectural monuments, as well as less glamorous structures. This stunning book, beautifully designed, and illustrated with superb pictures by the distinguished architectural photographer Frances Johnston, is a survey of the early architecture of Georgia. The great body of existing architecture, says Nichols, dates from the Early Republican or Federal period, which began about 1790. Germans, Swiss, "a few Jews from England" and Italian Piedmontese were among the mixed population which settled Georgia. The diversity of the people influenced the architecture, as did the diversity of topography—mountains, coastal plains, sand hills, swamps. There are discussed and displayed in this survey the elegant houses and the tenements of the coastal towns, the famous Classical Revival structures of the Piedmont, the mountain cabins and log houses of the Appalachian region, the simple coastal "plantation plain-style buildings," the spacious brick or tabby homes of the great swamp where the prosperous rice and indigo plantations were located. Seen together these make a fascinating social and architectural record. In every way worthy of its subject, this volume is an ornament of book-making, illustration and scholarship.

THE LIFE OF BACTERIA, by Kenneth V. Thimann. The Macmillan Company (\$13.50). The tiniest living things rule us. Their power lies in their number. A handful of soil contains as many microorganisms as there are human beings in the world. A noted 19th-century botanist, Ferdinand Cohn of Breslau, gave a very graphic illustration of the size of bacteria: "If one could inspect a man under a similar lens-system he would appear as big as Mont Blanc or even as Mount Chimborazo. But even under these colossal magnifications the smallest bacteria look no larger than the periods and commas of good print; little or nothing can be distinguished of their inner parts, and of most of them their very existence would have remained unsuspected if it had not been for their countless numbers." For some 200 years many men have labored to develop methods for studying these "smallest

members of creation." The remarkable progress that has been made is shown in this excellent book, which presents a summary of what is known today about the growth, metabolism and relationships of bacteria. After tracing a brief history of microbiology, the book discusses the internal structure of bacteria, the conditions of their culture, the relationship of the bacterial cell to other organisms, the role of microorganisms in the nitrogen cycle, the different kinds of fermentation, growth and protoplasm formation, assimilation, the autotrophic mode of life, bacterial photosynthesis, the inhibition of bacterial growth by antibiotics and other means, the evolution of bacteria. This work fully justifies the 15 years the author devoted to it. Many illustrations.

ON NUCLEAR ENERGY, by Donald J. Hughes. Harvard University Press (\$4.75). In the few years since Hiroshima nuclear energy has emerged as a force of almost unlimited promise for human welfare and as the greatest threat of all time to human survival. This book is concerned only with the promise. The principal topics with which the author deals are the potentialities of atomic power; the different kinds of reactors; the possibility of controlling fusion; the applications of radioisotopes in technology, agriculture, medical diagnosis and therapy; the uses of neutrons from reactors as tools for penetrating other particles and learning more about the fundamental structure and binding forces of matter. He also explains the scientific elements of nuclear energy, and discusses the work of the international atomic energy agency and some aspects of the safety and security matters handled by the U. S. Atomic Energy Commission.

A HISTORY OF LUMINESCENCE, by E. A. Newton Harvey. The American Philosophical Society (\$6). The emission, under various circumstances, of light without heat was well known to the ancients. The firefly is, of course, the very symbol of the phenomenon. From the beginning certain types of reflection, such as the glowing eyes of cats and humans and the apparent light that appears when the eyeball is pressed or struck, were confused with true luminescence; but the ancients also recognized instances of the latter, among them the aurora borealis, the light of the sea, luminous animals, phosphorescent wood and flesh, and *ignis lambens*, a silent electrical discharge in air. The isolation of phosphorus in 1669, and the observa-

A COLLEGE EDUCATION DOES NOT MAKE AN EDUCATED MAN



A message from Dr. Mortimer J. Adler,
EDITOR, THE SYNTOPICON

"The greatest mistake anyone can make about liberal education is to suppose that it can be acquired, once and for all, in the course of one's youth and by passing through school and college.

"This is what schoolboys do not know and, perhaps, cannot be expected to understand while they are still in school. They can be pardoned the illusion that, as they approach the moment of graduation, they are finishing their education. But no intelligent adult is subject to this illusion for long, once his formal schooling is completed.

"He soon learns how little he knows and knows how much he has to learn. He soon comes to understand that if his education were finished with school, he, too, would be finished, so far as mental growth or maturity of understanding and judgment are concerned.

"With the years he realizes how very slowly any human being grows in wisdom. With this realization he recognizes that the reason why schooling cannot make young people wise is also the reason why it cannot complete their education. The fullness of time is required for both."



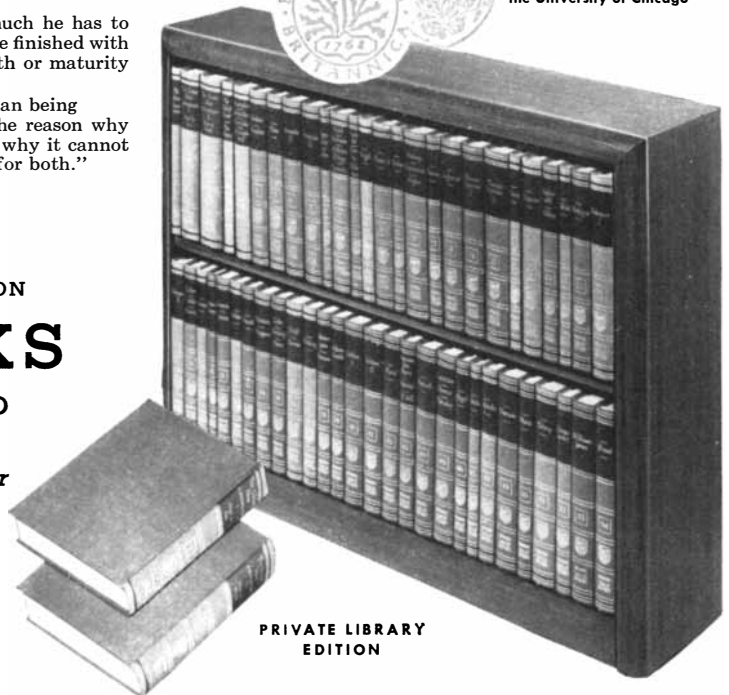
Published by
the Encyclopaedia
Britannica
in collaboration with
the University of Chicago

ESSENTIAL IN THE
LIBRARY OF EVERY THINKING PERSON

GREAT BOOKS OF THE WESTERN WORLD

Now available direct from the publisher
with great new

SYNTOPICON fascinating "idea-interpreter"



THE publication of this Private Library Edition of the GREAT BOOKS is regarded as an outstanding event in the fields of literature, philosophy and science. It is not just a reprint of books already in your library. The 54 volumes which comprise the GREAT BOOKS were published after 8 years of research by 75 scholars at a cost of over two million dollars. Many of the books have been especially translated into English. Many of them are out of print and unobtainable through normal channels. Together they include all the accumulated wisdom of 3,000 years of civilization.

The list of authors is impressive—Homer, Plato, Dante, Shakespeare, St. Augustine, Milton, Machiavelli, Faraday, Kepler and St. Thomas Aquinas—to name just a few of the 74 authors and scholars whose works are represented in this special edition of the GREAT BOOKS. The area of thought is limitless. Every great idea that has shaped the lives of thinking

men is explored—astronomy, ethics, philosophy, war, peace, religion, death, love, mathematics, medicine, science, theology—102 ideas that have occupied great minds since man could think.

But the magnitude of the GREAT BOOKS is not in its authors and subject matter alone. Published with them is a great new SYNTOPICON designed to make your reading more meaningful. The SYNTOPICON is quite literally a great teacher "living" in your home . . . always at your disposal to guide your reading . . . interpret the great ideas . . . make clear to you the most abstract thought. With the SYNTOPICON you will find new excitement in new ideas . . . new absorbing interests . . . new understanding of yourself and other people.

We urge you not to miss this opportunity to en-

rich your mind with this Private Library Edition of the GREAT BOOKS. Send now for the free booklet which describes this handsome edition in detail. Look it over . . . think it over. But don't wait to mail in the coupon below. The supply of these booklets is necessarily limited. Avoid the chance of disappointment by mailing your coupon now!

MAIL THIS COUPON TODAY FOR FREE BOOKLET



GREAT BOOKS OF THE WESTERN WORLD,
DEPT. 174-B
425 N. Michigan Avenue, Chicago 11, Illinois

Please send me, free and without obligation, your handsome booklet which pictures and describes the revolutionary SYNTOPICON and the GREAT BOOKS in full detail. Also, include complete information on how I may obtain this magnificent set, direct from the publisher, on your special budget plan.

Name _____
(please print)

Address _____

City _____ Zone _____ State _____

NOW— There's a New RELAXED WAY to Learn a LANGUAGE



at home—
almost overnight

RELAX like a child . . . SPEAK like a native . . . almost overnight. Find out about the Linguaphone Scientific Shortcut to language learning. Mail coupon TODAY or call for FREE BOOK with fascinating details—no obligation.

34 LANGUAGES BY

LINGUAPHONE

World's Standard Conversational Method

AT HOME — ABROAD

For Business, Travel, Culture

LINGUAPHONE INSTITUTE

Dept. D-3038 Radio City, New York 20, N. Y. Circle 7-0829

Please send me your FREE Book on languages
—No obligation.

Name _____

Address _____

City _____ Zone _____ State _____

Please check your language interest:

- Spanish (American) Spanish (European)
 French Italian German Russian
 Modern Greek Japanese Icelandic
 Other _____

The handbook for tomorrow
is here today —



the space encyclopaedia

by Sir Harold Spencer Jones & Others

"Not until this book has been one important reference book which has been able to explain all phases of the new age—the space age. Anyone selecting this book cannot possibly put it down feeling that it has been anything other than a fascinating experience."—Milton B. Wenger, *Vitro Corp. of America*.

Lavishly illustrated with over
300 photographs, maps
and diagrams.

\$6.95 at your bookstore

DUTTON

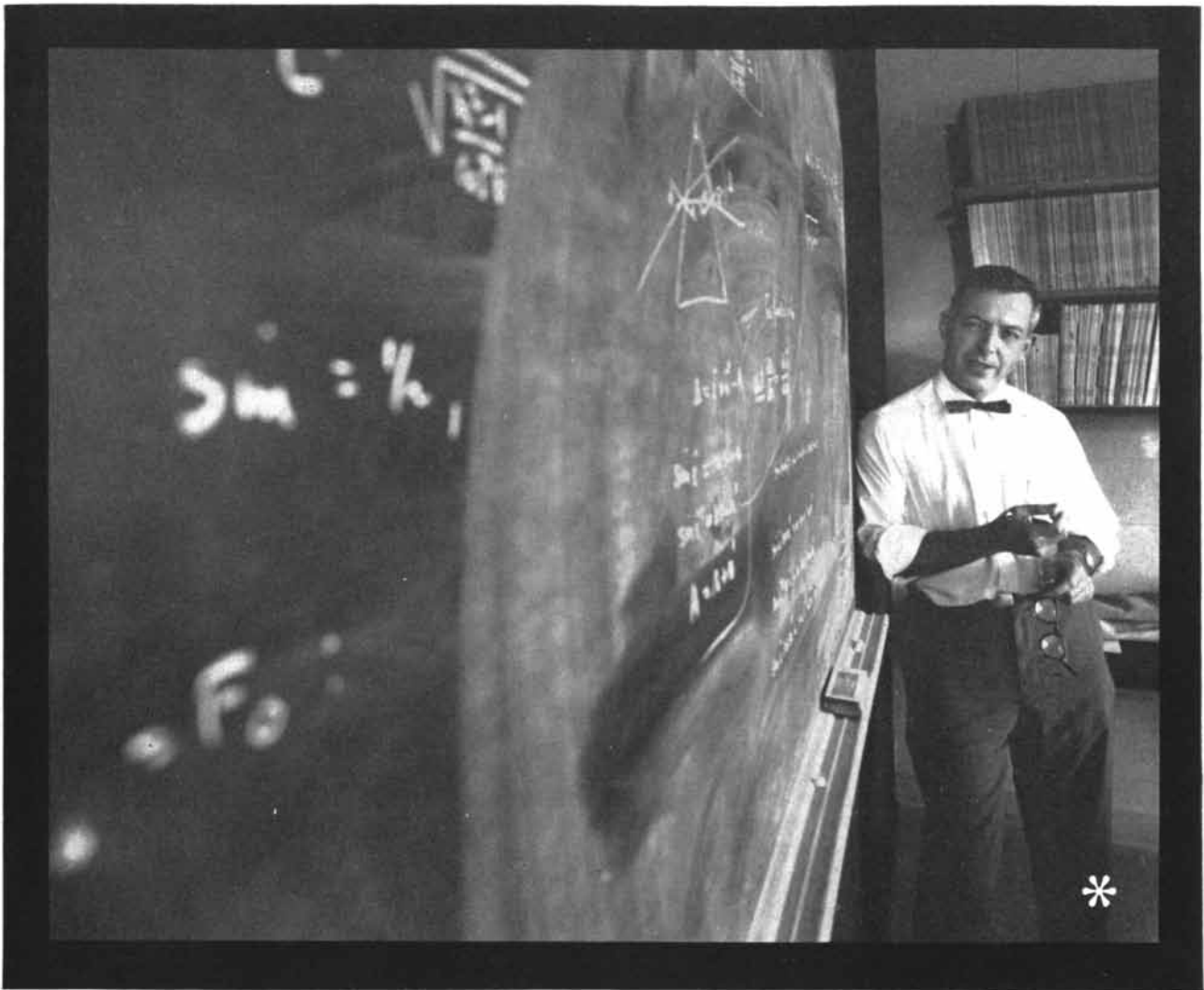
tion of the glow in partially evacuated vessels brought near an electrical machine, added other examples of the phenomenon. In 1888 the physicist E. Wiedemann recognized luminescence "as the antithesis to incandescence" and invented a classification, expressing the method of excitation, which has not been improved upon. He defined the categories of photoluminescence, where light itself is the exciting agent, which is divided into fluorescence and phosphorescence; thermoluminescence, which is light from gentle heating; electroluminescence, characteristic of gases in electrical fields; crystalloluminescence, occurring when solutions crystallize; triboluminescence, the emission of light on rubbing or crushing organic or inorganic crystals; chemiluminescence, which accompanies chemical reactions. (Bioluminescence, a property of many living animals and plants, is recognized as a form of chemiluminescence.) Since the formulation of the quantum theory and the development of atomic physics, a comprehensive theoretical basis has been laid for every type of luminescence. The postulated explanation is that when an atom or molecule acquires excess energy, one of its electrons is displaced to a higher energy level. The source of this energy may be light, X-rays, various particles (including other electrons), mechanical or chemical energy. After a time, depending on the cause of the displacement, the electron returns to the lower level and a quantum of light is emitted; the total of these quanta constitutes luminescence. Harvey, a foremost authority who has written many papers and books on the subject, has devoted 10 years of special study to the preparation of the present work, a detailed and fascinating survey from the earliest times until the discovery of the electron. As he points out, the modern era of physics ushered in by Max Planck has added a new dimension to the study of luminescence. With the help of sensitive instruments many phenomena have been detected which were hitherto invisible to the human eye, so that the "historian of the future will have a wholly new world of unseen luminescence with which to contend."

ARTIFICIAL INSEMINATION IN THE HUMAN, by A. Schellen. Elsevier Press, Incorporated (\$14). To the majority of readers it will probably come as a surprise to learn that more than 100,000 children were born in the U. S. during recent years as the result of artificial fertilization with the semen of a donor. Many more children were conceived in

intermarital artificial insemination. The growth of A.I., as it is called, led to the present monograph by a young Dutch physician who, in addition to studying the subject abroad, observed the methods used in sterility clinics throughout the U. S. Intermarital A.I. raises only medical and physiological questions; donor insemination, however, also has legal, social and theological implications. All of these are discussed by Schellen. He concludes, after long and soul-searching analysis, that while barren marriages are a misfortune, and donor insemination "may in many cases produce the desired result, a child," the means by which the result is achieved is "encumbered with many immoral, asocial and unnatural elements," which outweigh its advantages. This book proves once again that theology and science make an awkward pair.

LE CIEL ET LA TERRE, edited by André Danjon, Pierre Pruvost and Jules Blache. Librairie Larousse (8,850 francs). **LA PHYSIQUE**, edited by Louis de Broglie. Librairie Larousse (9,600 francs). These two books constitute Volumes II and III of *Encyclopédie Française*, 12 volumes of which have already appeared. *Le Ciel et la Terre* consists of articles by 36 leading French astronomers, geologists and geophysicists, embracing the present state of knowledge about the earth and the solar system, the sun and stars, galaxies, the terrestrial globe, the earth's crust, the formation of the earth's topography. To the volume on physics some 50 specialists contribute comprehensive and succinct surveys of such topics as measurement, the uses of mathematics in physics, symmetry and dissymmetry in physical phenomena, relativity theory, classical mechanics, electromagnetic theory, thermodynamics, elasticity, optics, acoustics, the structure of matter, crystallography, radar, fundamental particles, wave and quantum mechanics, nuclear physics. The articles are clearly written for a professional audience; there are many illustrations, and rather skimpy bibliographies.

DISCOVERY OF THE UNIVERSE, by Gérard de Vaucouleurs. The Macmillan Company (\$6). An outline of the history of astronomy from its origins to 1956. The author, who is on the staff of the Lowell Observatory in Flagstaff, Ariz., states that he is less concerned with biographical details than with the evolution of ideas. But even in this department he traverses whole periods at high velocity. All of pre-Copernican



an oblique look

tech/ops scientists know there are at least three ways of attacking a problem: head on, as an amphibious force hits a beach; flank-wise, as a tactician likes to strike; and *slantwise*, the offbeat way.

This is a basic principle in operations research, the new *team* method of attacking problems, in which *tech/ops* is a leader and pioneer. It is this habit of taking an oblique look—of applying a group of apparently unrelated disciplines to the problem—that has developed, at *tech/ops*, unique solutions in weapons systems, tactics, organizations and logistics.

You may profit by taking an oblique look at your own career problem—and joining a team of *tech/ops* scientists looking for new ways to the future.

Address: ROBERT L. KOLLER

TECHNICAL OPERATIONS, INCORPORATED
Burlington, Massachusetts

at your career in

BURLINGTON, MASS., or Washington, D.C.: mathematical statistician (PhD with five years' experience) for research in sensitivity of stochastic games, statistical analysis of such games; creative, with skill to develop essentially new mathematics in relatively unexplored area; also mathematician (PhD with five years' computer experience) to develop sophisticated computer programs.

FORT MONROE, VA.: Logician with computer knowledge; mathematical economist; electrical engineer with background in information or queuing theory; senior operations analyst, master's level or above, in physical sciences or mathematics.

MONTEREY, CALIF.: Applied mathematician with understanding of application of high speed computers to data analysis; scientist or engineer with heavy math orientation to act as project leader of field experimentation group; senior scientist on PhD level in operations research, math, physics.

(Please indicate location preference.)



* Dr. Eric Clarke, *tech/ops* vice president, takes a look at a problem in his office at Burlington, Mass.

P
H
O
E
N
I
X

At the crossroads of opportunity for men with vision in Electronic Engineering.

GOODYEAR AIRCRAFT CORPORATION

ELECTRONIC LABORATORY
Arizona Division
Litchfield Park, Arizona
A Subsidiary of the
GOODYEAR TIRE & RUBBER CO.

**WE HAVE OPENINGS IN OUR
MODERN LABORATORIES FOR
ADVANCED ENGINEERS
IN ELECTRONIC RESEARCH**

Long range research and development projects.

University of Arizona graduate studies available under company financed evening courses.

LEISURE LIVING AT ITS BEST
"IN THE VALLEY OF THE SUN"
Modern Inexpensive Housing
Send resume to: A. E. Manning
Engineering and Scientific Personnel

GOODYEAR AIRCRAFT

LITCHFIELD PARK
PHOENIX, ARIZONA
Similar opportunities available in our
Akron, Ohio, Laboratory

ATOM HARVEST



**A
British
View of
Atomic
Energy**

By Leonard Bertin

"... the bitter story of how British-American atomic collaboration broke down after the war, leaving Britain with no bombs of its own, and no plant or know-how to build them. Mr. Bertin . . . tells about Britain's remarkably quick, economical and successful program to acquire without American help both nuclear weapons and effective power reactors. He writes well, and is unhampered by official secrecy." N. Y. Times Book Review

Order directly from the publisher **\$3.25**



W. H. FREEMAN AND COMPANY

660 Market Street
San Francisco 4, Calif.

astronomy, for example, is disposed of in a few pages, with a single—and that not very helpful—sentence devoted to the system of deferents and epicycles. Modern developments, including galactic studies, solar-system and stellar physics, and radio astronomy are more deliberately served.

Notes

THE HYPERCIRCLE IN MATHEMATICAL PHYSICS, by J. L. Synge. Cambridge University Press (\$13.50). Professor Synge here describes a technique, to the development of which he has devoted 10 years, for the approximate solution of certain boundary value problems of mathematical physics.

MATHEMATICS FOR EVERYMAN, by Egmont Colerus. Emerson Books, Inc. (\$3.95). An English translation of a popular German survey of mathematics, from number systems to the calculus.

SURVEY OF BIOLOGICAL PROGRESS, edited by Bentley Glass. Academic Press, Inc. (\$7.50). Reviews of topics in biology: embryological concepts in the 20th century, trends in systematic botany, chemoreception and the behavior of insects, the mechanisms of action of hormones on cells, respiration and cellular work and the regulation of the respiration rate in plants.

BIOGRAPHICAL MEMOIRS OF FELLOWS OF THE ROYAL SOCIETY, VOL. II. The Royal Society (30 shillings). The 1956 obituary volume contains memoirs of 22 fellows, among them Walter Adams, Gleb Anrep, Alexander Fleming, Edmund Whittaker, Robert Wood.

SET THEORY, by Felix Hausdorff. Chelsea Publishing Company (\$6). An English translation from the third German edition of an authoritative work on the theory of sets.

VERTEBRATES OF THE UNITED STATES, by W. Frank Blair, Albert P. Blair, Pierce Brodkorb, Fred R. Cagle and George A. Moore. McGraw-Hill Book Company (\$12). An identification manual containing taxonomic keys, check lists, geographic ranges and descriptions of all known U. S. vertebrates.

HEAT TRANSFER, by Max Jakob. John Wiley & Sons, Inc. (Vol. I, \$13.50; Vol. II, \$15). The second volume of the late Max Jakob's treatise completes a monumental survey of the concepts (including their historical development), fundamental topics, basic analyses and applications of heat transfer.

AC-THE ELECTRONICS DIVISION OF GENERAL MOTORS.....	26, 27
Agency: D. P. Brother & Company	
ALLEN-BRADLEY CO.....	87
Agency: The Fensholt Advertising Agency, Inc.	
ALLIED CHEMICAL & DYE CORP.....	80
Agency: Benton & Bowles, Inc.	
ALTEC LANSING CORPORATION.....	8
Agency: Stromberger, LaVene, McKenzie: Advertising	
ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION.....	Inside Back Cover
Agency: Ketchum, MacLeod & Grove, Inc.	
AMERICAN CYANAMID COMPANY.....	62, 63
Agency: Hazard Advertising Company, Inc.	
AMERICAN OPTICAL COMPANY, INSTRUMENT DIVISION.....	51
Agency: Baldwin Bowers & Strachan, Division of The Rumrill Company Inc.	
AMPEX CORPORATION, INSTRUMENTATION DIVISION.....	57
Agency: Boland Associates	
ARGONNE NATIONAL LABORATORY.....	139
Agency: Grant-Jacoby Studios, Inc.	
ATOMICS INTERNATIONAL, A DIVISION OF NORTH AMERICAN AVIATION, INC.....	15
Agency: Batten, Barton, Durstine & Osborn, Inc.	
AVCO RESEARCH AND ADVANCED DEVELOPMENT DIVISION.....	143
Agency: Benton & Bowles, Inc.	
BARCOCK & WILCOX COMPANY, THE, ATOMIC ENERGY DIVISION.....	77
Agency: O. S. Tyson and Company, Inc.	
BAKELITE COMPANY, DIVISION OF UNION CARBIDE CORPORATION.....	6, 7
Agency: J. M. Mathes, Incorporated	
BAUSCH & LOMB OPTICAL CO.....	90
Agency: Ed Wolff & Associates	
BEATTIE JET PRODUCTS, INC.....	102
Agency: Rose-Martin, Inc.	
BELL TELEPHONE LABORATORIES.....	13
Agency: N. W. Ayer & Son, Incorporated	
BENDIX AVIATION CORPORATION, COMPUTER DIVISION.....	60
Agency: The Shaw Company	
BERKELEY ENTERPRISES, INC.....	124
Agency: Norman D. Waters & Associates, Inc.	
BOOK FIND CLUB, THE.....	151
Agency: Roeding & Arnold Incorporated	
BRITISH INDUSTRIES CORPORATION.....	102
Agency: The Zlowe Company	
BULOVA WATCH COMPANY, BULOVA RESEARCH AND DEVELOPMENT LABORATORIES, INC.....	1
Agency: Duncan-Brooks Inc.	
BURNDY CORPORATION.....	23
Agency: Ted Gravenson, Inc.	
CARBORUNDUM COMPANY, THE.....	18, 19
Agency: G. M. Basford Company	
CITY BANK FARMERS TRUST COMPANY.....	2
Agency: Lewin, Williams & Saylor, Inc.	
COOPER ALLOY CORPORATION.....	25
Agency: St. Georges & Keyes, Inc.	
COPPER & BRASS RESEARCH ASSOCIATION, THE.....	115
Agency: J. M. Hickerson Inc.	
CORNING GLASS WORKS.....	109
Agency: The Rumrill Company Inc.	
DECKER CORPORATION, THE.....	111
Agency: The Harry P. Bridge Company	
DOUGLAS AIRCRAFT COMPANY, INC.....	78, 79, 148
Agency: J. Walter Thompson Company	
DOVER PUBLICATIONS, INC.....	153
Agency: Equity Advertising Agency	
DOW CORNING CORPORATION.....	55
Agency: Church and Guisewite Advertising, Inc.	

INDEX OF ADVERTISERS

MARCH, 1958

DU MONT, ALLEN B., LABORATORIES, INC., INDUSTRIAL TUBE SALES.....	75	INSTRON ENGINEERING CORPORATION.....	10	PARSONS, RALPH M., COMPANY, THE.....	21
Agency: Lescarboursa Advertising, Inc.		Agency: Larcom Randall Advertising, Inc.		Agency: Dozier Eastman and Company	
DU MONT, ALLEN B., LABORATORIES, RESEARCH AND DEVELOPMENT DIVISION	124	INTERNATIONAL BUSINESS MACHINES CORPORATION.....	129	PERKIN-ELMER CORPORATION.....	85
Agency: Conti Advertising Agency, Inc.		Agency: Benton & Bowles, Inc.		Agency: G. M. Basford Company	
DU PONT DE NEMOURS, E. I., & CO., INC., ELASTOMER CHEMICALS DEPT.....	101	JAEGERS, A.....	138	PHILLIPS CHEMICAL COMPANY, PLASTIC SALES DIVISION, A SUBSIDIARY OF PHILLIPS PETROLEUM COMPANY.....	17
Agency: N. W. Ayer & Son, Incorporated		Agency: Carol Advertising Agency		Agency: Lambert & Feasley, Inc.	
DU PONT DE NEMOURS, E. I., & CO., INC., FILM DEPT.....	97	JOHNS HOPKINS UNIVERSITY, THE, APPLIED PHYSICS LABORATORY.....	106	PHILOSOPHICAL LIBRARY, PUBLISHERS.....	146
Agency: Batten, Barton, Durstine & Osborn, Inc.		Agency: M. Belmont Ver Standig, Inc.		Agency: The Leonard Rattner Co.	
DU PONT DE NEMOURS, E. I., & CO., INC., POLYCHEMICALS DEPARTMENT.....	131	KENNAMETAL INCORPORATED.....	50	PLASTICS ENGINEERING COMPANY.....	12
Agency: Batten, Barton, Durstine & Osborn, Inc.		Agency: Ketchum, MacLeod & Grove, Inc.		Agency: Kuttner & Kuttner, Inc.	
DU PONT DE NEMOURS, E. I., & CO., INC., TEXTILE FIBERS DEPARTMENT.....	116, 117	LEFAX PUBLISHERS.....	154	PUTNAM'S, G. P., SONS.....	154
Agency: Batten, Barton, Durstine & Osborn, Inc.		Agency: H. Lesseroux		Agency: Denhard & Stewart, Inc.	
DUTTON, E. P., & CO.....	156	LIBRARY OF SCIENCE, THE.....	144	RADIO CORPORATION OF AMERICA, DEFENSE ELECTRONIC PRODUCTS.....	164
Agency: Franklin Spier, Inc.		Agency: B. L. Mazel, Inc., Advertising		Agency: Al Paul Lefton Company Inc.	
EASTMAN KODAK COMPANY.....	49	LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION.....	14	RADIO CORPORATION OF AMERICA, INDUSTRIAL ELECTRONIC PRODUCTS.....	83
Agency: The Rumrill Company Inc.		Agency: J. M. Mathes, Incorporated		Agency: Al Paul Lefton Company Inc.	
EDMUND SCIENTIFIC CO.....	137	LINDSAY CHEMICAL COMPANY.....	24	RAMO-WOOLDRIDGE CORPORATION, THE	16
Agency: Walter S. Chittick Company		Agency: C. Franklin Brown, Inc.		Agency: The McCarty Co.	
FERSON OPTICAL COMPANY, INC.....	138	LINGUAPHONE INSTITUTE.....	156	RAND CORPORATION, THE.....	28
Agency: Godwin Advertising Agency		Agency: The Kaplan Agency, Inc., Div. of Lewin, Williams & Saylor, Inc.		Agency: Calkins & Holden, Incorporated	
FORD INSTRUMENT COMPANY, DIVISION OF SPERRY RAND CORPORATION.....	125	LOCKHEED MISSILE SYSTEMS DIVISION, LOCKHEED AIRCRAFT CORPORATION.....	161	SANDIA CORPORATION.....	163
Agency: James Thomas Chirurg Company		Agency: Hal Stebbins, Inc.		Agency: Ward Hicks Advertising	
FOXBORO COMPANY, THE.....	113	LUDWIG, F. G., INC.....	52	SCHAUM PUBLISHING COMPANY.....	147
Agency: Noyes & Company, Incorporated		Agency: Van Lear Woodward Associates, Inc.		Agency: Sam Singer Advertising	
FREEMAN, W. H., AND COMPANY.....	158	MALLORY-SHARON METALS CORPORATION	5	SIGMA INSTRUMENTS, INC.....	56
GARFIELD, OLIVER, CO., INC.....	110, 136	Agency: The Griswold-Eshleman Co.		Agency: Culver Advertising, Inc.	
Agency: Daniel & Charles, Inc.		M I T LINCOLN LABORATORY.....	162	SOLAR AIRCRAFT COMPANY.....	99
GARRETT CORPORATION, THE, AIRESEARCH MANUFACTURING DIVISIONS.....	121	Agency: Randolph Associates		Agency: The Phillips-Ramsey Company	
Agency: J. Walter Thompson Company		MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL PRODUCTS GROUP.....	123	SPERRY GYROSCOPE COMPANY, DIVISION OF SPERRY RAND CORPORATION.....	92, 93
GENERAL ATOMIC DIVISION OF GENERAL DYNAMICS CORPORATION.....	Back Cover	Agency: The Aitkin-Kynett Co., Inc.		Agency: Reach, McClinton & Co., Inc.	
Agency: Barnes Chase Company		MINNESOTA MINING AND MANUFACTURING COMPANY.....	88, 89	STATHAM INSTRUMENTS, INC.....	20
GENERAL MOTORS CORPORATION, NEW DEPARTMENT DIVISION.....	91	Agency: MacManus, John & Adams, Inc.		Agency: Compton Advertising, Inc., Industrial Division	
Agency: D. P. Brother & Company		MODERNOPHONE, INC.....	112	STOKES F. J., CORPORATION, VACUUM EQUIPMENT DIVISION.....	53
GENERAL PRECISION EQUIPMENT CORPORATION.....	132, 133	Agency: The Kaplan Agency, Inc., Div. of Lewin, Williams & Saylor, Inc.		Agency: The Aitkin-Kynett Co., Inc.	
Agency: Geer, DuBois & Company, Inc.		MONSANTO CHEMICAL COMPANY, ORGANIC CHEMICALS DIVISION.....	103	SYSTEM DEVELOPMENT CORPORATION.....	122
GOODYEAR AIRCRAFT CORPORATION, A SUBSIDIARY OF THE GOODYEAR TIRE & RUBBER CO.....	158	Agency: Gardner Advertising Company		Agency: Stromberger, LaVene, McKenzie: Advertising	
GRAPHIC SYSTEMS.....	112	NEW YORK STATE DEPARTMENT OF COMMERCE.....	84	TECHNICAL OPERATIONS, INCORPORATED	157
Agency: Diener & Dorskind Incorporated		Agency: Kelly, Nason, Incorporated		Agency: Dawson Mac Leod & Stivers	
GREAT BOOKS OF THE WESTERN WORLD.....	155	NORTON COMPANY, REFRACTORIES DIVISION.....	11	UNION CARBIDE CORPORATION.....	Inside Front Cover
Agency: Dancer-Fitzgerald-Sample, Incorporated		Agency: James Thomas Chirurg Company		Agency: J. M. Mathes, Incorporated	
HAMILTON STANDARD DIVISION OF THE UNITED AIRCRAFT CORPORATION, ELECTRONICS DEPT.....	141	NUCLEAR MEASUREMENTS CORP.....	58	UNION CARBIDE CORPORATION, BAKELITE DIVISION.....	6, 7
Agency: Chambers Wiswell Shattuck Clifford & McMillan, Inc.		Agency: W. H. Rohr, Jr.		Agency: J. M. Mathes, Incorporated	
HAYDON, A. W., COMPANY, THE.....	58	NUCLEAR PRODUCTS—ERCO DIVISION OF ACF INDUSTRIES INCORPORATED.....	9	UNION CARBIDE CORPORATION, LINDE DIVISION.....	14
Agency: Cory Snow, Inc.		Agency: Conti Advertising Agency, Inc.		Agency: J. M. Mathes, Incorporated	
HEWLETT-PACKARD COMPANY.....	107	NUCLEAR SCIENCE AND ENGINEERING CORPORATION.....	4	UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.....	140
Agency: L. C. Cole Company-Inc.		Agency: Lando Advertising Agency		Agency: Robert Hartwell Cabine, Advertising	
HUGHES PRODUCTS, A DIVISION OF HUGHES AIRCRAFT COMPANY.....	126, 127	OPERATIONS RESEARCH OFFICE, THE, JOHNS HOPKINS UNIVERSITY.....	160	UTICA DROP FORGE AND TOOL DIVISION, KELSEY-HAYES CO.....	61
Agency: Foote, Cone & Belding		Agency: M. Belmont Ver Standig, Inc.		Agency: Zimmer, Keller & Calvert, Inc.	
INDUSTRIAL EXHIBITIONS LIMITED.....	22	OXFORD UNIVERSITY PRESS, INC.....	150	VAN NOSTRAND, D., COMPANY, INC.....	149
Agency: Commercial Publicity (London) Ltd.		Agency: Denhard & Stewart, Inc.		Agency: Lewin, Williams & Saylor, Inc.	
INSTITUTE FOR AIR WEAPONS RESEARCH, THE UNIVERSITY OF CHICAGO.....	58	PARKER-HARTFORD CORPORATION, THE, CAM DIVISION.....	114	VARIAN ASSOCIATES, TUBE DIVISION.....	59
Agency: K. C. Shenton Advertising Service		Agency: K. C. Shenton Advertising Service		Agency: Boland Associates	
				VITRO CORPORATION OF AMERICA.....	54
				Agency: Molesworth Associates	
				WESTINGHOUSE ELECTRIC CORPORATION, ATOMIC POWER DEPARTMENT.....	130
				Agency: Ketchum, MacLeod & Grove, Inc.	
				WESTINGHOUSE ELECTRIC CORPORATION, BETTIS ATOMIC POWER DIVISION.....	142
				Agency: Groody Advertising Co.	
				YALE UNIVERSITY PRESS.....	152
				Agency: Langeler-Stevens, Inc.	

AN INVITATION TO JOIN ORO

Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

At ORO, a civilian and non-governmental organization, you will become one of a team assigned to vital military problems in the area of tactics, strategy, logistics, weapons systems analysis and communications.

No other Operations Research organization has the broad experience of ORO. Founded in 1948 by Dr. Ellis A. Johnson, pioneer of U. S. Opsearch, ORO's research findings have influenced decision-making on the highest military levels.

ORO's professional atmosphere encourages those with initiative and imagination to broaden their scientific capabilities. For example, staff members are taught to "program" their own material for the Univac computer so that they can use its services at any time they so desire.

ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

The cultural and historical features which attract visitors to Washington, D. C. are but a short drive from the pleasant Bethesda suburb in which ORO is located. Attractive homes and apartments are within walking distance and readily available in all price ranges. Schools are excellent.

For further information write:
Professional Appointments

**OPERATIONS RESEARCH
OFFICE** 

The Johns Hopkins University

6935 ARLINGTON ROAD
BETHESDA 14, MARYLAND

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful.

ATOMIC POWER IN BRITAIN

ATOMIC ENERGY RESEARCH AT HARWELL. K. E. B. Jay. Philosophical Library, 1955.

CALDER HALL: THE STORY OF BRITAIN'S FIRST ATOMIC POWER STATION. Kenneth Jay. Harcourt, Brace & Company, Inc., 1956.

THE GRAPHITE-MODERATED GAS-COOLED PILE AND ITS PLACE IN POWER PRODUCTION. "Sir Christopher Hinton in *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy*, Vol. 3, paper 406, pages 322-329; August, 1955.

HARWELL: THE BRITISH ATOMIC ENERGY RESEARCH ESTABLISHMENT, 1946-1951. Philosophical Library, 1952.

NUCLEAR ENERGY IN BRITAIN. British Information Services, 1957.

THE FIRE ANT

EFFECTS OF DIELDRIN ON FISHES AND INVERTEBRATES OF A SALT MARSH. Robert W. Harrington, Jr., and William L. Bidlingmayer in *Journal of Wildlife Management*, Vol. 22, No. 1, pages 76-82; January, 1958.

EVALUATION OF WILDLIFE IMPORTATIONS. Herbert W. Levi in *The Scientific Monthly*, Vol. 74, No. 6, pages 315-322; June, 1952.

INTRODUCED MAMMALS AND THEIR INFLUENCE ON NATIVE BIOTA. Antoon de Vos, Richard H. Manville and Richard G. Van Gelder in *Zoologica*, Vol. 41, part 4, pages 163-194; December 31, 1956.

THE NATURAL HISTORY OF ANTS. Translated and annotated from an unpublished manuscript of René Antoine Ferchault de Réaumur by William Morton Wheeler. Alfred A. Knopf, 1926.

VARIATION AND ADAPTATION IN THE IMPORTED FIRE ANT. Edward O. Wilson in *Evolution*, Vol. 5, No. 1, pages 68-79; March, 1951.

NORMAN CASTLES

THE BAYEUX TAPESTRY. Eric Maclagan. Penguin Books Limited, 1943.

THE BAYEUX TAPESTRY: A COMPREHEN-

SIVE SURVEY. Sir Frank Stenton, Simone Bertrand, George Wingfield Digby, Charles H. Gibbs-Smith, Sir James Mann, John L. Nevinson and Francis Wormald. Phaidon Publishers, Inc., 1957.

RECENT ARCHAEOLOGICAL EXCAVATIONS IN BRITAIN. Edited by R. L. S. Bruce-Mitford. Routledge & Kegan Paul, Limited, 1956.

PARTICLE ACCELERATORS

THE CYCLOTRON. W. B. Mann. Methuen & Co., Ltd., 1940.

HIGH-ENERGY ACCELERATORS. M. Stanley Livingston. Interscience Publishers, Inc., 1954.

NUCLEAR REACTORS FOR RESEARCH. Edited by Clifford K. Beck. D. Van Nostrand Company, Inc., 1956.

"IMPRINTING" IN ANIMALS

EFFECTS OF MEPROBAMATE ON IMPRINTING IN WATERFOWL. Eckhard H. Hess in *Annals of The New York Academy of Sciences*, Vol. 67, Article 10, pages 724-733; May 9, 1957.

KING SOLOMON'S RING: NEW LIGHT ON ANIMAL WAYS. Konrad Z. Lorenz. Thomas Y. Crowell, 1952.

LEARNING AND INSTINCT IN ANIMALS. William Homan Thorpe. Harvard University Press, 1956.

HELMHOLTZ

HERMANN LUDWIG FERDINAND VON HELMHOLTZ. John Gray M'Kendrick. T. Fisher Unwin, 1899.

HERMANN VON HELMHOLTZ. Leo Koenigsberger. Translated from the German by F. A. Welby. Oxford University Press, 1906.

ON THE SENSATIONS OF TONE AS A PHYSIOLOGICAL BASIS FOR THE THEORY OF MUSIC. Hermann von Helmholtz. Translated from the German by Alexander J. Ellis. Peter Smith, 1948.

HELMHOLTZ'S TREATISE ON PHYSIOLOGICAL OPTICS. Edited by James P. C. Southall. Optical Society of America, 1924-25.

HYPOTHERMIA

HIBERNATION. Charles P. Lyman and Paul O. Chatfield in *Scientific American*, Vol. 183, No. 6, pages 18-21; December, 1950.

HYPOTHERMIC ANESTHESIA. Robert W. Virtue. Charles C. Thomas, Publisher, 1955.

THE METABOLIC RATES AND BODY TEMPERATURES OF BATS. Raymond J.

*A report to engineers and scientists from Lockheed Missile Systems—
where expanding missile programs insure more promising careers.*

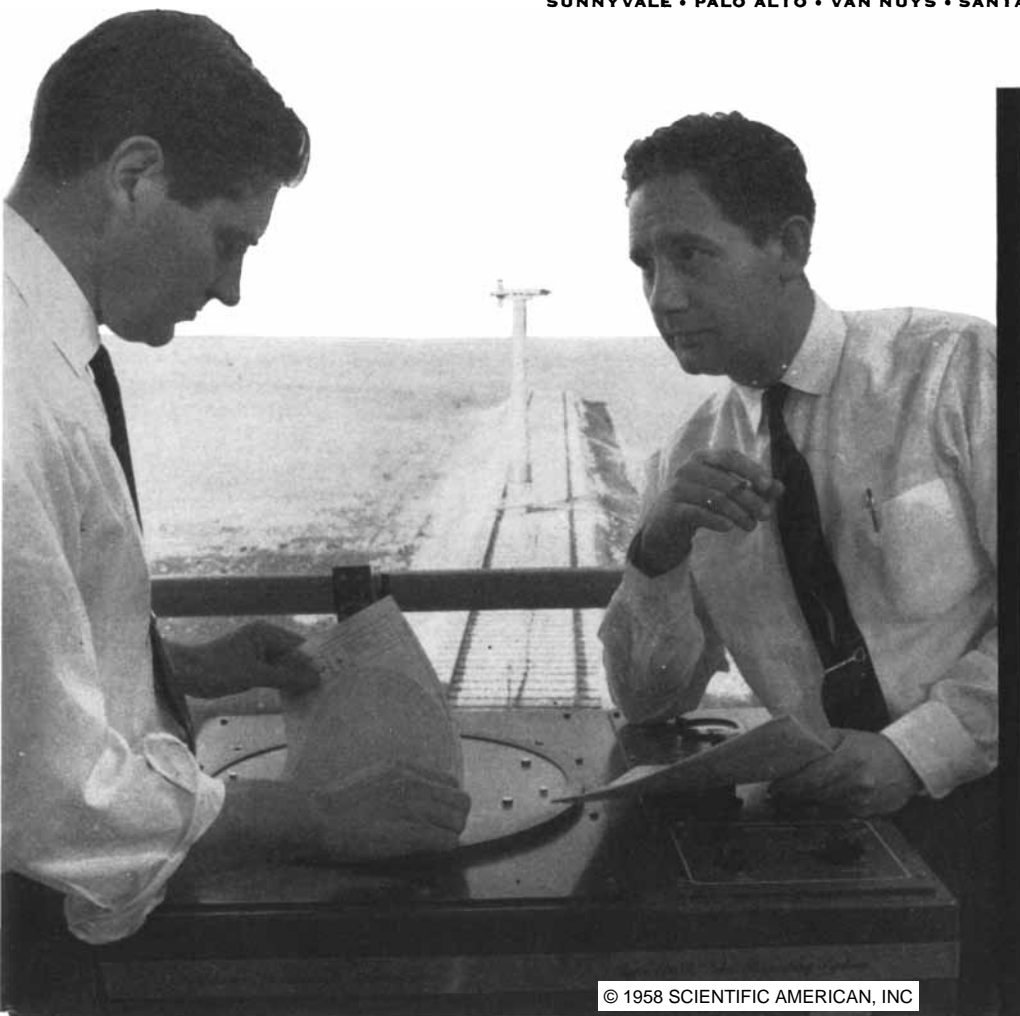
NEW LAB MEASURES ANTENNA PATTERNS; PROBES OUTER SPACE

A new laboratory at Sunnyvale, California today gives Lockheed scientists antenna patterns, scattering and propagation data, and promises exciting new discoveries in the problems of space communication. Laboratory studies include the effect of upper space on radar and radio signals, the radar pattern presented by space vehicles and missile shapes, and the design of antennas to survive the rigorous environment of the upper atmosphere and hypersonic speeds. Findings could pave the way for communication with manned space ships of the future or for the remote guidance of unmanned space ships.

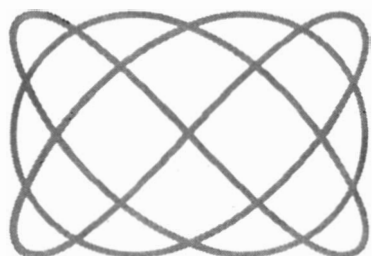
Research and development studies by Division scientists contribute heavily to the projects that place Lockheed in the forefront of U.S. missile developers. These projects include the Polaris solid fuel ballistic missile, Q-5 target ramjet, and X-7 test vehicle. Positions created by expansion on these and still other programs we cannot discuss offer unusual opportunities for advancement with our growing young division. Besides Antenna and Propagation, openings are in **Solid State Electronics, Telecommunications, Instrumentation, Radar and Data Link**. Other openings include **Information Processing, Reliability-Producibility, Ground Support, Flight Controls**. Qualified engineers or scientists may write to M. W. Peterson, Research and Development Staff, Palo Alto 4, California.

Lockheed **MISSILE SYSTEMS**

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE • PALO ALTO • VAN NUYS • SANTA CRUZ • CALIFORNIA



Mr. Emmanuel A. Blasi, right, Manager of Antenna and Propagation Department, discusses results of radiation performance after antenna pattern measurements with staff scientist Allen S. Dunbar. Column bearing missile in background is operated automatically from laboratory.



PHYSICISTS

ENGINEERS

MATHEMATICIANS

are invited to join the Lincoln Laboratory scientists and engineers whose ideas have contributed to new concepts in the field of electronic air defense.

A brochure describing the following Laboratory programs will be forwarded upon request.

HEAVY RADARS
MEMORY DEVICES
TRANSISTORIZED DIGITAL COMPUTERS
SCATTER COMMUNICATIONS
SOLID STATE
AEW (air-borne early warning)
SAGE (semi-automatic ground environment)
SYSTEMS ANALYSIS

In certain of these programs, positions of significant professional scope and responsibility are open to men and women with superior qualifications.



Research and Development

MIT

LINCOLN LABORATORY
BOX 18
LEXINGTON 73, MASSACHUSETTS

Hock in *The Biological Bulletin*, Vol. 101, No. 3, pages 289-299; December, 1951.

PHYSIOLOGY OF HIBERNATION IN MAMMALS. C. P. Lyman and P. O. Chatfield in *Physiological Reviews*, Vol. 35, No. 2, pages 403-425; April, 1955.

THE MICROSOME

AMINO-ACID SEQUENCE OF THE α -MELANOCYTE-STIMULATING HORMONE. J. Ieuan Harris and Aaron B. Lerner in *Nature*, Vol. 179, No. 4,574, pages 1,346-1,347; July 29, 1957.

THE ENDOPLASMIC RETICULUM. George E. Palade in *The Journal of Biophysical and Biochemical Cytology*, supplement to Vol. 2, No. 4, pages 85-98; July 25, 1956.

ENZYMATIC CARBOXYL ACTIVATION OF AMINO ACIDS. Mahlon B. Hoagland, Elizabeth B. Keller and Paul C. Zamecnik in *The Journal of Biological Chemistry*, Vol. 218, No. 1, pages 345-358; January, 1956.

MEMBRANE STRUCTURES OF CYTOPLASM AND MITOCHONDRIA IN EXOCRINE CELLS OF MOUSE PANCREAS AS REVEALED BY HIGH RESOLUTION ELECTRON MICROSCOPY. F. S. Sjöstrand and V. Hanzon in *Experimental Cell Research*, Vol. 7, No. 2, pages 393-414; November, 1954.

NUCLEIC ACIDS. F. H. C. Crick in *Scientific American*, Vol. 197, No. 3, pages 188-200; September, 1957.

POWERHOUSE OF THE CELL. Philip Siekevitz in *Scientific American*, Vol. 197, No. 1, pages 131-140; July, 1957.

STUDIES ON THE MECHANISM OF PROTEIN SYNTHESIS. P. C. Zamecnik, Elizabeth B. Keller, M. B. Hoagland, J. W. Littlefield and R. B. Loftfield in *Ciba Foundation Symposium on Ionizing Radiations and Cell Metabolism*, pages 161-173; 1956.

MATHEMATICAL GAMES

IS NATURE AMBIDEXTROUS? Martin Gardner in *Philosophy and Phenomenological Research*, Vol. 13, No. 2, pages 200-211; December, 1952.

ON SYMMETRY. Ernst Mach in *Popular Scientific Lectures*, 1895.

SYMMETRY. Hermann Weyl. Princeton University Press, 1952.

THE AMATEUR SCIENTIST

MICROBES AND YOU. Stanley E. Wedberg. The Macmillan Company, 1957.

FUNDAMENTALS OF MICROBIOLOGY. Martin Frobisher. W. B. Saunders Co., 1957.

ABOUT

MEN AND WEAPONS



For centuries men have tried to develop new and more powerful weapons to achieve victory in war.

Lately these have been weapons of unprecedented power.

Now war can become race suicide, and victory thus gained is a delusion.

Yet we keep on trying to develop new and more powerful weapons, because we must.

Not because we seek victory through a nuclear war, but because through strength we may prevent one.

For as long as there are powerful forces with a record of cynical duplicity and oppression, the free world must have weapons capable of neutralizing them.

At least until men learn that the only alternate to peace is oblivion.

At Sandia, we play an important part in providing this protective strength. Our

scientists and engineers are responsible for research, design, and development of nuclear weapons for the Atomic Energy Commission. This makes these men exceptionally valuable assets in our nation's efforts to secure the future.

We need more such men — outstanding engineers and scientists in many fields, especially at the highest academic and experience levels. At Sandia in Albuquerque and at our branch laboratory in Livermore, California, we need their knowledge, skill, and perseverance.

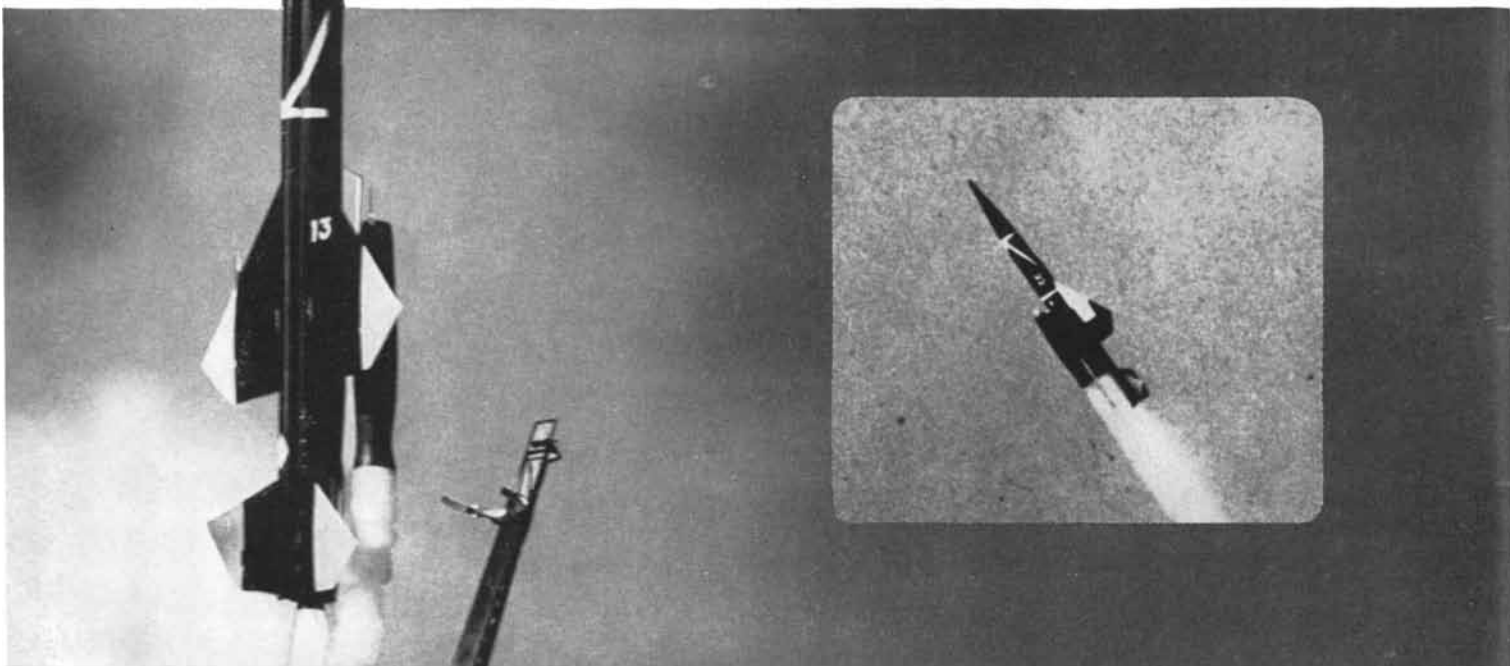
If you can help us meet this need, or if you know anyone who can, write Staff Employment Section 569.

SANDIA
CORPORATION

ALBUQUERQUE, NEW MEXICO

Preserver of Peace...

BOMARC



Official U.S. Air Force Photo

It tracks down an enemy at 300 miles

Described as the most potent of all ground-to-air defense missiles, the Bomarc pilotless interceptor, designed by Boeing, stands poised for the destruction of any "enemy" bomber within a 200-300 mile range. Its booster rocket has the power to hurl it more than 60,000 feet straight

up; then, powered by two ramjet engines, it hurtles by electronic instinct to its target at up to 3 times the speed of sound. For this guardian of our homes and way of life, RCA has been privileged to supply important advance components of the guidance system.



RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, NEW JERSEY



mix imagination with Alcoa Aluminas

to discover new worlds of product and process improvement. It is difficult to find an industry in which some form of product or process improvement has not been made possible by imaginative use of Alcoa® Aluminas. Rubber and plastics, glass, textiles, machine tools, porcelain, abrasives, refractories, enamel, paper and ink, cosmetics . . . all these and scores of other products have had their physical, chemical, thermal or electrical properties improved by Alcoa Aluminas. Specific performance requirements are met precisely by a wide range of high purity aluminas. Additional types and grades are constantly

being developed by Alcoa research to meet special needs. If you have a product or process problem, it will pay you to see what happens when you mix imagination with Alcoa Aluminas.

For information concerning your particular problems, write ALUMINUM COMPANY OF AMERICA, Chemicals Division, 706-C Alcoa Building, Pittsburgh 19, Pa.

For finer products . . . let Alcoa add new directions to your creative thinking!



"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

A NEW HARNESS FOR
THE PEACEFUL ATOM

URANIUM-ZIRCONIUM HYDRIDE is a recent
accomplishment of many minds and hands
at General Atomic's John Jay Hopkins

Laboratory for Pure and Applied Science.
General Atomic scientists achieved the massive
hydriding of uranium-zirconium alloy —
providing a new, solid homogeneous nuclear
fuel-moderator — making possible the con-
struction of compact, inherently safe nuclear
reactors operating at useful power levels.



Construction of *TRIGA*, a 10 kw, training,
research and isotope producing reactor is
nearing completion at the Laboratory.

TRIGA is one of three inherently safe research
reactor types designed by General Atomic.

Its core elements contain uranium-zirconium
hydride — fuel and moderator — a new,
safe harness for the peaceful atom — a joint
achievement of pure and applied science.

GENERAL ATOMIC
DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO 12, CALIFORNIA

Research, development and production
in the nuclear field Basic research in the
sciences Advanced fission power systems
Controlled thermonuclear research
Research and isotope reactors