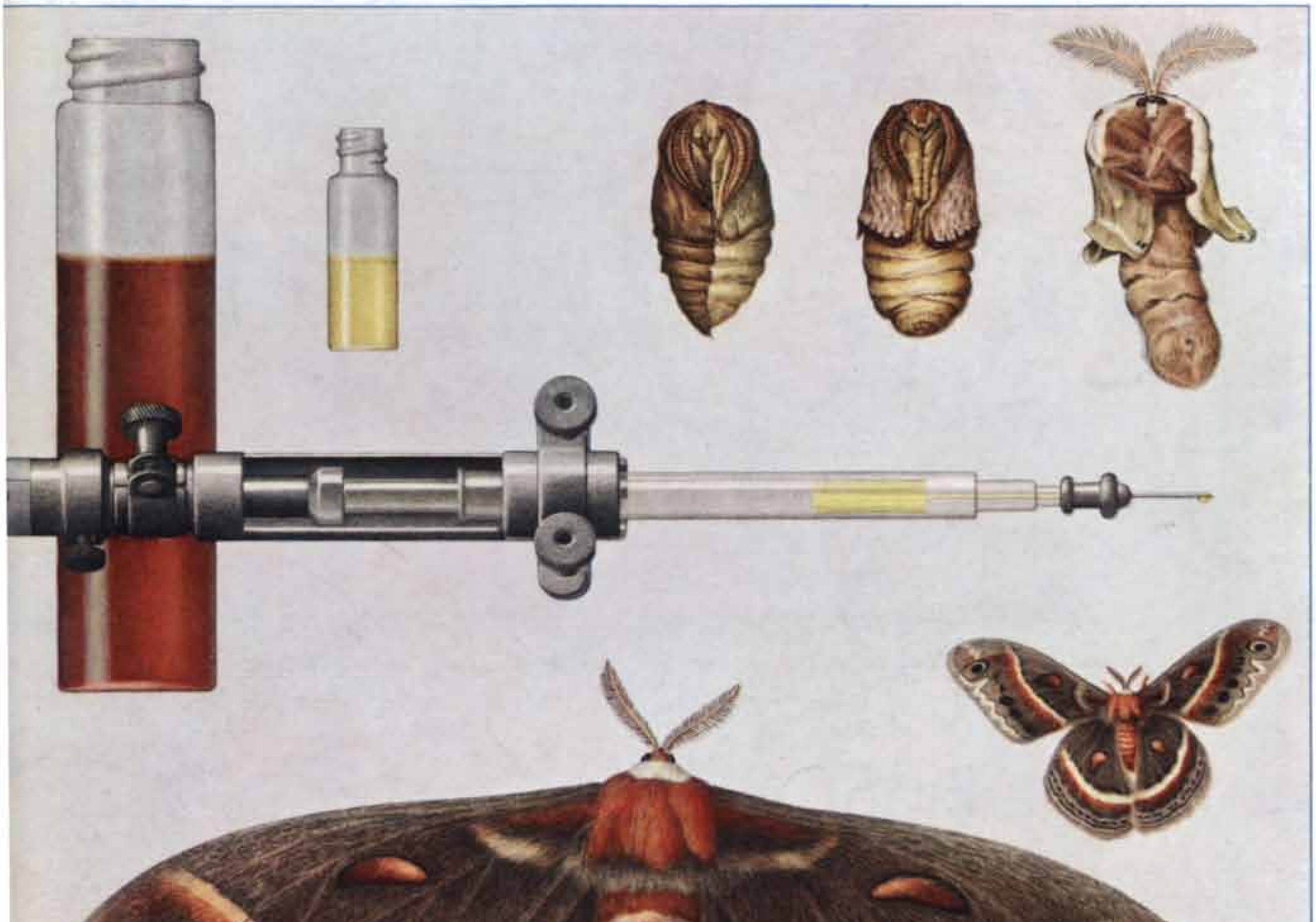
SCIENTIFIC AMERICAN



INSECT HORMONE

FIFTY CENTS

February 1958

How to make a brand weigh more

TO THE MAN with a taste for thick, juicy steaks—or the rancher who stakes his brand and reputation on the beef he ships to market, here is news . . .

Beef cattle are growing bigger and healthier now, with the help of Shell Chemical's new fertilizers applied to rangeland. Growth of grass and clover is *doubled* because of this new concept in beef production, developed by university and government researchers.

Forage grows earlier, faster, richer. And better grass naturally grows better steers. More profitably, too. Shell's pioneering tests have already shown that fertilizer costs can be repaid threefold when the fattened cattle reach market.

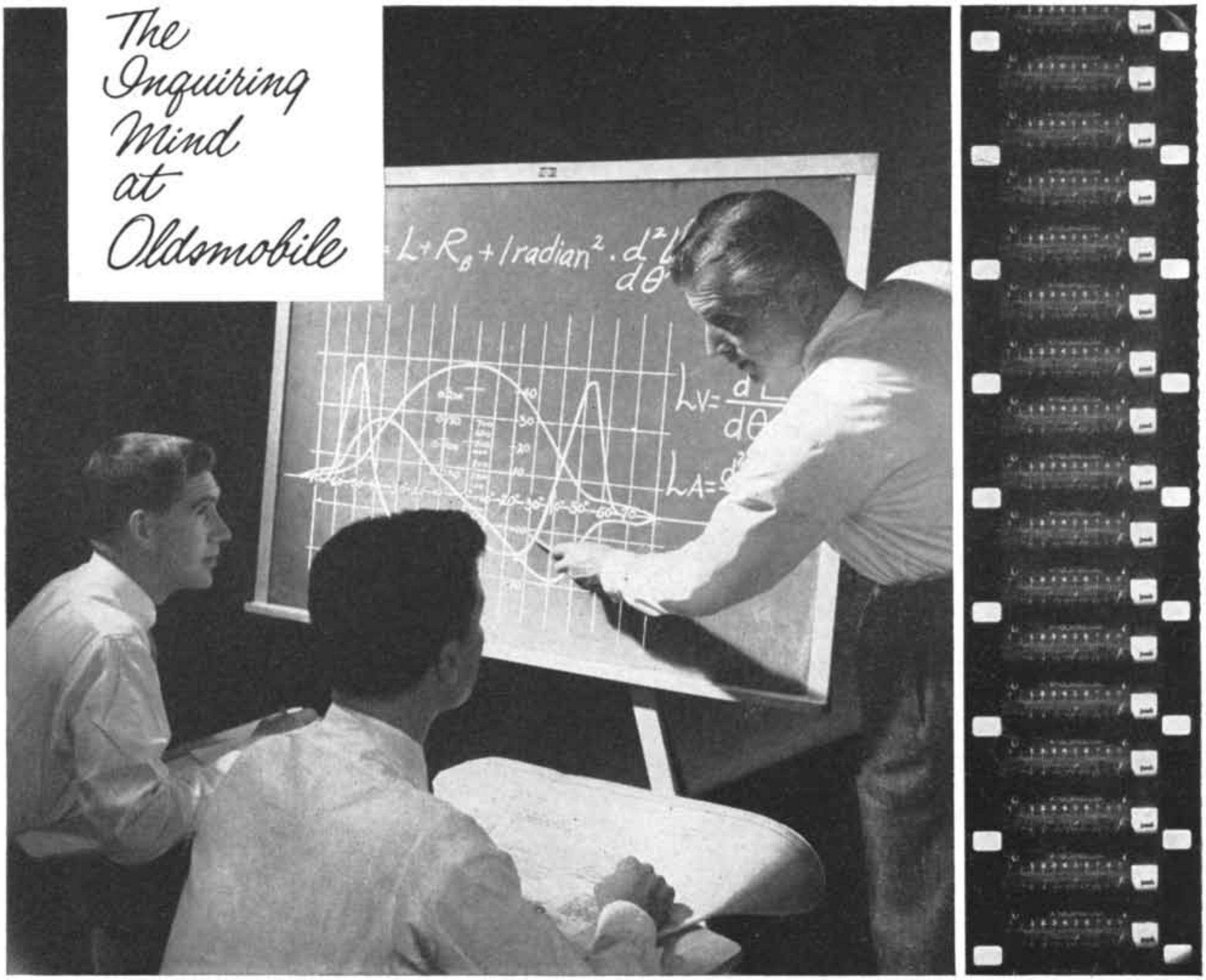
Next time you sink your teeth into an unusually tasty steak, remember that this may have come about because Shell helped Nature do her job better.

Shell Chemical Corporation

Chemical Partner of Industry and Agriculture

SAN FRANCISCO

SHELL



no.1 OF A SERIES

FORMULA FOR A NEW BABY OF OURS

High speed photography helps Oldsmobile engineers translate the theory of camshaft design into practical reality.

Developing the "brains" of an engine—its camshaft—demands engineering skill of a high order, both in theory *and* practice. Advanced techniques of precision measurement guide Oldsmobile engineers in creating a profile design of optimum efficiency.

To determine exactly what happens in a valve train system, movies are taken at speeds up to 15,000 frames per second. The valve train under study is assembled in an engine block and driven by an electric dynamometer at precisely controlled speeds. A vernier scale, silver soldered to the valve spring retainer, is photographed as it moves with the valve's opening and closing.

Essentially, these photographs act as an analog computer. Analysis gives a plot of the actual "lift curve" of the camshaft—the exact linear movement of the valve at each degree of camshaft rotation. It tells at what points the valve opens and closes and also whether the valve lifter is following the cam as it should. This curve, compared to the theoretical lift curve is a definite point for refining to begin—to make sure that design theory will be production practice. With this exact and rapid technique of analysis, as many as 50 experimental camshafts may be tested before a final design is fixed.

The Inquiring Mind at Oldsmobile is never at rest in its attempt to build the best engineered car in the industry. Test drive the '58 Oldsmobile and you'll find it's the finest product in our 60-year history.

OLDSMOBILE DIVISION, GENERAL MOTORS CORP.

OLDSMOBILE

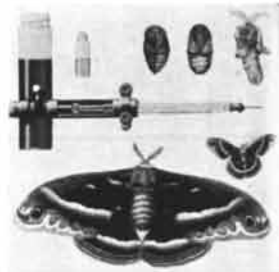
Pioneer in Progressive Engineering
...Famous for Quality Manufacturing

Established 1845 **SCIENTIFIC AMERICAN** February, 1958 Volume 198 Number 2

ARTICLES

DEPARTMENTS

PUBLISHED MONTHLY BY SCIENTIFIC AMERICAN, INC., 415 MADISON AVENUE, NEW YORK 17, N. Y. COPYRIGHT 1958 IN THE U. S. AND BERNE CONVENTION COUNTRIES BY SCIENTIFIC AMERICAN, INC. ALL RIGHTS RESERVED. ENTERED AT THE NEW YORK, N. Y., POST OFFICE AS SECOND-CLASS MATTER JUNE 28, 1879, UNDER THE ACT OF MARCH 3, 1879. ADDITIONAL ENTRY AT GREENWICH, CONN. SUBSCRIPTION RATE IN THE U. S. $5 PER YEAR.



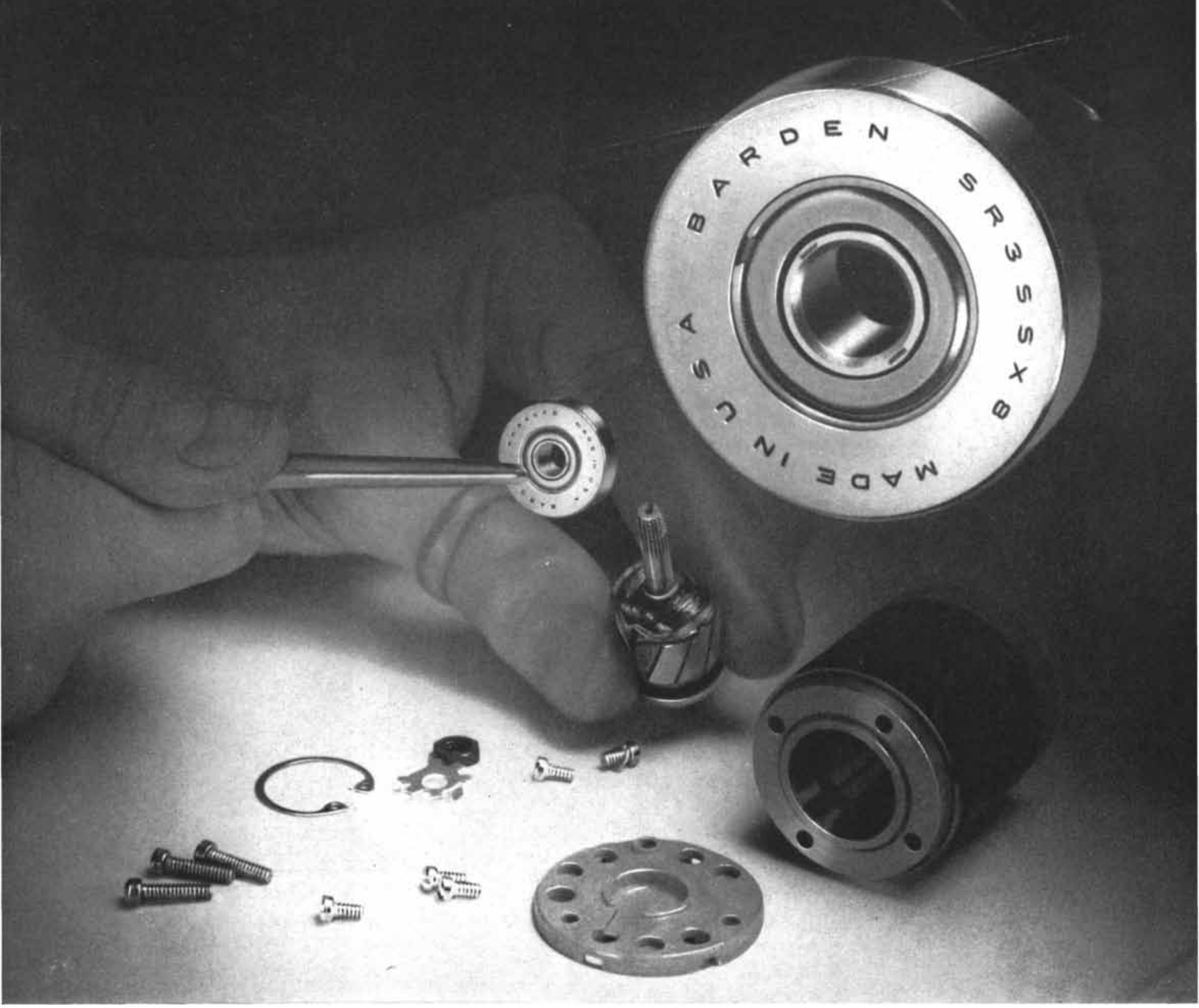
THE COVER

The objects on the cover symbolize the study of the juvenile hormone of insects (*see page* 67). It is this hormone which keeps an insect larva from becoming a pupa until it is full-grown. Beneath the syringe is a vial containing a crude extract of the hormone. The smaller vial contains a purer extract. At bottom are two Cecropia silkworm moths. Administration of the hormone has made one moth a giant and the other a dwarf. At upper right are three test animals. The one at right received an injection of inactive extract; it has turned into a moth with its wings still unfurled. The one in the middle received a small amount of hormone; it is a mixture of pupa and moth. The one at left received a large amount; the old pupal skin has been removed from one side, revealing a second pupa beneath it.

THE ILLUSTRATIONS

Cover painting by John Langley Howard

Page	Source
23-26	James Egleson
28	Harvard University
29	University of California (*top*); Sol Libsohn (*bottom*)
30-32	James Egleson
35-37	Eric Mose
38	U. S. Department of Agriculture
55	Roman Vishniac
56	University of Chicago (*top*), Irving Geis (*bottom*)
57	Cesare Emiliani
58-62	Irving Geis
67	Frank White
68-74	John Langley Howard
76-78	Bernarda Bryson
80	Feldhaus Archiv
82	Deutsches Museum
84	James Egleson
89-94	Bunji Tagawa
97	Douglas W. Schwartz
98-99	Bunji Tagawa
100	Douglas W. Schwartz
102	Bunji Tagawa
114-118	Roger Hayward



Barden Precision SR3SSX8 bearings as used in a synchro transmitter/receiver.

BARDEN *functional testing assures precision performance*

The SmoothRator, an electronic performance tester, was developed by Barden to check vibration as a measure of overall functional quality. A standard quality control instrument at Barden, the SmoothRator is also used by many leading component and systems manufacturers.

Precision-built synchros require small, uniform air gaps and consistently low torque to provide accurate response to a generated signal.

Barden Precision low torque bearings assure the required air gap by close control of radial play and concentricity. The SR3SSX8 has an extra large O.D. which eliminates the need for end caps, increasing air gap accuracy and reducing synchro complexity and cost.

From research and design, through quality controlled production, functional testing and application engineering each *Barden Precision* bearing is planned for performance. *Barden Precision* means not only dimensional accuracy but performance to match the demands of the application.

Barden Precision bearings must pass rigid functional tests on the SmoothRator, the Torkintegrator and other Barden-developed or standard test devices. This functional testing is your assurance of consistent precision performance.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature or high speed. For less difficult applications, Barden *predictable* performance can cut your rejection rates and teardown costs.

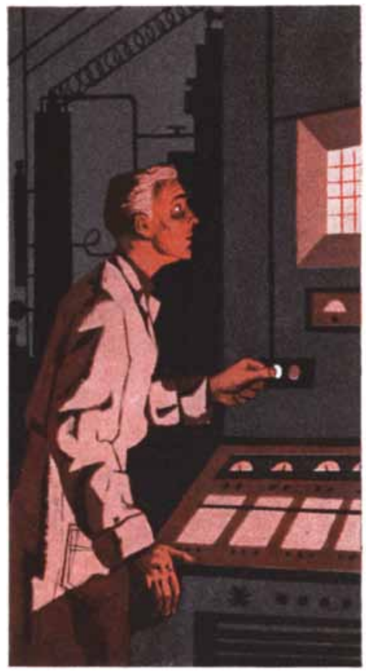
THE BARDEN CORPORATION

43 East Franklin Street, Danbury, Connecticut

Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS *he 'triggers off' the* **BIG ONES!**

The push of a button . . . a roar that shakes the earth . . . and another giant missile rises smoothly on a cushion of flame to heights beyond the range of human vision!



where

AC

fits in this picture

An almost impregnable blockhouse at Cape Canaveral, Florida, protects one of the most complex assemblies of electro-mechanical equipment ever assembled, and the men who operate it. Their purpose—to launch and study in flight the missiles of the ICBM, IRBM, and "Air-Breathing" Missile Programs.

Here, the greatest missile experts of the free world gather as the count down begins. The air becomes electric and the tension builds to an almost unbearable pitch as the moments slip by. Finally, firing time arrives. The weird iron skeleton surrounding the missile is wheeled back. The missile itself, an enormous white pencil, is left standing alone. The blockhouse is sealed . . . the area cleared . . . and the final seconds tick away as an impersonal voice calls off the count. Within the blockhouse, a hundred eyes watch television screens and study the maze of instruments which record invaluable data from every second of flight. Suddenly the first flames lick out, and the earth trembles as the missile rises slowly from its firing pad . . . streaks straight up and out of sight with only the ponderous thunder of its engines to remind you that what you saw is real.

What is AC's role?

AC's part in this tremendous project is to produce an inertial guidance system capable of directing missiles on their course over tremendous distances and with fantastic accuracy. This system, known as the AChiever, has proved its ability to withstand the tremendous shock of launching and to operate within required limits under all the conditions to be found within a missile in flight.

AC engineers together with research groups in American universities, scientists in industry, and in our armed forces, form a team whose responsibility it is to design, test and produce operational missiles. Today, the AChiever stands ready—fully capable of directing a missile to a target anywhere in the world—or far out into space. It is entirely self-contained and independent. Nor can it be affected by man-made interference—electronic, radar or infra-red.

If you are an engineer with electronic or mechanical experience and feel you could contribute to this program—and, if you are not now in the armed forces—write the personnel section of AC in Milwaukee.

AC THE ELECTRONICS DIVISION OF GENERAL MOTORS

LETTERS

Sirs:

For many years I have been intrigued by a largely unprovable hypothesis about the coexistence of *Homo sapiens* and Neanderthal man; J. E. Weckler's article in the December, 1957, *Scientific American* has led to this letter.

My assumption is that these two species met in Northern Europe and lived together for many generations. It is based upon the numerous folk tales and myths involving a fairly easily recognizable stereotype of *Homo neanderthalensis,* who appears as a gnome, troll or Nibelung. He is invariably small, hairy, ugly, an underground or cave dweller, a worker in metals, almost human but not quite, in a state of armed truce or cold war with *Homo sapiens.*

Why does such a creature literally overrun the folklore of the Nordic and Teutonic people, yet hardly, if at all, appear in the Bible, in Greek or Roman mythology? Nor am I familiar with his like in the folklore of Asia, Africa or the Amerindians.

Could this be coincidence? Certainly that is a possibility which cannot completely be discarded. It seems quite unlikely, however, that such a large number of stories of this character (brought to the New World in Rip Van Winkle) would pervade this region if no reason other than chance were to be attributed.

It is well recognized that myths and folk tales are often based on fact, altered by numerous passages through the minstrels and storytellers of the times. I submit that *Homo neanderthalensis* lives among us today in the stories of Andersen and the Grimms and in the Wagnerian Ring of the Nibelungs—immortalized in legend, though no longer in the flesh.

EMIL ROTHSTEIN, M.D.

West Newton, Mass.

Sirs:

The story of Robert Stroud in "The Amateur Scientist" [SCIENTIFIC AMERICAN, December, 1957] cannot easily be forgotten.

It is an outdated penal code that will condemn a criminal to solitary confinement for life. Aside from any legal aspect, a humane attitude would call for rehabilitation for a man with such unusual achievements as Stroud's. To maintain the vivid interests, to use the imagination and skill described in the face of total isolation, Stroud must possess an extraordinary will to live and to make use of life. This is further shown in his embarking on a new study when transferred to Alcatraz and unjustifiably deprived of that which he had lived with and worked for over the years.

To come to realize that in this era, in this country, authorities are entitled to subject a human being to that much frustration comes as a shock, at least to this reader, and I am sure to many more. It is true that single individuals were not without understanding, but the penal machine could only operate coldly in the vacuum of abstract data. Nothing much is related in the article about the "very difficult individual," but, in fact, how many under similar circumstances would have shown the resourcefulness of Stroud? Would they not have become more hardened criminals, or, more probably, lost their sanity?

If one recalls that society's role in dealing with antisocial behavior is not primarily punitive, but one of protection for its members and rehabilitation of the delinquent, one may well wonder at the treatment accorded Stroud, and at our potential gain and actual loss. Still, over and above the waste of a valuable mind, remains the useless and extended suffering imposed upon a human being. The laws of our country are based upon the dignity of man. To those who break them we owe an opportunity to start a better life, or else we ourselves lose that dignity which we claim.

F. A. VELAY

Philadelphia, Pa.

Sirs:

The story of Robert Stroud told in "The Amateur Scientist" filled me with great horror and indignation. That a human being should be treated as Robert Stroud has been is unbelievable. What cruelties and indecencies lie hidden behind an Ice Curtain of official silence?

One shudders when one remembers how the German people protested that they knew nothing of the atrocities committed by Hitler under their noses! What goes on that we Americans do not know about—injustices and horrors sanctioned and encouraged by Government officials?

Yet we are all our brothers' keepers. I have written to President Eisenhower and to James V. Bennett, director of the Federal Bureau of Prisons, expressing my concern over the treatment of Robert Stroud and voicing my opinion that such a medieval dungeon as Alcatraz has no place in our society.

Thank you for the article on Robert Stroud, about whom I had never heard before. I should like to do whatever I can in my small way to help end such inhumanity of man toward man as illustrated by his case.

HILIA ELAN

Glen Oaks, N.Y.

Sirs:

I have just read the article in "The Amateur Scientist" about Robert Stroud. I am not an ornithologist, nor do I know much about birds. I am, however, truly disgusted with the actions and apparent philosophy of certain bureaucrats in the Bureau of Prisons. Assuming that Stroud is not a troublemaker, there is no reason why he should not be permitted to continue his studies. He apparently is not even allowed the humane treatment that a criminal deserves. . . .

CHARLES R. HAGENER

University of Illinois
Champaign, Ill.

Scientific American, February, 1958; Vol. 198, No. 2. 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.

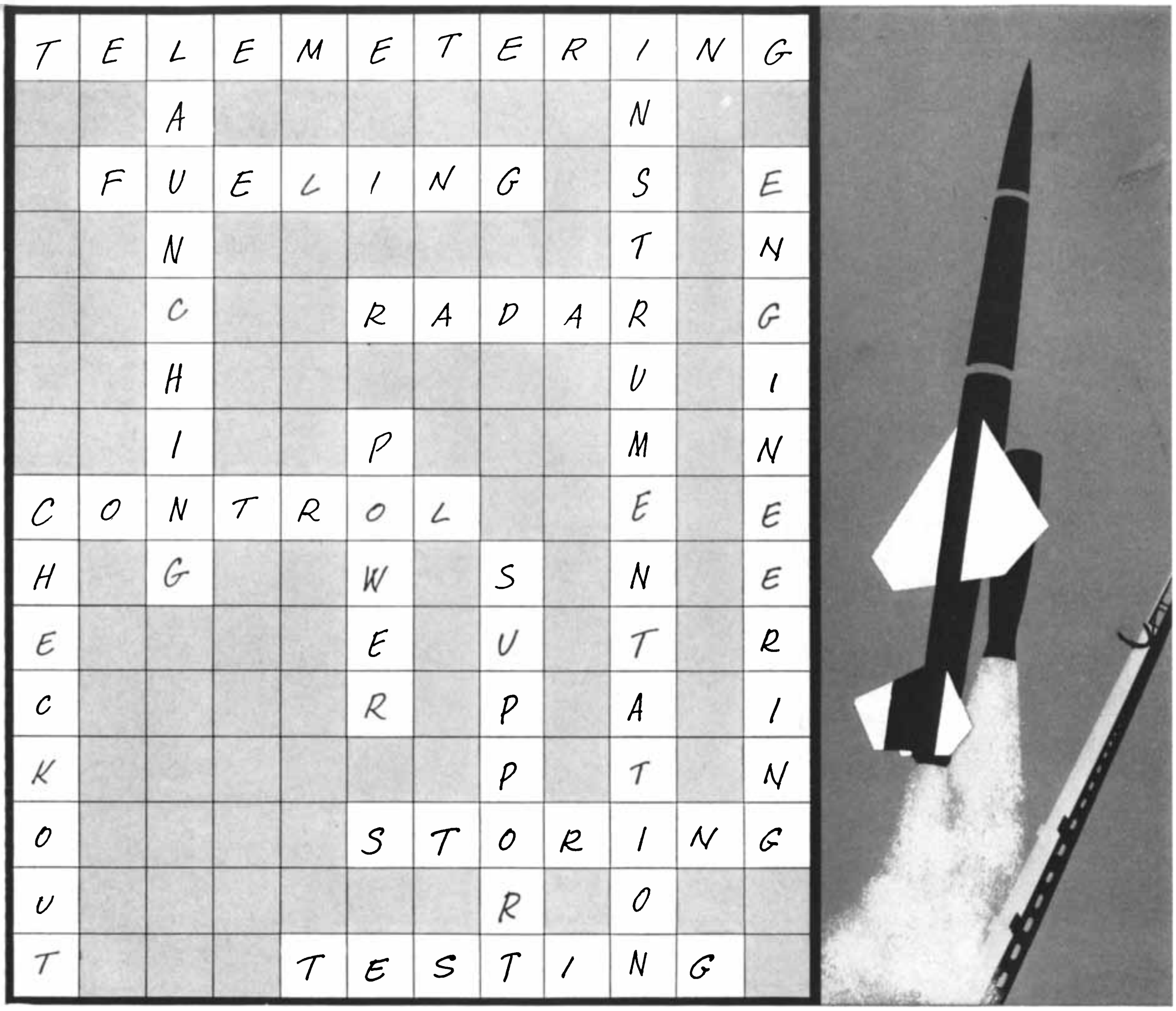
Editorial correspondence should be addressed to The Editors, SCIENTIFIC AMERICAN, 415 Madison Avenue, New York 17, N. Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

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.



Looking for solutions?

AMF has missile experience you can use

• Building a reliable missile system introduces problems at every step . . . the kind AMF solves daily. From drawing board to target, AMF is constantly bridging the gap between missile concept and performance. • This wealth of experience, gained as a leading contributor to numerous major missile programs, can produce the solution to your particular problem. • For a full description of AMF engineering and production facilities in the missile field, as well as a review of their performance, contact the AMF Defense Products Manager in any of the cities listed below.

• *Armament*
• *Ballistics*
• *Radar Antennas*
• *Guided Missile Support Equipment*
• *Auxiliary Power Supplies*
• *Control Systems*

AMF DEFENSE PRODUCTS

Defense Products Group
AMERICAN MACHINE & FOUNDRY COMPANY
1101 North Royal Street, Alexandria, Va.

Asbury Park • Atlanta • Boston • Brooklyn • Dallas • Dayton • Los Angeles • Seattle • Tucson • Washington, D. C.

Progress with TITANIUM

Giant autoclave *is divided into six inner compartments, each with a turbine impeller for agitating slurry, which contains cobalt, nickel, copper arsenic, iron and sulfuric acid, and iron-arsenic compounds. The reaction is carried out at pressures of 550-600 psi, at temperatures exceeding 400°F. The Calera Mining installation, at Garfield, Utah, was engineered by Chemical Construction Corporation.*

4TH BIRTHDAY FOR TITANIUM TURBINE

in corrosive slurry that quickly kills other metals

THIS encrusted, scale-covered turbine impeller made from Mallory-Sharon titanium is a thing of beauty to the cost-conscious Calera Mining Company. It's passing inspection after four years service in as corrosive an environment as you are likely to meet.

Calera oxidizes and leaches cobalt-arsenic-sulfide concentrates in a giant high-pressure, high-temperature autoclave. The autoclave, or pressure vessel itself is lined with acid resisting brick. But the turbines, piping, thermowells, and flange linings must be metal.

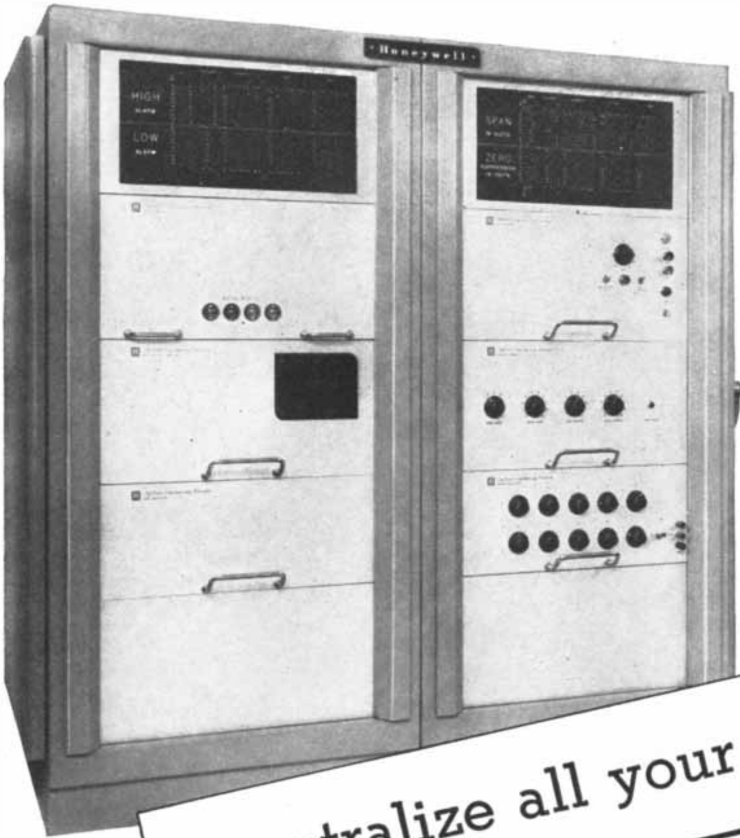
The piping, fabricated from Mallory-Sharon titanium, has seen continuous service—where alloy steels and nickel alloys failed in a matter of *hours*. Even on the hefty turbines, the longest service obtained was a *few weeks*—before titanium was fully specified for all turbine parts including fasteners. With flange linings and other parts the story is the same—titanium is the only choice from an economic standpoint.

Have *you* a corrosion headache that titanium can turn into a success story? We can help you evaluate this remarkable metal in your plant, supply engineering assistance, and deliver your sample or prototype requirements from stock. Call or write now for complete information.

MALLORY-SHARON

METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals



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

H HONEYWELL *First in Controls*

The legendary Firebird, the Phoenix, rose young and strong again and again from flames . . . This is the new Norton Firebird — symbol for the exciting new fused materials made in Norton's electric furnaces.

BORON: gift of the Firebird

Comparable to the ancient Firebird legend is the wonder-working energy of Norton electric furnaces. Here, raw materials are transformed into new, high-purity compounds of tremendous importance to scientific and industrial progress.

For example, Norton began development of stable boron compounds a quarter century ago and now provides boron as the nitride, the carbide or as borides and experimentally in its elemental form.

Norton electrochemical engineering may be a valuable aid to your own processing. It enables users to improve manufacture with an increasing variety of boron-rich compounds, including intermediates for chemical processing and additives for metal alloying. Technical cooperation is available with all these *Gifts of the Firebird.*

Gifts of the Firebird: compounds of silicon • zirconium • boron • aluminum • magnesium • titanium • chromium . . . . . including many borides • carbides • nitrides • oxides.

NEW
CATALOG AVAILABLE

Write to NORTON COMPANY, Electrochemical Division, 541 New Bond Street, Worcester 6, Massachusetts.

NORTON

ELECTROCHEMICALS

MAKING BETTER PRODUCTS . . . TO MAKE YOUR PRODUCTS BETTER

50 AND 100 YEARS AGO

FEBRUARY, 1908: "Signs are not wanting that the time is ripe for just such a rapid development of the art of navigation of the air as was witnessed in the development of the automobile, when the French applied their great mechanical genius to that end. And we ask the question: Is the U. S. to take its proper place as the leading nation in this era of development, or are we to follow along two or three years behind the rest of the world and buy our dirigibles and aeroplanes from abroad, just as we were obliged to buy our first automobiles from France and Germany? The Government has asked for bids for aeroplanes; and on the day of opening, February 1, no less than 41 tenders were found to have been submitted, of which three were accepted, namely, that of the Wright brothers for a machine to cost $25,000, of A. M. Herring for a $20,000 machine, and that of J. F. Scott for one to cost $1,000. Now that the War Department has lent its great prestige to the promotion of aeronautics, we feel that the time is ripe for an appeal to Congress for a sufficiently liberal appropriation to encourage the inventors, mechanics and engineers of the U. S. to throw themselves into this promising field of endeavor."

"Commander Robert E. Peary states that he will leave New York on July 1 next on another Polar expedition. He will winter at Cape Sheridan, and prepare for a dash to the Pole during the summer of 1909. At Cape Sheridan the sun sets on October 12, and does not rise again till the first of March."

"Though Navy Department officials at Washington have so far refused to declare themselves, as have the naval authorities in England and France, in favor of the exclusive use of turbine propulsion for warships in place of the reciprocating engines, the U. S. Navy is by no means backward in its use on ships now under construction. The policy of the Department has been against making a decision toward adopting turbine engines until actual tests have demonstrated their superiority. The Parsons type of turbine has been adopted exclusively by the English Admiralty and recently by the French Ministry of Marine. A number of English ships have been fitted with them, the most important being the battleship *Dreadnought*."

"After but three months of active experimentation, Henry Farman, an Englishman residing in Paris, succeeded in winning, on January 13 last, the Deutsch-Archdeacon prize of $10,000 for a circular flight of one kilometer (.621 mile) by an aeroplane or other heavier-than-air type of flying machine. In attempting circular flight, Farman found that it was necessary to ride the aeroplane in much the same manner as a bicyclist rides a bicycle. In making a turn, one has to incline the body and the machine toward the inside of the circle. He points out that the aviator not only has to steer to the right and to the left, but that he also has to maintain the fore-and-aft equilibrium of the machine and counteract its tendency to dive downward at any angle while at the same time tipping to one side. Besides all this, he is obliged to control the powerful 8-cylinder motor."

"The committee of the French Academy of Sciences in control of geodetic operations on the Equator announces the completion of the second measurement of the historic arc of Peru, a great scientific work, perhaps the most important completed thus far in the 20th century. This arc is known as a part of an astronomical circle traversed by the sun or a star between its rising and setting and was first measured by the French savants to decide a question in regard to the form of the earth which had arisen over the result of Cassini's surveys in France. This work is a costly and gigantic task, and, when it was first accomplished, the feat gave additional luster to the scientific fame of France. When the result was made known, the scientific world accepted Newton's theory of our globe being an oblate spheroid."

FEBRUARY, 1858: "The class of fast-sailing clipper ships which were called into popular existence by the discovery of gold in California, in order to make quick passages, have been somewhat unpopular with their owners. It is stated that very few of them pay expenses. The great number of sailors required to work them, their great original cost and small amount of room for cargo, are bigger drawbacks in a pecuniary way than all the advantages obtained from making fast voyages. All the new ships which have recently been built are of greater carrying capacity than the genuine clipper ships built four or five years ago."

"Mungo Park, James Bruce and Gordon Cumming have all told such marvelous tales of rich plains and verdant hills, rivers and inland seas, that people have put them down as, at least, romancers; but at last the time has come when all their accounts of beauty and fertility are corroborated and the idea of African deserts has received, in a great measure, its death blow from two gentlemen whose travels are now before the world: one of them, Dr. Livingstone, a missionary, and the other, Dr. Barth, a medical man who was sent out, we believe, by the British Government to make an official report of his discoveries and researches. The former gentleman has chiefly explored Western Africa, and has discovered a vast inland sea (Lake Ngami). Dr. Livingstone's book contains much valuable and interesting information and is full of exciting anecdotes and pleasant details of the manners and customs of the tribes who entertained him, but it is to Dr. Barth's travels in North and Central Africa that we must turn for practical information. He tells us that there is uninterrupted water communication from the Bay of Biafra to the great Lake Tsad (or, as it is spelt on the maps, Tchad) by means of the rivers Bi-nuwé and Kwara."

"By the latest news from Europe, we learn that the *Leviathan*—formerly called the *Great Eastern*—was successfully launched. The final floating of the great iron ship was accomplished with ease and without accident. The mode of launching was the same from first to last in all the trials, but more powerful and more numerous agencies—hydraulic rams, chains, beams, windlasses and levers—had to be finally employed than were at first calculated upon. Much has been learned by this affair in regard to moving large masses. It was the first ship launched broadside in England, and the greatest mass of overtowering gravity ever attempted to be slid on ways. She was towed to Deptford where she is to remain until all her engines and internal arrangements are completed."

Who's the old hand in inertial navigation?

Self-guided missiles are stage front now. Missiles with their destiny and destination sealed in at departure; missiles that are unaffected by radio, radar, sunspots, weather or any other remote influence; missiles bearing inertial navigation systems.

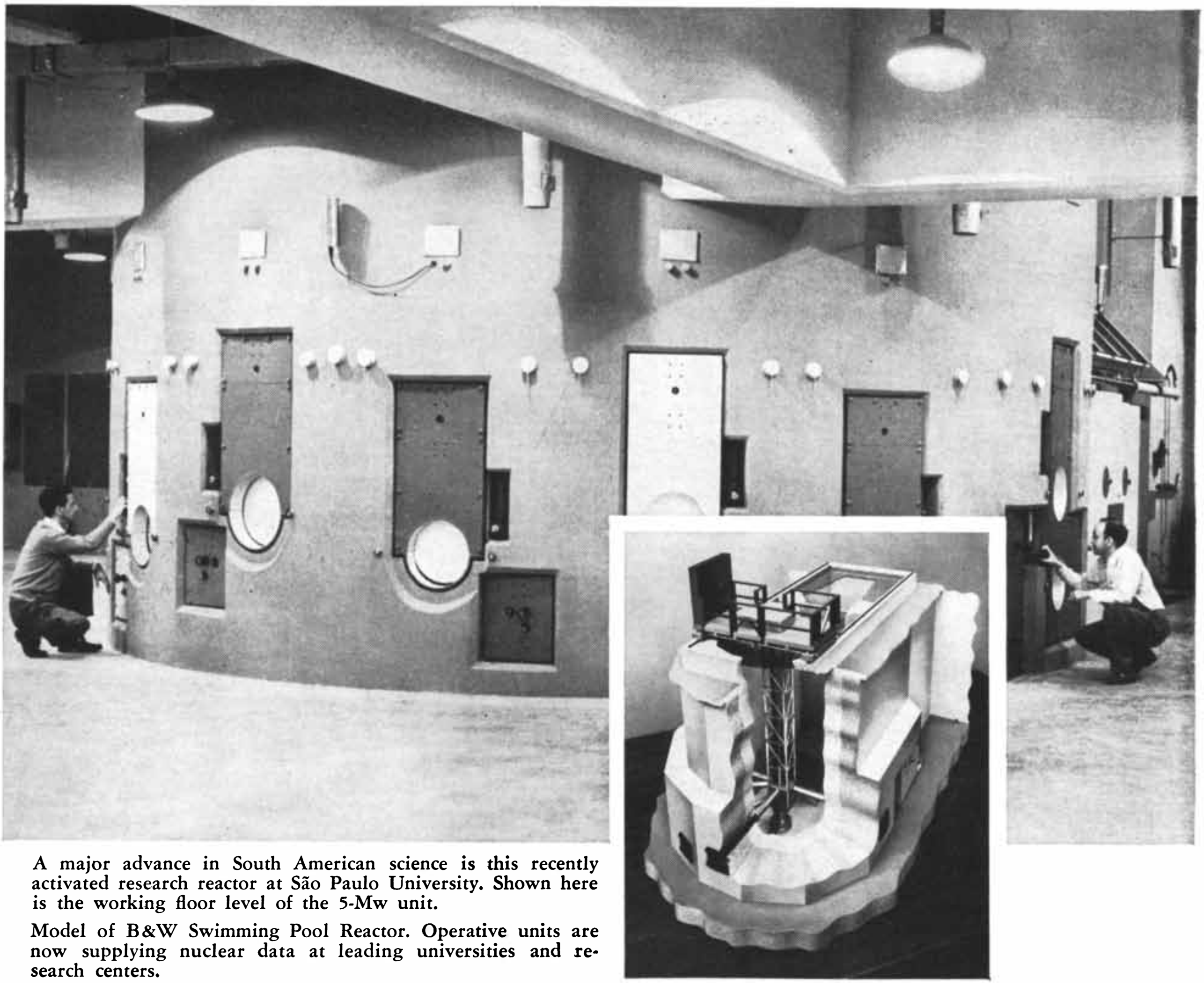
Developing, designing and manufacturing these rugged but incredibly delicate systems are all ARMA specialties. Right now, ARMA is developing one of the systems for the new Air Force ICBM—Titan. Tomorrow, an ARMA system may be at the controls of the space craft that whisks you off to a lunar vacation.

ARMA can be at the controls for you right now as well, if you're seeking guidance in problems that involve electronic or electro-mechanical engineering of the highest order.

ARMA... Garden City, New York. A Division of American Bosch Arma Corporation. 5602

There are challenging employment opportunities in inertial navigation at ARMA

AMERICAN BOSCH ARMA CORPORATION



A major advance in South American science is this recently activated research reactor at São Paulo University. Shown here is the working floor level of the 5-Mw unit.

Model of B&W Swimming Pool Reactor. Operative units are now supplying nuclear data at leading universities and research centers.

First South American reactor is dedicated at Brazil's University of São Paulo

Designed to produce 5000 kw of power . . . the highest capacity of any "swimming pool" type of reactor in existence . . . this new research reactor will play an important role in Brazil's contribution to the fields of medical, biological and industrial nuclear research. Operating successfully at the University of São Paulo, it has achieved Latin America's first sustained nuclear fission. The "swimming pool" reactor's name is derived from the water-filled concrete pool in which the core is submerged.

The reactor and the fuel elements which make up the reactor core were designed, fabricated and installed by The Babcock & Wilcox Company. The fissionable material in each fuel element is 20 percent enriched uranium 235.

Typical of B&W thoroughness and sound engineering were the extensive tests and research that assured successful operation. These included criticality experiments conducted in a similar research reactor in the U. S. under conditions duplicating those expected in Brazil. The result is an important step in President Eisenhower's "Atoms For Peace" program, which was designed to encourage and aid the development of nuclear energy for peacetime uses throughout the world.

In nuclear power development, B&W is a leading source for power reactors, propulsion reactors, research reactors, fuel elements, reactor components and experimental reactor development. The Babcock & Wilcox Company, Atomic Energy Division, 161 East 42nd Street, New York 17, N. Y.

AE-50

BABCOCK & WILCOX

ATOMIC ENERGY DIVISION

THE AUTHORS

AMRAM SCHEINFELD ("The Mortality of Men and Women") is a well-known writer on human genetics. At high school in Milwaukee he took the science curriculum and turned out articles, stories and cartoons for the school magazine. But as there was then no recognized profession of science writing, he found no way to combine his literary and scientific interests. Instead he plunged into general journalistic work, serving as reporter, feature writer, columnist, cartoonist and editor for many periodicals and syndicates. But he also found time to study science at the University of Wisconsin, New York University and the New School for Social Research. *You and Heredity*, his first book, was a Book-of-the-Month Club selection in 1939. This was followed by *Women and Men*, *Postscript to Wendy* (a novel) and *The Human Heredity Handbook.*

HAROLD P. FURTH, MORTON A. LEVINE and RALPH W. WANIEK ("Strong Magnetic Fields") worked together on high-powered magnets at the synchrocyclotron laboratory of Harvard University. Furth was born in Vienna, came to the U. S. at the age of 11 and attended Harvard University, where he held a National Science Foundation Fellowship. He is now a theoretical physicist at the University of California Radiation Laboratory in Livermore, Calif. Levine was born in Boston, worked at Los Alamos during World War II and graduated from the University of Massachusetts. After graduate study with Winston H. Bostick at Tufts College he became chief of the hydromagnetic section of the Thermoradiation Laboratory at the Cambridge Research Center of the Air Force. Waniek was born in Milan. After traveling widely as a student and a journalist he received a Ph.D. from the University of Vienna in 1950, then he came to Harvard.

TERENCE A. ROGERS ("The Metabolism of Ruminants") teaches physiology to medical students at the University of Rochester. His research there has to do with the effect of acidosis on metabolism. Rogers was born in England and served during World War II as a flight navigator in the Royal Navy. There he met his wife: "She too is a physiologist, and so, of course, was employed in the Navy as a radio mechanic. I met her while she was looking after the radar on my airplane." After the war the Rogers family decided to try the simple life. Rogers took a degree in agriculture at the University of British Columbia, and they settled down on a Canadian dairy farm. Says Rogers: "After four years I decided that cows got up too early and that I was more interested in animal physiology." Selling the farm, the Rogerses moved to the Davis campus of the University of California, where Rogers studied the biosynthesis of milk-fat with Max Kleiber.

CESARE EMILIANI ("Ancient Temperatures") has been interested in the Pleistocene period ever since, as a boy, he discovered "an outcrop of marine Pleistocene sediments with abundant microfossils" in his own back yard in Bologna. After studying at the University of Bologna he became a field geologist and micropaleontologist for the National Hydrocarbon Company of Florence. In 1948 a fellowship brought him to the University of Chicago; there he earned a Ph.D. in geology. In 1952 he took over the University of Chicago's project for the study of ancient temperatures, which had been begun by Harold C. Urey. Emiliani is now teaching marine geology at the University of Miami, where he has received a grant from the National Science Foundation to continue his research on paleotemperatures. He created a stir with a recent article in the *American Scientist* signed by six fictitious co-authors ("to make the mystical number seven") in which he suggested that technical journals should be replaced by wandering minstrel troupes who would chant accounts of scientific discoveries at night-long banquets.

CARROLL M. WILLIAMS ("The Juvenile Hormone") was born in Richmond, Va., and attended the University of Richmond. ("Everybody immediately recognizes that I am a Virginian," he says. "How they do this is a great mystery: I almost never mention Patrick Henry or Robert E. Lee.") Appointed to a fellowship at Harvard University, Williams earned a Ph.D. there in 1941 with a dissertation on the flight physiology of fruit flies. He then entered Harvard's Society of Fellows and began to study part-time at the Harvard Medical School. In 1946 he both received his M.D. *summa cum laude* and was appointed assistant professor of zoology at Harvard; he is now full professor.

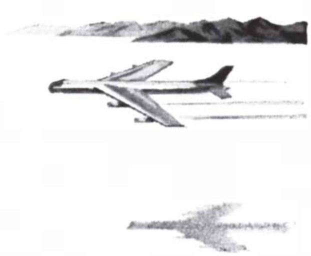
OTTO HAHN ("The Discovery of Fission") won the Nobel chemistry prize in 1944 for the discovery described in his article. Hahn was born in Frankfurt-am-Main in 1879. He studied at the universities of Marburg and Munich, at University College London and at McGill University. In 1907 he received his *privat-dozent* (university teaching license), and in 1910 he became professor of chemistry at the University of Berlin. Shortly afterwards Hahn began his 33-year-old association with the Kaiser Wilhelm Institute of Chemistry (for 17 years he was its director). Hahn now heads the Max Planck Society for the Advancement of Science in Göttingen.

H. W. LEWIS ("Ballistocardiography") is professor of physics at the University of Wisconsin. He graduated from New York University in 1943, served a stint in the U. S. Navy and took a Ph.D. under J. Robert Oppenheimer at the University of California. After some time at the Institute for Advanced Study in Princeton, Lewis returned to the University of California to teach. Later he took a job at Bell Telephone Laboratories. "I have worked in various fields of physics, both theoretical and experimental, including high-energy physics, low-temperature physics, solid-state physics and relativity. This catholicity of taste is what led me into ballistocardiography. After our first child my wife gave up her job as a flight instructor and took a position at the ballistocardiographic laboratory of the New Jersey Neuro-Psychiatric Institute. Inevitably I too was drawn to work on this fascinating problem."

DOUGLAS W. SCHWARTZ ("Prehistoric Man in the Grand Canyon") is assistant professor of anthropology and director of the Museum of Anthropology at the University of Kentucky. He has been exploring the Grand Canyon since 1949. Grants from Yale University and the Wenner-Gren Foundation enabled him to live for six months with the Havasupai Indians in their canyon home. After receiving a Ph.D. from Yale, Schwartz taught at the University of Oklahoma and surveyed some previously unexplored territory in the northwest part of the Grand Canyon. He is now doing archaeological work near Mammoth Cave, Ky.

M. BREWSTER SMITH, who reviews *The Fabric of Society* in this issue, is professor of psychology at New York University and editor of *The Journal of Abnormal and Social Psychology*. His books include *For a Science of Social Man* and *Opinions and Personality.*

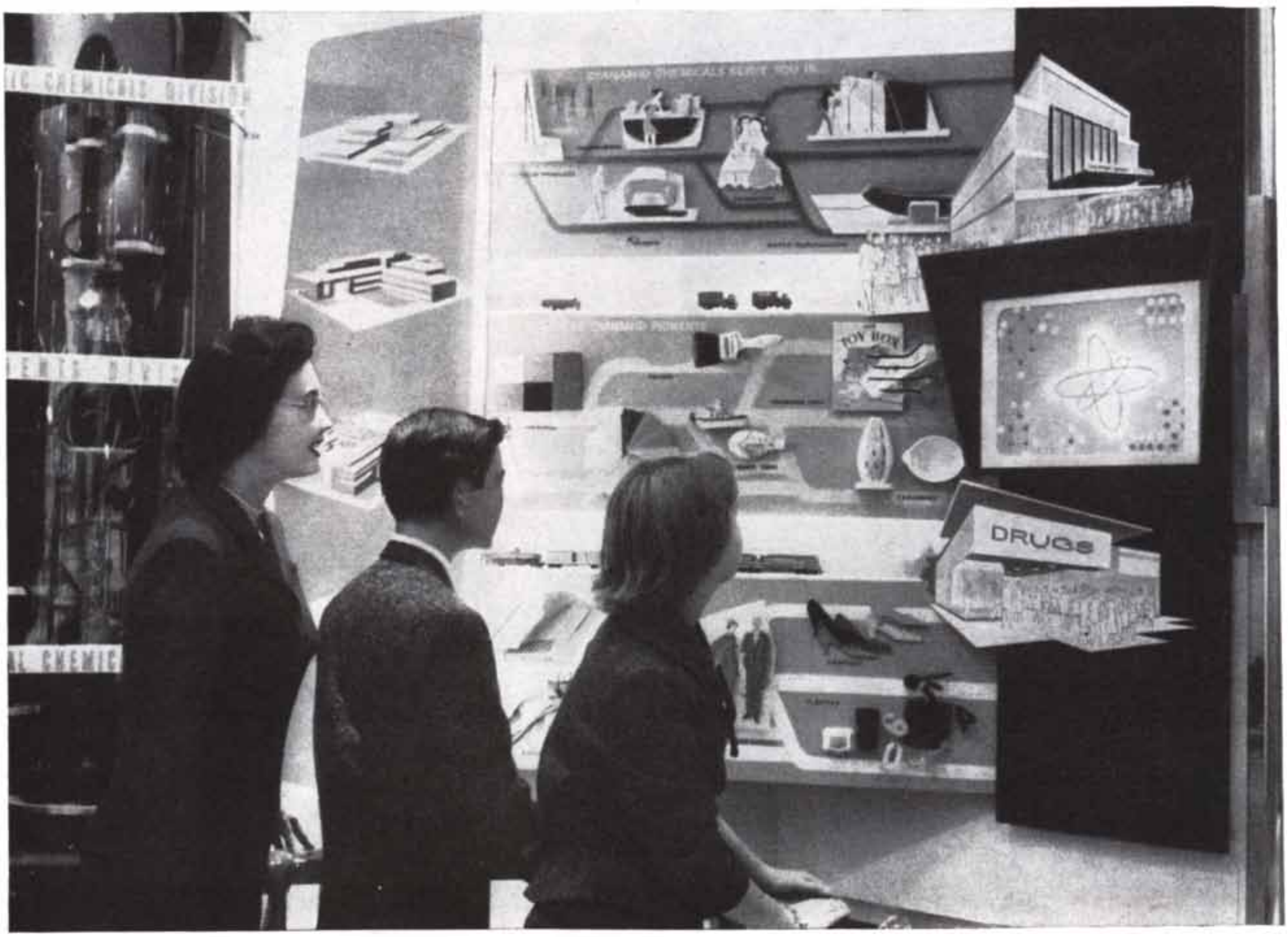

U.S.ARMY

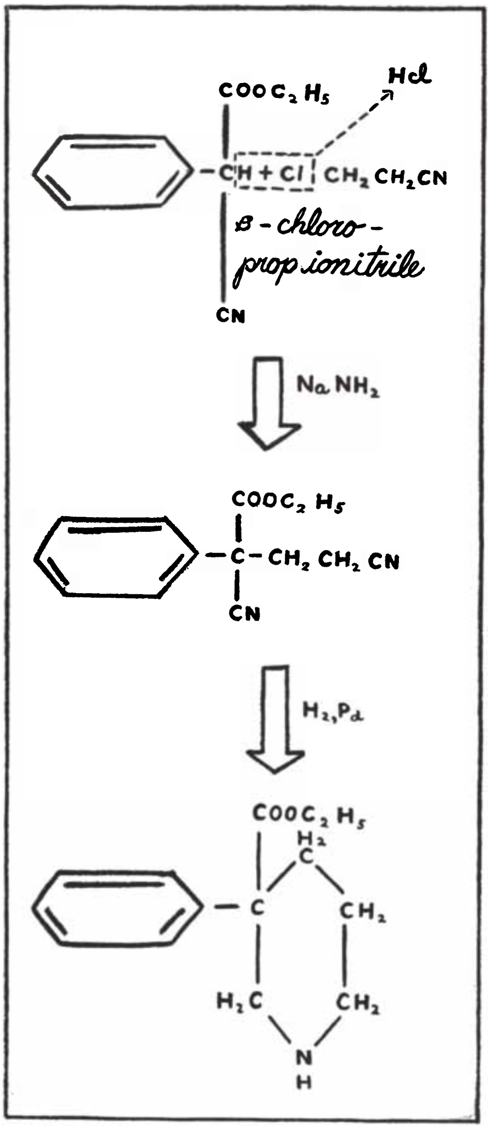


Life on the Chemical Newsfront

PLASTIC KEYS CONDUCT AN ORCHESTRA OF LIGHT. The Lumitron Lighting Control System permits one operator to play infinite variations in the stage-lighting effects using handles and slide bars molded of BEETLE® *urea plastic*. BEETLE, an excellent dielectric, requires no insulation. Molded-in colors are permanent, permit quick circuit identification for console operator. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of dependable performance. (Plastics and Resins Division)

HOW MORE THAN 5000 CYANAMID CHEMICALS for industry, farm, home and health contribute to everyday living is dramatized in Cyanamid's new exhibit hall at 30 Rockefeller Plaza in New York. Product exhibits, dioramas, slide films and movies combine to present an over-all picture of Cyanamid's diversified chemical activities. Commentaries on the several exhibit areas are provided by pickup phones. Drop in when you are in New York . . . your family will enjoy the exhibit, too!

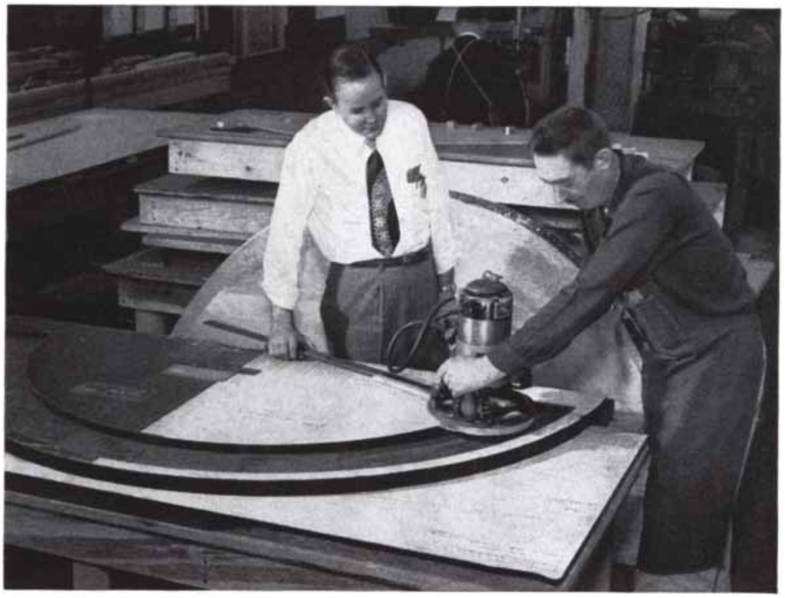




A ROUTE TO HETEROCYCLICS is just one of the reaction possibilities of *β-chloropropionitrile.* This double-ended molecule combines an aliphatic nitrile with an activated alkyl chloride, and either group can be reacted separately. Illustrated is the condensation with an arylacetonitrile to form a glutaronitrile. Catalytic hydrogenation yields the heterocyclic 3-phenyl-3-carbethoxy piperidine. A technical bulletin on β-chloropropionitrile is available on request.

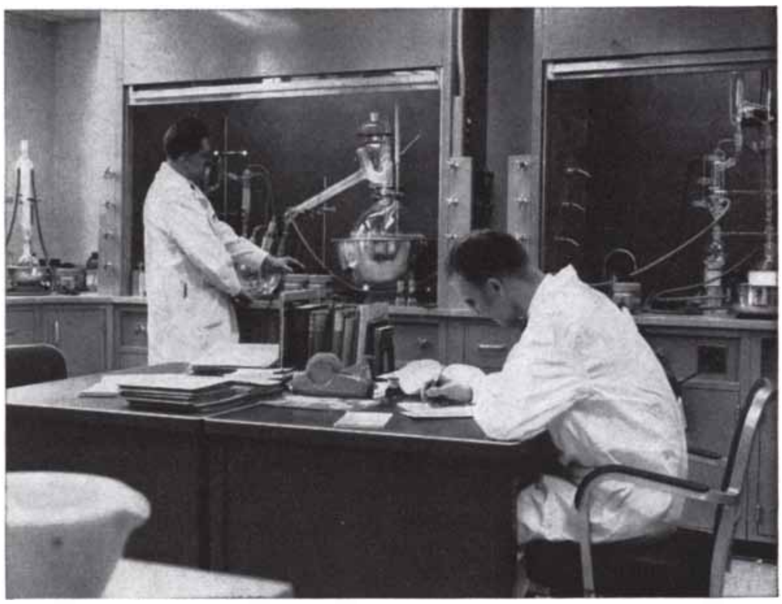
(Market Development Department*)

*__NOTE THIS NEW NAME__ . . . for the New Products Development Department. The functions of the group are unchanged—providing assistance in developing practical applications for Cyanamid's new chemical products.



NEW ACRYLIC-FIBER PAPERS are showing considerable promise. Their excellent dimensional stability suggests their use in layout or lofting papers for mechanical design work. In filter papers, high wet strength, chemical resistance and lack of absorption lead to efficient filtration. Acrylic fibers, such as Cyanamid's CRESLAN® are polymers or modified polymers of *acrylonitrile.* Increased demand for this reactive monomer is being met by expansion of Cyanamid's acrylonitrile production facilities at Fortier, La.

(Organic Chemicals Division and Fibers Division)



IMPROVED STEROIDS are the goal of highly developed synthesis techniques at Lederle Laboratories. By modifying the chemical structure, the remarkable curative properties of a steroid drug can be maintained while minimizing or eliminating undesirable side effects. A recent successful development of this work is ARISTOCORT® *triamcinolone.* Primary investigation has shown ARISTOCORT, available only on prescription, to have considerable promise in a widening field of steroid therapy.

(Lederle Laboratories Division)

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

Established 1845 SCIENTIFIC AMERICAN February, 1958 Volume 198 Number 2

The Mortality of Men and Women

The tendency of women to live longer than men is increasing. The study of differences in the death rates of the sexes may hold clues to the prevention and treatment of many diseases

by Amram Scheinfeld

Recently two social scientists—one a Jesuit priest, Father Francis C. Madigan, the other a sociologist, Rupert B. Vance of the University of North Carolina—made a study of the comparative life expectancies of American Catholic nuns and Brothers in various teaching orders. They obtained data on nearly 30,000 Catholic Sisters and more than 10,000 Brothers. Aside from the sex difference the two groups were about as closely matched as one could find: all white, native-born, unmarried, doing the same work (teaching), living under the same conditions, partaking of the same diet and medical care, all abstaining from drinking and smoking and all equally free from financial or family worries. Yet the investigators found that despite these great similarities in background and environment, nuns outlive Brothers by a wide margin. At age 45 the Sisters have an average remaining life expectancy of nearly 34 more years; the Brothers only a little over 28 years—a difference of 5½ years in favor of the women.

Father Madigan and Professor Vance had undertaken their study to find light on a general question of growing interest and importance: What accounts for the wide longevity advantage of women over men? It has been commonly supposed that differences in their conditions of life are responsible. But here, where the conditions were as similar as could be, the margin of the women over the men was actually wider than in the general population: among white men and women in the U. S. as a whole the women's life expectancy at age 45 is 4.5 years longer than the men's—31½ more years as against 27.

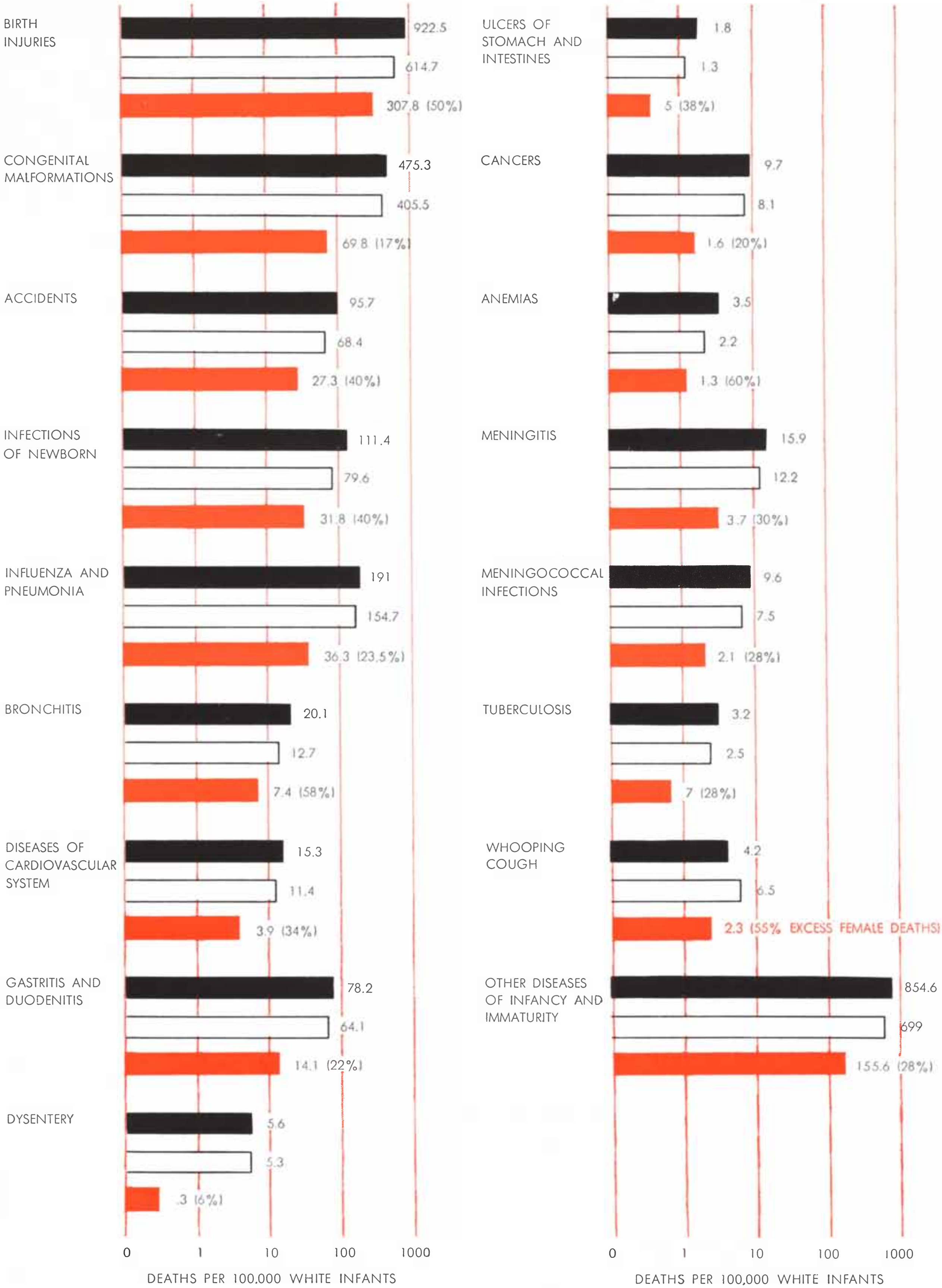
The two social scientists concluded that the advantage enjoyed by women is probably more biological than environmental. This finding is in line with that of other investigators (the writer among them), who have observed that in many other species of animals besides the human the female seems to be inherently the hardier sex. There is now much evidence that the human male takes second place to the female in general vitality: in susceptibility to most diseases and defects his is the inferior sex. Under modern conditions in the U. S., for almost every gain in health and longevity made by the male the female has been able to say: "Anything you can do, I can do better."

Let us start with prenatal life and early infancy. In the womb deaths are 50 per cent higher, on the average, among male fetuses than among female. In the first four weeks after birth, among full-term babies, male deaths exceed female by more than 40 per cent; among premature babies, by more than 50 per cent. Throughout the whole first year of life male mortality is markedly higher than female. Furthermore, as general infant mortality in the U. S. has declined, the difference between males and females has widened. A half-century ago the male death rate in the first year of life exceeded the female by about 23 per cent; by 1955 the male excess had risen to 33 per cent.

Susceptibility to the various major causes of death shows much the same pattern in infancy as in later years. Cardiovascular diseases and cancer claim 35 per cent more male than female infants; ulcers of the stomach and intestines (so often spoken of as "psychosomatic" among adults) claim 44 per cent more male infants; birth injuries kill 53 per cent more males than females among full-term babies and 80 per cent more among the premature; throughout infancy accidents of all kinds consistently kill more males than females [*see chart on opposite page*]. Among all the important causes of death in infancy the only exception is whooping cough: for reasons unknown, this disease each year claims more girl than boy infants, although its absolute death rate has declined.

Through childhood the disparity between male and female mortality becomes steadily more marked. From ages 5 to 9, male mortality exceeds female by 44 per cent; from 10 to 14, by 70 per cent; from 15 to 19, by 145 per cent. This indicates that differences in the habits and activities of boys and girls play a part. But the ground pattern of biological difference evidently continues to operate. Our task is to disentangle the inherent factors from the environmental factors.

First, this question: How different are the sexes as they begin life? The one great genetic difference between them is



DIFFERENCES IN RATE OF DEATH of U. S. male and female white infants due to various causes during the first year are presented. The black bars on the logarithmic scale represent male deaths per 100,000; the white bars, female deaths; the colored bars, the difference between the two. The data, which are for the year 1954, are from *U. S. Vital Statistics, Summary Tables,* Vol. 1, 1954.

that a female has two X chromosomes whereas a male has an X and a Y—a much smaller chromosome than the X. In other words, the human male and female differ by only a single chromosome out of the 46 or 48 in the nucleus of the cell (recent studies indicate the number may be 46 rather than 48, as was long thought). Yet this difference manages to throw the development of the sexes widely apart. How this is achieved is still largely unknown, but presumably it involves the relative influence of "femaleness" genes, largely concentrated in the X chromosome, and "maleness" genes distributed among the other chromosomes. The small Y, which has very few genes and probably no "sex" genes, may act as no more than a blank.

More specifically, a double quota of "femaleness" genes (two Xs) may work to create a female-slanted biochemical environment within the cells; when there is only one X, the "maleness" genes take the upper hand to produce another kind of biochemical environment. The important point here is that the difference between males and females derives not from distinctive genes but from the way the genes work. For instance, in a female cellular environment the genes responsible for sexual organs produce ovaries and female genitalia, whereas in a male cellular environment the very same genes work to produce testes and male genitalia. Again, at successive stages the "body-form" genes work to produce heavier bones and bigger muscles in the male; at puberty the "breast" genes produce large breasts in the female and rudimentary breasts in the male, and so on.

In short, the surface differences between the male and the female (in body form, genitalia, beard, voice, etc.) are, like the top of an iceberg, only the external expressions of a more basic difference that lies beneath in every cell of the body. This difference must extend to every aspect of the body's physiological structure and functioning, so it is not unreasonable to assume that the sexes differ in their reactions to biological adversities, such as diseases, and in their capacities for survival. Biologists have already identified many specific distinctions in the biological reactions of men and women.

Most clearly sex-slanted are the disorders attributable to defective genes in the X chromosome. If an abnormal gene turns up in a male's single X, he is at its mercy, whereas a female usually has a normal gene in her extra X to counteract a defective one. A good example of an X-linked defect is hemophilia, which almost never afflicts females. Other examples are color blindness and a host of other defects or diseases of the eyes, bones, muscles, skin and inner organs.

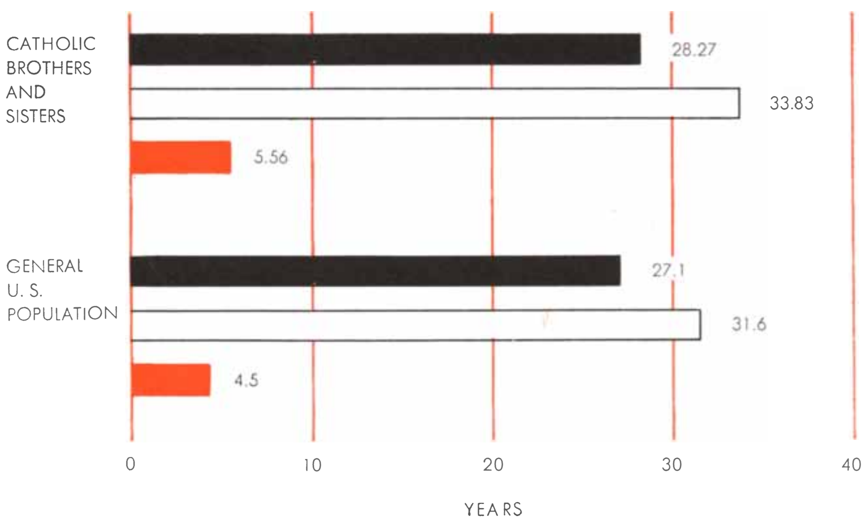
A second biological disadvantage of the male is his comparatively slow development in the early years, from conception onward. At every prenatal stage the female leads the male in rate of biological growth; at birth the male is four to six weeks behind the female. In that sense a full-term male baby can be considered "premature," compared with a full-term female. (If a male is bigger and heavier than the female at birth, it is only because he is heading toward an ultimately greater size.) Since a male fetus or newborn infant is retarded with respect to the female, it is obviously exposed to greater hazard at any given stage. This may be one of the reasons why congenital abnormalities are much more common among male babies.

The developmental lead of the female grows as she moves on into childhood. She achieves puberty a year and a half or two years ahead of the male. She reaches full physical maturity at about 21 years, whereas a male usually does not until 24. Thus until adulthood a female is biologically more mature than a male of the same chronological age. Once both have arrived at maturity, the situation may shift. There is a possibility, though it is not yet proved, that the female may age and run down biologically at a slower rate than the male.

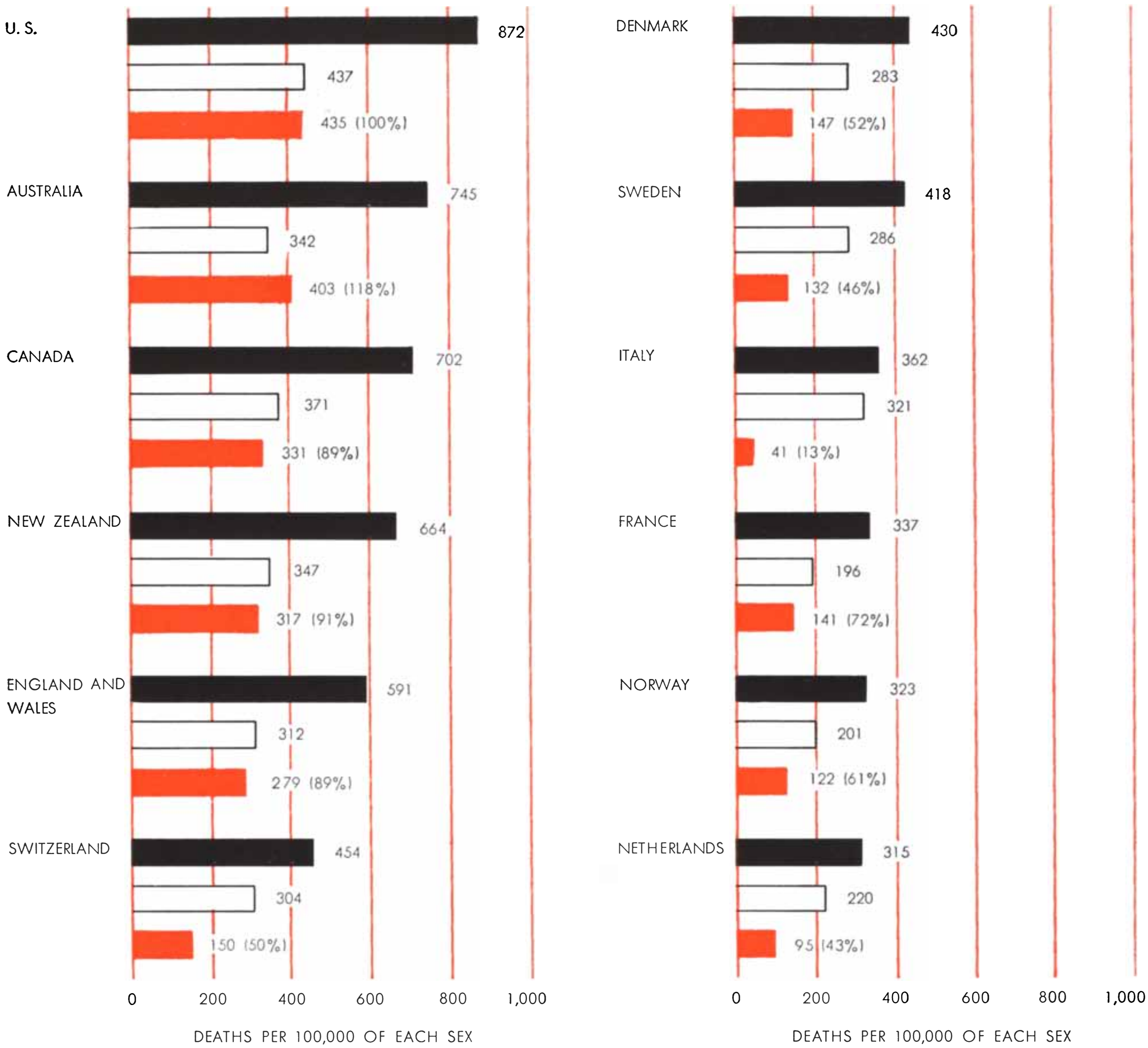
In the realm of biochemical differences, the most readily recognizable are in the sex hormones. The male and female production of these hormones differs not in kind but merely in amount. Males produce more androgen than estrogen, while in females the proportions are reversed. Aside from the sex hormones, there may also be sex differences in other parts of the endocrinal system, including the thyroid and possibly the pituitary.

The endocrinal diseases are the only major class of ailments to which women are more susceptible than men. Diabetes, a disease of the pancreas, claims almost 50 per cent more females than males; the thyroid diseases, such as goiter, are far more prevalent and serious among women; diseases of the gallbladder and biliary ducts also attack more women than men. On the whole, however, the female biochemical environment seems better adjusted to withstand bodily stresses. Perhaps this greater adaptability arises from the female's need to adjust to the great hormonal and other biochemical changes that take place during menstruation, childbearing and the menopause. In any case women usually manage to pull through stresses such as infections or serious accidents better than do men. For example, syphilis produces milder symptoms in women and is less likely to involve the heart or central nervous system. Indeed, years ago a noted syphilologist, John H. Stokes, called syphilis a "chivalric" disease because it shows women such special consideration. He remarked that it "manifests itself in the female almost as if she were of another animal species."

When it comes to afflictions of the sex-



LIFE EXPECTANCIES of Catholic Brothers and Sisters, and of men and women in U.S. white population, are compared. The black bars represent the average years remaining at age 45 for the men; the white bars, for the women; the colored bars, the difference between them. The data, for the years 1950-54, are from Francis C. Madigan, S. J., and Rupert B. Vance.



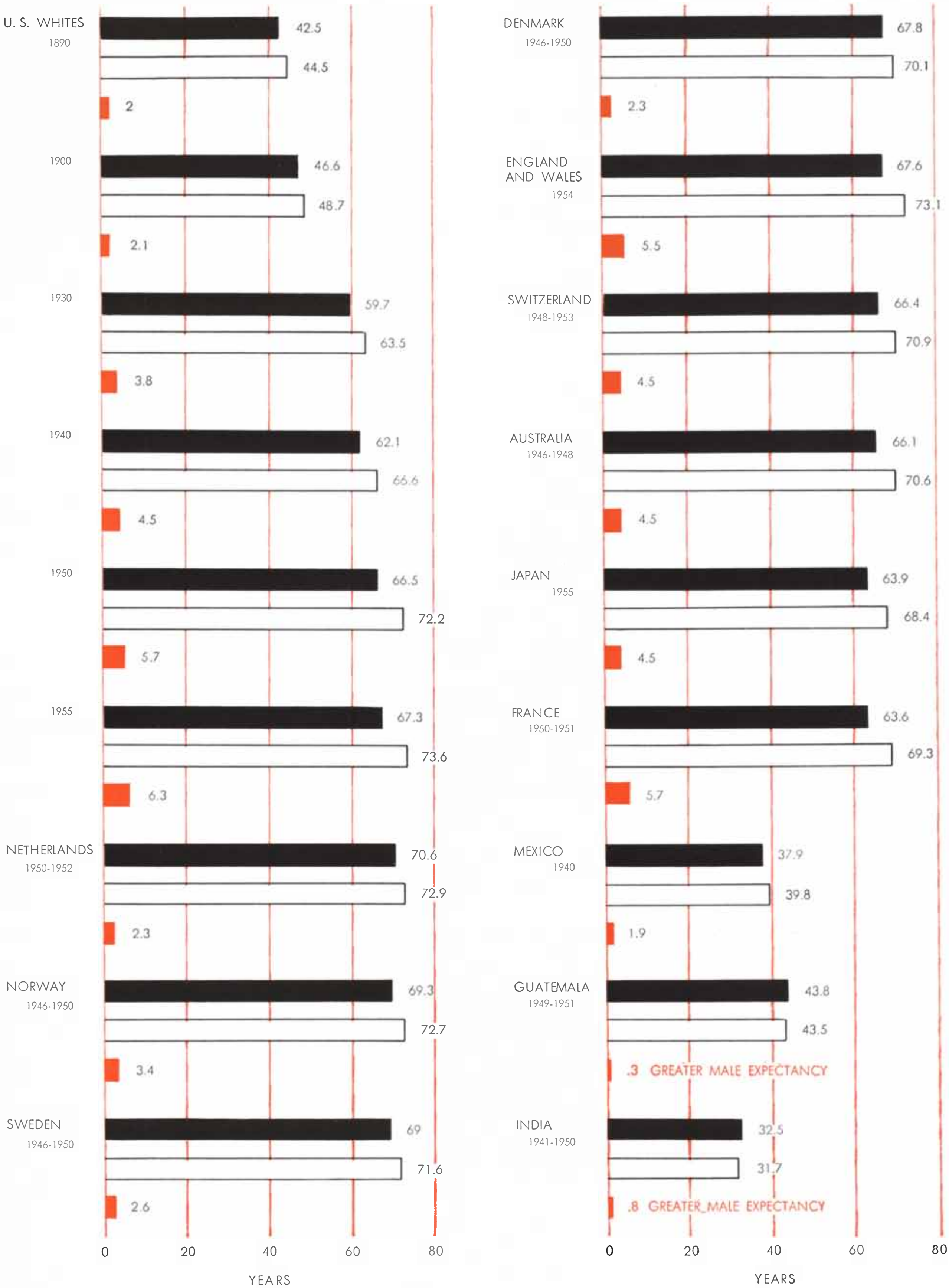
TWELVE COUNTRIES are compared for the difference in the mortality of their men and women due to heart disease. The black bars represent the deaths per 100,000 men aged 40 to 74; the white bars, the deaths per 100,000 women of the same ages; the colored bars, the difference between the two. The data, for the years 1951-53, were compiled by Metropolitan Life Insurance Company.

ual organs, women appear to be more vulnerable than men. Cancers of the uterus and breast produce a much higher mortality than do male cancers of the prostate and testes. Childbearing, of course, has been a considerable hazard to women in the past. But the maternal mortality rate among U. S. women has now dropped to less than one per 2,000 births—only about one seventh the rate of 50 years ago.

That men have a much higher rate of death from accidents and violence than women is well known. The common impression is that this is due simply to greater exposure because of the nature of male activities in our society. But it can be shown that inherent biological influences are at work. From infancy onward the male (not only in the human but in other animal species) is more accident-prone because he is biologically more active, more aggressive, more given to acts of violence (including combat with other males). It is true that the male is generally delegated to more rigorous and more dangerous work than the female, but this fact is not unrelated to natural sex differences.

The life-expectancy figures for various countries support the conclusion that environment is not the primary factor behind the sex difference in mortality. In a harsh frontier or backward environment, where all are exposed to severe hazards and all have a short life expectancy (*e.g.*, in India), the mortality of men and women is about the same. But in every highly civilized country women's life expectancy is better than that of men. The female's biological advantage asserts itself wherever the population as a whole improves its security, and particularly where women most closely approach the same status and activities as men, as in the U. S. With the rise in life expectancy of both sexes in the U. S., the margin of women over men has increased from two years in 1890 to more than six years today: in 1955 their respective life expectancies at birth were 73.6 and 67.3 years.

Of course the degree of the female advantage does not depend simply on a country's state of advancement. In the Netherlands and the Scandinavian countries the margin of longevity between



LIFE EXPECTANCIES AT BIRTH of white men and women in the U. S. over a period of 65 years, and of men and women in 12 other countries over various periods, are compared. The black bars represent men; the white bars, women; the colored bars, the difference between the two. The data for U. S. are from various sources; data for other countries, from United Nations *Demographic Yearbook.*

men and women is substantially smaller than in the U. S. [*see chart on opposite page*].

We may find some clues to explain such variations in heart-disease statistics compiled by the Metropolitan Life Insurance Company (to which I am indebted also for some other information used in this article).

In the crucial age range from 40 to 74, heart diseases kill twice as many U. S. males as females: the rates are 872 per 100,000 males versus 437 for females [*see chart on page 25*]. But among the Dutch both the over-all rate and the difference between the sexes are considerably smaller: 315 male heart deaths to 220 female—a ratio of less than 3 to 2. In other advanced countries, all of which have a lower heart death-rate than the U. S., the male-to-female ratio varies greatly. Medical science has lately been seeking the reasons for the national differences in susceptibility to heart disease. But it cannot lose sight of the fact that in all countries heart diseases kill off more males than females—from infancy onward. Whatever factors of diet or way of life may be involved, there appear to be inherent elements which discriminate against males, and it is important to identify these elements. Several leads have turned up.

For one thing, it has been shown that the average normal blood pressure of females is higher than that of males: 156/84 for female adults against 145/82 for males. This suggests that women may tolerate a high pressure more safely than men. Perhaps the female hormones act as diuretics, helping to remove or dissolve cholesterol and to prevent clogging of the arteries. Jessie Marmorston, a Los Angeles endocrinologist, and others have reported "a great deal of evidence" that estrogens may protect against heart damage from blood clots: women seem to become more susceptible to clot formation when their production of estrogen falls after menopause.

Treatment or prevention of sex-slanted diseases by altering the biochemistry of the body with hormones has already shown interesting results. The National Cancer Institute reports that in men with cancers of the prostate or breast promising effects have been produced by shifting the sex-hormone balance heavily toward the estrogen side; females with inoperable breast cancer have been helped by androgens together with treatment to reduce their production of estrogen. A synthetic estrogen has been used to minimize the effects of mumps, a disease which threatens one in five afflicted males with sterility.

Ordinary baldness appears to be associated with a masculine biochemical environment. James B. Hamilton, an anatomist at the New York State College of Medicine, found that castrated men do not become bald, even when they have inherited the tendency to baldness. But when treated with male hormone such men do lose their hair. If the male hormone treatment is stopped and estrogens are administered instead, their hair begins to grow back.

Gout, a metabolic disorder producing excessive uric acid in the blood, is mainly a masculine disease; although the responsible gene may be inherited impartially by either sex, it is much more likely to express itself in males than in females. Hereditary muscular dystrophy, which may be due to a metabolic defect, afflicts twice as many males as females. Lionel S. Penrose of England has pointed out that albinism, retinitis pigmentosa (an eye disease), alkaptonuria (the "black urine" disorder) and a certain form of congenital idiocy afflict males more often than females, although all these conditions arise from recessive genes and should therefore occur equally in both sexes.

Diabetes, on the other hand, develops in females much more often than in males, although again the susceptibility can be inherited equally by both sexes (ordinarily through recessive genes, but perhaps sometimes through a dominant gene). Women also seem to be more subject to two genetically influenced mental diseases: manic-depression and the rare, terrible Huntington's chorea, a convulsive disorder. Among other mysterious anti-female diseases are Sydenham's chorea (three times as many girls as boys) and the fatal anemic condition called Niemann's disease (six times more common among females). In all of these conditions, as in the diseases slanted against males, we could profit greatly by knowing just what biochemical elements cause the discriminations.

Is it possible to devise standards of biological "masculinity" or "femininity" as measures of individual susceptibility to sex-slanted diseases? Some years ago George Draper, a New York City physician, correlated "andric" and "gynic" physical traits with various diseases. He claimed that the more "andric" types (among both males and females) were more susceptible to ulcers, and that women with gout tended to be of the "andric" type. Contrariwise, men who had gallstones, a female-slanted condition, tended to be of the "gynic" type. Hence the relative proportions of "andric" and "gynic" components in individuals of either sex might determine their predispositions to given diseases. If Draper's idea is correct, we may eventually have a scale for measuring biological masculinity and femininity, just as there is already the Terman scale for measuring degrees of psychological "masculinity" and "femininity." The biological sex scale may be based on musculature, bone structure, body form, genitalia, facial hair, androgen-estrogen output, blood chemistry and so on. Such a scale might enable us to detect, in time for preventive therapy, tendencies to sex-slanted heart diseases, cancers of the stomach, lungs, throat and breasts, thyroid conditions, ulcers and many other diseases.

If that day comes in medicine, people may be faced with a choice between health and sexuality. How far would an individual wish to go in sacrificing traits of his or her own sex to acquire biological advantages of the opposite sex? Would a man elect to buy several more years of life at the cost of some of his "masculinity"? Would a woman choose athletic prowess or more drive toward masculine-slanted forms of achievement at some sacrifice of feminine beauty and a shorter life span? Fortunately we may not be confronted with so hard a choice. It seems likely that the chemists will be able to create synthetic hormones and other chemicals whose effects will be limited to attacking a given disease. Already, it is reported, estrogen has been modified to a form which can reduce the cholesterol level but is robbed of virtually all of the feminizing effects of this hormone. Possibly the natural estrogens and androgens can be broken down to elements which can be used separately to combat specific diseases without disturbing the general biochemical balance.

As medicine turns more and more to chemistry for its answers and treatments, there is every reason why it should give particular attention to the sex differences. The biochemist Roger J. Williams, of the University of Texas, emphasizes the role of what he calls "biochemical individuality" in all sorts of human traits and diseases. Certainly the biochemical differences between the male and the female are at least as significant as those between individuals. And if these basic divergences can lead us to ways of combatting mankind's deadly ills, we may well echo the famed exclamation of a French deputy: *"Vive la différence!"*

Strong Magnetic Fields

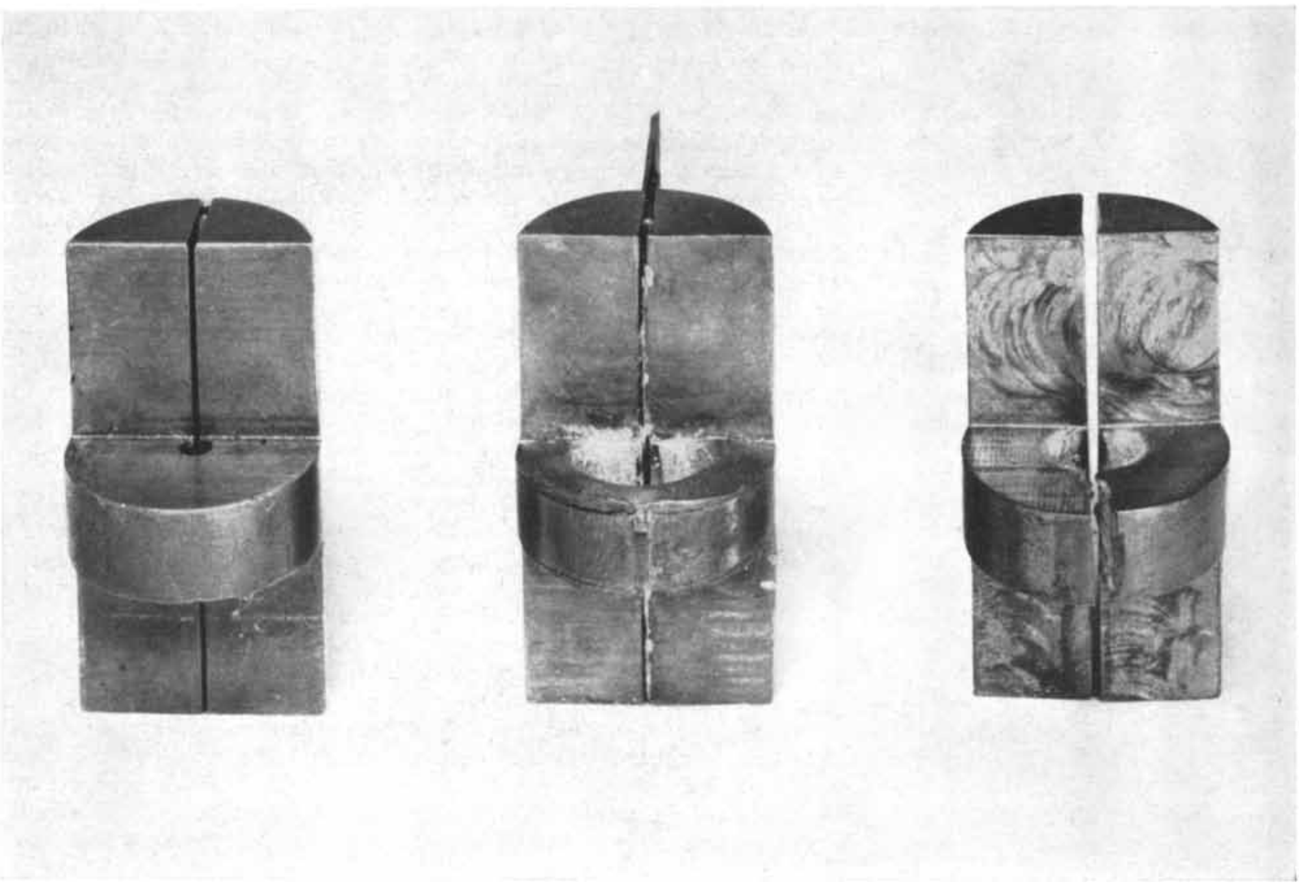
Physicists are building electromagnets whose fields compare with TNT in their concentration of energy. The resulting forces can explode the massive metal coils which produce them

by Harold P. Furth, Morton A. Levine and Ralph W. Waniek

I've seen those Samothracian iron rings leap up and iron filings in the brazen bowls seethe furiously when underneath was the magnet stone.

—Lucretius
De Rerum Natura

The demonstrations so beautifully described by the Roman poet are still a wonder and delight to students in physics classes. Magnetism has always seemed one of the most fantastic phenomena of nature, and we can amuse ourselves by speculating on what Lucretius might have thought about some of its modern manifestations. There are magnets today which can make metals harder than Samothracian iron run like melted butter, or even explode like a bomb. Superstrong magnetic fields have lately become a matter of considerable practical interest [see "Fusion Power," by Richard F. Post; SCIENTIFIC AMERICAN, December, 1957], and of basic experiment in laboratories. Our article deals with recent efforts to produce fields of unprecedented strength.

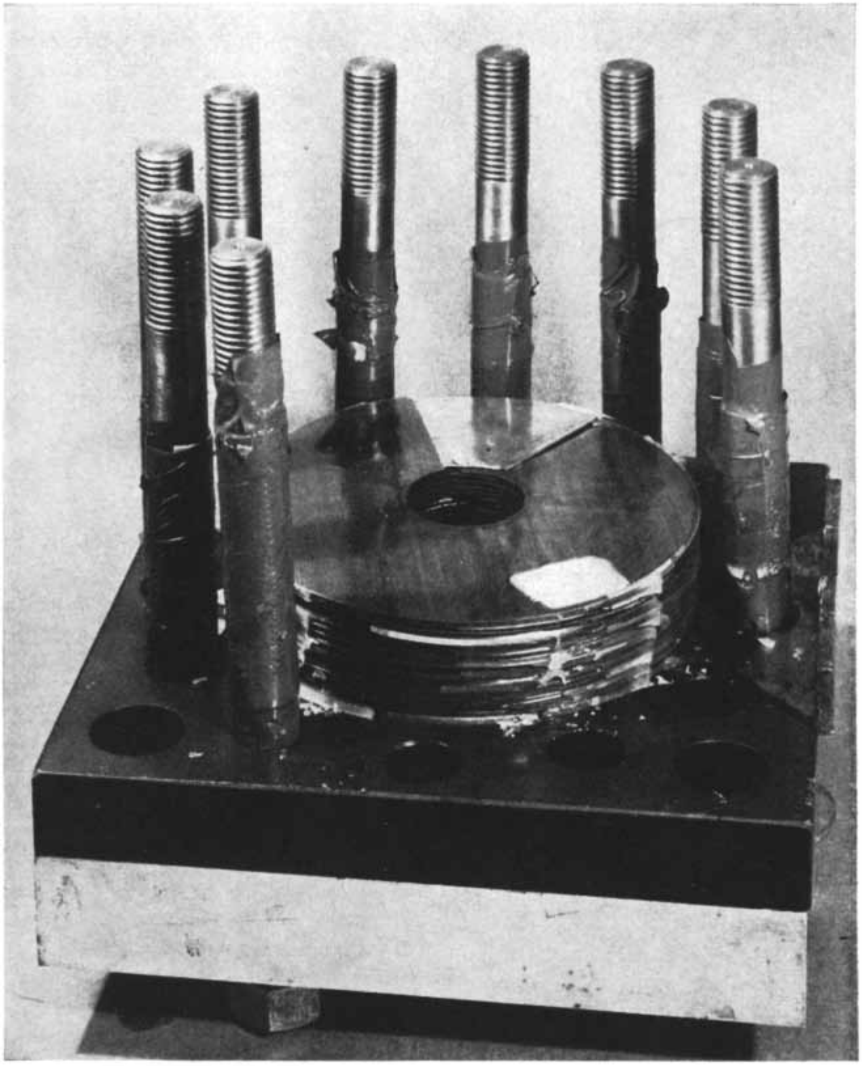


SINGLE-TURN COILS of bronze used to produce very high magnetic fields are about an inch wide and have a central hole about one eighth of an inch in diameter. The coil at the left remained intact after a pulse of 700,000 gauss. The one in the center flowed under a 1.6-million-gauss field. The coil at the right broke into two pieces when the field strength reached 1.3 million gauss.

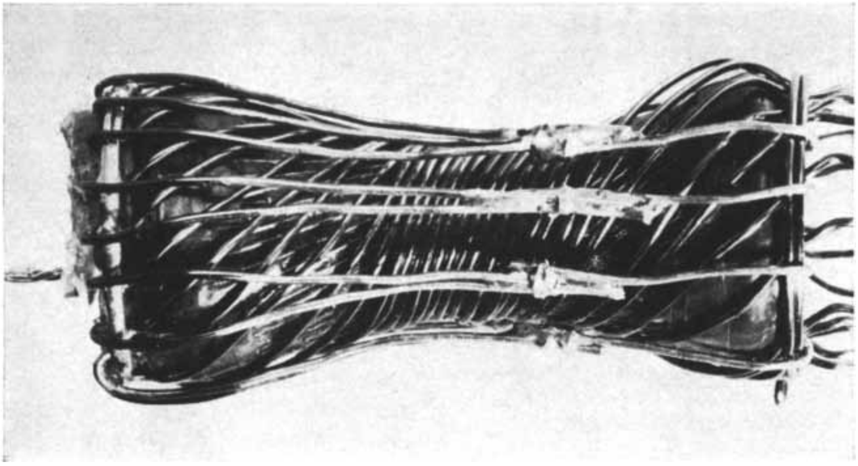
Magnetism has been known to mankind for several thousand years. In China as early as 2600 B.C., so the legend goes, the emperor Huang-ti devised south-pointing carriages to keep his troops on the heels of the rebel Chi-yu, who had managed to disappear behind an artificial curtain of smog. While the authenticity of this stunt is open to question, records from only slightly more recent times attest to the antiquity of the use of magnets. In 500 B.C. a skillful Indian surgeon named Susruta performed eye operations with a magnet, according to Indian literature. The compass is at least as old as medieval times, when it served Arab navigators. In the 13th century Peter Peregrinus, a contemporary of Roger Bacon, explained some of the properties of magnets, and, as is well known, William Gilbert, physician to Queen Elizabeth I, inaugurated the modern investigation of magnetism in 1600.

Until the 19th century the only known source of magnetism was the lodestone—that is, the iron ore magnetite, named after rich deposits at Magnesia in Asia Minor. Around the turn of the 19th century the German physicist J. W. Ritter, in a letter to his former pupil Hans Christian Oersted, predicted that the year 1820 would see a scientific event of the first magnitude. Oersted obliged by discovering electromagnetism in 1819. Scientific research in those days seems to have been carried on in much the same busy and competitive spirit as today. Barely three weeks after the announcement of Oersted's experiment showing that an electric current generated a magnetic field, André Marie Ampère went on to show that current-carrying wires would repel or attract each other like magnets. A few years later the English inventor William Sturgeon made the first electromagnet—a coil of wire with a piece of soft iron inserted inside the coil to intensify the magnetic field.

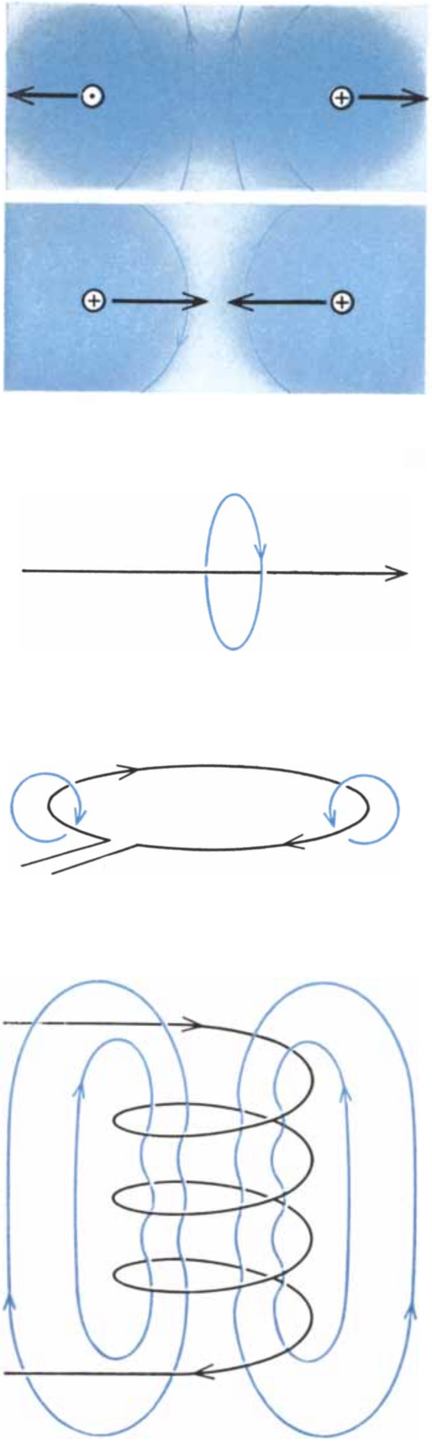
Scientists and engineers alike were vastly intrigued by this new form of energy. Experimenters naturally attempted to make stronger and stronger magnets. The strength of a magnetic field is measured in gauss (named for Karl Friedrich Gauss, the great German mathematician). The field of an ordinary bar magnet amounts to 2,000 or 3,000 gauss. The best permanent magnets (*i.e.*, magnets made of ferromagnetic metal) are no stronger than about 10,000 gauss. An electromagnet, using a core of metal to amplify the field generated by the elec-



LARGE HELICAL MAGNET, made of alternating conducting and insulating disks, was photographed at the University of California Radiation Laboratory in Livermore, Calif. The magnet produces a field of 200,000 gauss in the central chamber, two and one-quarter inches in diameter. It is pulsed three times per minute, each pulse lasting for 500 microseconds. It was built by one of the authors (Furth) in collaboration with Dale Birdsall.



PRINCIPLE OF FORCE-FREE COIL can be seen in this early version of the device, made at the Air Force Cambridge Research Center. Innermost winding runs almost parallel to axis of coil. This is covered by a second winding at a much larger angle to the axis.



MAGNETIC FIELDS around current-carrying conductors are shown as colored arrows in these drawings. Black arrows indicate direction of current. At top two wires carry current in opposite directions (*out of page at left, into page at right*), producing intense field (*colored tone*) between them, which pushes wires apart. Two currents in same direction (*second from top*) produce a weak field between them; wires are pushed together. Lower drawings show field around straight wire, loop and helix.

tric current in the coil, can reach 60,000 gauss at most, because the magnetic capacity of metals is limited. To go much higher, therefore, one must abandon the core and produce the magnetic field in air or a vacuum.

With high electrical power one can generate extremely strong magnetic fields, but the difficulty is that such fields place severe strains on the coil, or solenoid, as it is called. A magnetic field can produce both mechanical and heating effects. The mechanical effects are illustrated by a clever gadget known as Roguet's spiral. It is a suspended coil with its lower end dipping into a bowl of mercury. When a current passes through the coil, the magnetic field around the loops causes the adjacent turns of the coil to be attracted to each other while the opposite sides of each loop repel each other. As a result the coil becomes fatter and shorter, so that its lower end rises out of the mercury. Since the current then stops flowing, the magnetic fields disappear; the coil relaxes, dipping into the mercury again and starting a new cycle. In the high-field coils of modern research the same basic mechanical effects occur as in Roguet's spiral.

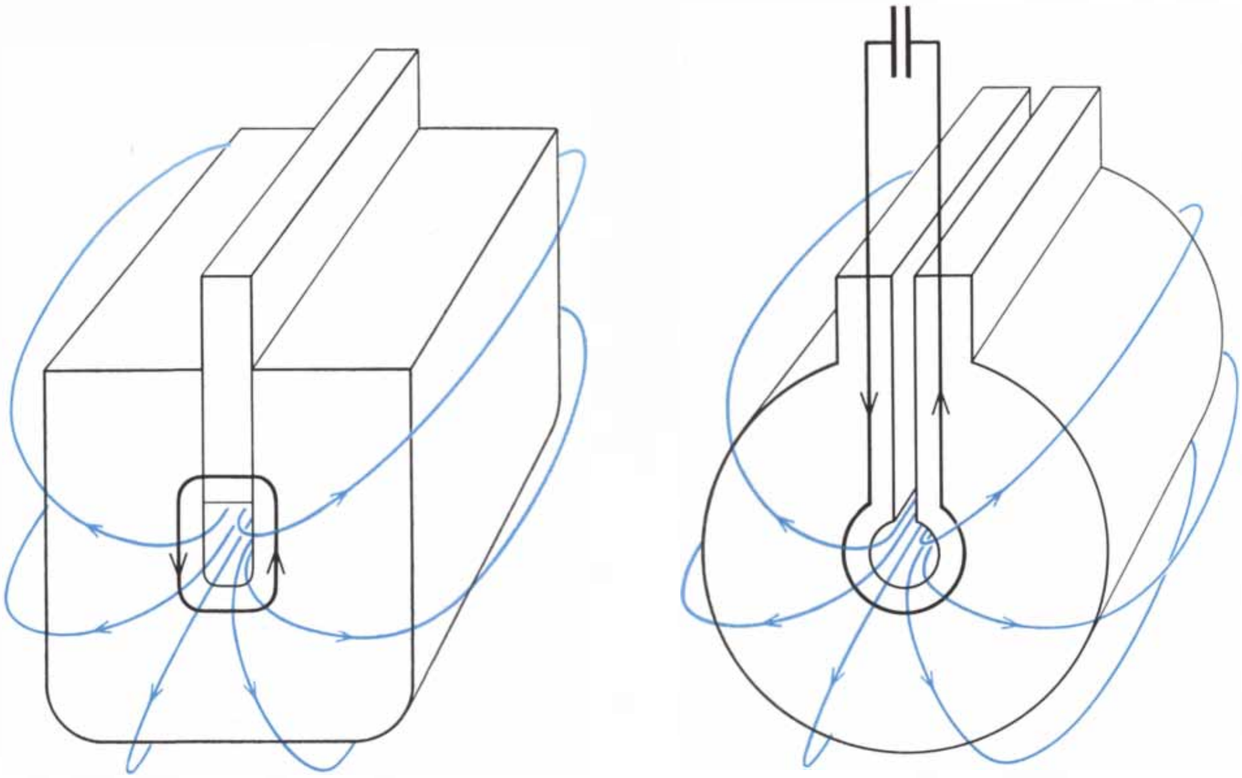
In the 1920s the famous Russian physicist Peter Kapitza, in a classic series of experiments in the Cavendish Laboratory at the University of Cambridge, succeeded in operating at fields as high as 300,000 gauss or more with pulsed currents. But above that level his coils gave way, in spite of all his ingenious devices for reinforcing them. Under the great forces exerted by these fields the response of the coils was not like the gentle movement of Roguet's spiral but more like an explosion.

Kapitza's record magnetic fields were not exceeded for more than two decades. But in recent years physicists have returned to the challenge. Several years ago we set up a high-field project at the Cyclotron Laboratory of Harvard University. Our immediate objective was to create magnetic fields strong enough to act on atomic particles tracked in photographic emulsions. It would be extremely useful to be able to use a magnetic field in this medium as it is used in the Wilson cloud chamber: to determine the charge and momentum of a particle by the deflection of its track by the magnetic field. Since it takes a very powerful field (200,000 gauss or more) to control the path of a particle in the dense emulsions, we came to look for new means of generating magnetic fields. This quest proved even more interesting than the original problem, and we have been able to produce transient fields of well over a million gauss.

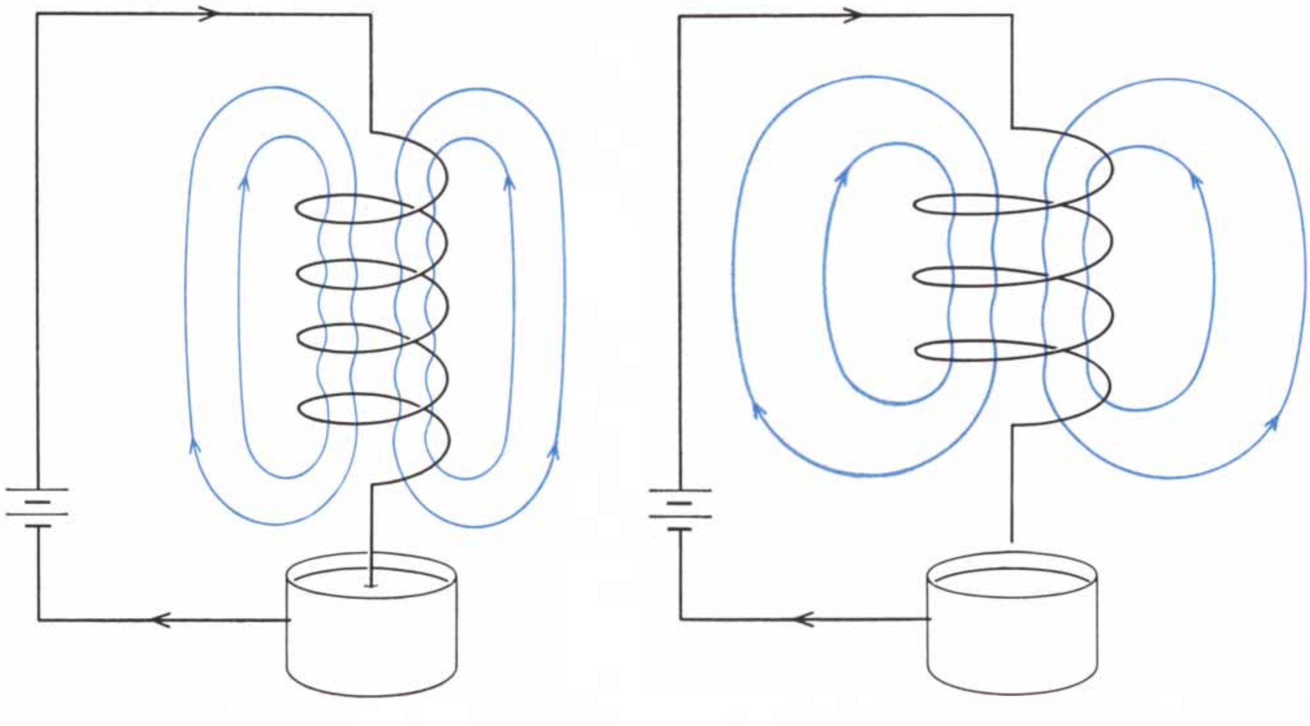
A useful analogy for understanding (and working on) this subject is to think of a magnetic field as a gas. When a magnetic field is compressed—that is, when the lines of magnetic force are crowded together—the pressure of its concentrated energy rises, just as the pressure of a gas rises with compression. The density and pressure of the stored energy increase as the square of the strength of the magnetic field: if you double the strength of the field, the pressure (energy density) increases fourfold. Obviously with increases in field strength this pressure can build up to high values. Indeed, in 1917 a French inventor proposed that the principle be used to make a magnetic cannon, observing that such a gun could fire missiles at much higher velocity than ordinary artillery. (Recent experiments have proved his idea correct, though for various practical reasons there is little danger that future wars will be fought with magnetic guns.)

To compress a gas you must confine it in a container of some kind. In the case of a magnetic field the container is a sheet of current. This current can flow in a wire coil or in any kind of conducting wall. If a piece of copper or any other good conductor of electricity is thrust into a magnetic field, the field causes currents to flow on the surface of the piece. These currents exclude the magnetic field from the bulk of the metal by exerting a momentary opposing pressure. In a very short time, however, the currents are pushed into the walls and the field penetrates uniformly into the metal. So we can speak of the magnetic field as being confined transiently within a conducting chamber on the surface of which a current flows.

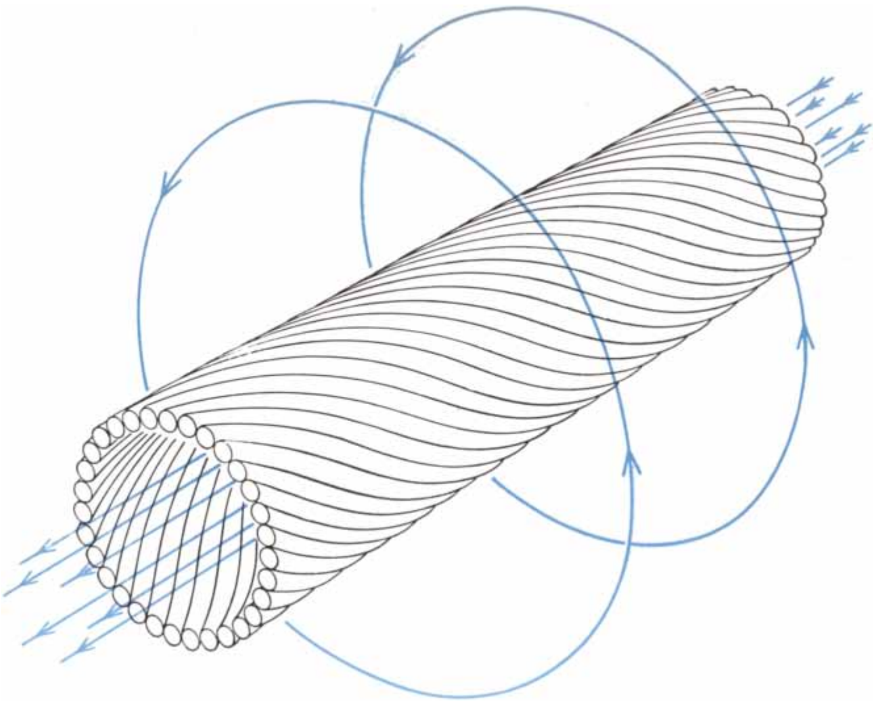
Our first problem is that the container leaks like a sieve: it is much like trying to hold a gas in a vessel with porous walls. To extend the analogy a little, trying to build up a magnetic field in the container by pouring in electrical juice is like attempting to fill a sieve from a water faucet. It can be done by using the limited flow from the faucet to fill a bucket, and then dumping the contents quickly into the sieve. In the electrical case the bucket is a group or bank of capacitors, which is charged slowly at low power and then discharged very quickly at enormous power. One of our large capacitor banks discharges at the rate of four billion watts for 10 micro-



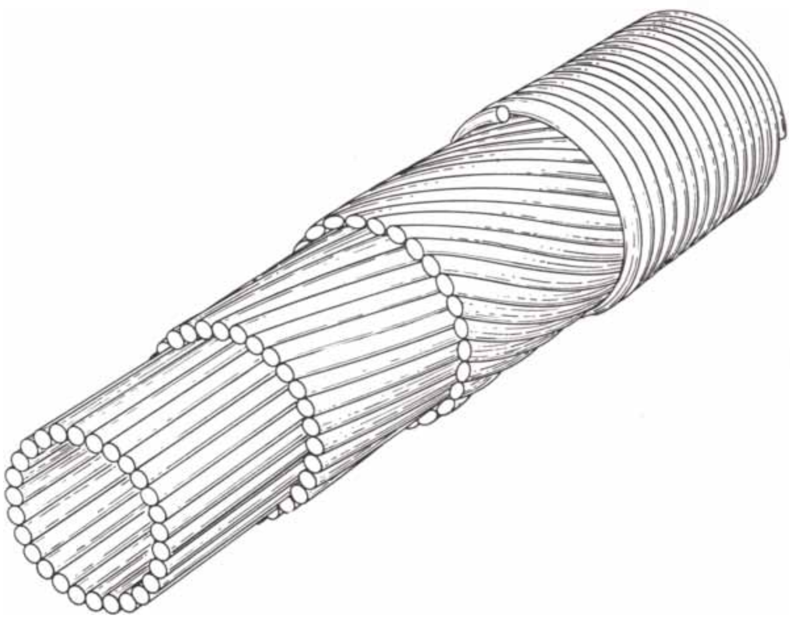
COMPRESSING MAGNETIC FIELDS increases their intensity. This might be done mechanically with a conducting cylinder and piston (*left*). Field (*colored lines*) is enclosed by current flowing around chamber (*black rectangular loop*). In practice it is usually done electrically (*right*) by discharging a condenser (*top*) into a massive coil. Field is again contained by current flowing around coil.



ROGUET'S SPIRAL consists of a loose coil connected to a battery through a cup of mercury. Current flows (*left*) and the field created in the coil expands, increasing radius of the turns. Magnetic loops shrink and contract coil lengthwise. When end of coil rises out of mercury (*right*), the circuit breaks and the field disappears. Coil then returns to original shape and cycle repeats.



THEORY OF FORCE-FREE WINDING is illustrated by a single coil wound so that the wires make an angle of 45 degrees with the axis of the cylinder. When a current flows through the coil, a magnetic field (*colored lines*) is set up. This field can be resolved into two components: a straight field within the coil and a circular field surrounding it. The internal field tends to expand while the external field tends to contract, so that the forces offset each other. In practice, however, this simple scheme would not work because the windings of the coil would be crushed between the interior and exterior forces.



FORCE-FREE WINDINGS IN PRACTICE are made of several layers, with the pitch of the windings changing gradually from a direction nearly along the axis of the coil to one which spirals almost perpendicularly to the axis. In this way the transition from the straight internal field to the circular external field is achieved in small steps, with the result that the compressional force on each layer of the winding is comparatively low.

seconds. The sudden input of this energy sometimes sounds like a clap of thunder.

As the flood of energy rushes into the coil, it creates a very high magnetic field which in turn exerts immense mechanical pressure on the coil walls—about 140,000 pounds per square inch in the case of a field of 50,000 gauss. A wire coil could hardly contain such pressures. Our coil (in one version) is a massive block of metal—made of a special alloy of copper and tungsten—and it is encased in a reinforcing shell of hardened steel. The coil resembles a collar: it has a small cylindrical hole in the middle for the magnetic field and is slit along its length so that it forms a "single-turn" coil [*see diagram at top of preceding page*].

This coil is strong enough to withstand pressures of magnetic fields up to nearly a million gauss. At 900,000 gauss the inner surface of the coil is damaged, but it is sufficiently intact to be used again. Under higher fields the metal begins to give way, but thanks to inertia it holds together long enough (some 15 microseconds) to contain a considerable field. We have reached fields up to more than a million and a half gauss while the coil was exploding.

There is a good deal of talk these days about using a "magnetic bottle" to hold a hot "plasma" of electrically charged particles, but bottling a magnetic field itself can be a formidable problem. The problem is twofold. First, there is the mechanical effect of the pressure, which can push tough metal about as if it were soft plastic. Secondly, diffusion of the magnetic field into the metal heats it up, and at the surface of the coil the heat may be sufficient to cause melting. The heating effect can damage the coil even before an extremely high field is reached. If there is a small flaw or pit on the surface of the metal, the surrounding surface area becomes hot and melts. This melting expands the size of the flaw so that it grows with increasing speed. The resulting notches resemble cuts made in the coil with a saw. Thus we speak of the "magnetic saw effect."

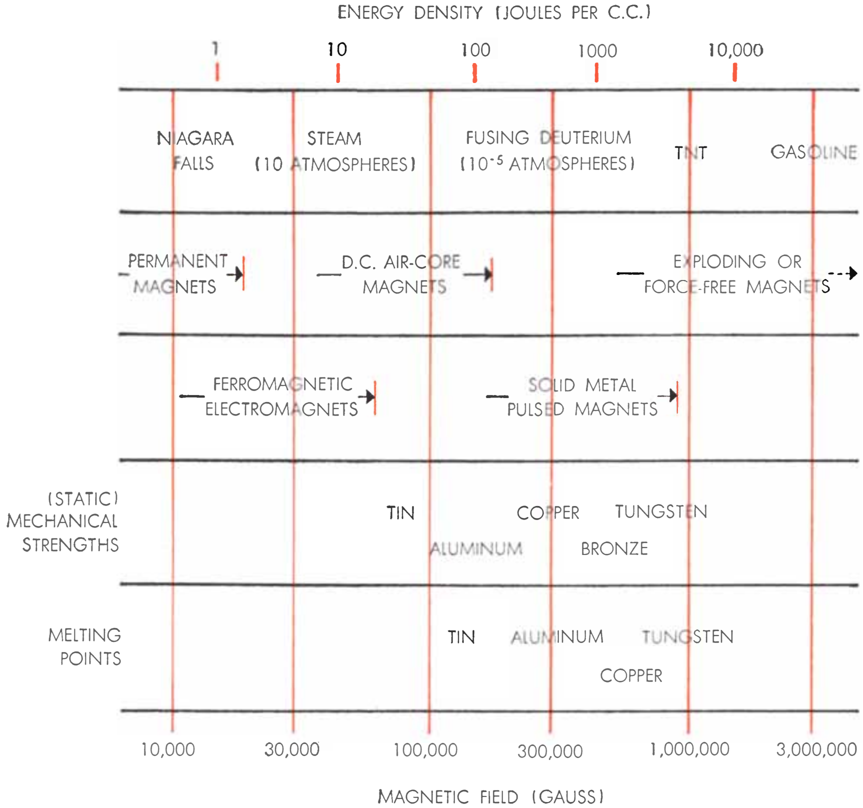
Single-turn coils are best able to withstand disruption by mechanical pressure and the saw effect, and the very highest fields have been achieved through their use. When working at somewhat lower field strengths, however, it is often convenient to use a coil in which the current makes more than one circuit around the magnetic chamber. Each turn of current around the chamber produces a magnetic field, and the total field is the sum of those from all the turns. Therefore a given field can be achieved with a smaller current than in a single-turn coil.

A multi-turn coil that has considerable mechanical strength has been invented by Francis Bitter of the Massachusetts Institute of Technology. It consists of a stack of alternating conducting and insulating disks [*see photograph at top of page 29*]. The conductors are connected through appropriately placed notches in the insulators so that when current has flowed around one of them it passes to the next lower disk and travels down the stack as down a spiral staircase.

Bitter, incidentally, has been successful in producing fairly high magnetic fields (about 100,000 gauss) with continuous current instead of pulses. To accomplish this he must keep filling his coil with magnetic field as fast as it leaks out—a procedure involving a million-watt generator for power and part of the Charles River for coolant.

Facing stern mundane limits upon our magnetic fields, we have turned to astrophysics for ideas about how we might get to higher fields. Our somewhat noisy and destructive experiments may seem to have little common ground with the placid contemplations of the astronomer. But we find a meeting place in the field of plasma physics. It is well known that there are substantial magnetic fields in outer space (amounting in strength to only a small fraction of a gauss). How they can be contained in the extremely tenuous, almost pressureless clouds of gas in space is a puzzle. The German astrophysicists A. Schlüter and R. Lüst have suggested that the fields maintain their form through a balance of purely magnetic forces; in other words, that there are certain special field configurations which are "force-free" in the sense that they do not tend to expand or alter their shape. We have tried to design some force-free systems in the laboratory, and have found the problem less labyrinthine than we expected.

Imagine a set of wires wound into a helical coil in such a manner as to produce three-dimensional magnetic fields [*see diagram at top of opposite page*]. This coil will have a longitudinal field inside it, seeking to expand, and a circular field running around it, seeking to contract. In short, these fields balance so that there is no inward or outward force. The main trouble comes at the ends of the system: the compensation breaks down there and consequently the force-free configuration is disturbed. A way out is suggested by the torus, or doughnut, a system without ends. One of the authors of this article (Levine), who produced the first stabilized pinch effect on a low-pressure plasma at Tufts University in 1954, proved thereby that a force-free magnetic field is possible in a toroidal shape. We have begun to experiment with this and various other shapes suitable for practical force-free coils. It seems reasonable to hope that fields as high as 10 million gauss may be achieved in these devices.



ENERGY STORAGE in magnetic fields and other systems is shown at the top of this chart. Storage is given in joules per cubic centimeter (a joule is the energy delivered by a one-watt power source in one second). Magnetic field strengths are read along the bottom line. The metals are located to show approximately how strong a field each can withstand before melting or deforming. Horizontal arrows indicate the range of field strengths produced by various types of magnets. The maximum field for force-free magnets is still unknown.

Meanwhile there are plenty of uses for the high fields already attained. The original objective—to make fields strong enough to control particles moving in emulsions—has been realized and is being applied in some laboratories. The same ability of high magnetic fields to deflect charged particles sharply can be useful in many other ways. High magnetic fields may make it possible to reduce the huge size of our super-cyclotrons. The gigantic University of California Bevatron, if rebuilt to operate with 300,000 gauss instead of around 16,000, would shrink to something that could be put on a dining-room table. And of course strong magnetic fields will be very helpful in producing thermonuclear reactors of relatively small size.

At the level of basic physics, high magnetic fields should bring us new knowledge about the nature and behavior of matter. Fields of the magnitude we have been discussing are strong enough to dominate the motions of charged particles within atoms. They can cause some crystals to contract, can make a conducting metal extremely resistant to electrical current or opaque to infrared radiation and can produce other profound changes in matter. We can expect research in high magnetic fields to yield many new insights, just as there will doubtless continue to be startling explosions.

The Metabolism of Ruminants

How is a cow able to digest the tough cellulose of plants? It does so with the help of four stomachs and microorganisms which both break down its food and provide it with vitamins

by Terence A. Rogers

Sentimentalists have argued for centuries about whether man's best friend is the dog or the horse. But a biologist would not cast his vote for either of these animals. In value to mankind the animal that wins hands down is the cow. Aside from the fact that cows usually have attractive and gentle dispositions and are far more intelligent than popular fancy supposes, they provide us with the bulk of our animal proteins. They do this without competing with man for their own food, since they feed mainly on plants inedible by man—namely, grass. Indeed, beef cattle can be raised on pasture land which is unsuited for growing other crops. And whereas the only plant materials that man can convert to energy are grains, fruits and roots, the cow can extract energy for us from cellulose—the main constituent of plants.

Our topic is the remarkable machinery by which the cow accomplishes this. As everyone knows, the cow is a ruminant, meaning literally that it chews the cud. It can fill its stomach rapidly with grass and spend the rest of the day quietly working over the meal in some peaceful retreat—an advantage that must have been of great survival value for this type of animal in the wild state. The machinery that makes possible the extraordinary metabolic feats of the cow (and of other ruminants such as goats, sheep, camels and deer) consists of the animal's multiple stomach and a group of microorganisms, with which the cow lives in happy and mutually profitable association.

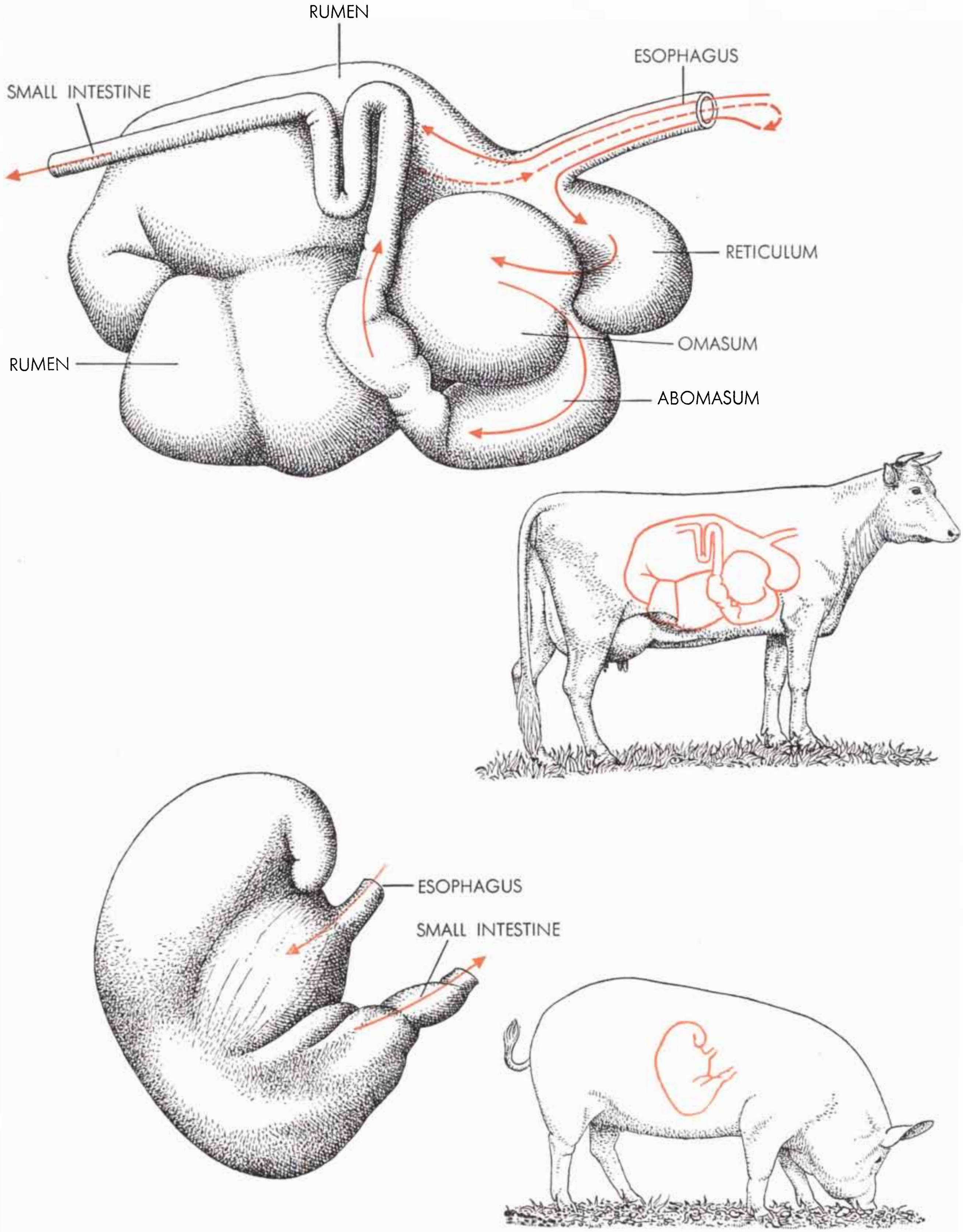
The cow has four stomachs. The first two, known as the rumen and reticulum, are connected by an opening so large that they can be considered one compartment. This serves as a fermenting vat. In a large cow its capacity is as high as 40 or 50 gallons. Here the animal deposits the mass of plant material that it has chewed and rechewed. An enormous population of microorganisms breaks down this indigestible stuff into simpler compounds. The walls of the rumen slowly knead the semiliquid mass back and forth and gradually push it toward the third stomach, called the omasum. The function of that compartment seems to be to squeeze the water out of the pulp. The material then passes to the fourth stomach, the abomasum, where it is digested in the ordinary way which is common to the stomachs of other animals.

Until recently it was believed that the only function of the microorganisms in the rumen was to break down cellulose. Studies in the past few years, however, have shown that they also synthesize substances which are used directly by the cow as food. For example, they synthesize B vitamins, so that the cow does not need to have these vitamins supplied in its diet, as man does. What is even more important, the bacteria and protozoa in the rumen make amino acids and proteins from simple materials and so supply them to the cow. In other words, the cow does not require amino acids in its food.

It is this great gift that makes cattle so valuable as producers of human food. They can convert low-grade plant material, with biologically inferior protein and much indigestible roughage, into meat and milk. To be sure, milk cows produce more if their diet is enriched with high-protein feeds, but their basic usefulness rests on their ability to make proteins from simple substances. Recent studies have shown that cows can even produce proteins from urea, ordinarily a waste product. Some microbes in the cow's rumen can split urea to ammonia, and others then fix the nitrogen of the ammonia to make it available for synthesizing amino acids. Many dairy feeds now contain a small percentage of urea—which must be the cheapest "protein" feedstuff on record. Only a small amount of urea can be fed, because if there is too much ammonia, the organisms will produce nitrites, which are toxic both to the microbes and the cow.

The microbes' synthesis of foods is one side of their role; their breakdown of substances to provide the cow with energy is the other. Fermenting the plant material in the rumen, they decompose its complex carbohydrates into large quantities of short-chain fatty acids, principally acetic acid. The salts of these acids go directly into the bloodstream through the wall of the rumen, in much the same way that other mammals take up alcohol and similar simple foods through their stomach wall. A ruminant's metabolism of carbohydrates is quite different from that of a nonruminant such as man. We digest carbohydrates to form simple sugar, mainly glucose, and produce short-chain fatty acids later in the tissues. Consequently our blood contains substantial amounts of glucose but almost no short-chain fatty acids. The cow's blood exhibits the opposite—a low level of glucose (only half as much as in man) and a comparatively high level of fatty acids. It has been calculated that 90 per cent of the cow's energy requirements are supplied by the acetic acid produced in the rumen. Apparently the cow's body tissues are exceptionally efficient in utilizing acetate directly for energy.

A ruminant animal does not begin using this digestive system from birth but rather develops it as an adjustment to the progress of its feeding habits. A



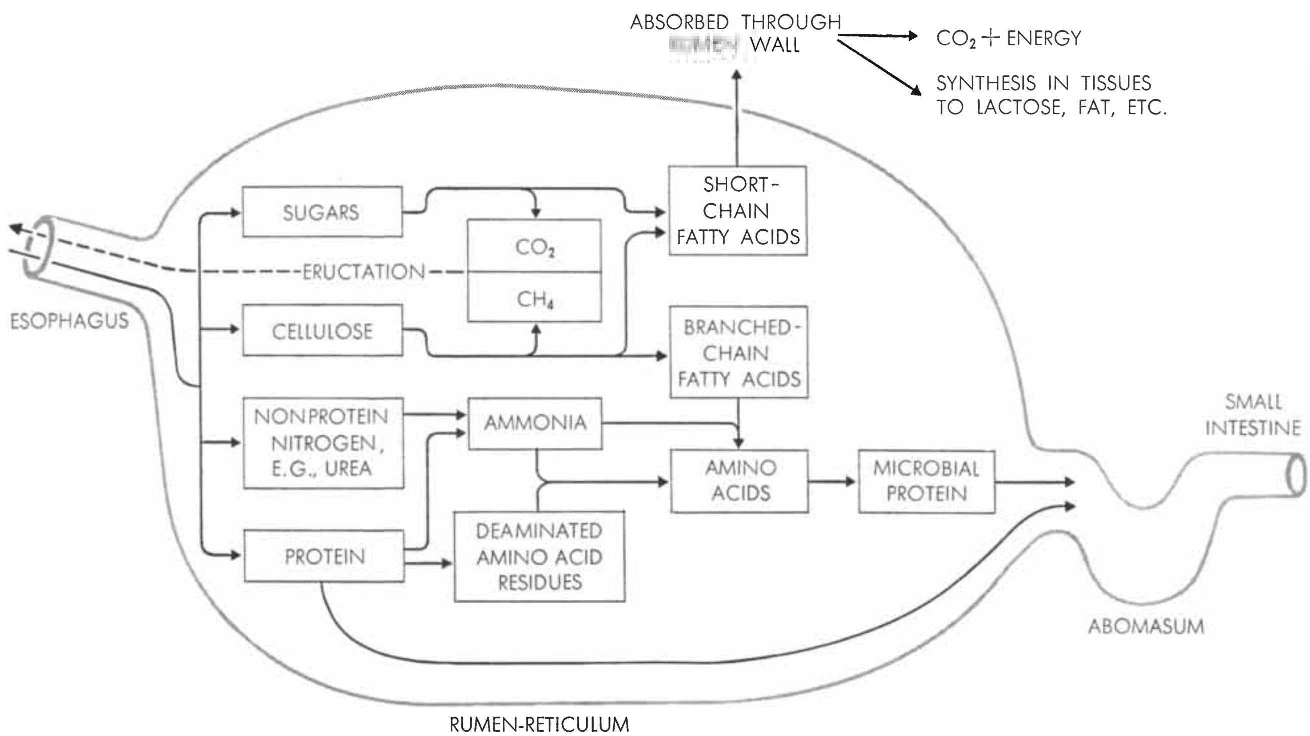
COW AND PIG STOMACHS are compared. The cow has four stomachs: the first two (reticulum and rumen) together act as a fermenting vat; excess water is removed in the third stomach (the omasum); conventional digestion takes place in the fourth stomach (the abomasum). A nonruminant such as the pig has only one stomach, the function of which corresponds to that of the abomasum.

young calf, as long as it feeds on its mother's milk, metabolizes its food in much the same way as other animals. Its rumen is undeveloped and comparatively free of the digestive microbes. At this stage of life the addition of small amounts of antibiotics to its food will accelerate its growth, as it does that of swine and poultry. But when the calf reaches the age of four months, the feeding of antibiotics becomes harmful, because it kills the helpful microbes in the rumen. As soon as the calf starts to eat grass and hay its rumen enlarges, the population of microbes grows and its pattern of metabolism changes. The sugar level in its blood falls, and acetate becomes more and more important. Apparently the animal responds to its changed diet by manufacturing enzymes which facilitate the metabolic production of energy from acetate by its tissues. This is not to say that the cow can get along without glucose. Like most other animals it stores energy in the form of liver glycogen, and of course this must be synthesized from glucose. In addition it needs glucose for the nerve tissues. Above all, it must have glucose to make milk, for the milk sugar, lactose, is produced from glucose. A lactating cow requires a large and continuous supply of sugar. Since sugars formed in its rumen are fermented before they reach the digestive gut, the animal must synthesize sugar in its tissues from other materials. Recent work has shown that the main source of the cow's glucose is the short-chain fatty acids.

With the help of radioactive carbon as a tracer a good deal has been learned about how a cow makes milk [see "the Synthesis of Milk," by J. M. Barry; Scientific American, October, 1957]. A team of workers under Max Kleiber at the University of California demonstrated that the cow synthesizes glucose from all the short-chain fatty acids. The California group and workers in England have also shown that the cow uses the same fatty acid units—acetate, propionate and butyrate—to make milk fat. The fatty acids also provide material for the synthesis of the proteins in the milk, according to an analysis by the California workers. All this points up the sharp contrast between the metabolism of ruminants and that of other mammals. The ruminants' energy and substance are derived largely from the fatty acids produced in the rumen, whereas man depends on glucose and amino acids supplied by his food.

Tracer studies of this kind have opened up a large field for study of biosynthetic processes in a living animal. By investigating the cow's manufacture of milk we can examine its synthesis of substances without disturbing the animal in any way.

The ruminant digestive system gives the animal great advantages by simplifying its food-seeking problem, but it also has disadvantages. One of them is that the fermentation in the rumen generates large quantities of gas—carbon dioxide and methane. Normally the animal discharges the gas by frequent belching. But if something interferes with this release of gas, the rumen swells and the animal is afflicted with the spectacular calamity known as bloat. Cattle die of this condition unless it is relieved by an operation puncturing the body wall. An accumulation of carbon dioxide in the rumen not only distends the stomach but also acts as a drug on the nervous system, preventing the animal from belching. Bloat usually attacks cattle that have been feeding on rich leguminous pastures. Studies in California and New Zealand have shown that the plants responsible for bloating contain foaming agents (saponins). The froth traps the gases so that belching cannot release them. The New Zealand workers found that they could prevent bloat by dosing the animals with an antifoaming agent. Dairymen have long followed the practice of feeding cows some hay, to



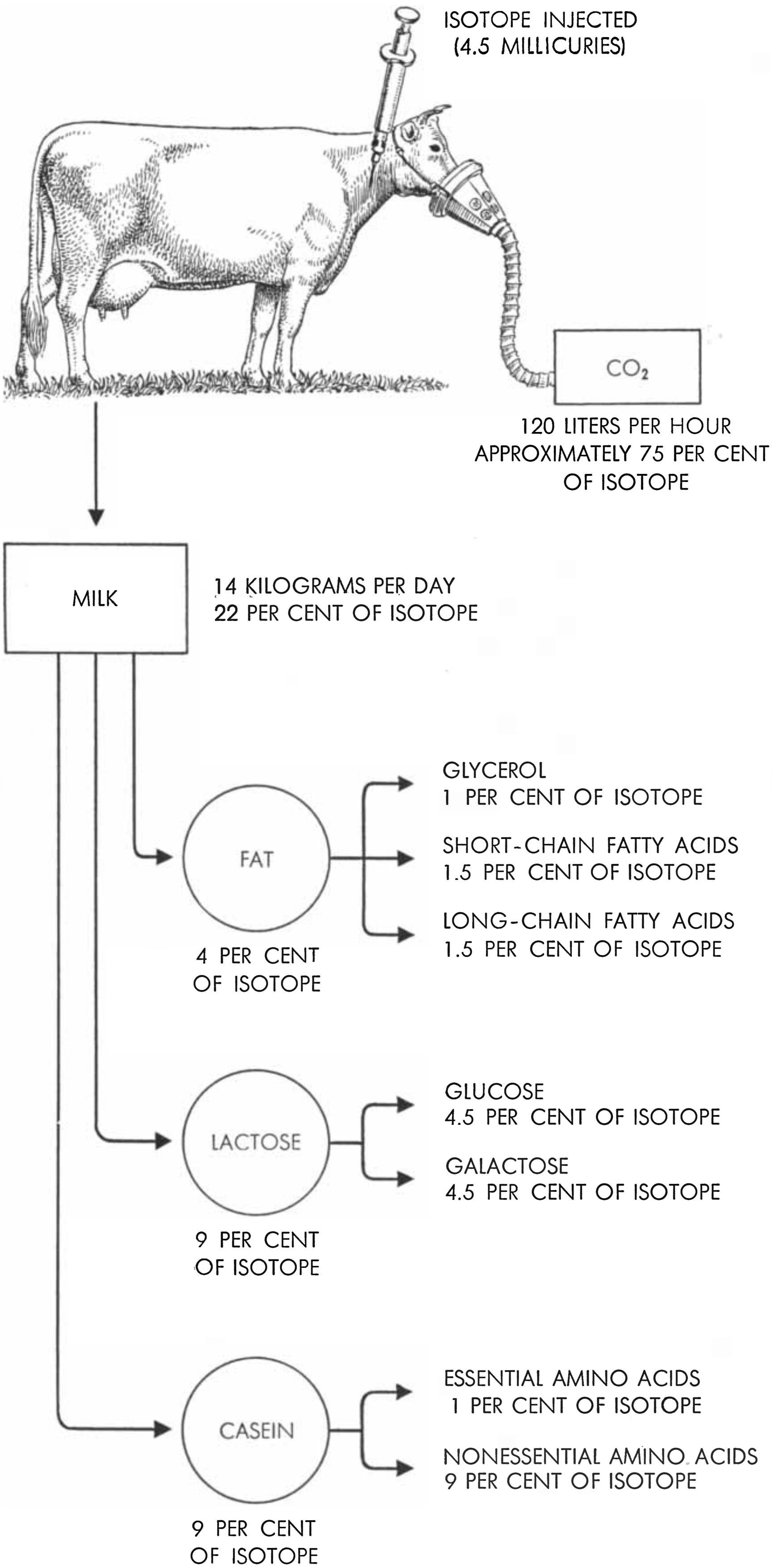
DIGESTION AND SYNTHESIS both take place in the rumen and reticulum. Cellulose and sugars are broken down to fatty acids and the gases carbon dioxide (CO_2) and methane (CH_4), which are removed by eructation (belching). Proteins and other foods containing nitrogen are broken down to amino acids and ammonia, and then rebuilt into microbial protein. This protein is redigested.

dull their appetites, before turning them into leguminous pastures.

Another serious ailment of cattle is ketosis, or excessive formation of ketones in the body, which gives the urine and exhalations a fruity smell. The disease is somewhat like diabetes in man. Although the cow's blood shows a deficiency rather than an excess of sugar, the metabolic disorder in each case has the same net result: a shortage of glucose in the cells. In the cow the deficiency of sugar in the blood seems to be the cause of the ailment. Modern, high-producing dairy cows are particularly susceptible to the disease because they must have large amounts of glucose for the milk. Sheep in the late stages of pregnancy also commonly suffer from ketosis. In both cows and ewes the symptoms can be cleared up rapidly by injecting glucose into the blood, but the response is only transitory. By the time the disease is recognized, the animal has usually stopped eating and seems unable to "catch up" with its need for sugar. It should be noted that glucose or molasses fed by mouth are quite valueless, for the microbes in the rumen immediately ferment the sugar to short-chain fatty acids. Recently the condition has been treated with the hormone ACTH, which promotes production of glucose from protein in the body, but some workers argue that this is a rather expensive way of providing sugar.

The biochemical facts suggest that the primary cause of the disease may be either a defect in the metabolism of certain fatty acids or some shortcoming in the diet or the microbial population that results in reduced production of these substances in the rumen. The latter speculation might explain the curiously epidemic nature of ketosis outbreaks on certain farms.

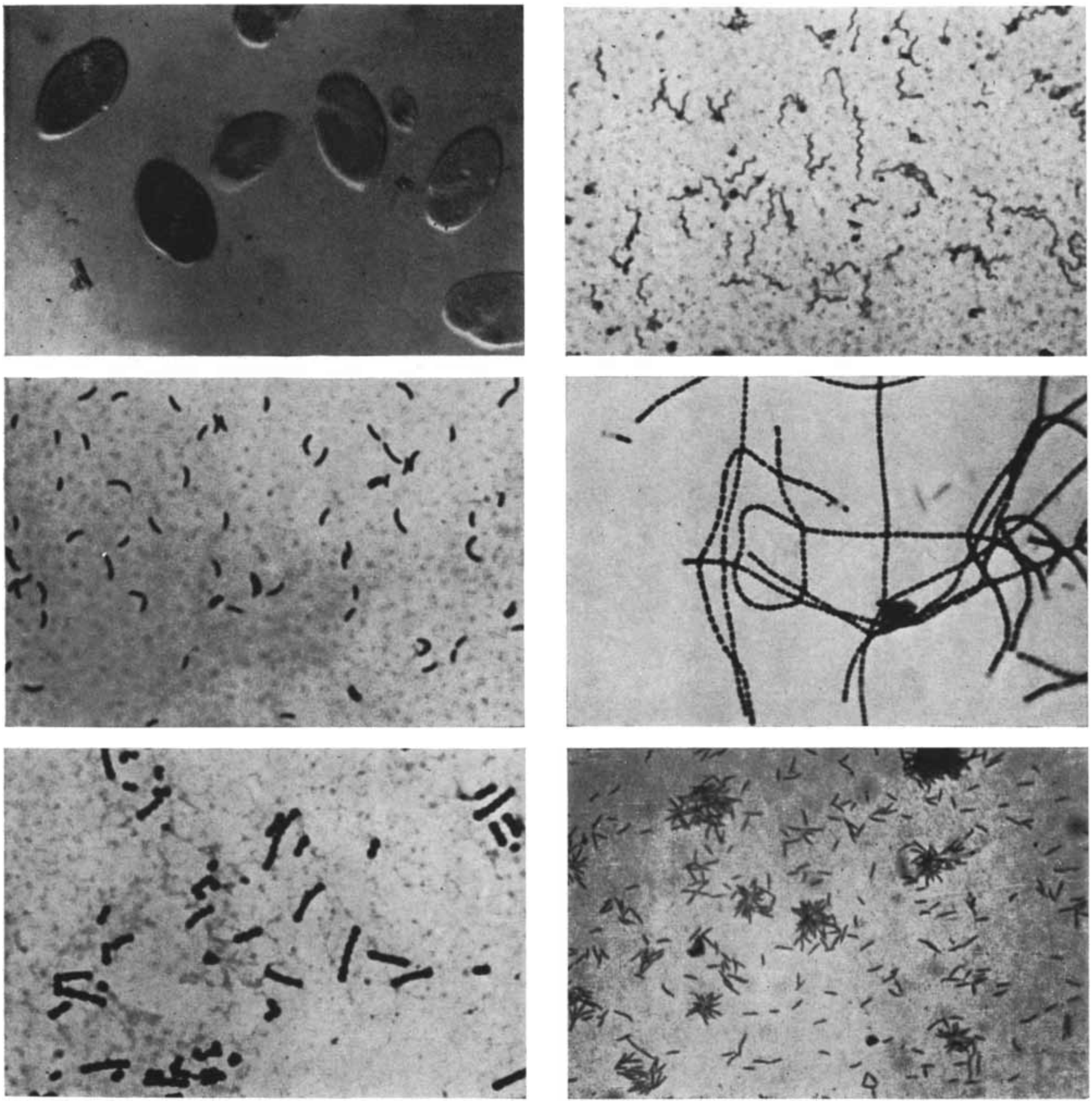
It is in the underdeveloped countries of the world that better knowledge of the metabolism of cows (and goats) will pay the greatest dividends. In the highly developed Western countries breeding and an abundance of feed have raised cattle to high productivity. But the backward countries, most of which lie in the tropical belt, are under two great handicaps in animal husbandry—heat and a shortage of good feeds. The high-quality cattle stocks developed in the temperate regions do not thrive in hot climates. Since the cow cannot sweat, it is vulnerable to overheating. The European breeds go off their feed and may suffer heat strokes. However, the Brahman and Zebu cattle of India and some cattle of



LABELED BUTYRATE, a fatty acid, was injected into the vein of a cow, and then milk and respired air were analyzed for radioactive carbon to indicate how butyrate is utilized. The chart above is based on data obtained by Max Kleiber of the University of California.

Africa are considerably more tolerant of heat than our breeds, and the King Ranch of Texas has developed a new breed based on a Brahman-Hereford cross which is adapted to warm temperatures and at the same time retains the beefiness of the Hereford. It is to be hoped that this experience will help cattle breeders in India to improve the productivity of their native cattle.

The feed problem will be more difficult to solve. In the tropical countries the arable land is already almost fully occupied to produce rice and other staples for human consumption. But ways to enlarge the supplies of cattle fodder may be found by research. One possibility under study is lignin, which, with cellulose, forms the main bulk of plants and often imprisons digestible material. The microbes in a ruminant's stomach make no impression on lignin. Plant material can be made more digestible, however, by grinding it to break down the lignin walls of the plant cells. If a cheap chemical method for doing this can be found, it will be possible to feed cows in the tropics on pineapple foliage, sugar-cane waste and other coarse materials. During World War II sawdust was fed to cows in Sweden, but it yielded little nutrition. The problem is to make the lignin itself digestible by rumen microbes. If we could do this, we could envision an animal husbandry based on sawdust and urea. However appalling this may seem to pastoral romanticists, it would have a decisive impact on the world's food supply.



RUMEN MICROORGANISMS were photographed by workers of the U. S. Agricultural Research Service. Jose Gutierrez made the picture of the protozoon *Isotricha intestinalis* (*top left*). Bacteria photographed by Marvin P. Bryant include *Borrelia spirochaetales* (*top right*); *Selenomonas ruminantium* (*center left*), which ferments carbohydrate; a starch-fermenting coccus (*center right*); two that digest cellulose, *Ruminococcus flavefaciens* (*bottom left*) and *Bacteroides succinogenes* (*bottom right*).

Kodak reports on:

keeping your fingers dry . . . why they still use cellulosics in lacquer . . . what every practical-minded photomicrographer should know

Brute force

Photographic paper which requires no processing is of itself no news.* There may be a little news in that at least two major manufacturers of moving-mirror oscillographs now offer recording instruments based on what we call *Kodak Linagraph Direct Print Paper*. If *they* want to call it something else, we love them none the less.

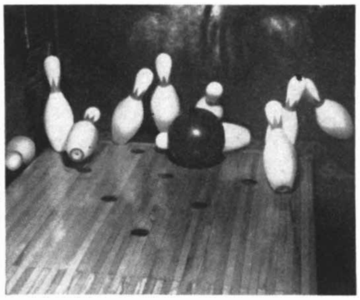
In giving up photographic development, one gives up for the sake of dry fingers an energy amplification factor of enormous power. Nevertheless, we agree that dry fingers are nicer than wet fingers. We bow low to the optical design ingenuity that has contrived cool and quiet little boxes in which most satisfactory traces are put down through brute force of u-v radiation. One company claims frequencies to 2,000; the other, to "above 3,000," with trace velocities "above 30,000 inches per second."

At low recording and writing speeds, focused energy from a high-intensity Hg-vapor ultraviolet point source is sufficient for a legible record. Where it isn't, use is made of a post-exposure to some 60 foot-candles from a fluorescent lamp. For all practical purposes the post-exposure raises the speed several hundred times. The trace comes out blue on a buff background. As with most miracles, the miracle of *Kodak Linagraph Direct Print Paper* becomes a little less miraculous upon quantitative study. The total energy delivered to the paper in the writing and the post-exposure is about the same as the radiant energy required by a conventional photographic enlarging paper. It's just that the energy requirement can be supplied in two separate doses.

If interested in this type of oscillography, watch for pertinent ads in the technical press and alert your purchasing agent to send in the next man who comes around with one of these instruments. If you have other ideas for this type of paper, Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y., will try to be helpful by arranging with a local dealer to sell you some of it for experimentation.

*For better than 60 years we have made studio proof paper. On it many portrait photographers submit those brownish-purple proofs from which the customers select the poses they like. The proofs are to be returned. People who instead stick them up on their boudoir mirrors find they don't last very long in the light of day. That's the idea with studio proof paper—no developing *and no fixing*.

The polymer that steers easily



Know what looks good for the base of the lacquer to protect these things? Cellulose acetate butyrate.

Twenty-seven years of our life we have given to cellulose acetate butyrate. If you care to devote the next two or three minutes of yours to the subject, you will learn as much as a mildly interested outsider can take.

From each of the anhydroglucose units that constitute the links of the long chains of cellulose, three hydroxyl groups protrude. Hydroxyls of adjacent chains attract each other. The affinity keeps the chains packed together and thus maintains the structure of the plant tissue. This doesn't serve man's whims as well as it used to. The hydrogen bonds can be broken and the unchanged chains put into new shapes such as cellophane sheet and continuous rayon filaments. Such regenerated cellulose, however, has few parameters to play with. It does not melt. There are no volatile solvents from which it can be recovered undamaged.

To provide more room for maneuver, the next step (conceptually, if not historically) is to replace the protruding hydrogens with acetyl and butyryl groups. After drying, the product looks rather like the original wood pulp or cotton linters before the treatment with acetic and butyric acids or anhydrides. Now, however, the chains no longer cling together so. Heat them and they mobilize to a viscous liquid long before a destructive temperature is reached. They are likewise free to be separated and whirled off into liquid mobility by a grand variety of organic solvents useful in lacquers. Because of the randomness with which acetyls and butyryls have replaced the hydrogens, the lockstep is broken. Chain molecules move in small aggregates, governed by statistics. The statistics are readily adjustable in the manufacturing process. An acetyl is larger and less attractive than a hydroxyl, and a butyryl is larger and less attractive than an acetyl. Their relative proportions and the length of the molecule are subject to fine control.

Longer molecules mean higher viscosity at a given concentration; with this goes toughness of the film left after evaporation of the solvents. If you want higher solubility, lower specific gravity, better tolerance for lower-cost solvent extenders, better compatibility with resins and plasticizers, more flexibility and moisture resistance in the films, you increase the ratio of butyryl to acetyl groups. If you want more resistance to grease and assorted chemical agents, better tensile strength and hardness of the films, and higher melting point, you decrease the ratio of butyryl to acetyl. To control embrittlement during weathering, you back off and restore about one in twelve of the replaced—

Does any of this really matter to you? If so, we shall be overjoyed to send without charge a new 75-page data book, "Cellulose Acetate Butyrate." Address Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company). The book even tells what we have for sale in this line.

Up two bits

Whoever wants to learn how to do photography through the microscope should read "Photography through the Microscope." Kodak dealers stock it or can order it from us, the publishers.

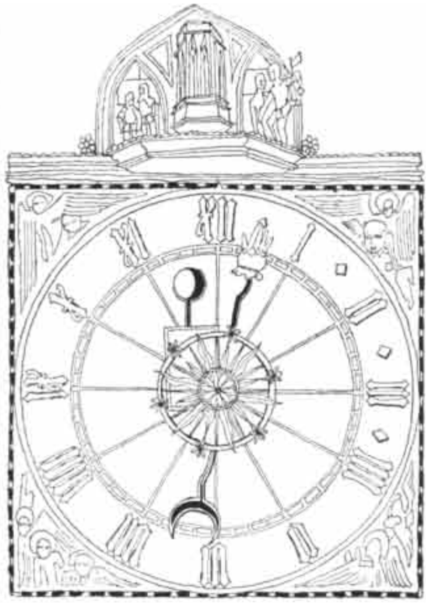
The main difference between the 75¢ Second Edition and the 50¢ First Edition is that the didacticism on the theory of the photographic process has been eased off. In its place there is a tour under escort of a practical-minded photomicrographer along the shelves of new photographic materials uncorked in the last few years.

Price quoted is subject to change without notice.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Kodak
TRADEMARK

SCIENCE AND



Acceleration

The U. S. Atomic Energy Commission has authorized the building of the world's most powerful particle accelerator at the Argonne National Laboratory in Illinois. The machine, which will accelerate protons to energies of 12.5 billion electron volts, will be designed to produce a beam more intense than that of "any other of the multibillion-electron-volt accelerators now in operation or under construction anywhere in the world."

Meanwhile the National Science Foundation also announced last month that plans are going forward for the first national astronomical observatory in the U. S. The site is to be in Arizona, "one of the few remaining areas in the U. S. where an observatory can be located sufficiently distant from light and dust generated by cities."

Task Force for Physics

To stimulate interest in science among U. S. students, the American Institute of Physics will sponsor lectures at colleges and high schools in the coming year. Sixty-two physicists, including Nobel prize winners, will visit 100 colleges and 60 high schools. Besides lecturing, they will discuss research and teaching problems with physics faculty members and seek to acquaint other members of the academic community with recent developments in physics.

The program, according to Elmer Hutchisson, director of the Institute, seeks to "develop an informed citizenry who will appreciate the role of science in a technological society." The project will be financed by the National Science Foundation and the Ford Foundation. William C. Kelly, on leave from the University of Pittsburgh, is administering it. Among the participating scientists are Nobel prize winners Polykarp Kusch, C. N. Yang, William Shockley and Walter H. Brattain. Other prominent participants include R. E. Marshak, Hans A. Bethe and Luis W. Alvarez.

Pay Raises

The U. S. Government has announced a general pay increase for engineers and physical scientists in Federal Government employment. It raised all employees in these categories to the maximum for their grade, regardless of length of service. The increases, applying to everyone except scientists already at the $16,000 maximum, ranged up to $1,080 per year. They affect some 48,000 physicists, chemists, mathematicians and engineers, and will add $22 million to the annual payroll. An additional $3.5 million will be spent to hire 4,000 more physical scientists in the coming year. Most of the cost will be borne by the Department of Defense, the largest Government employer of scientists and engineers.

Biologists protested their exclusion from the raise. Hiden T. Cox, head of the American Institute of Biological Sciences, said that the 28,000 biologists on the Federal payroll were being treated as "second-class scientists." He declared that superior students need to be attracted to biology, because there are "qualitative shortages in almost all fields of biology and many are in areas critical to the national defense effort."

Harris Ellsworth, chairman of the Civil Service Commission, said that the Commission was studying shortages in the biological and other sciences. Under existing law the starting pay for Federal employees can be raised only if it is clearly necessary for the recruitment of personnel.

Academic Disorder

What U. S. universities need most is "some peace and quiet and order," according to J. C. Warner, president of Carnegie Institute of Technology. In an article published last month he said that

THE CITIZEN

Government emphasis on applied research has so disorganized university work that many scientists are "living a life of intellectual chaos." Their energies have been channeled away from teaching and creative research and often are dissipated in administrative work.

Writing in *Chemical and Engineering News*, Warner observed that Government money, which has multiplied research work in universities about 10-fold during the past 15 years, is seldom usable at the discretion of the university and its scholars. Most of it is given for contract research which must restrict itself to a fairly circumscribed area. "I do not believe," he said, "that any board, committee, agency, administrator, or the scholar himself can predict ahead of time the most fruitful direction a scholarly study will take. . . . I would rather have $10,000 in unrestricted funds . . . than $30,000 a year in Government contracts."

Warner asserted that Government support of research has had undesirable effects on scientists. Some have "yielded to the temptation of building research empires. . . . They cease being scientists and become administrators and promoters of team research." Team research, he said, does not produce the new generalizations, ideas and comprehensive theories which "constitute the essence of new science."

Many scientists, he added, have become restless, as shown by mounting requests for leaves of absence "to spend a semester or a year abroad, or in another institution . . . or on a glamorous missile or satellite project." Some "run from committee meeting and symposium to committee meeting and symposium." Warner concluded with the complaint that fewer leading scientists and engineers than formerly "have a real interest in good teaching, especially at the undergraduate level."

Basic Research in the U.S.S.R.

The U.S.S.R. has not yet caught up with the U. S. in basic science, two leading Soviet scientists stated last month. Interviewed at an international meeting of physicists at Stanford University, D. I. Blokhintsev said: "We hope to achieve the same level as America." In Moscow Alexander N. Nesmeyanov, president of the Soviet Academy of Sciences, told the Soviet parliament that "great efforts" were needed to overtake the U. S. in all branches of science.

A U. S. physicist who lectured in the U.S.S.R. last summer doubts the ability of the Soviet system to close the gap in fundamental science. In an article in *Physics Today* Donald J. Hughes of the Brookhaven National Laboratory said that the Soviet Academy's "absolute control over scientific activities" and the concentration of effort on isolated large projects produce spectacular successes in applied fields such as rocketry and the building of large accelerators, but they do "not work at all in basic research."

Even in high-energy physics, "where the Russians have pushed so hard . . . the actual discoveries in basic science are not impressive," Hughes said. At the time of his visit, the Soviet 10-billion-volt accelerator, though operating, was not yet usable for experiments. "In other fields of basic science the activity is almost zero. . . . In neutron physics I could find no activity to compare with that in the U. S."

Hughes, disagreeing with the impressions of other visitors to the U.S.S.R., said that Soviet scientists are not highly paid: except for Academy members the pay scale is only about half that in the U. S. He found that few scientists own cars and most live in small apartments.

A.A.A.S.

The annual meeting of the American Association for the Advancement of Science in Indianapolis last month reflected the increasingly strong interaction between science and everyday affairs. In view of the current ferment of political activity affecting science and science education, the Council of the A.A.A.S. passed a resolution calling for "a widely representative meeting of scientists" to discuss current issues and make recommendations to the appropriate agencies. The meeting, which is being arranged by a committee headed by Warren Weaver, vice president of the Rockefeller Foundation, will be held in Washington in the next few weeks, during the early part of the present session of Congress.

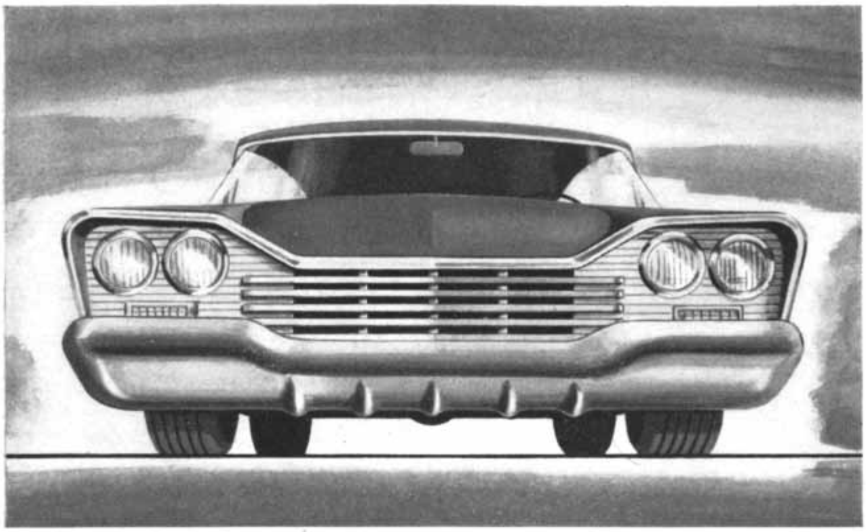
The A. A. A. S. Committee on the Social Aspects of Science, set up at the 1956 meeting, held its first symposium, devoted to the fallout problem as an example of the social impact of science. The chief paper, by Barry Commoner of Washington University in St. Louis,

SILICONE NEWS

The Road Ahead: Silicones

- Increase Efficiency
- Reduce Upkeep Costs

WHAT'S AHEAD IN AUTOMOBILES?—*With '58 models newly sparkling in the nation's showrooms, auto men are turning their attention to future car designs. Whether the '59 and '60 editions will be fatter, finnier, or fuel-injected is anyone's guess . . . Detroit doesn't tell. But one thing certain is the increasing importance of Dow Corning Silicones in automobile performance. Silicones began appearing in cars only in recent years, but their application by designers has constantly increased: the future holds much more.*



NEW EFFICIENCY — In an unexpected place (the cooling fan) auto engineers have found a new source of usable horsepower. Ten or more horsepower per engine! And the discovery hinges on silicones.

This latest power booster is really a power saver known as the Thermo-Modulated Drive. It works on a fluid drive principle . . . the fan revolves only as fast as required for cooling. The fan is connected to the engine via an adjustable coupling, containing silicone fluid, rather than direct drive. A thermostat determines how hot the engine cooling water is, and adjusts the fluid coupling — therefore fan speed — accordingly.

Only silicone fluids are able to keep a constant enough consistency for this drive mechanism. They don't thin out in heat or become "heavy" when cold, as petroleum oils do. Auto men already knew this from using silicone damping fluids to prevent jiggling of dash instrument needles. Dow Corning silicone fluids for new "air rides" have similar features.

MORE MILES BETWEEN "PIT STOPS" — Silicones help reduce auto maintenance too. Here are some current examples . . . future ones are almost limitless!

Item: SEALS MADE OF SILASTIC*, the Dow Corning silicone rubber, prevent oil leakage in automatic transmissions. Despite the fact that transmission oil temperatures now average 250 F and may reach 325 F, Silastic defies heat, provides a positive seal, assures long, trouble-free service.

Item: DOW CORNING 4 X is specified by all auto manufacturers to protect and keep weather stripping and rubber mounts from "squeaking." Widely used by auto repair shops too . . . in spray or greaselike form.

Item: JACKETS MOLDED OF SILASTIC protect spark plugs from moisture . . . keep them firing when humidity's high. Unlike ordinary rubber, Silastic is not harmed by engine heat, always maintains a flexible, effective moisture guard.

Item: SILICONE BASED POLISHES, everyone's favorite for protecting a car . . . give the finest, durable gloss with the least effort!

NEXT YEAR'S GUIDE— to silicones is the 1958 catalog of Dow Corning products, just published. 16 pages, fully illustrated, and conveniently indexed, the '58 guide is a practical one-source reference to the fascinating new world of silicones. Send for your free copy today.

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

FOR MORE INFORMATION **on any of these silicone products or applications, write Dept. 982**

first in silicones

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

dealt with the triple responsibility of scientists: to inform themselves on the technical problems involved; to see to it that this information is made available to the public; and to participate, as citizens, in the making of political decisions.

Chosen as president-elect of the Association, to serve in 1959, was Paul E. Klopsteg, associate director for research of the National Science Foundation. The 1958 president is Wallace R. Brode, associate director of the National Bureau of Standards. The retiring president, who becomes chairman of the board of directors, is Laurence H. Snyder of the University of Oklahoma.

The number of A.A.A.S. prizes was increased this year. Some are awarded for papers delivered at the meeting and some in recognition of work extending over several years.

The Newcomb Cleveland Prize went to Martin Schwarzschild and J. B. Rogerson, Jr., of Princeton University and J. W. Evans of the Sacramento Peak Observatory, who reported on the photographs of the sun made last summer from a balloon at an altitude of 80,000 feet. These pictures, the clearest ever made, showed new details of the sun's atmosphere, including eddies as small as 120 miles in diameter.

A new prize—the A.A.A.S.-Campbell Award for Vegetable Research—was given to S. H. Wittwer and F. G. Teubner of Michigan State University for work in increasing the yield of tomato plants. Exposure to low temperatures (50 to 55 degrees Fahrenheit) at the beginning of the flowering period produced a large increase in the number of flowers in the first cluster.

Irvine H. Page of the Cleveland Clinic won the Ida B. Gould Award for cardiovascular research. He discovered the substances angiotensin, which controls the caliber of blood vessels, and serotonin, which has proved to have a wide variety of physiological effects [see "Serotonin," by Irvine H. Page; SCIENTIFIC AMERICAN, December, 1957].

The annual prize for a socio-psychological essay was given to Irving A. Taylor of the Pratt Institute for a study showing that extreme "authoritarian" and "equalitarian" personalities are basically the same.

For work on the biochemistry of steroid hormones Paul Talalay of the University of Chicago won the Theobald Smith Award in Medical Sciences. Talalay studied soil bacteria which can satisfy their entire nutritional requirements with a single steroid. He was able to isolate the enzyme systems by which the

bacteria digest the steroid and to identify the active chemical groups involved in the reactions. Using purified enzymes, Talalay devised highly sensitive biochemical tests to measure steroid hormones in body fluids.

The Anne Frankel Rosenthal Memorial Award for Cancer Research went to Roy Hertz of the National Institutes of Health. Investigating the relation between hormones and cancer, Hertz discovered that the breast and the uterus require certain specific chemicals such as folic acid for their growth. By administering folic acid antagonists he has been able to stop the growth of tumors in these organs.

The William Procter Prize for Scientific Achievement, awarded by the Scientific Research Society of America, went to Crawford H. Greenewalt, president of E. I. du Pont de Nemours & Company.

Shippingport

The pressurized-water reactor at Shippingport, Pa., the first full-scale nuclear power plant in the U. S., "went critical" on December 2, 1957—15 years to the day after the original nuclear chain reaction was achieved in Chicago. By December 23 the plant was feeding its full capacity of 60,000 kilowatts into the power grid of the Duquesne Light Company.

The plant, built by Westinghouse Electric Corporation, cost $72.5 million plus another $50 million for research and development work. Duquesne contributed $5 million in cash and provided the site and the turbine-generator. The remaining cost was defrayed by the U. S. Government. According to preliminary estimates, electricity from the reactor will cost about 62 mills per kilowatt-hour. Duquesne will buy the power at the going rate of about eight mills.

Officials of the Atomic Energy Commission said that a large part of the cost was consumed by experimental features, and that a similar reactor, delivering higher power, could now be built for substantially less. Operating costs also could be lowered, particularly through improvements in fuel design.

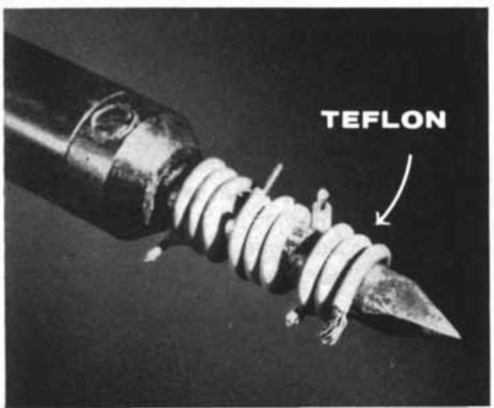
Fire in a Nuclear Reactor

On October 10, 1957, some of the fuel rods in a British experimental reactor at Windscale caught fire and burned for more than a day, releasing measurable amounts of radioactivity over the surrounding countryside. The

It's easy to tell which are the TEFLON TFE-fluorocarbon resins . . . as other wire insulations (Fig. A) soften, (Fig. B) melt, and (above) finally char.

B

A



fluorine-saturated molecule is resistant to heat

It's the unique structure of the molecule that gives TEFLON TFE-fluorocarbon resins their amazing physical properties. The long carbon chain is totally saturated at every bond with a fluorine atom. This fluorine-to-carbon bond is very powerful. The large atoms of fluorine, spiraled about the chain of smaller carbon atoms, blanket this bond still further against external conditions.

That's why the TEFLON resins are so resistant to heat and corrosives. It takes a lot of thermal energy to shake these strongly bonded atoms apart. The soldering-iron photos demonstrate this heat resistance. TEFLON resins are rated for use to 500°F. The sheath of fluorine atoms also serves as an impenetrable shield, protecting the carbon chain from attacking reagents. So, TEFLON resins display practically universal chemical inertness.

Learn how this same molecular structure also gives these resins unsurpassed electrical properties, unique non-adhesiveness, low coefficient of friction, usefulness at cryogenic temperatures. Investigate their many applications and methods of fabrication. TEFLON resins may provide the opening wedge to expanded operations in your scientific or business future.

For the technical facts and product ideas, write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 382, Du Pont Building, Wilmington 98, Del. In Canada: Du Pont Company of Canada (1956) Ltd., P.O. Box 660, Montreal, Quebec.

TEFLON®
TFE-fluorocarbon resins

DU PONT
REG. U. S. PAT. OFF

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

accident produced something approaching panic among the local population. Last month a committee of inquiry of the Atomic Energy Authority published a White Paper detailing the causes of the accident and the measures taken to cope with it.

The fire started during a maintenance operation known as "Wigner release." This involves heating the graphite moderator to anneal out certain atomic dislocations in its crystals, caused by neutron bombardment. (The name derives from the physicist Eugene Wigner, who first predicted the dislocations.) To let the graphite heat up, the flow of cooling air through the pile is reduced. Because the reactor was designed before the Wigner effect was well understood, its temperature-monitoring devices were not placed at the points that get hottest during the annealing process. Hence the operator did not know that some of these points had overheated enough to start the neighboring fuel rods burning.

By the time the fire was discovered, the affected rods had swollen so much that they could not be pulled out of the reactor. The rods surrounding them had to be removed to prevent the fire from spreading, and an unsuccessful attempt was made to quench it with carbon dioxide. Eventually the physicists in charge decided to use water, and the reactor was doused for more than 24 hours.

During the fire, fission products from the burst fuel elements poured out of the reactor's chimney. The surrounding air became 10 times as radioactive as normally. But measurements on people who were cycling near the reactor showed that they had not been exposed to dangerous levels of radiation. Apparently through oversight, milk from cows grazing in the area was not checked until 34 hours after the accident. Then it was found to contain a level of radioactivity considered slightly too high for safety, and distribution of the milk from these cows was suspended for several days.

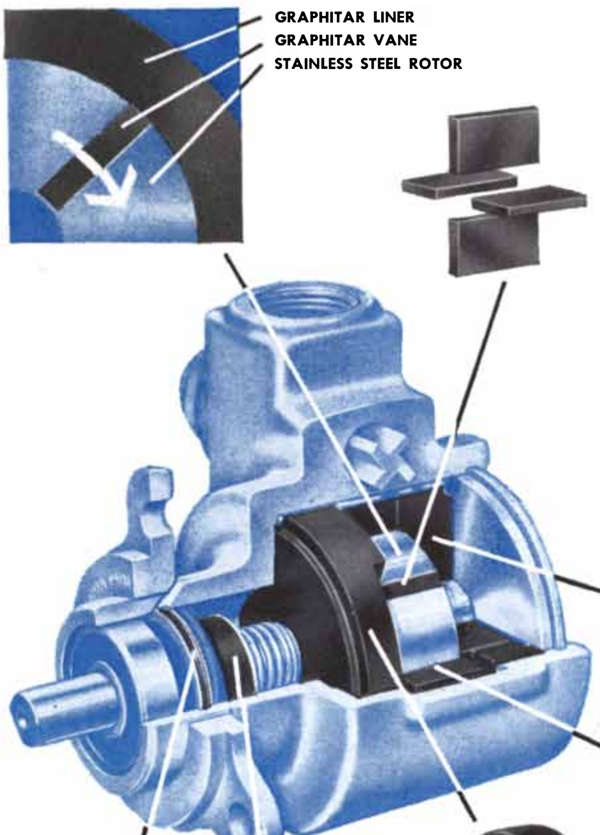
The investigators found that none of the workers in the plant was over-exposed to radiation and that no damage was done to people in the neighborhood.

Neutron Mystery

The neutron has no electric charge, yet it produces a magnetic field. Physicists have tried to explain this puzzle by supposing that the neutron is electrified internally, with a positively charged core and negatively charged circulating mesons that balance the core

GRAPHITAR® (CARBON-GRAPHITE) running against GRAPHITAR

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*



Mixing soft drinks . . . pumping chemicals, ethy-glycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating, and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.

For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-255-2

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 6, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES charge and so give the neutron a net charge of zero. The charged, moving mesons presumably would account for the neutron's magnetism. But a group of Stanford University physicists last month threw some doubt on this idea.

Robert Hofstadter and his colleagues reported to the international gathering of physicists at Stanford some recent experiments they have performed on neutrons. Bombarding atomic nuclei with high-speed electrons, they found that the diameter of the neutron's magnetic field is about seven tenths of a fermi—approximately the same as that of a proton. But the electrical diameter of the neutron (the range of its supposed electric charges) is practically zero. In short, they found no electric charges circulating around the core—at least not far enough from the center to produce magnetism. So the neutron's magnetism is more mysterious than ever, and at the moment it appears that the theory of the neutron's structure will have to be revised.

More and More People

A runaway increase in world population has added about 172 million—the equivalent of the population of the U. S.—to the total in the last four years. The rate of increase has jumped to 1.7 per cent a year, double the rate in 1950. In the last seven years there has been a greater rise in the rate of increase than had taken place in the full century before 1950.

These facts from a United Nations report on the world social situation are discussed by Robert C. Cook in *Population Bulletin*. He attributes the present spurt to a spectacular drop in death rates rather than to a rise in birth rates. In economically underdeveloped areas mortality is being sharply reduced by improved health facilities, but the birth rates remain high. Some countries in Latin America, for instance, are increasing their population at the unprecedented rate of 3 per cent a year.

"The fertility obsession—once so necessary and now so dangerous," says Cook, "threatens world peace and security" by hindering economic improvement of the people in the underdeveloped areas.

A few areas with population problems have reduced their birth rate significantly—notably Italy, Japan and Puerto Rico. Japan has achieved a remarkable decline in births since it legalized abortion and sterilization in 1948. Its birth rate now has fallen to the traditionally low rate of France.

Photo courtesy Princeton Knitting Mills, Inc., New York, N. Y.

How's this "fur" ingenuity?

Man-made mink is now a reality and just one of a number of minor miracles being wrought by today's textile manufacturers.

Their sorcery stems from two recent developments. First is a knitted fabric with a long, luxurious, cut pile of soft, but sturdy, synthetic fibers. And second is its *back-size,* based on a combination of CHEMIGUM LATEX and PLIOVIC LATEX.

The latex backing is important as it provides essential body, pile lock, dimensional stability, flexibility and resistance to raveling. CHEMIGUM LATEX is used because it imparts these properties on a long-term basis, thanks to its excellent resistance to dry cleaning and aging. PLIOVIC LATEX—a vinyl latex—is used, primarily, to control the "hand" of the fabric.

If you are interested in making a pile fabric of outstanding quality, be sure you have the full story on both CHEMIGUM LATEX and PLIOVIC LATEX in back-sizes. It's yours for the asking. Just write to Goodyear, Chemical Division, N-9457, Akron 16, Ohio.

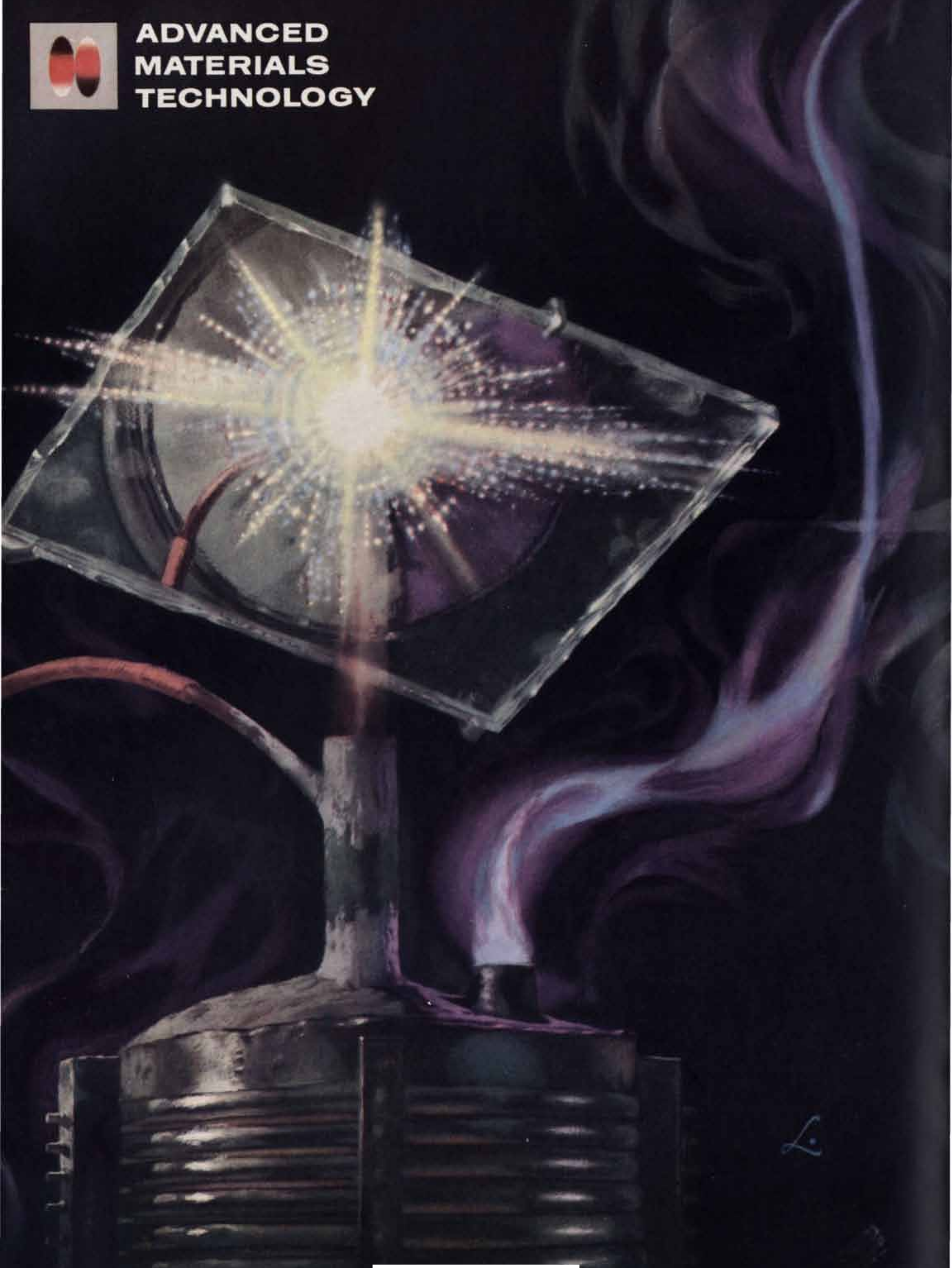
CHEMIGUM
PLIOFLEX
PLIOLITE
PLIOVIC
WING-CHEMICALS

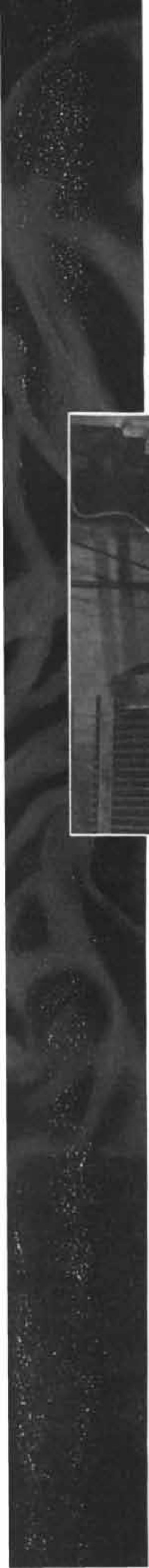
High Polymer Resins, Rubbers, Latices and Related Chemicals for the Process Industries

CHEMICAL
GOODYEAR
DIVISION

COATINGS DEPARTMENT

Chemigum, Plioflex, Pliolite, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio


ADVANCED
MATERIALS
TECHNOLOGY



Break-through...

ADVANCED MATERIALS HELP LICK INDUSTRY'S HEAT BARRIERS

4700° F TEMPERATURE reflected in the mirror above an induction furnace forms the subject of the dramatic artist's rendering at left. Mirror is employed in conjunction with an optical pyrometer to measure extreme temperature inside test furnace at Carborundum's Research & Development Laboratories. Actual equipment is shown in photo above.

In the blinding flash of an atomic explosion, in the searing blast of a rocket motor and in the intense heat of many industrial processes, much of today's progress goes hand in hand with tremendously high temperatures. "Hot as the sun itself" is no longer a mere figure of speech: it is already within the realms of scientific accomplishment.

Breaking through the heat barrier—finding materials that will stand up under higher and higher temperatures—is now a problem that concerns practically all industry. More and more of the answers are being found in the growing family of advanced materials produced by the Carborundum Company.

New forms of silicon carbide, for example, that can be pressed or molded into tough, highly accurate and intricate shapes are already taking over many of the jobs of metals in applications where even the toughest alloys melt or lose their strength. Nozzles made of similar materials withstand the heat and shock of rocket motors that travel at Mach 11 speeds. The variety of Carborundum materials makes possible a solution for almost every problem involving intense heat or resistance to unusual conditions of abrasion or corrosion.

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

AM-2

Get your free subscription to industry's newest publication

ADVANCED MATERIALS TECHNOLOGY

"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

ANCIENT TEMPERATURES

The ratio of the oxygen isotopes in a fossil shell reflects the temperature of the water in which the shell grew. This "thermometer" is now used to study the climate of the past

by Cesare Emiliani

From a piece of uranium-bearing rock we can estimate the age of the earth; from a sliver of bone we can date a prehistoric camp site. The clocks that make such dating possible are radioactive isotopes of the elements. Within the last few years isotopes have provided us with another tool for looking into the distant past—a thermometer which tells the temperatures of ancient seas. The measurements so far made with it have already deepened and revised our understanding of the history of the earth and of mankind. They have staked out the broad climatic trends of the last 100 million years and plotted significant details of the glaciation cycles of the Ice Epoch in which we are living even now. As a result, we can begin to get a better insight into the causes of this epoch and even attempt to project its future course. The new findings also seem to have considerably shortened the hitherto accepted chronology of human evolution.

As with so many fruitful advances in science, paleotemperature research originated in an almost casual remark. In December, 1946, the University of Chicago chemist Harold C. Urey gave a lecture on his work with isotopes to a gathering of faculty and students of the famed Technische Hochschule of Zurich, Switzerland. Urey's theme in this lecture was that the isotopes of an element, although supposedly identical with one another chemically, did not actually behave exactly the same, even in chemical processes. For instance, he said, when a glass of water evaporates, the three isotopes of oxygen (oxygen 16, 17 and 18) do not go off at the same rate. The vapor will carry off a slightly higher proportion of the lightest isotope (common oxygen 16) than of the heavier ones. As a result, after a time the water in the glass will become slightly enriched in the rare heavy isotopes, 17 and 18. Urey concluded that the water in the oceans, long subjected to this process, should be a little richer in the heavier isotopes of oxygen than fresh water.

In the colloquy that followed, Paul Niggli, a distinguished Swiss crystallographer, drew a crystallographer's deduction from what Urey had reported. He pointed out that if sea water and fresh water had different oxygen isotope ratios, oxygen-bearing substances precipitated from these waters also should show the difference. Niggli suggested that isotopic analysis of carbonate deposits—limestone, coral or the limey skeletons of aquatic animals—would show whether the deposits had originated in fresh or marine water.

The Thermometer

Back in his Chicago laboratory Urey pondered this spur-of-the-moment remark and proceeded to calculate what the difference in isotope ratios between fresh water and marine carbonate would be. He found that the relative abundance of the oxygen isotopes in the carbonate would depend partly on the temperature of the water at the time the carbonate was deposited. As Urey later told the story: "I suddenly found myself with a geologic thermometer in my hands."

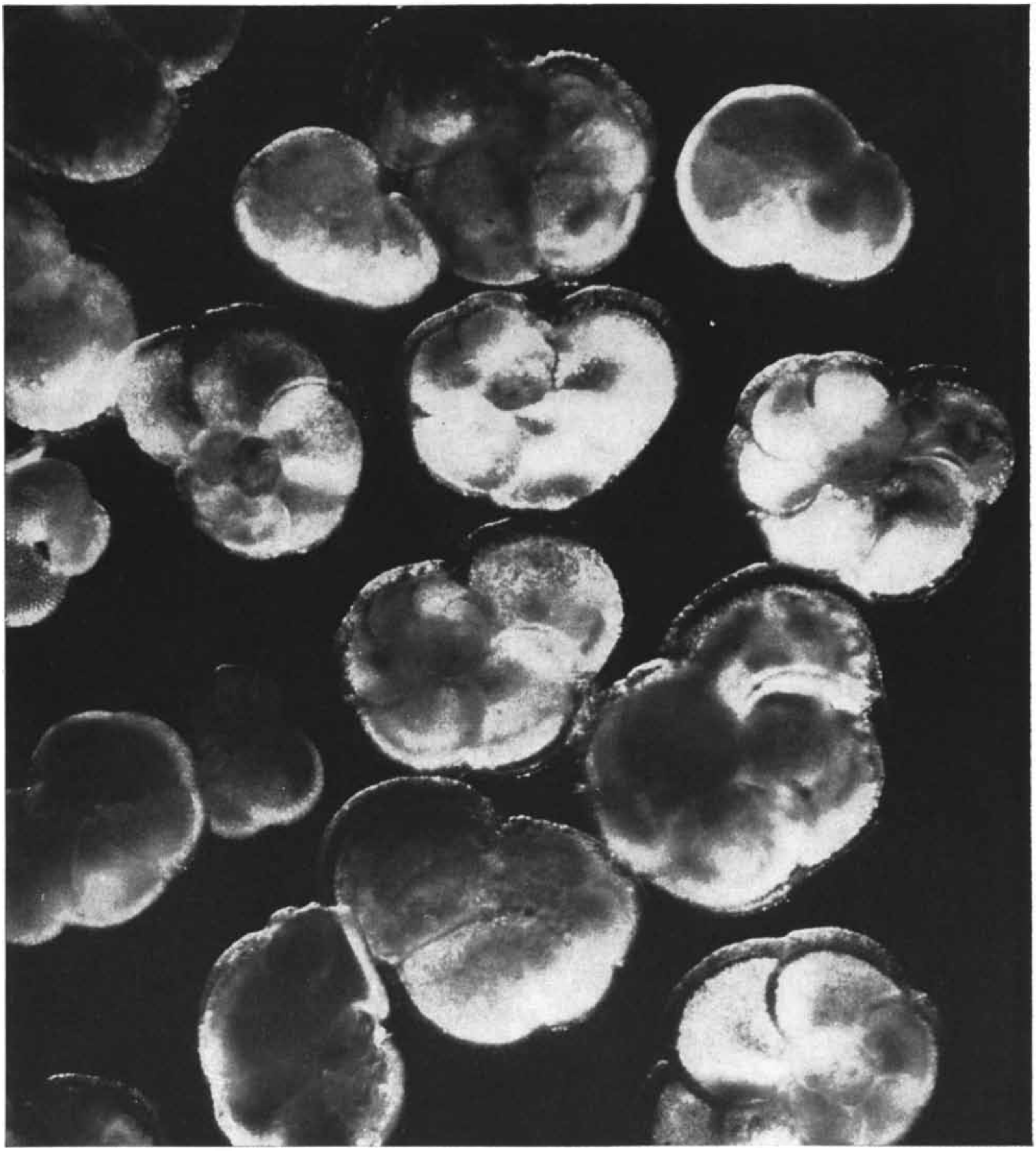
Actually in 1947 the thermometer was not yet in Urey's hands; it was still largely in his head. It took four more years to make isotopic temperature-measurement a practicable technique. One difficulty was that the temperature effect was too small to be measured by instruments then available. According to Urey's calculations, a difference of one degree centigrade in water temperature would produce a difference of only two hundredths of 1 per cent in the ratio of oxygen 18 to oxygen 16 in the carbonate. The smallest such difference measurable by the best mass spectrometer at the time was one fifth of 1 per cent. This meant that Urey's thermometer could not detect temperature differences smaller than 10 degrees C.—and a 10-degree difference in ocean temperatures can represent the difference between a temperate and an arctic climate! Urey's first task, therefore, was to improve the sensitivity of the mass spectrometer tenfold, and with the aid of a team of workers he was able to do this.

Second, it was necessary to establish an empirical temperature scale, in order to check and supplement the theoretical calculations. For this purpose the Scripps Institution of Oceanography supplied marine mollusks grown in the laboratory at known temperatures. The preparation of their shells for analysis, however, presented what Urey later described as "the toughest chemical problem I ever faced." Live mollusk shells contain not only carbonate but also small amounts of protein. The oxygen in the protein confused the first efforts to get a reading on the oxygen in the carbonate. But Urey and his collaborator Samuel Epstein found a way to remove this contaminating oxygen, and were able, by analyzing pure carbonates deposited at different temperatures, to show that Urey's calculations were essentially correct.

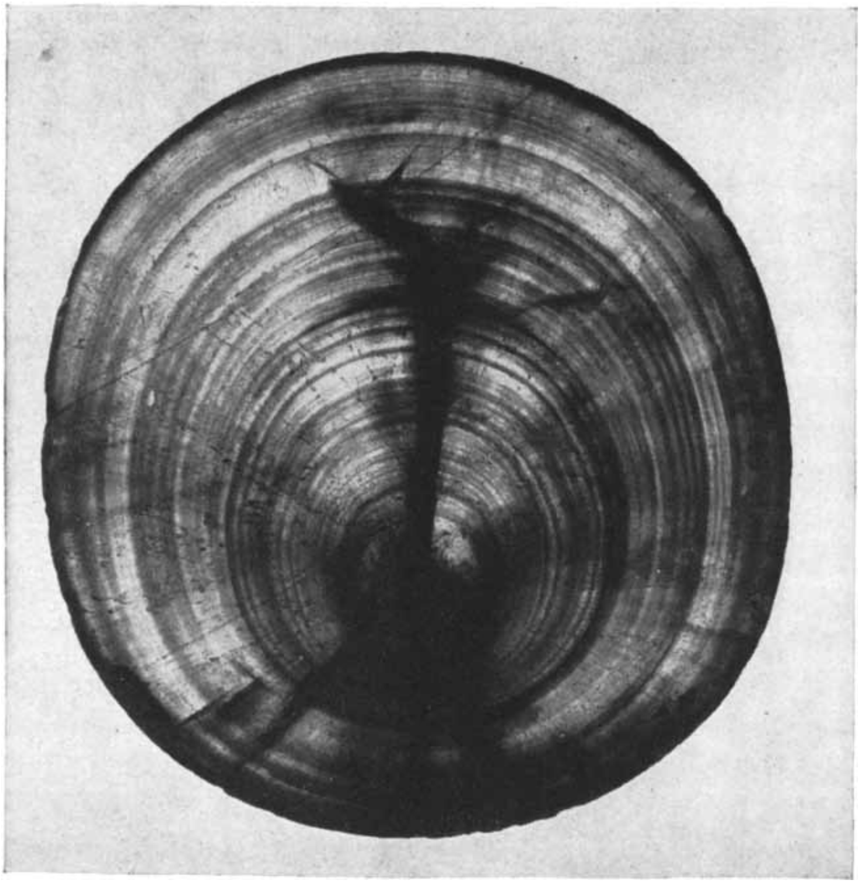
In the fall of 1950 Urey's laboratory at Chicago was ready to attempt the measurement of a fossil temperature. Urey selected the cigar-shaped skeleton of a belemnite, an ancestor of the modern squid which lived some 150 million years ago in the warm, shallow sea covering what is now Scotland. In cross section this fossil shows growth rings resembling those in a tree trunk [*see photograph at top of next page*]. But no one had yet determined how many seasons or years each ring represented. The concentric layers of the fossil were shaved off and analyzed one by one. The resulting measurements showed clearly the seasonal changes in temperature during the growth of the animal's skeleton [*see chart at bottom of next page*]. From these variations one could tell that the belemnite was born in the summer, lived almost four years and died in the spring. Clearly the geologic thermometer was usable.

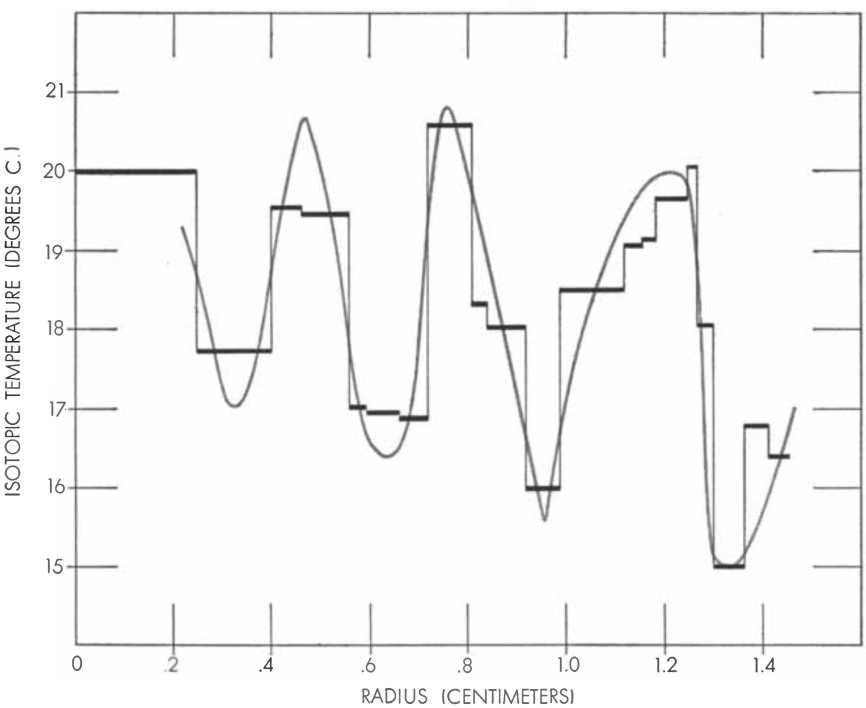
Before it could be put to work, however, an inherent limitation of the thermometer had to be faced. Its readings depend not only on the isotope ratio in a carbonate but also on the difference between this ratio and that in the water in which the carbonate was formed. The ups and downs in the ratio found in the belemnite fossil could be taken as accurate indications of relative temperature; to place these variations on an absolute scale, however, required an assumption as to the isotope ratio in the ocean in which the creature lived.

Up to this point Urey and his asso-



SKELETONS OF FORAMINIFERA from sea-bottom oozes are magnified 180 times. These species inhabited the ocean's upper layers from two to three thousand years ago. Analysis of their skeletons indicates the temperature of the water in which they lived.





FIRST MEASUREMENT **of ancient temperatures was made from a belemnite 150 million years old. In cross section (*top*) the cigar-shaped skeleton shows growth rings. Graph (*bottom*) gives temperatures obtained by analyzing concentric layers. These show seasonal changes indicating animal was born in the summer and died in the spring four years later.**

ciates had assumed that all oceans would show the same ratio of oxygen 18 to 16. A check of various waters, made by Epstein and Toshiko Mayeda, now disclosed that the ratio varied. Tropical surface water proved to be about .2 per cent richer in oxygen 18 than arctic; mid-ocean waters may differ considerably from those near shore, for excessive local evaporation or an influx of river water makes the sea water either richer or leaner in oxygen 18 than the average. Such variations must introduce error and uncertainty into the measurement of paleotemperatures. For the present, error is minimized by analyzing only fossils of animals that lived in the open ocean. Uncertainty remains, however, because the conversion of isotope ratios to temperatures must be based on estimates of the isotope ratio of the ancient ocean.

Eventually we hope to obtain absolute measurements with the help of another thermometer based upon the isotope ratios in the silicas or the phosphates sometimes associated with carbonates. These ratios also vary with temperature but on a different scale. With a little algebra, two such readings will yield an absolute temperature. We are reasonably confident, however, that our present measurements are close enough so that any future corrections we apply to them will not significantly alter the results.

Climatic Trends

The first systematic paleotemperature study was addressed to a question that has attracted much investigation by other means: Why did the great dinosaurs die? It had long been thought that the 150-million-year reign of these reptiles on the earth was brought to an end by cooling of the earth's climate about 65 million years ago. This idea was supported by geology, but the evidence was incomplete. At Urey's suggestion, Epstein and Heinz Lowenstam set out to survey the climate of the latter portion of the Age of Reptiles, formally designated as the Upper Cretaceous. They analyzed a large number of fossils from Europe and North America, and their results showed that temperatures rose during the first half of the period and declined during the second half [*see chart on page 58*]. Unfortunately they could not measure temperatures at the very end of the period, because they could not obtain suitable fossils. The study nonetheless supports the conclusion that a decline in temperature might well have played an important part in the extinction of the dinosaurs.

With the method now fully demonstrated, I undertook a study, in collaboration with Mrs. Mayeda and Harmon Craig, of temperatures during the last 65 million years. This long period of time—the Cenozoic Era, or Age of Mammals—has seen the emergence of many land areas, the building of many mountain ranges, the inception of the Ice Epoch and the evolution of man. Clearly a picture of its climatic trends would illuminate and clarify the record.

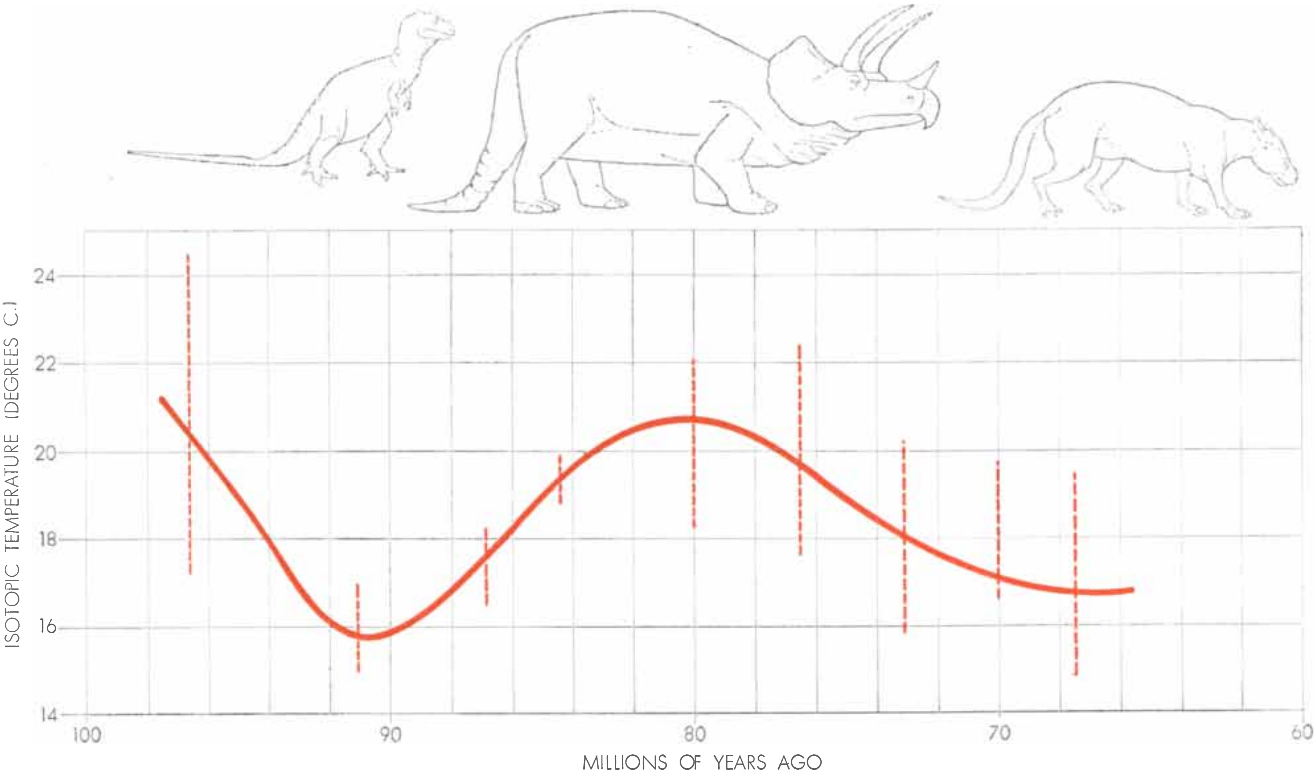
As our fossil subjects we chose the tiny one-celled marine animals called foraminifera. Our interest was sparked by a visit to Chicago in 1951 of Hans Pettersson, leader of the Swedish Deep-Sea Expedition of 1947-48 [see "Exploring the Ocean Floor," by Hans Pettersson; SCIENTIFIC AMERICAN, August, 1950]. Most species of foraminifera live on the deep ocean bottom, but some of them float in the upper sunlit strata of the ocean, where they feed on microscopic plants. When they die, their skeletons—minute snail-like shells or clusters of crystalline bubbles of calcium carbonate—rain down upon the ocean bottom. There, mixed with fine silt and clay, they form the foraminiferal oozes that carpet much of the deep-sea floor. These oozes accumulate very slowly, at rates averaging an inch in 1,000 years. Yet in some places they have built up to thicknesses of hundreds and even thousands of feet.

Thanks to the Swedish expedition and the many expeditions of the Lamont Geological Observatory of Columbia University, we had excellent samples of these sediments. The Swedish expedition had used a "piston-corer" developed by B. Kullenberg. This instrument can bring up cylindrical samples (cores) of the bottom more than 60 feet long; the expedition had collected more than 300 such cores in both the Atlantic and the Pacific, some of them reaching from the present down into sediments a million years old and more. The Lamont Observatory, using similar equipment, had assembled a collection of more than 1,000 deep-sea cores.

The Ancient Antarctic

To develop the general outline of the climatic history of the Cenozoic Era we decided first to survey the bottom temperatures. These, we thought, would not be influenced by short-term fluctuations, and would therefore give us a better idea of long-term trends. The

DEEP-SEA CORES can yield a continuous temperature record covering a million years or more. This photograph shows the upper 11 feet of a core from the equatorial Atlantic.



TEMPERATURES FLUCTUATED toward the end of the Age of Reptiles. A maximum was reached about 80 million years ago; the subsequent decline may have brought about the extinction of the dinosaurs. Above graph are two dinosaurs and a primitive mammal.

bottom water originates from the oceans' coldest surfaces; the cold water of the Antarctic Ocean, for example, sinks and flows into the deepest regions of the other oceans, because of its comparatively high density. Measurement of bottom temperatures would thus give us a picture of the climatic trend of the polar regions.

For this investigation we used three cores brought up from depths of more than 10,000 feet in the equatorial Pacific. Two of these cores were extraordinary because they contained sediments much older than expected. Evidently the piston-corer had hit an area of ocean bottom from which the more recent sediments had been removed (possibly by bottom currents). In order to measure the ancient bottom temperatures we had to sort out the fossils of bottom-dwelling foraminifera, which constituted only 1 per cent of the total. Several hundred shells were required to make up each five-milligram sample. Our analysis showed that 32 million years ago the bottom temperature of that part of the Pacific was about 51 degrees Fahrenheit; by 22 million years ago it had fallen to about 44 degrees; a million years ago the temperature was close to its present level—three degrees above freezing [*see chart on opposite page*]. During the last half million years the temperature has oscillated around an average somewhat colder than that of today.

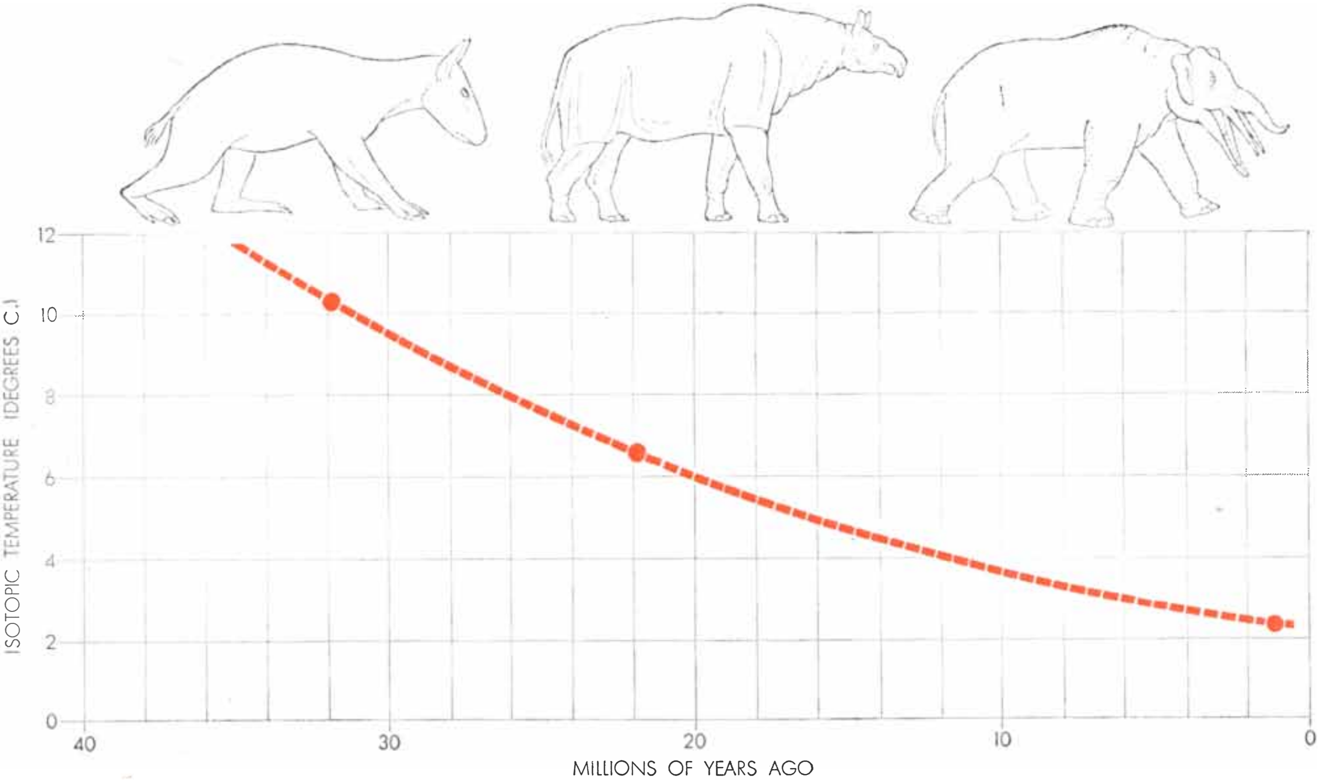
Our measurements show, then, that 32 million years ago the water of the Antarctic Ocean was as warm as that off Rhode Island today. The waters of the Arctic must have been equally warm. Indeed, we know from fossils that parts of Greenland, now treeless, were then covered by pine and spruce forests. The low temperatures a million years ago indicate that by that time Antarctica had become ice-covered, and the stage was set for the beginning of the Ice Epoch. The oscillations during the last half-million years reflect the relatively rapid climatic shifts accompanying the advance and retreat of the glaciers.

We next turned our attention to these glacial climates. From geological evidence we know that at least four times during the last half-million years or so great ice sheets, thousands of feet thick, pushed down from the north, reaching points south of present-day Chicago and Berlin. As they ground southward, they planed off the tops of hills. When they retreated north, they left behind moraines of boulders, sand and gravel and thousands of lakes, of which our Great Lakes are the largest. South of their shifting margins cold, dry winds laid down thick layers of silty soil called loess. From these and other geological features we can map the course of the ice sheets and estimate their duration, as well as that of the temperate interglacial periods. But unfortunately nowhere on land is there a complete sequence of deposits representing the entire glacial epoch. Geologists have had to reconstruct the Ice Epoch piecemeal, often resorting to dubious correlations between landscapes of widely separated regions.

A New Calendar

The deep-sea cores, we believed, could help considerably to straighten out the confusion and discontinuity of the land evidence. The record contained in the oozes is continuous and their most accessible upper layers embrace much or all of the Ice Epoch. By tracing out the variations in ocean temperatures over this period, we could reconstruct the changes in the earth's climate during the ice ages.

The reconstruction of climatic history in such detail called for study of the variations in the surface temperatures of the ocean, rather than the long-term variations at the bottom. We therefore had to restrict this study to



TEMPERATURES DECLINED during the Age of Mammals. Pacific bottom water originating around Antarctica dropped from 51 degrees F. to 36 degrees as a result of the change from temperate to frigid climate in polar regions. At top are three extinct mammals.

foraminifera of the floating species living within the top few hundred feet from the surface. Our first task was to establish the relative temperature level (*i.e.*, depth) at which each of these species lived; this we did by a preliminary analysis of present-day samples of the various species. We then examined a number of cores taken from the Atlantic, the Caribbean and the Mediterranean. We made an isotopic analysis of the foraminifera of each species at various levels down the core—each level representing a progressively older time. When we finally plotted the temperature curve for the successive times, it showed a series of climatic fluctuations. The peaks and valleys of these temperature cycles were quite consistent over the oceans, even in cores from sites several thousand miles apart [*see chart on next page*].

With the temperature cycles thus established, the next step was to date them by radiocarbon analysis. This was done by Hans Suess and Meyer Rubin at the Radiocarbon Laboratory of the U. S. Geological Survey. The most recent low point in ocean surface temperature, it turned out, came about 18,000 years ago, which coincides with the peak of the last ice age glaciers in North America. The low points in the earlier cycles cannot be dated by the radiocarbon method, because they occurred too long ago, but by extrapolation and by comparing our cores with others dated by different methods we have worked out a tentative time scale for the full depth of our cores [*see chart on page 61*]. We then correlated the temperature oscillations shown by the cores with the advances and retreats of the ice sheets on the continents. This correlation is certain for the last 100,000 years, but is less certain for older times. The analysis of still longer cores, which are not yet available, may require some revision of this correlation. If this dating scheme is correct, the first great ice sheet began its advance only 300,000 years ago, rather than 500,000 or more years ago, as geologists have hitherto estimated.

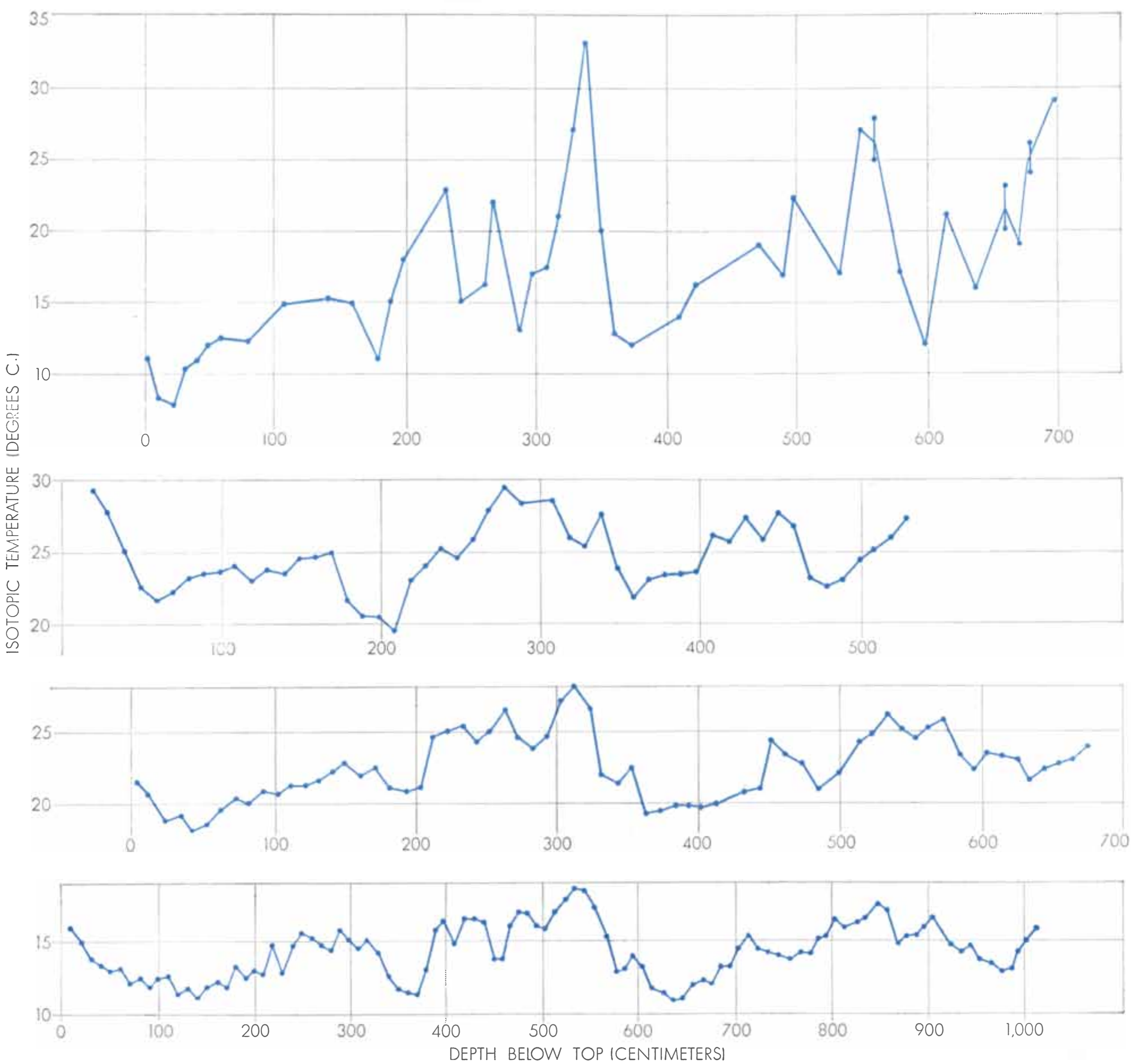
Causes of the Ice Ages

These results may be applied to the much-debated question of what caused the ice ages. Many theories have been proposed, ascribing the glaciations variously to changes in the earth's motions, to blanketing of the atmosphere by dust from volcanic eruptions, to mountain building, and so on [see "Origin of the Ice," by George Gamow, SCIENTIFIC AMERICAN, October, 1948; "Volcanoes and World Climate," by Harry Wexler, April, 1952; and "On the Origin of Glaciers," by Charles R. Warren, August, 1952]. Our findings seem to give support to the theory worked out in the 1920s by the Serbian physicist Milutin Milankovitch. According to the Milankovitch hypothesis, fluctuations in the earth's orbit and in its axis of rotation periodically change the pattern of reception of heat from the sun, so that there are long periods when the summers are cool and the winters mild, alternating with periods of hot summers and cold winters. In a period of cool summers which fails to melt much of the winter snow, ice will cover a much larger part of the earth than it does now. Milankovitch calculated that the coolest summers would come at intervals about 40,000 years apart. Our analysis of the fossils in the cores indicates that the low points in ocean temperatures did indeed occur at 40,000-year intervals.

The main difficulty with the Milankovitch theory is that it fails to explain why the Ice Epoch developed only recently—within the last million years—after 200 million years during which the earth had no ice ages. Looking back over the climatic changes of the last 100 million years, we can now see a possible explanation of how the current Ice Epoch originated.

The Lowenstam-Epstein analysis of Cretaceous fossils shows that temperatures reached a high point about 85 million years ago. At that time shallow seas occupied vast areas which are now land, and there were only a few low chains of mountains on the continents [*see maps on page 62*]. Toward the end of the Cretaceous Period a large part of the Pacific bottom southwest of the Hawaiian Islands began to sink, and similar founderings may have occurred elsewhere in the Pacific. Simultaneously there opened a great epoch of mountain building which ultimately produced the Rockies, Andes, Alps and Himalayas. These processes put millions of square miles of previously immersed land above water. Since dry land absorbs less solar radiation than water does, the world climate became steadily colder. Perhaps two million years ago permanent caps of snow and ice began to form in Antarctica and Greenland. This highly reflecting ground cover absorbed still less of the sun's rays. Some 300,000 years ago the climate had become so cold that one of Milankovitch's cool-summer cycles could have extended the northern ice south to northeastern North America and Scandinavia—both regions of heavy snowfall. Back-radiation of solar energy was still further increased, and the first great wave of ice was under way. The enormous mass of ice that overran the Northern Hemisphere must have influenced the climate of the entire earth. We know that glaciers formed over most of the great mountain chains of both hemispheres.

During this period, as our studies show, the oceans' surface temperature



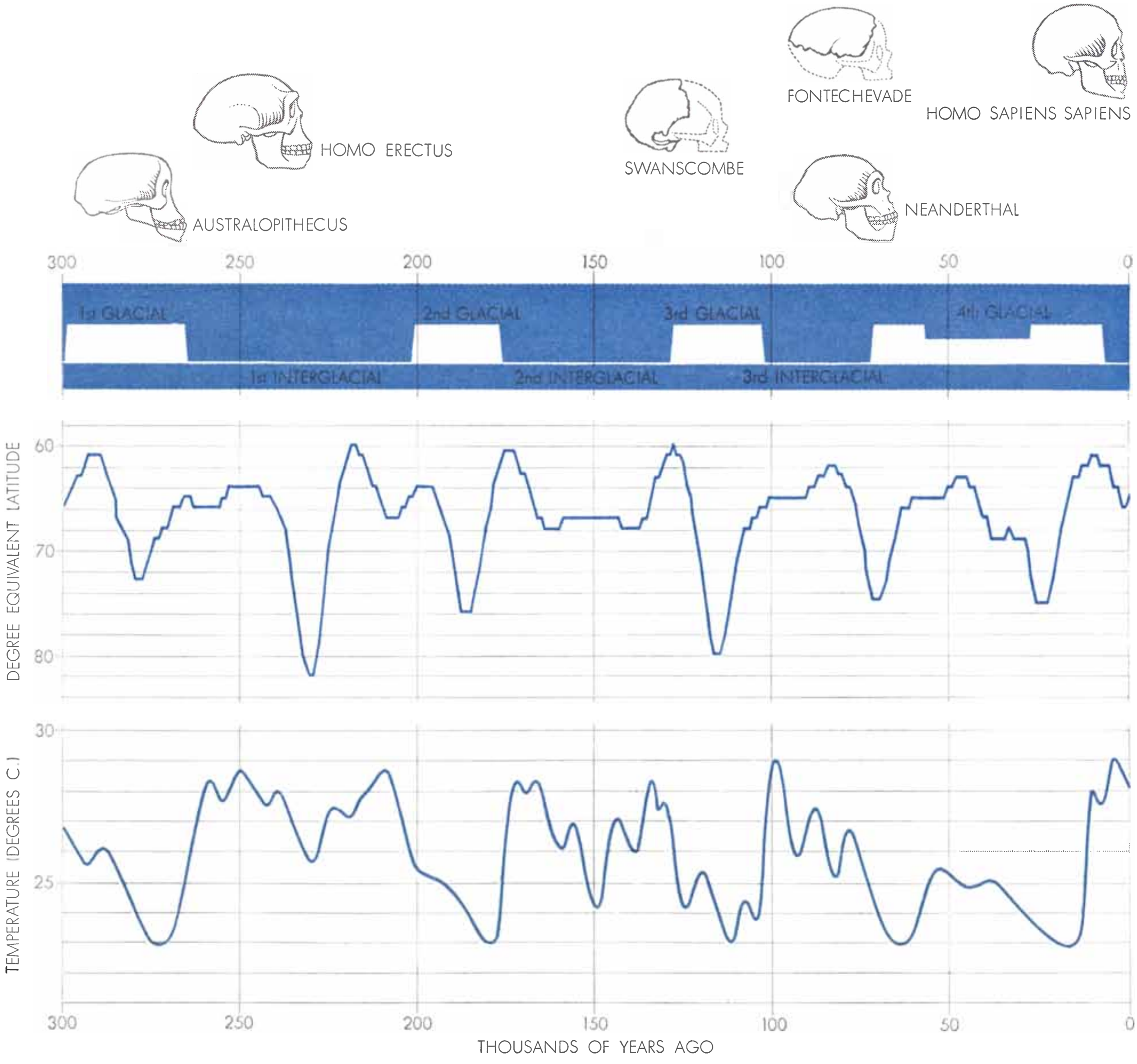
TEMPERATURE CURVES from cores originating in widely separated spots show strong similarities. The curves, covering some 200,000 years, are (*top to bottom*) from Mediterranean, Caribbean, equatorial Atlantic and North Atlantic cores. The land-locked Mediterranean shows the greatest range of temperature variations: from 8 to 33 degrees C. (46 to 92 degrees F.) Differences in core length, shown by the varying horizontal scales, indicate that marine sediments accumulated at different rates in these four areas.

dropped sharply. This started a reverse process, for cooler oceans mean less evaporation, drier air and less snowfall. Eventually winter snowfall decreased to a point where the summer shrinking of the glaciers was greater than their winter growth. A period of hot summers accelerated this process and pushed back the ice sheets until only those of Antarctica and Greenland remained.

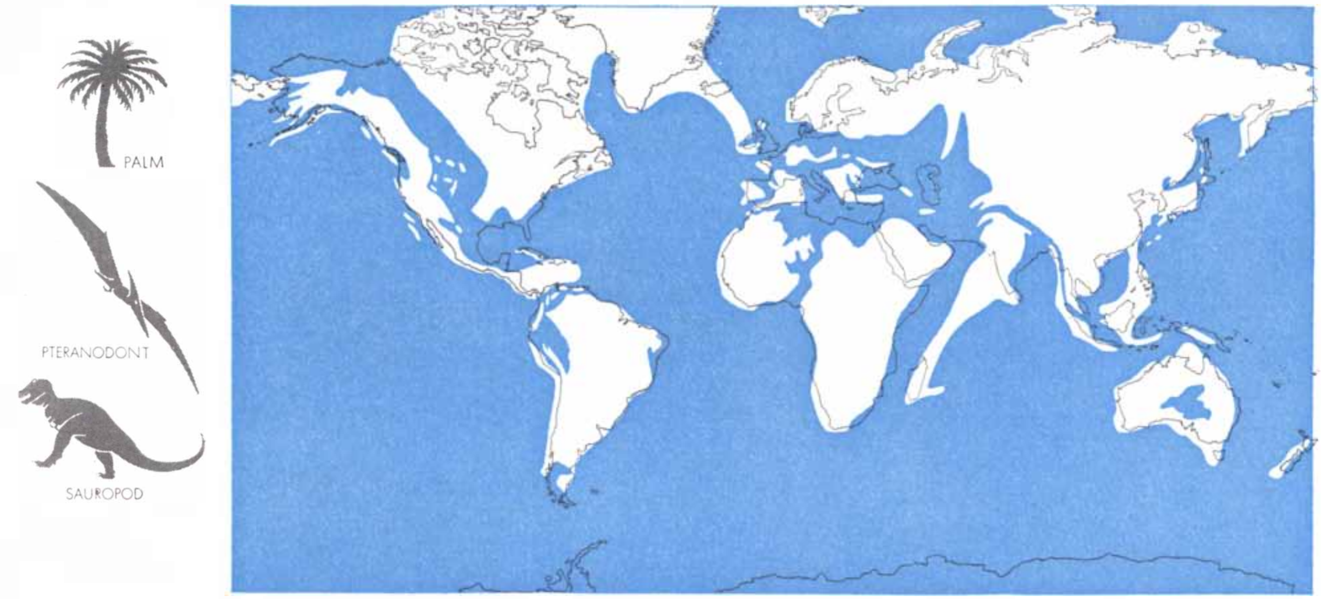
When the cool-summer part of the Milankovitch cycle returned, the glaciers began to grow again, and the whole process was repeated: advance of the ice sheets, cooling of the seas and eventually a new shrinking of the glaciers. If the theory is correct, about 10,000 years from now there will be another advance of the glaciers, burying Chicago, Berlin and Moscow under thousands of feet of ice. Indeed, we can expect periodic glaciations to continue until the earth's great mountain chains have been weathered down to hills.

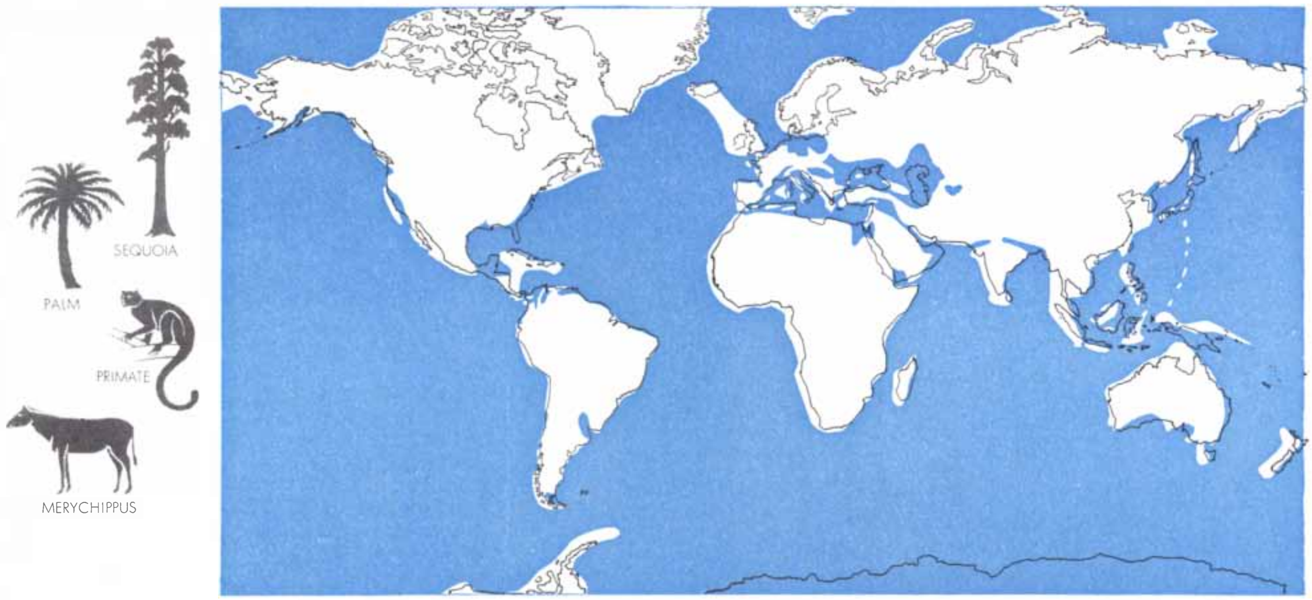
Dates of Man

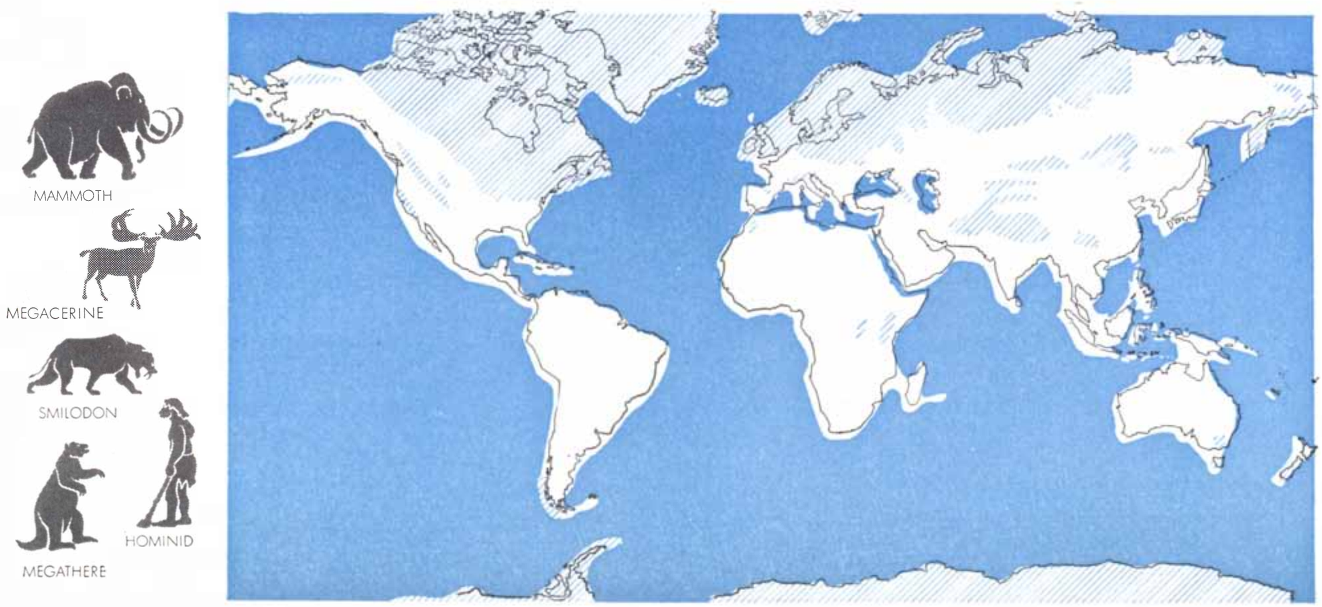
One of the most important products of the isotope thermometer is that it has given us a definite time scale, not only for the ice ages but also for the evolution of life. We can now date fossils of man and his ancestors and estimate the rates of human evolution with some confidence. In the past most of the human and manlike fossils have been dated, after a fashion, by the deposits in which they were found but the age of the deposits was often uncertain. With the fairly accurate new calendar of glaciation cycles obtained through Urey's thermometer, we can put the chronology of human evolution in order, for the migrations of early man and the rise of new types are often



COMPOSITE CURVE from six deep-sea cores (*bottom*) shows the climatic fluctuations during the Glacial Epoch. The similar curve above it shows variations in summer solar radiation at latitude 65 degrees North, where the great ice sheets were centered. These are expressed as apparent shifts in latitude; thus 25,000 years ago latitude 65 received no more solar heat in summer than latitude 75 does today. The human and prehuman skulls (*top*) are associated with the glacial events suggested by the colored area below them.


PALM
PTERANODONT
SAUROPOD


SEQUOIA
PALM
PRIMATE
MERYCHIPPUS


MAMMOTH
MEGACERINE
SMILODON
HOMINID
MEGATHERE

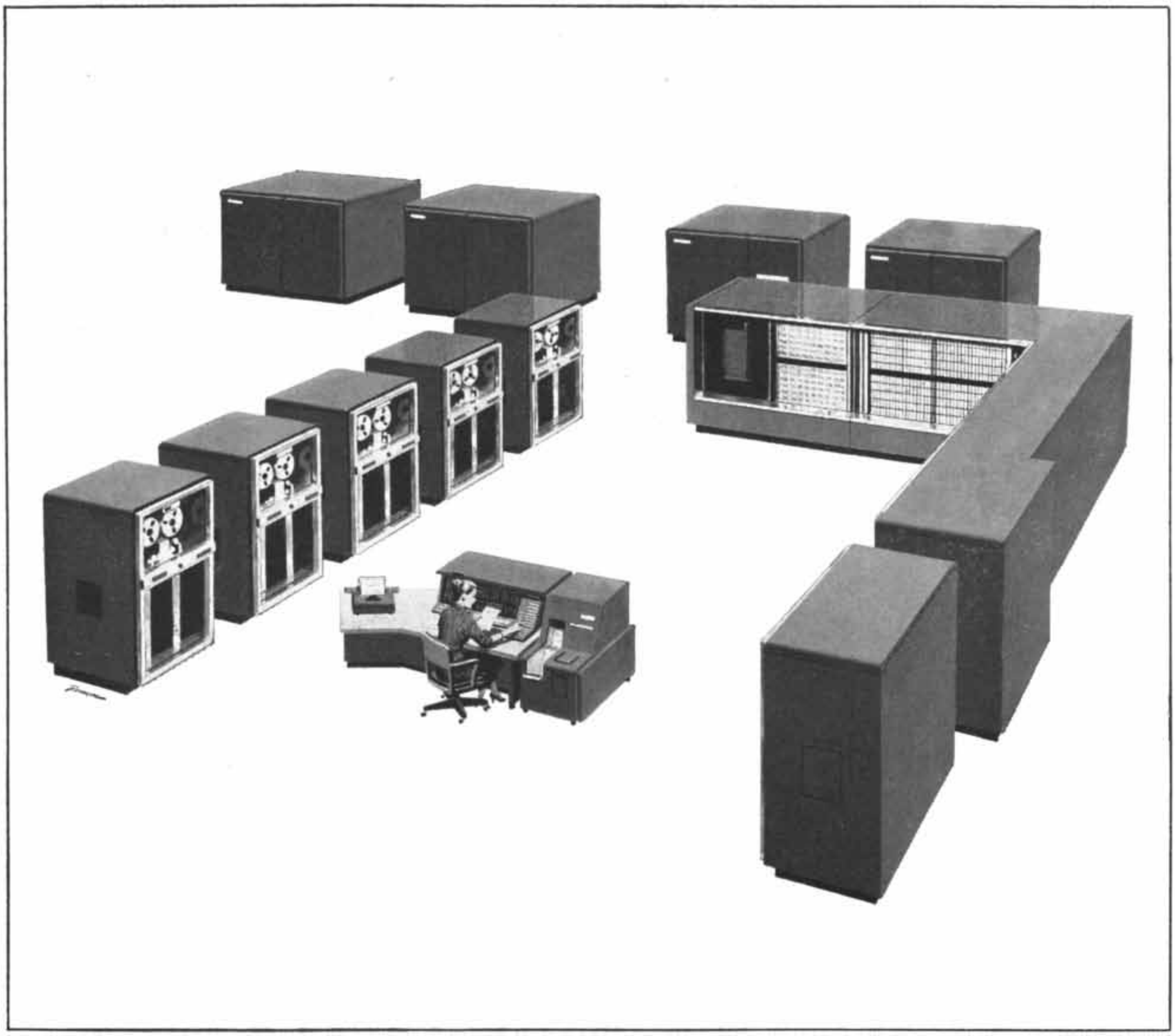
LAND EMERGENCE, roughly reconstructed in maps at left, helped bring the Ice Epoch. Eighty million years ago shallow seas covered vast areas (*top*); climate was tropical almost to the poles. Ten million years ago less land was submerged (*center*); climate was coolor, though warmer than now. Maximum emergence was less than 500,000 years ago (*bottom*); hatching shows ice sheets. Present coastlines are in black; animals and plants of each period are at side.

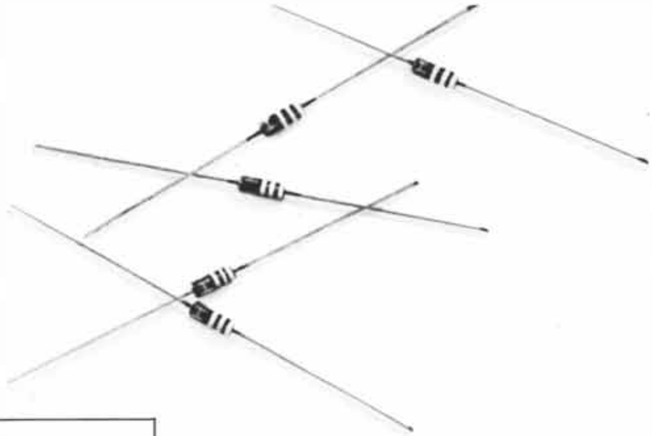
connected with glacial periods. We know, for example, that the man-apes of South Africa originated some time before the first glaciation and died out during the first interglacial period. According to the paleotemperature chronology, this means that they lived between about 400,000 and 200,000 years ago. Similarly we know that Pithecanthropus, Sinanthropus and Atlanthropus—men of a very primitive type which I prefer to assign to the single species *Homo erectus*—originated during the first interglacial, which we date at 200,000 to 250,000 years ago.

The Swanscombe skull bones, probably belonging to an ancestral subspecies of modern man, date from the second interglacial, about 125,000 years ago. The Fontéchevade remains, the oldest known fossils certainly belonging to modern man, are from the third interglacial, and are thus only about 100,000 years old. Since Neanderthal man also originated during the same interglacial period, he must be considered a separate offshoot parallel to modern man. Neanderthal, an unsuccessful experiment in humanity, became extinct during the last glaciation, about 50,000 years ago. Thus he lasted only about 2,000 generations. Evolution from *Homo erectus* to Swanscombe man took about 3,000 generations, and from Swanscombe to modern man, only about 1,000. This is evolution at a rapid rate. Equally rapid rates of evolution would obtain for other advanced animals.

So the reconstruction of the temperatures of ancient seas is only the beginning of the grand-scale prospects opened by our new thermometer. It enlightens us about the long-range climatic cycles of our planet. It will tell us much about how sediments are deposited in the oceans, about many animals of the sea (at what depths they live and how fast they grow), about the wandering of the geographic poles, about the history of man and about many other things. A number of scientists in the U. S., in Italy and in the U.S.S.R. are already busy exploiting this wonderful tool.

How to win friends and influence profits





Today, electronic data processing systems are a vital tool of modern management for gaining new customers and boosting profits. Take this IBM Model 705, for example. It's capable of adding 10,000 five digit figures per second! While you may not need this order of capacity, there is a profit producing system for almost every size of business.

Now greater efficiency can be added to such functions as cost accounting, inventory control, payroll, record keeping, and many others. To illustrate: in inventory control, electronic data processing systems can reduce lost sales due to "out-of-stock" mix-ups and unfreeze vital dollars tied up in excess inventory.

Basic to high-speed data processing machines is the tiny diode. Acting as lightning fast traffic controls, diodes direct computations by the million to secure the right answers.

Data processing system manufacturers like IBM, utilizing thousands of diodes per machine, use Hughes diodes because of their unexcelled reliability. This is the same reliability demanded in diodes for vital electronics systems designed and built by Hughes for U.S. air defense.

To assure top performance every Hughes diode is rigidly inspected with special visual, mechanical and electrical tests.

We at Hughes manufacture not only semiconductors such as diodes but a wide range of electronics components and systems. This electronics equipment is currently being used for both military and commercial applications. With our wide experience we may be able to help you with some of your problems.

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

International Airport Station, Los Angeles 45, California

Lycoming kept a copter going nowhere... fast!

Rarin' to go—after 750 hours—Lycoming's O-435-23B engine went on to power the new Hiller H23D *Raven* to a new record for helicopter tie-down performance. The *Raven* became the first Army copter to run 1000 hours without an overhaul. During this time, its 250-hp Lycoming engine encountered the most severe conditions which can be imposed, including use of full power in overspeed for ten per cent of the test time.

After the rigorous endurance run, Hiller engineers reported the Lycoming engine "could have run much longer"—one more tribute to the versatility and dependability of Lycoming.

Avco today . . . Its products are integral parts of the American scene—at home, in industry, and for defense. Its divisions are:

Lycoming—aviation, marine, industrial power plants . . . Crosley—electronics systems and aircraft structures . . . AK Division—kitchen equipment and architectural porcelain . . . New Idea and Ezee Flow—specialized farm equipment . . . Research and Advanced Development—missile and allied research . . . Crosley Broadcasting Corporation—the WLW Radio and TV Group . . . Moffats, Limited (Canada)—commercial gas and heating equipment.

Avco makes things better for America . . .

Avco

Avco Manufacturing Corporation
420 Lexington Avenue, New York, N. Y.

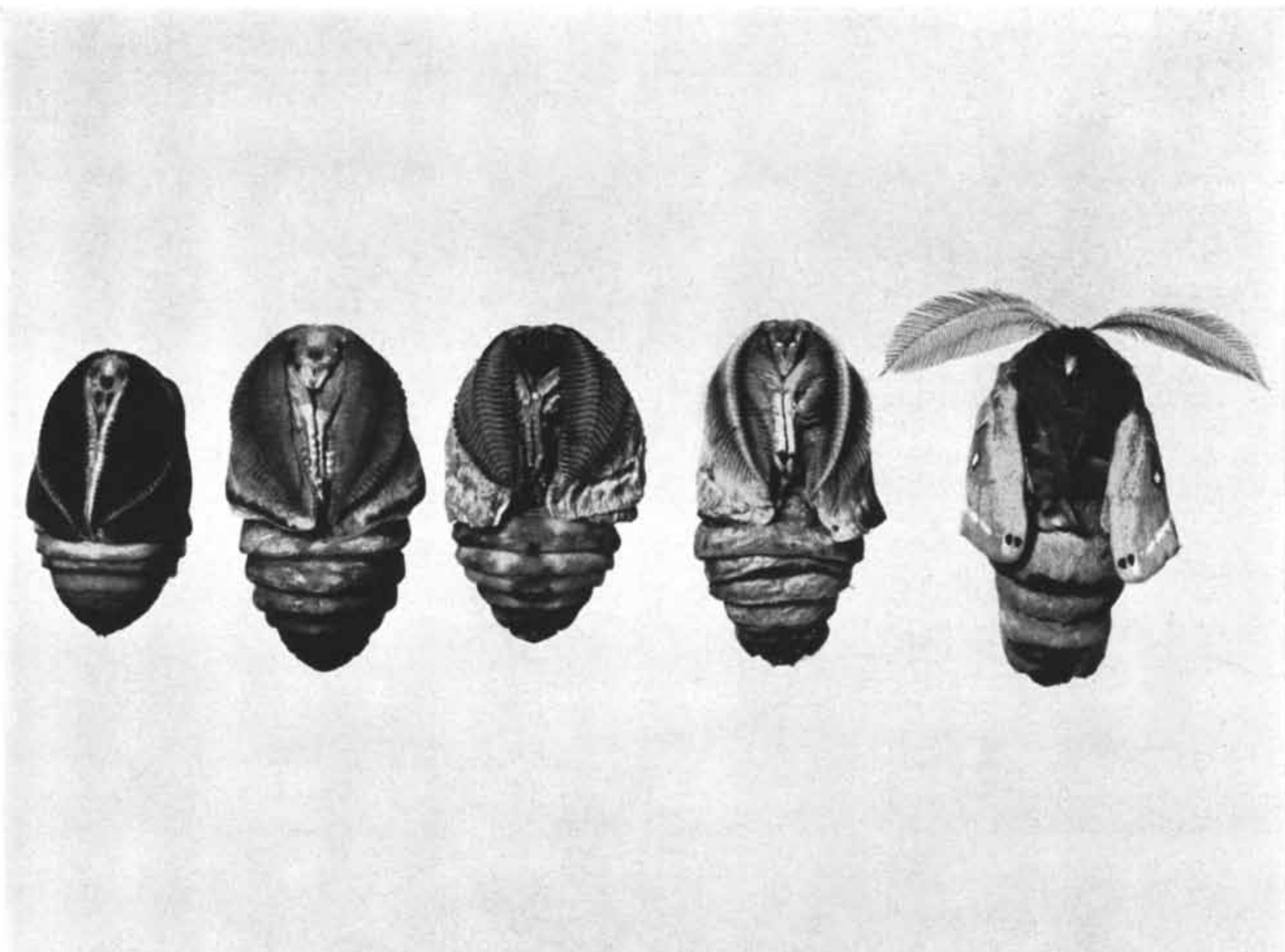
THE JUVENILE HORMONE

The larva of an insect makes a hormone which keeps it from changing into a pupa until it has reached its full growth. Recent experiments with this substance have produced both dwarf and giant adult insects

by Carroll M. Williams

Twenty-five years ago the British biologist V. B. Wigglesworth performed an experiment which has given fascinating employment to a number of biologists ever since. The experiment in question was an operation on larvae of his favorite experimental animal, a blood-sucking bug known as *Rhodnius*. All he did was to chop off their heads (evidently it is not for nothing that Wigglesworth is known as the "Quick Professor of Biology" at the University of Cambridge). The results of the experiment were remarkable. A considerable number of the beheaded, immature larvae promptly metamorphosed into miniature adult Rhodniuses!

With little more to go on, Wigglesworth decided that he had discovered a "juvenile hormone" which blocks the metamorphosis of a larva until it has



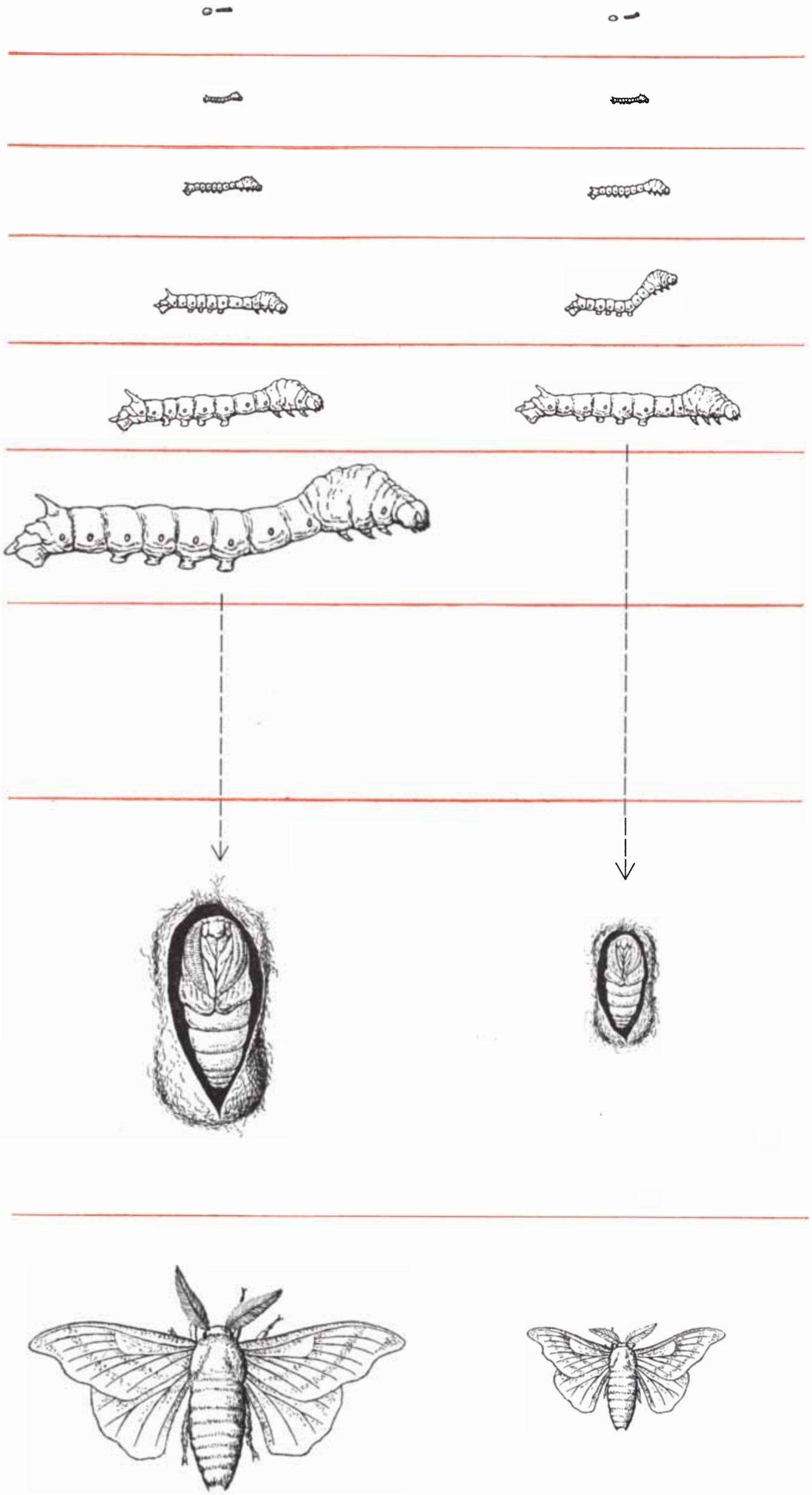
FIVE PUPAE of the Polyphemus silkworm in this photograph received graded doses of juvenile hormone from the Cecropia silkworm. In each pupa the old pupal case has been shed. The pupa at far left received the largest dose; it has entered a second pupal stage. The pupa at far right received the smallest dose; it has turned into an adult moth, except for an island of pupal tissue at the bottom.

achieved its full growth. Since the hormone had been removed by decapitation of the insect, its source must be somewhere in the head. After a microscopic study of the heads of his bugs, Wigglesworth concluded that the hormone came from a tiny cluster of cells just behind the brain—a pair of glands called the "corpora allata."

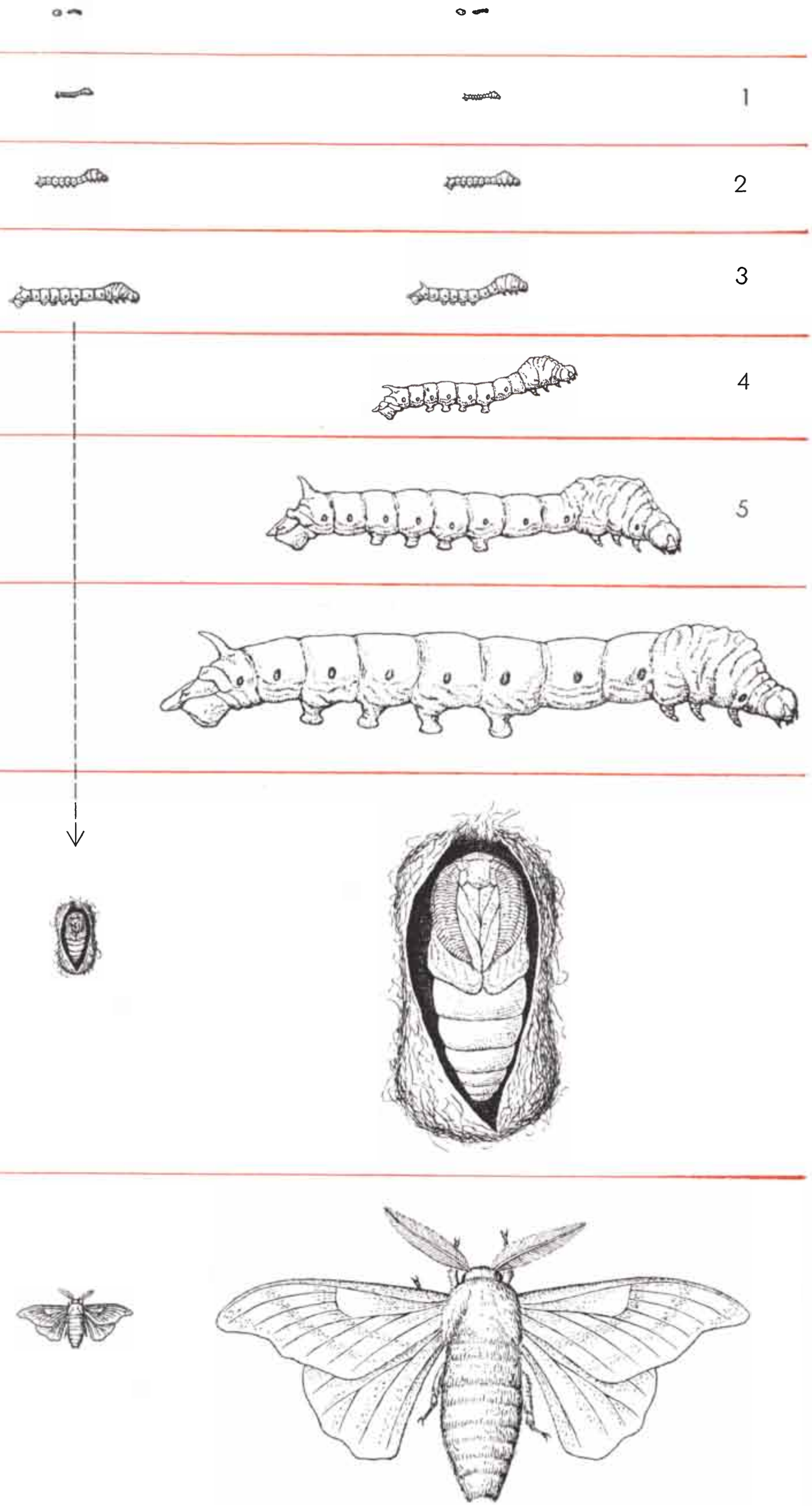
The test of scientific genius is the ability to reason to correct conclusions from inadequate evidence. Each and every one of Wigglesworth's conclusions proved to be correct. There *is* a juvenile hormone, it *does* prevent metamorphosis, and it *is* secreted by the corpora allata. Furthermore, the corpora allata and the juvenile hormone have become fruitful subjects of investigation in many laboratories—in the U. S., France, Britain, Germany and Japan. Investigators have found corpora allata in the heads of all species of insects except a few ancient forms that do not metamorphose. The organs are so tiny that even in the largest insects they are scarcely visible without the aid of a microscope. But a Frenchman, Jean Bounhiol, developed a delicate operation which permitted him to remove the corpora allata from the head. He excised these organs from silkworms and got a clear-cut result: the little silkworms cut short their growth as caterpillars, spun miniature cocoons, changed into tiny pupae and finally emerged as midget adult moths. In short, the removal of the corpora allata caused the insect to abbreviate its childhood and play its life history as an end game.

The juvenile hormone itself remained a will-o'-the-wisp. Chemists tried to extract it from the corpora allata, mashing up glands dissected from hundreds of insects to get enough material, but their extracts uniformly failed to show any activity. Notwithstanding this failure, biologists were able to learn a great deal about the hormone by using the living factory that makes it—the corpora allata. They transplanted these glands from one insect to another and studied the effects.

Among other things, they learned that, just as removal of the corpora allata from a young larva would produce a dwarfed adult, so addition of these active organs to an older larva would produce a giant. As a larva (*i.e.*, caterpillar) reaches mature size, the corpora allata cease to make the juvenile hormone. The caterpillar then stops growing and metamorphoses. But experimenters found that if they implanted active corpora allata from a younger larva into a ma-



DWARF AND GIANT MOTHS were made by removing and implanting the corpora allata, a pair of glands in the head of an insect. The column at left outlines the normal development of the commercial silkworm *Bombyx mori*. At the top of the column is the egg of the insect and its newly hatched larva. Below them are five stages in the growth of the larva. Below these is the pupa in its cocoon, and below this is the adult moth. The second column



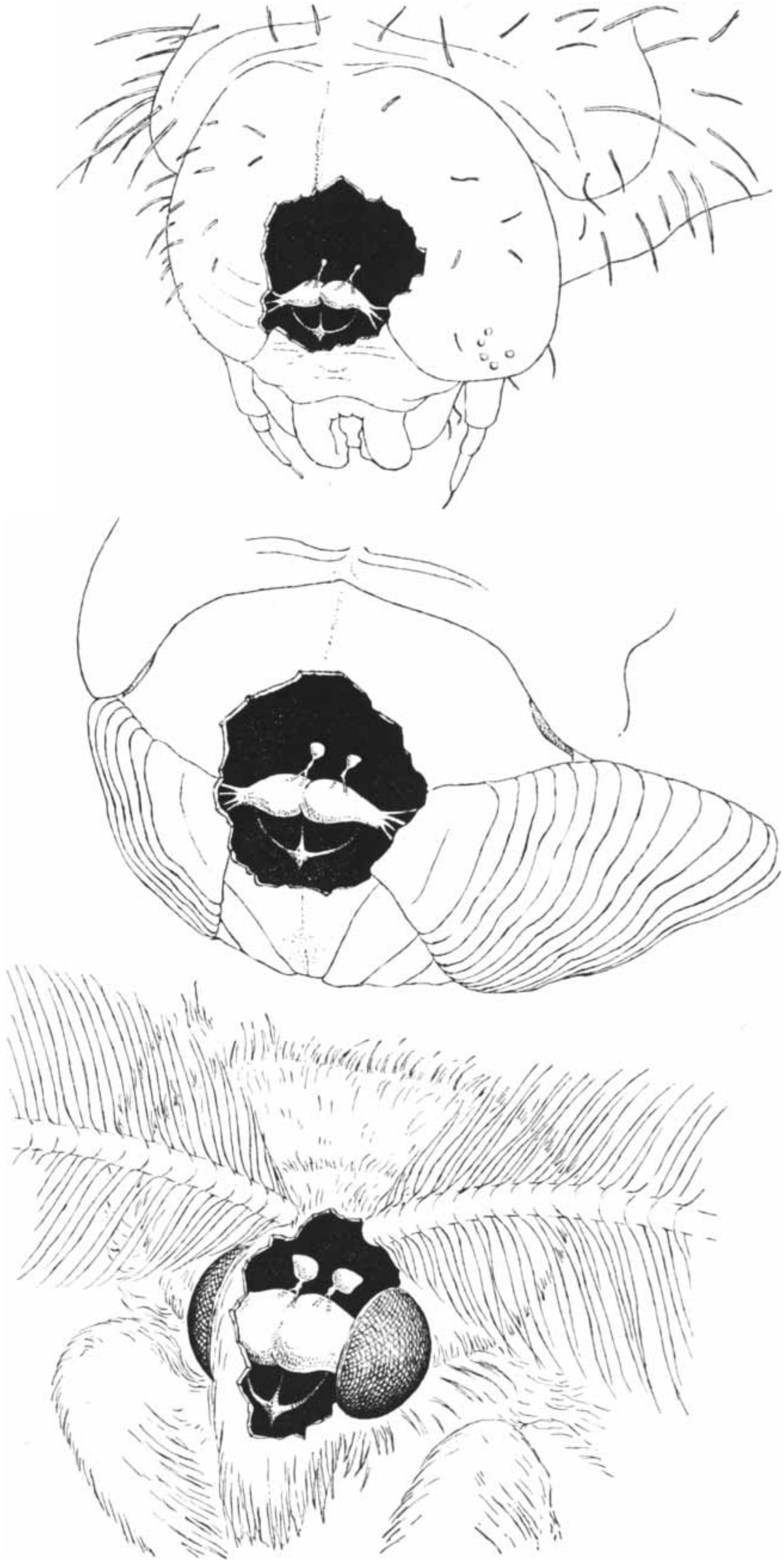
shows what happens when the corpora allata are removed at the fourth larval stage: the larva immediately changes into a dwarf pupa, and then into a dwarf moth. In the third column the corpora allata are removed at the third stage, resulting in an even smaller pupa and moth. In the fourth column the corpora allata of a young larva are implanted in a larva of the fifth stage. This larva continues to grow and then changes into a giant pupa and moth.

turing one, the rejuvenated caterpillar would postpone its metamorphosis and eventually grow into a giant insect. Incidentally, this seems to be the only way that nature can make a very large insect, and we can begin to understand how it produced the enormous insect species, with three-foot wingspread, that lived in the Carboniferous Period some 200 million years ago. In those days the corpora allata must have continued to pour out juvenile hormone for a much longer period than is now fashionable among insects.

The whole idea of a juvenile hormone —a substance that can delay maturity or aging without interfering with growth as such—has haunted some of us for many years. It is such a powerful tool for biological experiments, and offers so many fascinating possibilities, that we have scarcely been able to put it out of our minds for more than a few minutes at a time. In our laboratory at Harvard University we turned our attention to the process of metamorphosis itself—the stage when the insect, having advanced from a larva to a pupa, is finally transformed into an adult. The juvenile hormone, we found, plays no part in this transformation: the corpora allata have stopped supplying it. Suppose we supplied the hormone to the pupa artificially. What would happen? We implanted active corpora allata from young silkworms in pupal insects, inserting the glands through a hole in the skin and sealing the hole with melted wax. The pupa turned into a monstrosity. We got a creature which was a mixture of pupa and adult moth, possessing parts or tissues of each. The higher the concentration of juvenile hormone, the more complete was the suppression of adult development.

This finding suggested a practical method for assaying the activity of the corpora allata at various stages of an insect's development. We found, indeed, that the glands' activity declined just before pupation and disappeared immediately afterward. During almost the whole period of the insect's development into a full-fledged moth, the glands remained totally inactive. But, curiously enough, just before it emerged as a moth the corpora allata became even more active than they had been in the young larva!

Here indeed is a puzzle. What possible function can the juvenile hormone perform in the adult moth? We have not yet found the answer. But the paradox



BRAIN AND CORPORA ALLATA of the Cecropia silkworm are shown in cutaway views of the head of the larva (*top*), the pupa (*middle*) and adult moth (*bottom*). The corpora allata are the two small bodies which project backward from the hemispheres of the brain.

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_2O_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_6O_{11}. PRASEODYMIUM OXIDE	726 729.9	99 99.9	1 La + Nd + smaller amounts of Ce and Sm. 0.1 Ce + Nd.
60	Nd_2O_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_2O_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_2O_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_2O_3. GADOLINIUM OXIDE	928.9 929.9	99 99.9	1 Sm + Eu + trace Tb. 0.1 Sm + Eu + trace Tb.
65	Tb_4O_7. TERBIUM OXIDE	1803 1805	99 99.9	1 Gd + Dy + Y. 0.1 Gd + Dy + Y.
66	Dy_2O_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_2O_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_2O_3. ERBIUM OXIDE	1303 1305	99 99.9	1 Ho + Dy + traces Yb and Y. 0.1 Ho + Tm.
69	Tm_2O_3. THULIUM OXIDE	1405 1403	99.9 99	0.1 Er + Yb + trace Lu. 1 Er + Yb + trace Lu
70	Yb_2O_3. YTTERBIUM OXIDE	1201 1202	99 99.9	1 Er + Tm + trace Lu. 0.1 Tm + trace Lu + Er.
71	Lu_2O_3. LUTETIUM OXIDE	1503 1505	99 99.9	1 Yb + Tm + traces of others. 0.1 Yb + Tm + traces of others.
39	Y_2O_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"

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

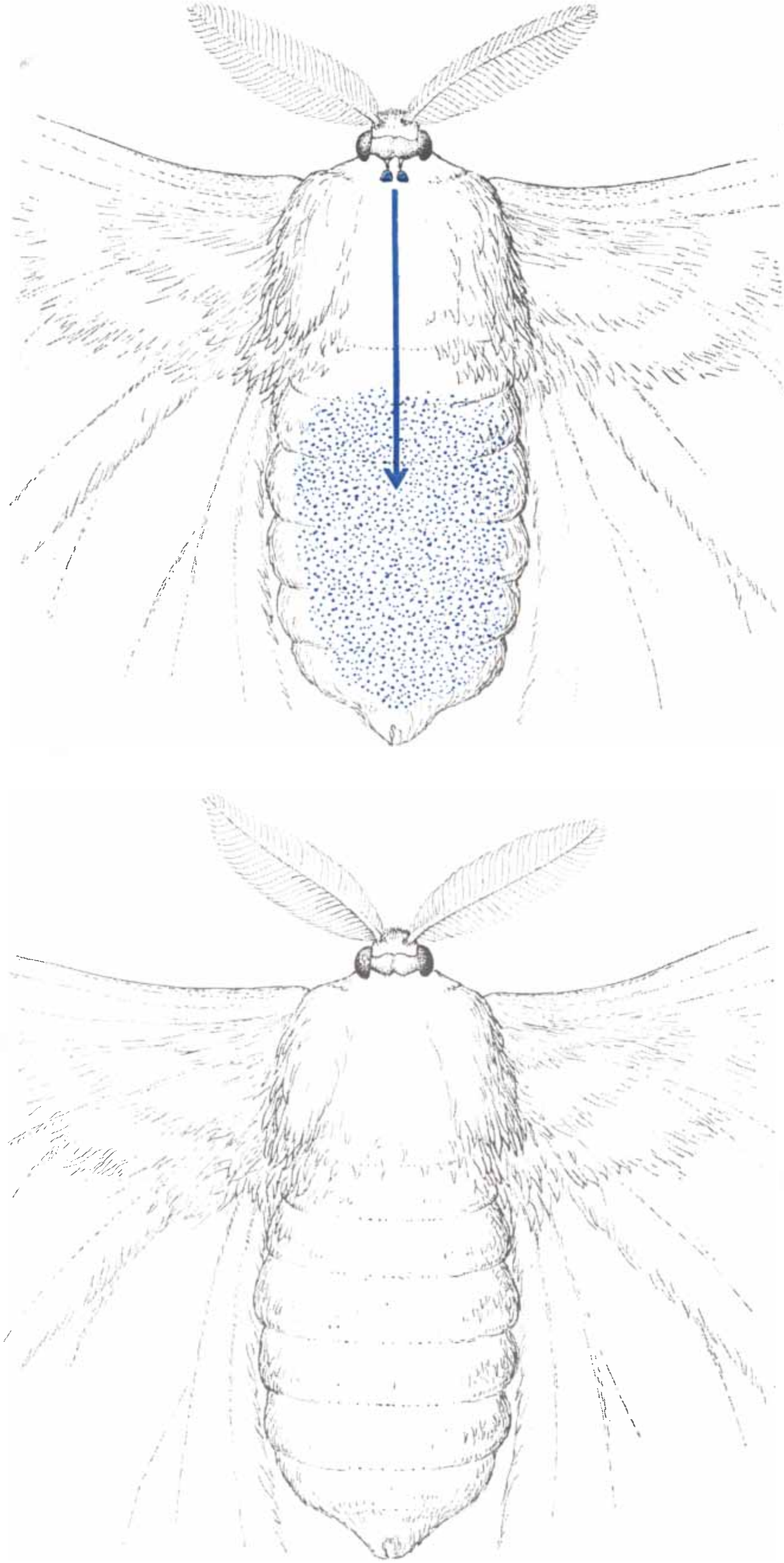
World's Largest Producer of Thorium and Rare Earth Chemicals

264 ANN STREET • WEST CHICAGO, ILLINOIS

did help us to run down and isolate the elusive juvenile hormone.

In other experiments, being pursued for reasons having nothing to do with juvenile hormone, we were grafting a pupa to a beheaded adult moth (of the well-known Cecropia species, our favorite experimental animal). When we performed the experiment with a male moth, we got a remarkable result. The headless male graft caused the pupa to go into a second pupal stage instead of metamorphosing into a moth, as it was supposed to do. That is to say, the pupa behaved as if it had received a rich dose of juvenile hormone. Where had the hormone come from? To make a long story short, we finally located the source in the abdomen of the headless adult moth. The abdomen proved to be full of juvenile hormone.

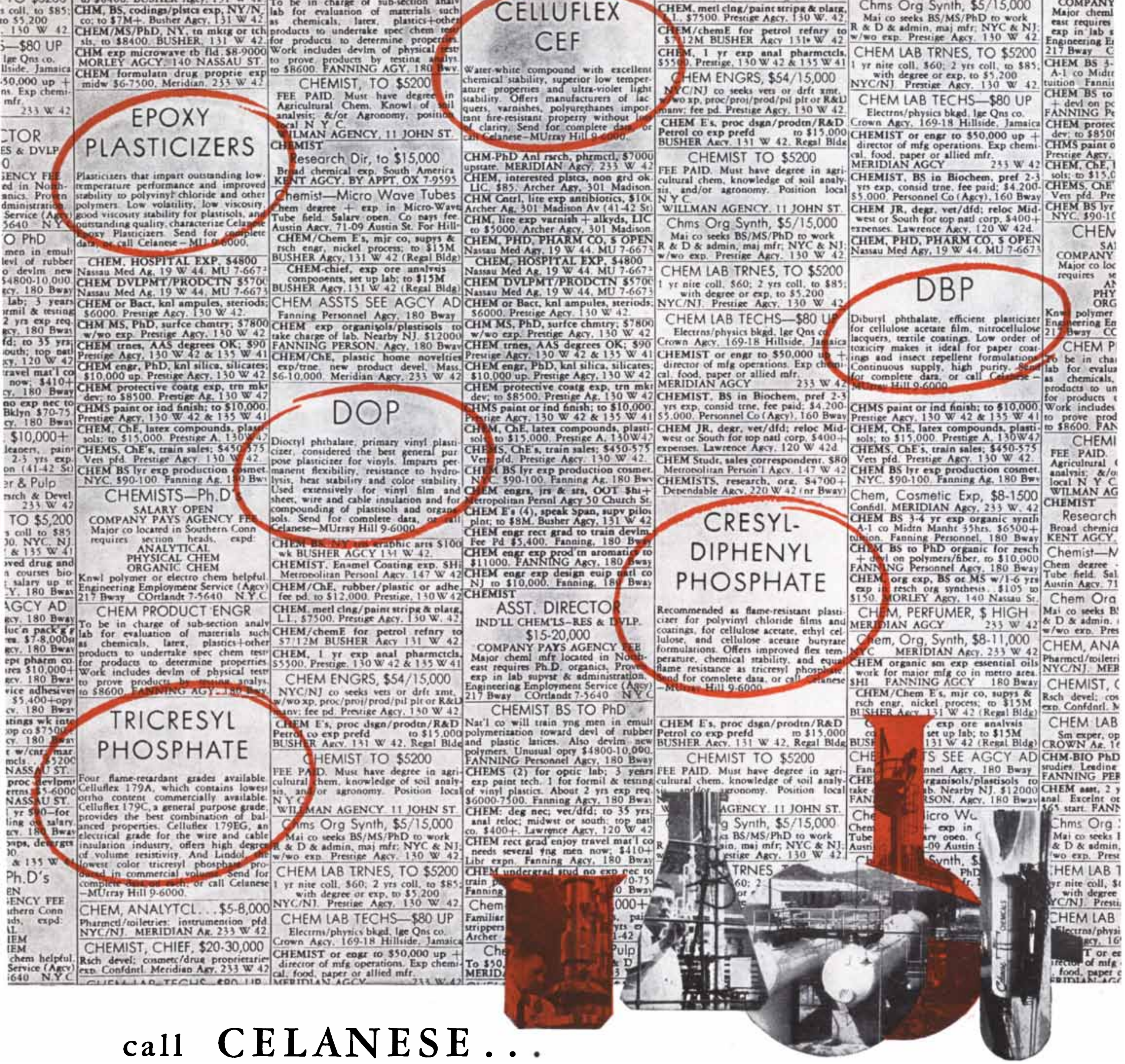
It was from this confusing state of affairs that we finally wrung forth the hormone itself. The abdomen cannot manufacture the hormone: it is secreted only by the corpora allata in the head. But the adult abdomen acts as a depot. When the corpora allata resume their production of the hormone in the adult moth, the abdomen receives and stores this output. Over a period of several weeks it caches away an enormous amount of the hormone. For some unknown reason only the male possesses this ability to take up the hormone in its abdominal tissues; the female abdomen has only a trace of it.



JUVENILE HORMONE IS STORED in the abdomen of the adult insect after it has been secreted by the corpora allata. In the drawing of the Cecropia moth at top the corpora allata are the small colored bodies; the stored hormone is represented by the colored stippling. In the drawing at bottom the corpora allata have been removed and no hormone is stored.

By a happy coincidence we succeeded in isolating our first extracts of juvenile hormone while visiting Wigglesworth's laboratory at Cambridge. We cut up the abdomens of adult male Cecropia moths and put them in ether to dissolve the soluble substances in the tissues. After evaporating the solvent, we had a beautiful golden oil, which proved to be extremely rich in juvenile hormone. A single insect's abdomen yields enough hormone to block the metamorphosis of 10 pupae. The extract from the Cecropia moth can act upon a great variety of other species and orders of insects. In each case it opposes metamorphosis and thus tends to preserve the *status quo*.

In collaboration, Howard Schneiderman and Lawrence Gilbert of Cornell University and I have now reduced the extract to a highly purified form of the hormone. Our best preparations are active at one part of hormone per million parts of insect. If all goes well, we hope we shall soon be able to write a chemical formula for the juvenile hormone. It ap-



call CELANESE . . .

Plasticizers: experienced, excellent character, salary reasonable

When industry has to "hire" a plasticizer, it calls Celanese. This has proved to be the most efficient way to obtain plasticizers with the right application experience . . . with the right chemical characteristics . . . and at the right price.

Reason for this is Celanese research—a continuing program to develop plasticizers of greater service for industry. For instance: this program has already produced four grades of flame-resistant Tricresyl Phosphate—four practical means for building fire resistance into a wide range of consumer and industrial products.

Research to develop plasticizers that satisfy specific needs . . . producing these in commercial volume to assure supply and economical cost . . . this is another example of Celanese filling the critical job requirements of industry.

Celanese Corporation of America, Chemical Division, Dept. 582-B, 180 Madison Avenue, New York 16, N. Y.

Celanese® Celluflex®

Basic reasons . . . .

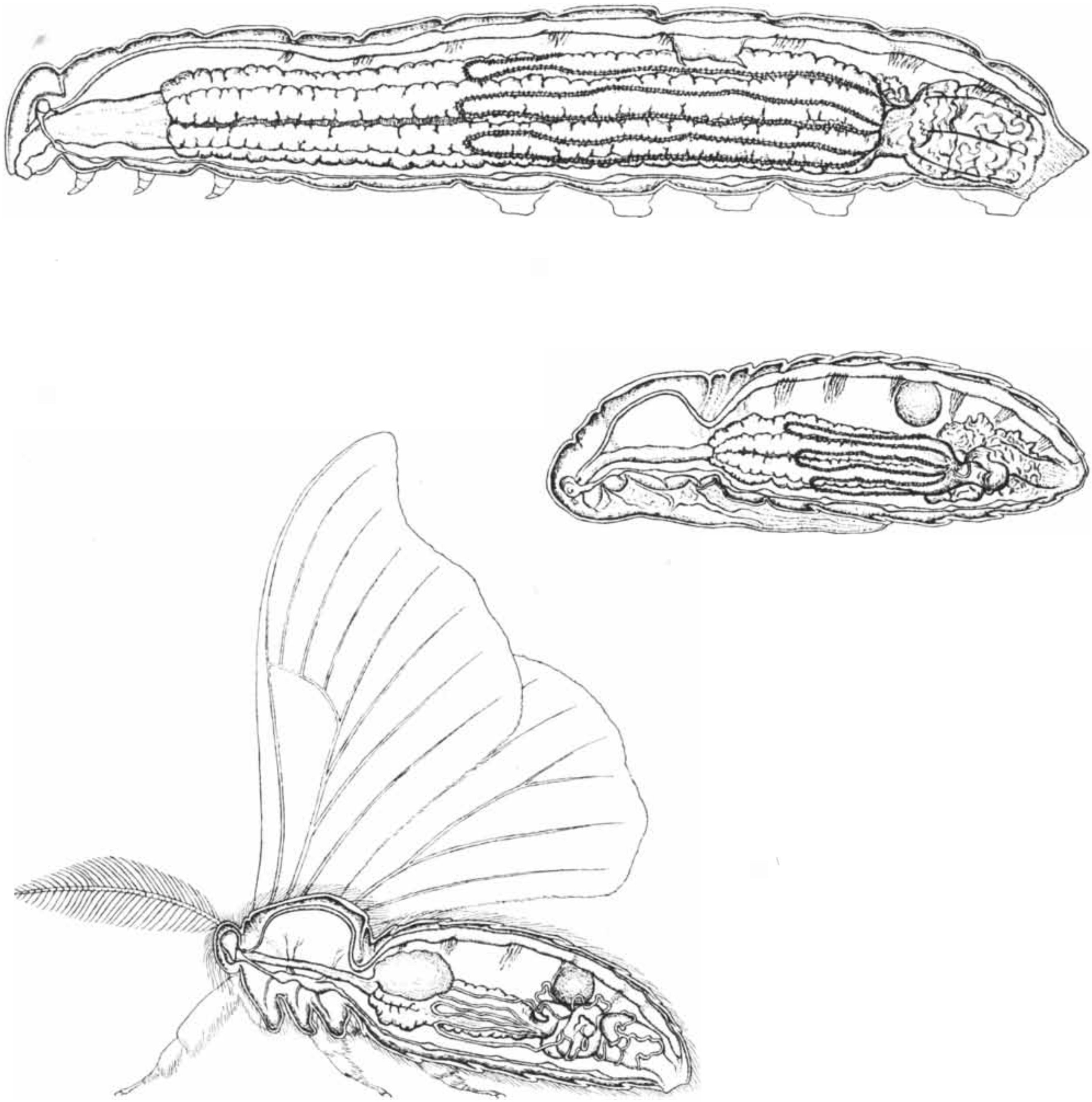
Acids
Alcohols
Aldehydes
Anhydrides
Esters
Functional Fluids
Gasoline Additives
Glycols
Ketones
Oxides
Polyols
Plasticizers
Salts
Solvents
Vinyl Monomers

Celanese CHEMICALS

. . . . for improved products

Agricultural
Automotive
Aviation
Building
Electrical
Paper
Pharmaceutical
Plastics
Surface Coatings
Textiles

Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16



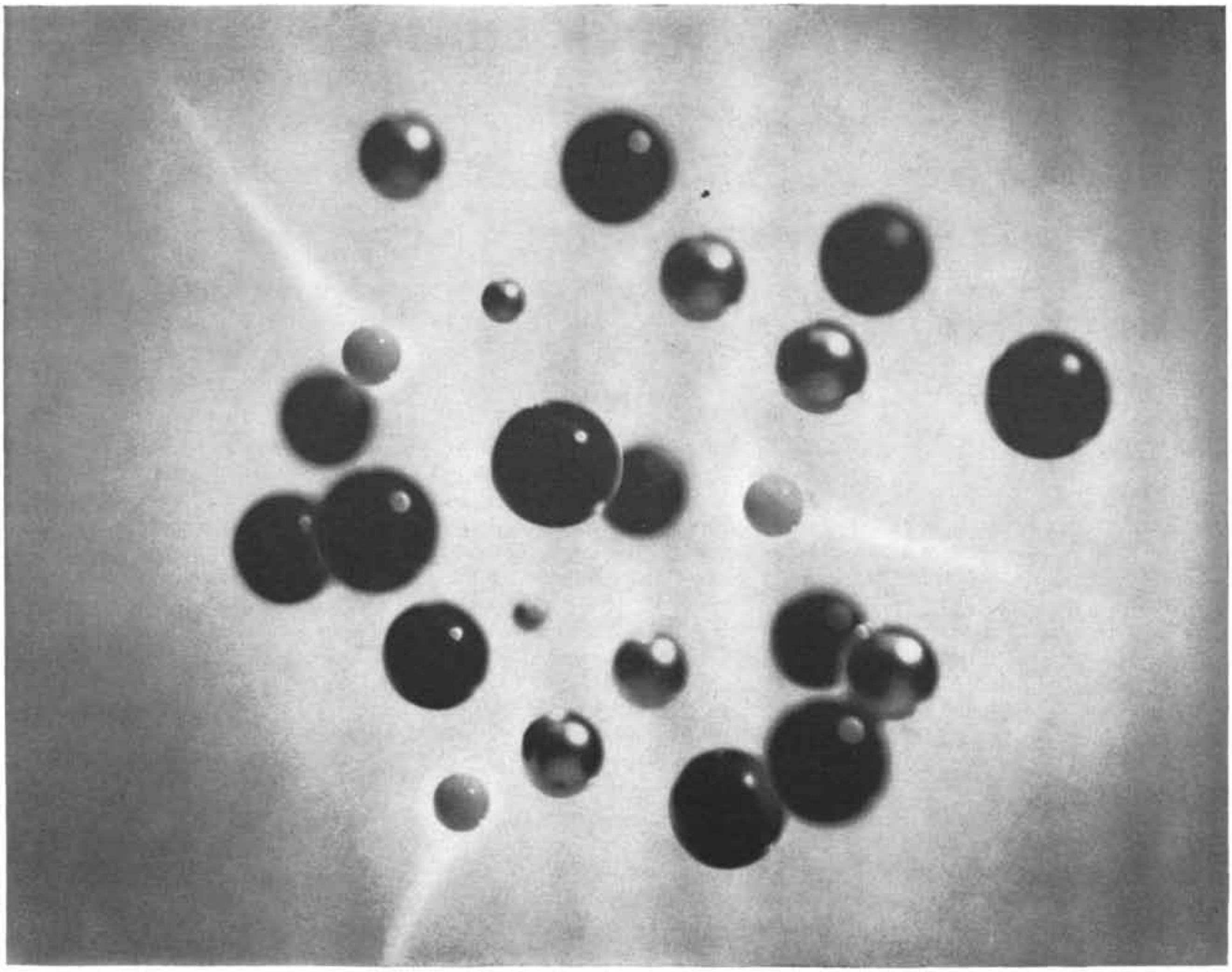
ANATOMY OF THE CECROPIA SILKWORM is shown in detail by these cutaway drawings. At top is the full-grown larva. At right center is the pupa. At bottom is the adult moth. The three stages are drawn to the same scale, but are about twice life size.

pears to be an extremely stable molecule—resistant to heat, dilute acids and bases. In fact, we have extracted active hormone from museum specimens of insects that have been dead as long as eight years.

One of our findings is that the hormone is effective even when it is merely applied to the surface of an insect's skin. Enough hormone gets into the body to foul up its metamorphosis. The animal soon dies, without completing its development. This suggests that we may be able to use insect hormones as an insecticide—a truly perfect insecticide, for the insects could hardly evolve a resistance to their own hormones.

Cosmetic chemists apparently have sensed another use for the juvenile hormone. They want to put the hormone into their lotions, adding it to the "royal jelly" already incorporated in some of these preparations. We may look forward to a whole generation of non-aging queen bees.

From the standpoint of pure science there seems little room to doubt that the juvenile hormone has much to tell us about the chemical engineering of growth. Here is an agent which somehow imposes a biochemical restraint on growing up without interfering with growth as such. It represents, at the insect level, a "Peter Pan hormone." Can there be such a thing in higher forms? Can we look forward to a chemotherapy for aging and senescence? Perhaps the juvenile hormone of insects may encourage a fresh look at this possibility.



Visual concept of the behavior of lithium ions in a fused salt bath

L I L L I P U T I A N

Lithium ions get around . . . in the tightest places!

The lithium ion really puts small size . . . high charge density . . . and directional properties to work. Unlike the ions of other alkali metals, it's trim enough *and* active enough to replace many other metals in a variety of crystals.

The small ionic radius of lithium, 0.60A, immediately suggests lithium's use in systems containing metals with ionic radii ranging from .5 to 1.0A. The resultant balance or unbalance created by such lithium substitutions may be used to produce significant stabilizing or catalytic effects. Ionic radius also makes lithium an excellent addition for increasing conductivity, and its high charge density can effectively decrease viscosity.

Small ionic radius, high charge density, and directional properties are just a few of the many unique characteristics that make lithium well worth investigation. Bring your knowledge of the subject up-to-date by requesting a copy of "Chemical and Physical Properties of Lithium Compounds"—a down to earth collection of facts, figures, and ideas on some 23 lithium compounds. Write the Technical Literature Dept., Foote Mineral Co., 454 Eighteen West Chelten Building, Philadelphia 44, Pa.

Foote
MINERAL COMPANY

LITHIUM CHEMICALS, MINERALS, METAL • STRONTIUM CHEMICALS • ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES • COMMERCIAL MINERALS AND ORES • ZIRCONIUM, TITANIUM, HAFNIUM (IODIDE PROCESS)

The Discovery of Fission

In 1939 Otto Hahn and Fritz Strassmann announced that uranium nuclei "burst" when they are bombarded with neutrons. How they came to this conclusion is a classic example of the nature of science

by Otto Hahn

The editors of SCIENTIFIC AMERICAN have asked me to set down my personal recollections of the discovery of uranium fission. This I am very pleased to do.

The story must go back to the year 1904, for that was the year in which I was "transmuted" from an organic chemist into a radiochemist and thus began to learn about radioactive elements. Armed with a letter of recommendation from the professor with whom I had taken my doctor's degree in Germany, I went to London in 1904 with two objectives in mind: namely, to learn English and to study with Sir William Ramsay, the discoverer of the inert gases. Sir William, who had just become interested in radium, gave me a dish with a barium salt which he said contained approximately 10 milligrams of radium, and he asked me if I would purify the radium by the method of Marie Curie. The barium salt, as it happened, came from a mineral which contained not only radium but also a good deal of thorium, and while working with the material I discovered a previously unknown radioactive substance. I called it radiothorium, "a new element." (Actually it was an isotope of thorium, but the existence of isotopes of elements was not yet known.)

Ramsay urged me to give up organic chemistry and devote myself to the study of radium. Accordingly, with a view to learning more about the field, in the fall of 1905 I went to Montreal to study with the then already famous Professor Ernest Rutherford. There an amicable argument about the stability of radiothorium with Rutherford's well-known associate, B. B. Boltwood of Yale University, led me to the hypothesis that another radioactive element, rather long-lived, must exist in the periodic table between thorium and radiothorium. And in fact, after returning to Germany to work at the University of Berlin, I found this substance, which I called mesothorium.

When I attempted to separate mesothorium from radium, however, it became obvious that this new "element" was practically indistinguishable chemically from radium. I first tried the separation method that Madame Curie had worked out for the purification of radium. In this method, after radium has been precipitated from the mineral with barium as the carrier substance, the radium is separated from the barium by fractional crystallization of the chlorides or bromides of the two elements: the radium is concentrated in the first fraction of crystals that comes out. I applied this crystallization treatment to the mixture of mesothorium and radium I had obtained from a thorium-uranium mineral. But mesothorium and radium refused to crystallize in separate fractions. And try as I would, with every conceivable method of separation, my efforts to segregate mesothorium from radium came to naught. I decided that the two substances were remarkably alike, but I did not have the courage to label them chemically identical.

With the discovery of "isotopy" a few years later by Frederick Soddy, also a former student of Rutherford and Ramsay, everything became clear. Mesothorium was now identifiable as an isotope of radium, and radiothorium as an isotope of thorium. By this time I had learned also that radiothorium was a decay product from mesothorium. The long-lived mesothorium slowly changes, without detectable emission of radiation, to a shorter-lived form which I called mesothorium 2; the latter is an isotope of the radioactive element actinium. In turn, mesothorium 2, with a half-life of 6.2 hours, decays by beta-particle emission to radiothorium.

Some of this information, as we shall see, is directly relevant to the subject of uranium fission. And in the course of these studies I was acquiring what was to be of the greatest help to Fritz Strassmann and myself later in discovering the fission process: namely, a thorough familiarity with methods of separating radioactive substances.

In the fall of 1907 an important event in my chronicle took place: Lise Meitner, the Austrian physicist, joined me at

FOUR WORKERS most closely associated with the discovery of fission are depicted

Berlin. She had come from Vienna to attend Max Planck's lectures in theoretical physics, and, having free time to spare, she visited my laboratory to work with me. What had been intended as a temporary stay in Berlin developed into a collaboration of more than 30 years—an association which was only terminated in the summer of 1938 through the actions of the Nazi regime. It is perhaps needless to say that the friendship has continued.

The working facilities in the overcrowded Chemical Institute of the University of Berlin were then very modest. Our laboratory was an unoccupied woodworking shop. But when, in 1911, Kaiser Wilhelm II inaugurated his Society for the Advancement of Science, we were given a radiochemical department in the first institute set up by the Society—the Kaiser Wilhelm Institute of Chemistry. Over the years this department developed into two large departments, one for radiochemistry under my direction and one for nuclear physics under Dr. Meitner.

In 1917 we discovered element 91, which we named protactinium. It was our work on the chemical properties of this substance that gave rise later to our keen interest in investigating the irradiation of uranium with neutrons. This part of the story, which leads directly to the discovery of fission, begins in the year 1932 in Rutherford's laboratory at the University of Cambridge.

James Chadwick's discovery of the neutron in that year not only explained the phenomenon of isotopy but also gave physicists a new and extraordinarily effective means of producing artificial transmutation of elements. Since neutrons carry no electric charge, they easily enter the nucleus of an atom. The first to point out the great value of neutrons for initiating nuclear reactions was Enrico Fermi in Italy. He and his co-workers—Edoardo Amaldi, Oscar D'Agostino, Franco Rasetti and Emilio Segrè—bombarded practically all the elements of the periodic table with neutrons and produced a great number of artificial, radioactive isotopes.

Extending their experiments all the way up to uranium, the heaviest natural element (atomic number 92), Fermi's group found that uranium, too, gave rise to new substances, some of which decayed very rapidly. Usually the capture of a neutron by a nucleus produces an unstable isotope which emits a beta particle and is thus transformed into the next higher element. Since Fermi's products from uranium emitted beta particles, he and his colleagues made the plausible assumption that the transmutation produced short-lived isotopes of uranium which then, by beta-decay, gave rise to elements beyond uranium—element 93 and possibly even 94.

Since no such elements occur in nature, Fermi's conclusion was widely disputed. Some physicists suggested that his best-identified new substance—a material with a half-life of 13 minutes—was actually an isotope of protactinium, rather than a "transuranic" element. Naturally Dr. Meitner and I were keenly interested, for we knew a good deal about the chemical properties of protactinium, our discovery. We decided to repeat Fermi's experiments to try to determine whether his substance was or was not protactinium.

Fermi's products were of course much too small in amount to be detected in any way except with a Geiger-Müller counter. But fortunately we had a convenient means of making a chemical test. I had myself discovered a beta-emitting isotope of protactinium, derived from uranium. This isotope, with a half-life of 6.7 hours, gave us a definite marker, or indicator, of the presence of protactinium in small amounts. Accordingly we added a certain amount of our protactinium isotope to the "transuranic" products obtained by Fermi's procedure, and then applied chemical precipitations to the mixture. Very little of the

in these drawings by Bernarda Bryson. At left is Otto Hahn. Second from left is Fritz Strassmann. Third from left is Lise Meitner. Fourth from left is O. R. Frisch. Three other figures in the history of the discovery are depicted in the drawings on the next page.

protactinium (less than one thousandth) came out with Fermi's newly discovered substances. This proved unequivocally that his substances could not be protactinium. We were also able to show with equal certainty that they were not isotopes of thorium or actinium. That they might be lighter elements seemed entirely out of the question. Ida Noddack did suggest, to be sure, that we could not be certain they were transuranic elements unless we excluded all the other elements of the periodic table as possibilities, but this thought was considered to be wholly incompatible with the laws of atomic physics. To split heavy atomic nuclei into lighter ones was then considered impossible. Thus our experiments appeared to establish the correctness of Fermi's assertion that he had detected "transuranic elements." Actually, as we were to learn later, all of the radioactive substances detected in these early experiments were fission products, not transuranic elements.

Over the course of years of work Lise Meitner and I, subsequently joined by Strassmann, found a great number of radioactive transmutation products, all of which we had to regard as elements beyond uranium. They could be arranged in a regular series, for in chemical properties they corresponded to known elements lower in the periodic table: namely, rhenium, osmium, iridium and platinum.

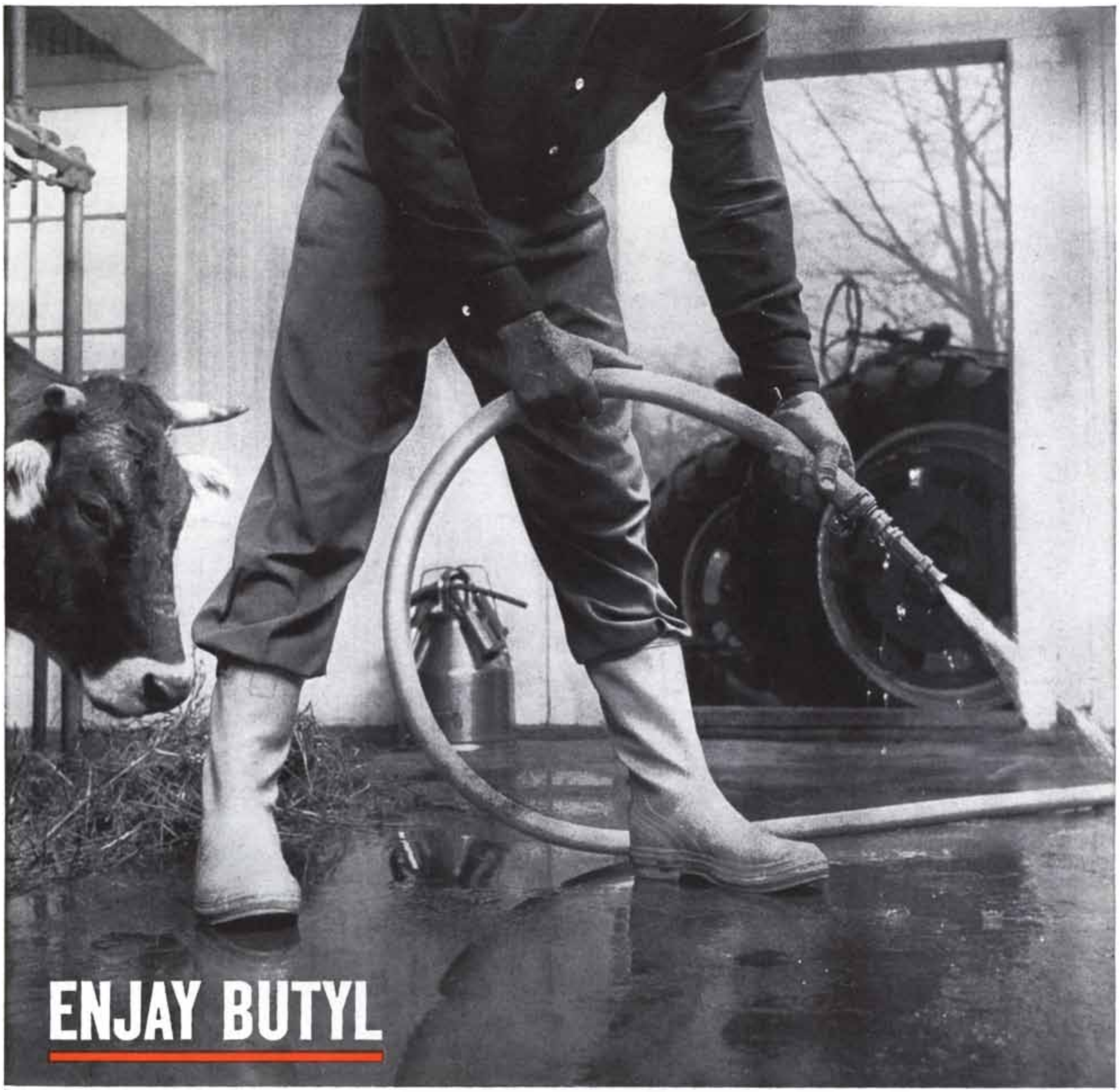
There was one product which, unlike Fermi's extremely short-lived "uranium isotopes," had a half-life of 23 minutes. Its life was sufficiently long for us to establish chemically that it was in fact an isotope of uranium. Since it emitted a beta particle, it was evident that this isotope must become an isotope of element 93, which we called eka-rhenium. We looked for the new element, but were unable to detect it. If we had not been convinced that we had already identified two other isotopes of element 93—an erroneous assumption, as it turned out—we would have prepared stronger samples of the material and made a determined effort to find the disintegration product of our 23-minute uranium isotope. We should then have had the pleasure of discovering element 93. Later Edwin M. McMillan and Philip H. Abelson in the U. S. identified an isotope of element 93 with a half-life of 2.3 days, and they named the element neptunium. Subsequently, when we ourselves obtained a stronger neutron beam for irradiating uranium, we had no trouble in detecting neptunium.

On the main road toward the discovery of fission, the next step in this curious chronicle of near-discovery was taken by Irène Joliot-Curie and P. Savitch in France. They were greatly puzzled by an artificially produced substance of 3.5 hours' half-life which they first took for an isotope of thorium, later for actinium, and finally for a "transuranic element" strongly resembling lanthanum. They believed that they had succeeded in separating the substance from lanthanum by fractional crystallization, but apparently they were misled by irrelevant separations in their mixture. Actually their substance was undoubtedly lanthanum itself: had Madame Joliot-Curie and Savitch recognized this, they would have been on the verge of discovering fission.

In a paper published by the French Academy of Sciences in 1938, Madame Joliot-Curie and Savitch concluded: "It appears, therefore, that this substance can only be a transuranic element, with properties very different from those of the other known transuranic elements." They considered various ways of fitting the element into a transuranic series, but the possibilities they discussed seemed to us highly unlikely. Strassmann and I decided to look further into their results. (Professor Meitner had gone to Stockholm, having been forced by the Hitler regime to leave Germany in July, 1938.)

We found that after the "transuranic elements" had been precipitated and re-

THREE FIGURES in the history of the discovery are William Ramsay (*left*), Ernest Rutherford (*center*) and Enrico Fermi (*right*). Hahn studied with Ramsay and Rutherford. Fermi thought neutron bombardment of uranium gave rise to transuranic elements.



all-purpose wonder rubber OFFERS TRIPLE VALUE

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In a wide variety of applications, Enjay Butyl stands *unmatched* in its resistance to deterioration caused by animal and vegetable fats, chemicals, hot and cold water . . . properties that make Butyl-made products *outstanding* performers.

Dairy boots, creamery hose, wading pools, hot material conveyor belts . . . in these and a wide variety of other products, Enjay Butyl out-performs and out-lasts all other types of rubber, synthetic *or* natural. Low-in-cost and immediately available in a grade tailor-made for *your* product, Enjay Butyl is *the* rubber to boost performance and cut costs. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world...the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.
Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

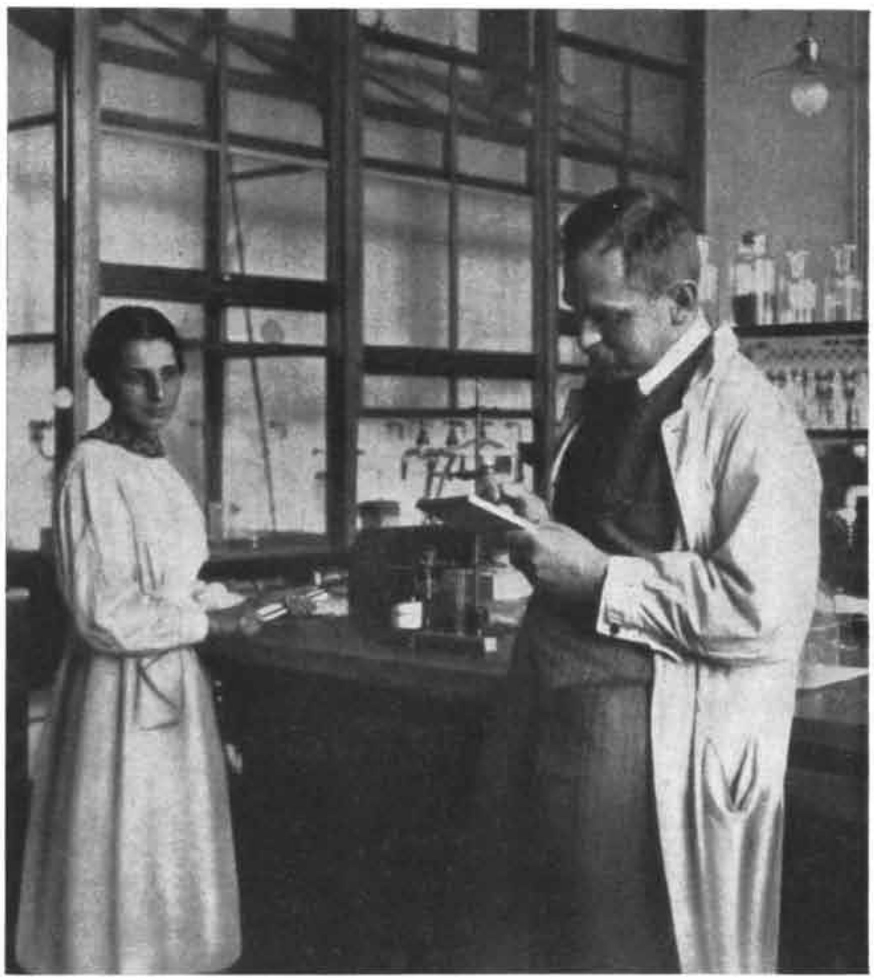
moved, the solution still contained some radioactive products. Experiments in chemical separation of these substances now gave a remarkable result. When we used barium as the carrier, three radioactive isotopes, with different half-lives, came down with the barium. We were certain that these could not be accidental impurities, because our barium precipitates were extraordinarily pure. At Strassmann's suggestion, the carrier we used was barium chloride, which is deposited from strong hydrochloric acid in beautiful small crystals that are free of any trace of adsorbed impurities.

Now the precipitates had to be either barium or radium, which is chemically similar to barium. There was nothing in the knowledge of nuclear physics at the time to suggest that barium could possibly be produced as a result of the irradiation of uranium with neutrons. Therefore we could only conclude that the products must be isotopes of radium.

Still, it was a strange affair to be producing radium from uranium under the conditions of our experiments. In order to reach radium (element 88) from uranium (92) we had to assume that the parent element decayed by emitting two alpha particles. But we had irradiated the uranium with low-energy (thermal) neutrons, and slow neutrons had never before been observed to produce alpha-particle transmutations, nor was it possible to understand how they could do so. In this case irradiation with slow neutrons was apparently yielding more intense nuclear reactions than had ever been produced by bombardment of a substance with fast neutrons.

We continued with our experiments and were able to distinguish no fewer than four isotopes of "radium" produced artificially from uranium. We called them radium I, II, III and IV. Their half-lives were less than one minute (an estimate), 14 minutes, 86 minutes and approximately 300 hours, respectively.

Now since we were dealing with very weak preparations, we undertook to separate the radium isotopes from the car-



HAHN AND LISE MEITNER were photographed in the Kaiser Wilhelm Institute of Chemistry in 1925. Meitner left Germany in 1938, a few months before the discovery.


Missiles designed to soar out of this world
...are sped by liquid oxygen from LINDE
Oil, kerosene, and alcohol "burn" by combining chemically with oxygen from the air. But it takes pure oxygen with these fuels to speed rocket planes faster than sound ... to drive missiles beyond the earth's atmosphere.
Liquid oxygen, vital to today's rocket engines and many types of missiles, was being produced by LINDE as long as 25 years ago. In fact, LINDE has been supplying oxygen to industry for more than 50 years. LINDE pipes oxygen directly to industrial users from nearby oxygen plants built and operated by LINDE. The user makes no capital investment, and pays only for the oxygen consumed —at a price guaranteed by LINDE.
LINDE also developed methods for transporting liquid oxygen efficiently, in large and small amounts, at 300 degrees below zero F. You can get LINDE oxygen in just the quantity you need, at the exact time and place you want it, as a liquid or a gas.
For detailed information about LINDE oxygen, write Dept. R-2, 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.
When you need Oxygen—call LINDE!
The terms "Linde," "Driox," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.
UID OXYGEN
YGEN
Liquid oxygen from LINDE's DRIOX oxygen units is teamed with liquid fuels to propel missiles and rocket planes.
Linde
TRADE-MARK
UNION CARBIDE

rier substance, barium, to obtain thinner layers of material, so that their radioactivity could be more easily measured. We used the method of fractional crystallization with which, 30 years earlier, I had separated the radium isotope mesothorium from barium.

Our attempts to concentrate our artificial radium isotopes by this method came to nothing. We then tried a more effective process that we had developed, using chromates of the substances instead of their chlorides or bromides. All in vain.

It next occurred to us that the "radium" might conceivably be failing to separate from the barium because it was present only in extremely small amounts—so few atoms that they could be detected only with the Geiger-Müller counter. To test this possibility, we put some natural, definitely identified radium through the same experiments. We meticulously purified this radium and diluted it to intensities as weak as those of the artificial "radium" isotopes in the aforementioned experiments. But this time the definitely known radium, in spite of its small amount, separated from barium upon crystallization as one should expect.

Finally we turned to "indicator" experiments such as I had used to check whether Fermi's product was protactinium. We mixed one of our supposed artificial radium isotopes with a known natural isotope of radium and then tried to separate the mixture from barium by fractionation as before. The experiments and their results were rather involved, and I shall not attempt to describe them here in detail. But the findings were quite clear: in each case most of the natural radium in the mixture separated out, but the artificial "radium" (*e.g.*, Ra III or Ra IV) stayed with the barium *in toto*, according to the radioactivity measurements. In short, our artificial "radium" could not be separated from barium for the simple reason that it was barium!

In January, 1939, we published an account of these "experiments that are at variance with all previous experiences in nuclear physics." In interpreting the experiments we expressed ourselves very cautiously, partly because the series of tests had not yet been quite finished—they took several weeks. But our caution was not due to any mistrust of our results. Indeed, we already had a strong check of our conclusion, for we had identified a decay product of one of our "radium" isotopes as lanthanum, which meant that the parent had to be not radium but barium.

Our overcautiousness stemmed primarily from the fact that as chemists we hesitated to announce a revolutionary discovery in physics. Nevertheless we did speak of the "bursting" of uranium, as we called the surprising process that had yielded barium, far down in the periodic table. In this first paper we also speculated on what the other partner of the splitting of the uranium atom might be. Not being physicists, we thought of uranium's atomic weight (238) rather than the number of its protons (92). Subtracting the atomic weight of barium (137) from that of uranium, we guessed at 101 as the atomic weight of the other fragment. This could be an isotope of technetium or of one of the medium-heavy metals.

Immediately after our paper appeared, Meitner and Otto R. Frisch came out independently with their historic publication showing how Niels Bohr's model of the atom could explain the cleavage of a heavy nucleus into two

FISSION OF URANIUM WAS DISCOVERED with this simple apparatus on the top of a table. The apparatus and the table are now preserved in the Deutsches Museum of Munich.

STOPPED!

LOST
10,000 man-hours

and your high-paid help talks TV

Stopped . . . because automatic control circuits and operating elements were not designed on the modular basis, with Cannon quick-disconnect electrical connectors at vital points.

But it could have been rolling in seconds or minutes! If only the circuitry had been arranged on the modular basis so that essential elements of the automatic control and operating system could be disconnected quickly . . . and complete, operable spare components inserted at a moment's notice. The units in trouble could have been repaired properly, too, at leisure . . . by trained personnel, at the right place, with the right facilities. Production could have gone on . . . thousands of man-hours and thousands of dollars saved . . . merely by the use of quick-disconnect components.

Are the controls in your electrical or electronic product designed on the modular basis? How about your production line? Will minor failure cause breakdown? Or do you need Cannon Connectors? Cannon makes over 27,000 different electrical connectors. If one of these does not meet your requirements, we'll design and make the electrical connector you need. Write today! Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. Please refer to Dept. 413.

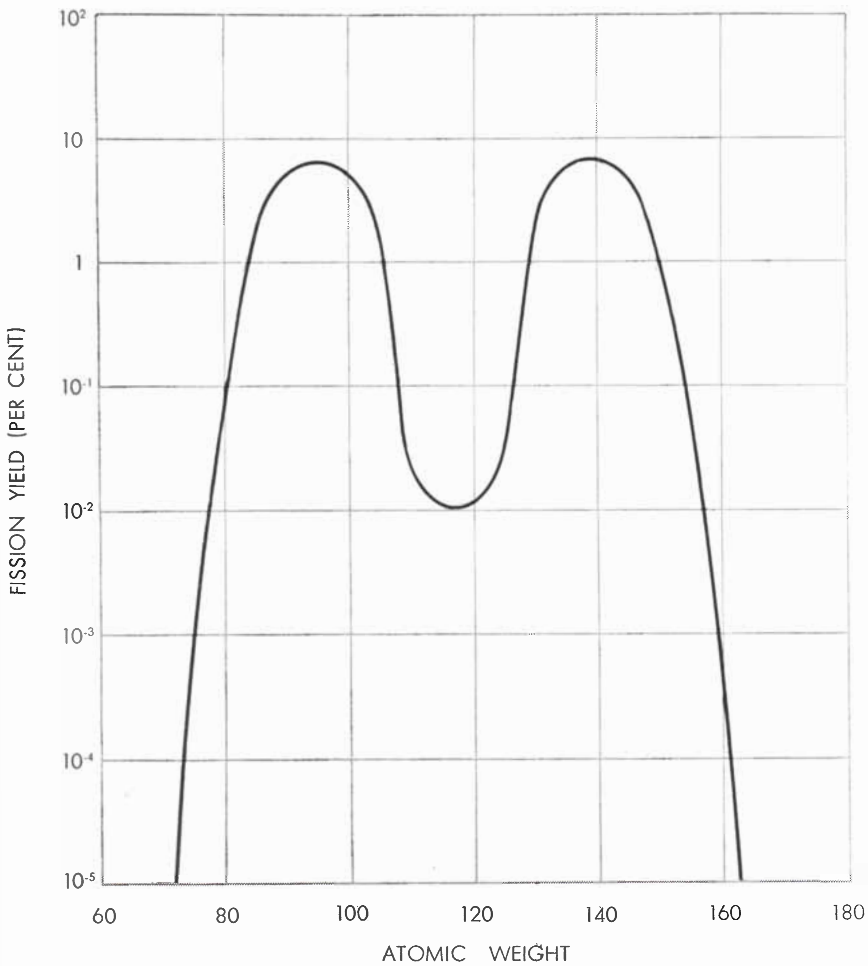
Send for explanatory material on how modular designs can save dollars.

CANNON PLUGS

Where Reliability for Your Product is Our Constant Goal nuclei of medium size. Meitner and Frisch named the process "fission." Subtracting the nuclear charge of barium (56) from that of uranium (92), they identified the other fission product as element 36, the inert gas krypton. And indeed, Strassmann and I had actually detected this element, or rather, its decay product, strontium, among the products of the neutron irradiation of uranium. Now in quick succession we discovered other fission products, determined their chemical properties and traced their subsequent transformations. We also found that thorium, like uranium, underwent fission when bombarded by fast neutrons.

This, in broad outline, is the story of the discovery of fission. The fact that the process is accompanied by the release of enormous amounts of energy was soon ascertained by Meitner and Frisch, and, independently, by John R. Dunning, Fermi and co-workers in the U. S. and by Frédéric Joliot-Curie in France. Strassmann and I conjectured, but did not prove experimentally, that neutrons were liberated in the process. This was later proved by Joliot-Curie, H. von Halban and L. Kowarski. The liberation of neutrons of course made it possible to harness the vast amount of energy released by the fission of uranium in the form of a "chain reaction," and this possibility was pointed out as early as mid-1939 by, among other workers, S. Flügge of the Kaiser Wilhelm Institute of Chemistry.

Strassmann and I did not concern ourselves with the harnessing of the energy of fission. During the war we continued, together with two or three co-workers, to investigate the complex fission processes and to publish our findings. By the beginning of 1945 we had made up a table containing approximately 100 fission products and their transformations. But the science of fission was then a classified subject in the U. S., and our results were not published there until November, 1946.



URANIUM FISSION PRODUCTS are distributed over much of the periodic table. This curve shows the abundance of the various products with atomic weight. One peak of the curve is in the vicinity of the element molybdenum; the other, in the vicinity of lanthanum.

A MAJOR ADVANCE!

A TRULY PORTABLE MAGNETOMETER

FOR GEOLOGICAL AND GEOPHYSICAL EXPLORATION

THE VARIAN M-49

operating on revolutionary nuclear-free-precession principle detects variations in the earth's magnetic field associated with magnetic ore bodies, subsurface faults and structural anomalies. Sensitivity of plus or minus 10 gammas is more than ample for the purpose. An extremely short (6 second) automatic reading interval permits rapid reconnaissance of large areas. Weight is only 16 pounds.

The Varian M-49 needs no leveling, calibration or orientation in azimuth. Its readings are precise even when the magnetometer is in motion — carried by a man on foot — mounted on horseback — or embarked in a boat. The sensing head is connected by cable and can be separated from the instrument body by several hundred feet—suspended by balloon—lowered over vertical cliffs.

To achieve these unique properties, Varian uses the proton free-precession principle which relies on an immutable nuclear constant (of the hydrogen atom). Other Varian magnetometers operating on this same principle are in use in magnetic observatories, airborne surveys, underwater surveys and in space vehicles.

FEATURES...

- Range 19,000 to 100,000 gammas.
- Direct reading meter in gammas; sensitivity of ± 10 gammas; no calibration required.
- Weighs only 16 pounds; all-transistor design; compact and rugged.
- Reading interval manually controlled or six-second automatic; usable stationary or in motion.
- Cable-connected sensing head separable by several hundred feet for multilevel surveys.
- Polarizing cells rechargeable by simple connection to automobile battery.

Write today for a full explanation of the Varian Magnetometer's principles, applications and equipment details.

VARIAN associates

INSTRUMENT DIVISION

611 Hansen Way, Palo Alto 7, California

Correct Lubrication in Action . . . in the

Maintenance cost cut

Mobil

Complete Engineering Program
Proved Petroleum Products

Mobil

SOCONY MOBIL OIL CO., INC., and Affiliates: MAGNOLIA PETROLEUM CO., GENERAL PETROLEUM CORP., MOBIL OVERSEAS OIL CO., INC.

Heavy Equipment Industry!

$58,500 in one year!

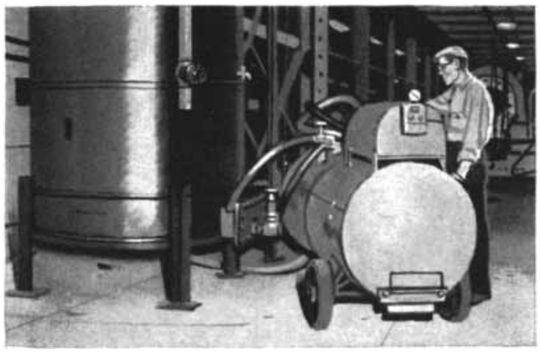
One of the many maintenance and production savings achieved by Fairbanks, Morse & Company with the help of Socony Mobil

In 1949, Fairbanks, Morse & Co. installed a Mobil Program of Correct Lubrication. This decision has continually paid off, as it can for you, by directly contributing to company profits.

To illustrate: First year after installation of a Mobil Program in the company's Beloit, Wisconsin plant figures showed machine repair maintenance costs were reduced 26.3 percent . . . $58,500. In fact, plant supervisors and Mobil engineers have co-operated so effectively under this service that today . . . nine years later . . . the Program shows continuing benefits, with the result that machine repair maintenance costs are now 49 percent lower than when the Program was inaugurated.

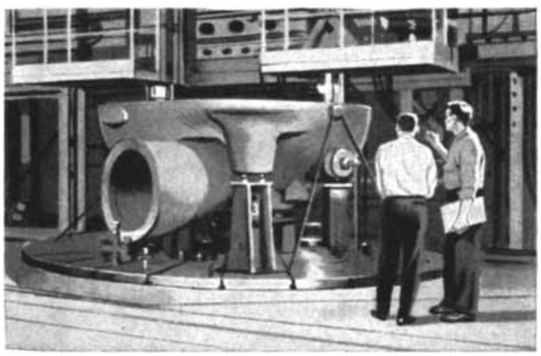
In dollars, this saving yearly is in excess of *twice the cost of plant lubricating oil requirements.* Here is another example of how Correct Lubrication in action can reduce maintenance costs and *increase profits.* It proved effective for this leading builder of heavy equipment. Why not for you?

In-plant training conducted by Mobil specialists demonstrates proper lubricant application and maintenance procedures . . . teaches Fairbanks, Morse personnel to recognize and prevent trouble before it results in downtime, repair costs.



Disposal of thousands of gallons of water-soluble cutting oils posed serious, expensive problem. Mobil recommendation of chemical separation process allowed disposal through plant sewage system . . . avoided stream pollution, saved substantial sum.

Control system cuts downtime:—Mobil lubrication charts cover plant's 2,300 machines . . . specify correct lubricants, lubrication periods . . . assure follow-through on application and maintenance.



High temperatures of Boring Mill way lubricant lowered viscosity . . . resulted in pressure drop, causing machine to stop. Mobil recommendation solved problem, allowed continuous operation.

Correct Lubrication

Another reason You're Miles Ahead with Mobil!

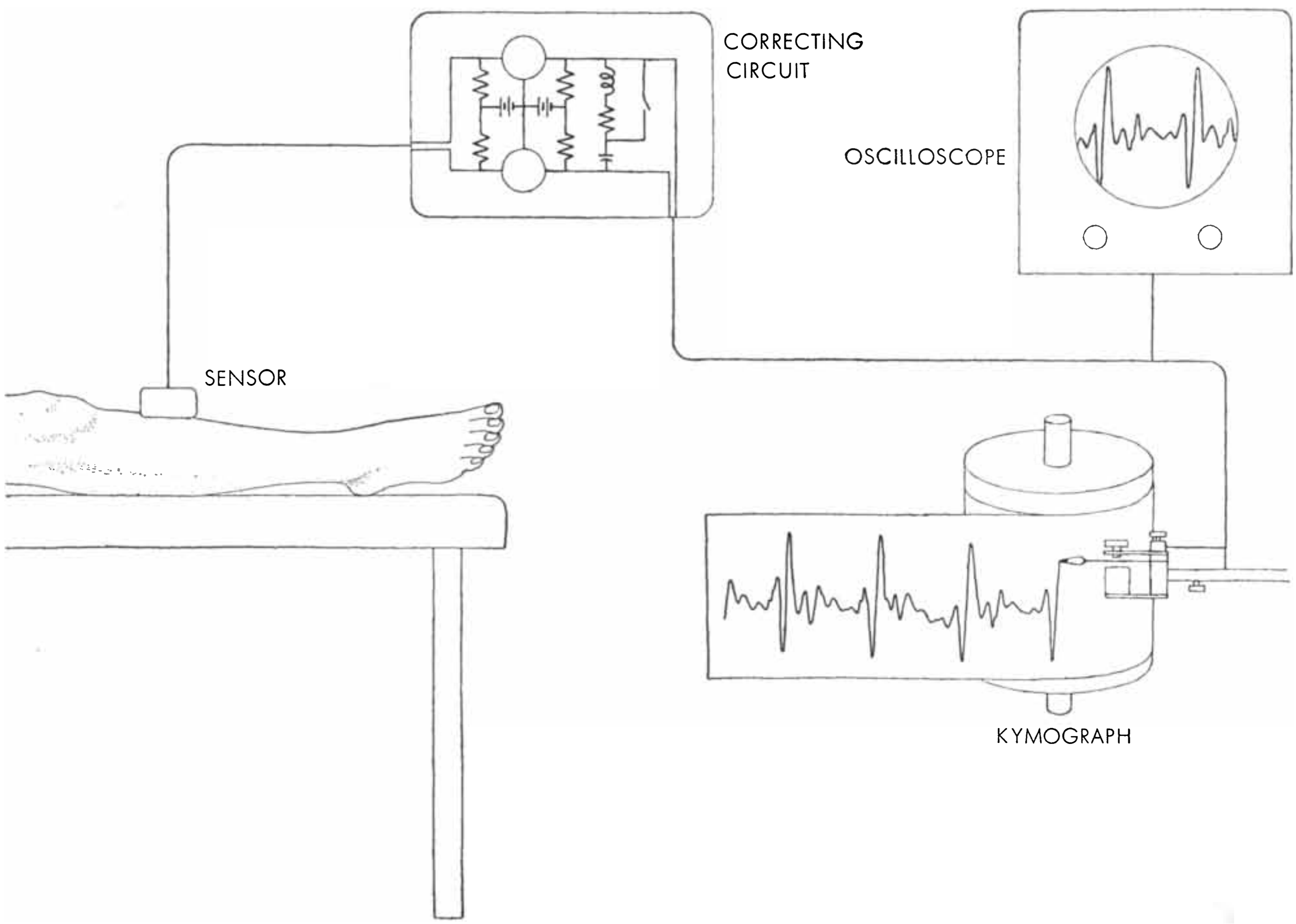
BALLISTOCARDIOGRAPHY

When the heart ejects blood, it recoils and shakes the whole body. Similar vibrations are caused by the impact of the blood. Records of these vibrations may have experimental and clinical usefulness

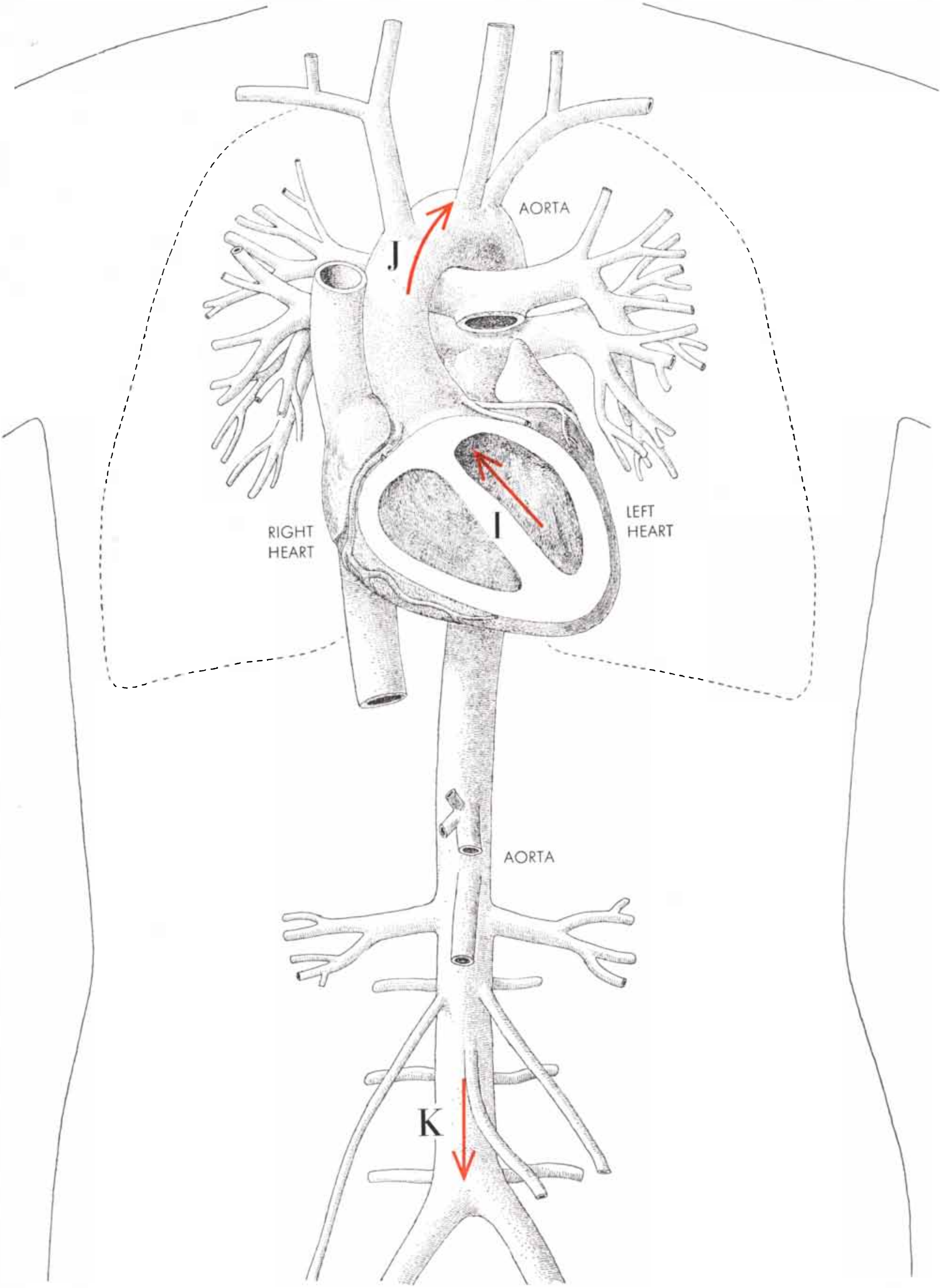
by H. W. Lewis

Eighty years ago a Britisher named J. W. Gordon, standing quietly on his bathroom scale, noticed an odd phenomenon. The needle seemed to be vibrating regularly at about the same rate as his heartbeat. Many of us have noticed the same vibration and have not thought twice about it. But Gordon did think twice. In a report to a scientific journal describing his discovery, he wrote:

"A person standing erect in a perfectly easy posture on the bed of an ordinary spring weighing-machine, and maintaining, as far as possible, perfect stillness, will be found, if the instrument is delicately adjusted, to impart a rhythmic motion to the index, synchronous with the pulse and according to the following rule: At each occurrence of systole in the heart, the needle will be vigorously deflected toward the zero point of the dial, and in the intervals of systolic action will return by a slower movement to the starting point. . . . The return of the needle is effected by a series of secondary vibrations which appear to bear



BALLISTOCARDIOGRAMS are made with this apparatus. Body movements picked up electrically by the sensor are filtered through a correcting circuit to eliminate resonant oscillations. The corrected signal is visible on oscilloscope and is recorded on kymograph.



BODY MOTIONS produced by blood circulation are outlined. Blood forced upward from the heart (I) produces body recoil downward. Impact of blood on the aortic arch (J) then causes upward motion; impact on lower arteries (K), a downward motion.

an appreciable but imperfect analogy to corresponding features in the sphygmograph [pulse-recording machine]."

Gordon reasoned correctly that the vibrations of the scale must be due to vibrations of the body caused by the beating of the heart. He likened the process to the recoil of a gun, recoil arising not only from the firing of the blood from the heart but also from the impact of the blood on the walls of the great arteries into which it is fired. Gordon went on to propose that valuable information about the heart and the circulatory system might be obtained by recording and analyzing these bodily vibrations.

Beyond the existence of his paper, we know nothing about Gordon. He never published any other work, and so far as science is concerned he simply vanished after this one publication in *The Journal of Anatomy and Physiology*. But his alert and thoughtful report inaugurated the study known as ballistocardiography (from the gun analogy). The body vibrations turned out to be complicated and very difficult to interpret. As Gordon wrote: "The process, which, though indirect, yields results of astonishing delicacy, is capable of being most extensively and instructively varied." It cannot be said that we have learned a great deal more about the process than Gordon deduced in 1877. However, there has been some rapid progress recently, and ballistocardiography now promises to become a useful tool in medicine.

The ballistocardiograph is related in a way to the electrocardiograph. The latter measures the electrical nerve impulses that cause the heart muscle to contract; the ballistocardiograph measures the body's mechanical responses to those contractions. One might say that the electrocardiograph is a wiretapper listening to the messages, while the ballistocardiograph is a machine that records the impact, or shock effects, of the messages.

In order to develop ballistocardiography as a tool we must solve three problems: (1) measuring the body vibrations arising from the heartbeat, (2) learning just how the vibrations are produced, and (3) interpreting this information to diagnose how well the heart and circulatory system are functioning. The first problem has been solved reasonably well; on the other two we can only report progress.

On the face of it, measuring the vibrations of the body seems a simple matter. You lay the subject on a table and record his bodily oscillations with some mechanical sensing device. Most of the ballistocardiograms in the past have been made in this way. (The first known use of the instrument was during the 1911 Pikes Peak expedition, when measurements were taken on members of the climbing party to try to find out whether the pumping rate of the heart increased in the rarefied higher air.) Unfortunately muscular vibrations due to gravity stresses on the body produce distortions of the vibrations stemming from the heartbeat. Gordon was acute enough to realize this, and he suggested a solution which is now used in some laboratories. The subject lies on a very light platform suspended from the ceiling by long wires, so that the platform "gives" with the natural body vibrations and does not stress the tissues as much as when it lies on an immovable table. Recently we have developed an electronic device for eliminating the distortions; packed in a small box, it can be carried about and so is not confined to the laboratory but can be used to take ballistocardiograms in a hospital or almost anywhere.

An undistorted ballistocardiogram is very different from one contaminated by extraneous vibrations [*see illustrations on next page*]. This is important when we come to analyze the heart-induced vibrations for their meaning.

We do not yet really understand these pictures, but there are a few things we can say. The heart, as everyone knows, consists of two halves—the right half pumping blood to the lungs, the left half to the rest of the body. Naturally the left heart, serving the whole body, is considerably larger and stronger than the right. Its firing therefore accounts for most of the force responsible for the body vibrations. Let us consider the geometry of the left heart and the aorta, the artery into which it shoots its blood.

When the heart beats, driving blood upward into the aorta with great speed, it recoils as if it were a rifle firing a high-speed cartridge. The recoil is taken up by the body (as the shoulder takes the recoil of a rifle), and this recoil is transmitted toward the feet. So in the ballistocardiogram we have a dip to start with, recording the heart's recoil. While all this is going on, the ejected jet of blood is shooting up through the aorta to the bend known as the aortic arch [*see illustration on opposite page*]. When it hits the arch, it bounces downward into the descending arm of the arch. There is, then, a second recoil of the body, this time toward the head, and it is recorded as a peak in the ballistocardiogram. Next, the blood, rushing down the aorta and into its branches, gives up its momentum as it is slowed by these vessels; as a result we have a new footward recoil of the body, which is signaled by another dip in the ballistocardiogram. In short, the record has three separate major waves which we can account for satisfactorily by these three recoils.

A good analogy to this system would be a man with a rifle (the heart) standing at one end of a sled (the body) and shooting at a target (the aortic arch) mounted at the head end of the sled which moves easily because it is on ice. When the rifle fires, the sled recoils footward. When the bullet (the blood) hits the target (aortic arch), the sled recoils headward. The ricocheting bullet now comes back and hits the rifleman, producing the last of the three ballistocardiogram waves (and, we hope, very little damage to the rifleman). To obtain the ballistocardiogram of the sequence of recoils, we have only to put a motion-measuring device on the sled.

Armed with this interpretation of the ballistocardiogram, a number of laboratories have pursued the problem of turning it into a useful diagnostic tool by studying normal and abnormal patterns. Unfortunately progress has been slow, for various reasons, but the pace is quickening nowadays. There have been several fairly clear-cut developments, both positive and negative, which I shall mention briefly.

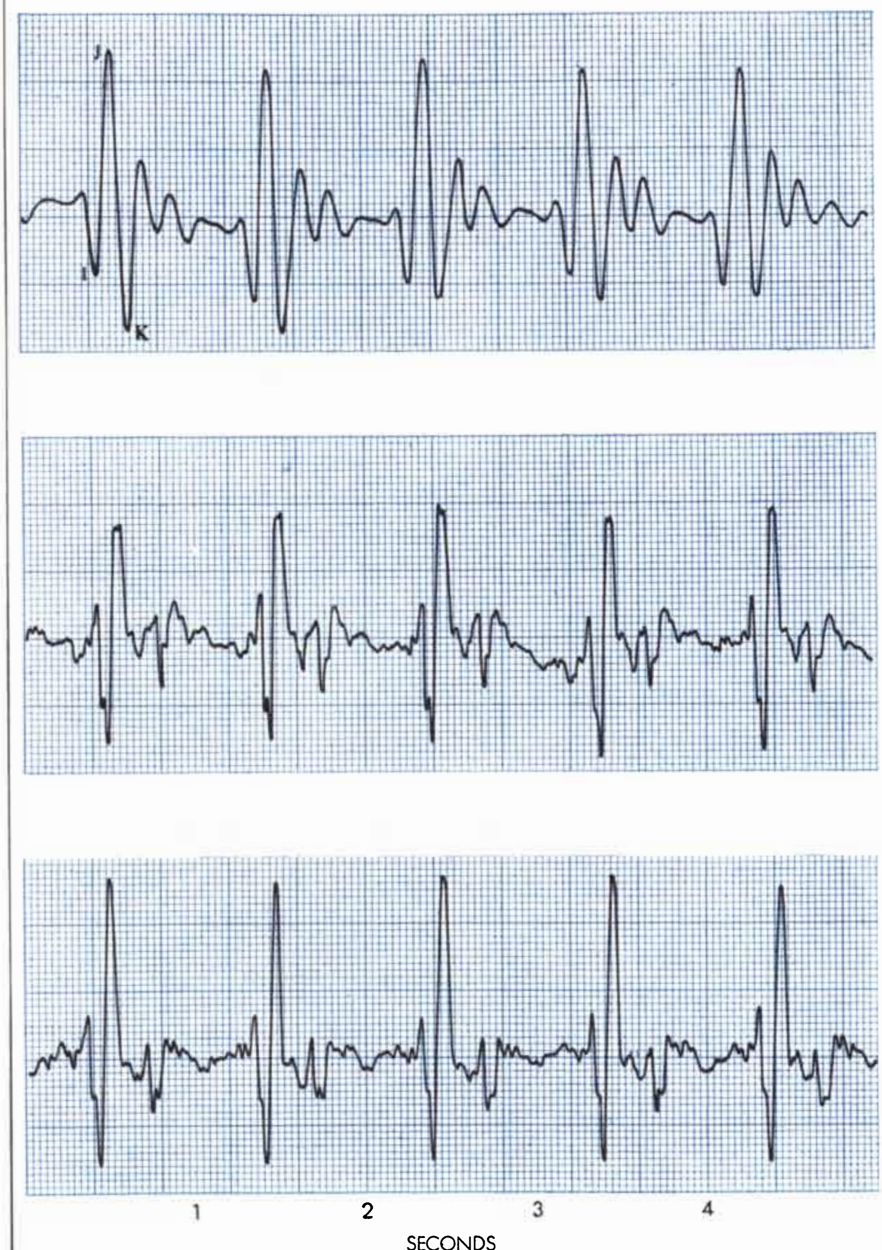
In the first place, a great deal of work has gone into sampling ballistocardiograms of normal persons and of patients with heart disease of various types. We have learned to recognize what is a normal and what is an abnormal ballistocardiogram. Usually an abnormal ballistocardiogram goes with an abnormal electrocardiogram and other signs of illness. Although we do not know its meaning in detail, it seems that an abnormal ballistocardiogram is generally a bad sign.

Some specific disorders seem to show specific effects on the ballistocardiogram. For example, high blood pressure tends to give a deep third wave, probably because the arteries slow down the rushing blood more abruptly than usual. This interpretation is supported by the fact that treatments which lower the blood pressure also tend to reduce the size of the dip in the ballistocardiogram. On the other hand, a constriction of the aorta, reducing the momentum of the downrushing blood, tends to be reflected by a reduced dip on the graph. Again, treatment relieving this condition seems to restore the curve to normal.

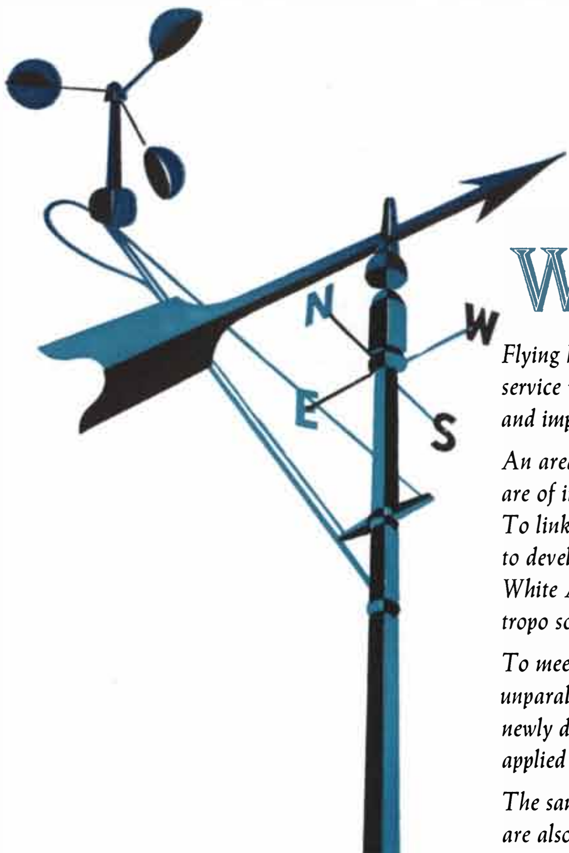
The upward peak in the curve, representing the impact of blood on the aortic arch, has been used to estimate the volume of blood pumped by the heart in one stroke. There are ambiguities here, but the measurements do seem to give an indication of the heart's output.

The foregoing may suggest that research in this field is making steady headway. Unhappily this is not true: there are dark spots and contradictions. The problem of measurement seems to be well in hand, but interpretation of the ballistocardiogram has run into snags.

The most troublesome enigmas have emerged in experiments with dogs, performed in several laboratories. The dog's heart is very similar to man's, and so, on the whole, is its ballistocardiogram. Some very surprising things have turned up, however, in the experiments. For example, the experimenters have looked into the effects of stopping blood flow by blocking the aorta, or, more dramatically, of draining out all the dog's blood for a brief moment. One would have supposed that, with no blood flowing, the recoils and ballistocardiogram waves



BALLISTOCARDIOGRAPH CURVES reflect I, J and K motions. Top curve is not corrected for resonant body oscillations. Middle curve is corrected electronically. In similar bottom curve oscillations were damped by suspending the measuring table by long wires.



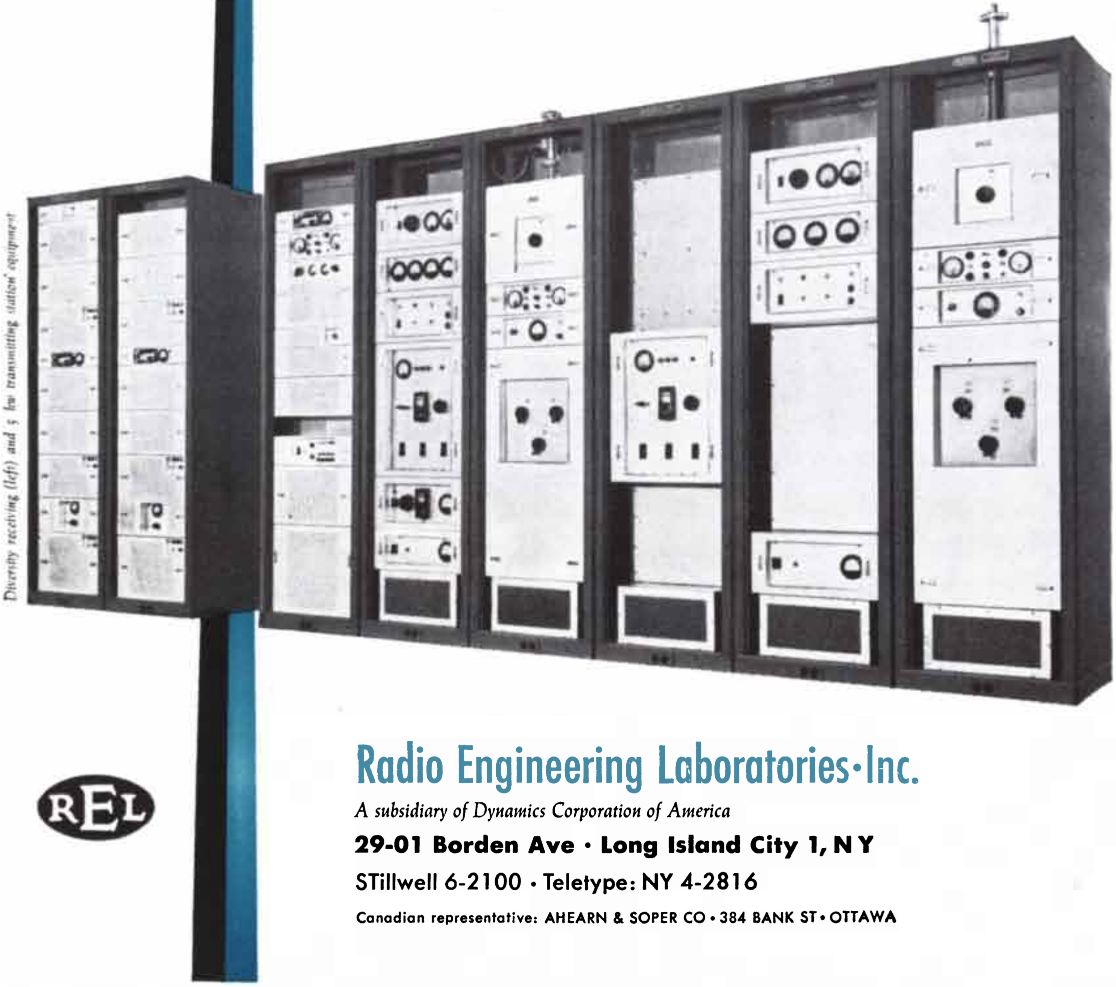
Weather links

Flying has been made safer and flights more regular by the weather information service which the Civil Aeronautics Administration is continually expanding and improving to keep pace with the growth of aviation.

An area of great meteorological importance is Alaska. Detailed observations there are of incalculable value in helping predict weather in much of the United States. To link its weather stations throughout Alaska, the CAA has commissioned REL to develop an ultra-reliable VHF communication system. It is to connect with White Alice, the giant military and civil Alaska communication system, whose tropo scatter radio equipment was also designed and manufactured by REL.

To meet—and exceed—the special requirements, REL has drawn upon its unparalleled experience in developing tropo scatter equipment. Improvements newly devised by REL for White Alice and other scatter systems are now being applied for the first time to line-of-sight communication.

The same imagination and resources which are setting new standards in this field are also available for the solution of your specialized radio problems.



Diversity receiving (left) and 5 kw transmitting station equipment

REL

Radio Engineering Laboratories·Inc.

A subsidiary of Dynamics Corporation of America

29-01 Borden Ave · Long Island City 1, N Y

STillwell 6-2100 · Teletype: NY 4-2816

Canadian representative: AHEARN & SOPER CO · 384 BANK ST · OTTAWA

GPE — 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.

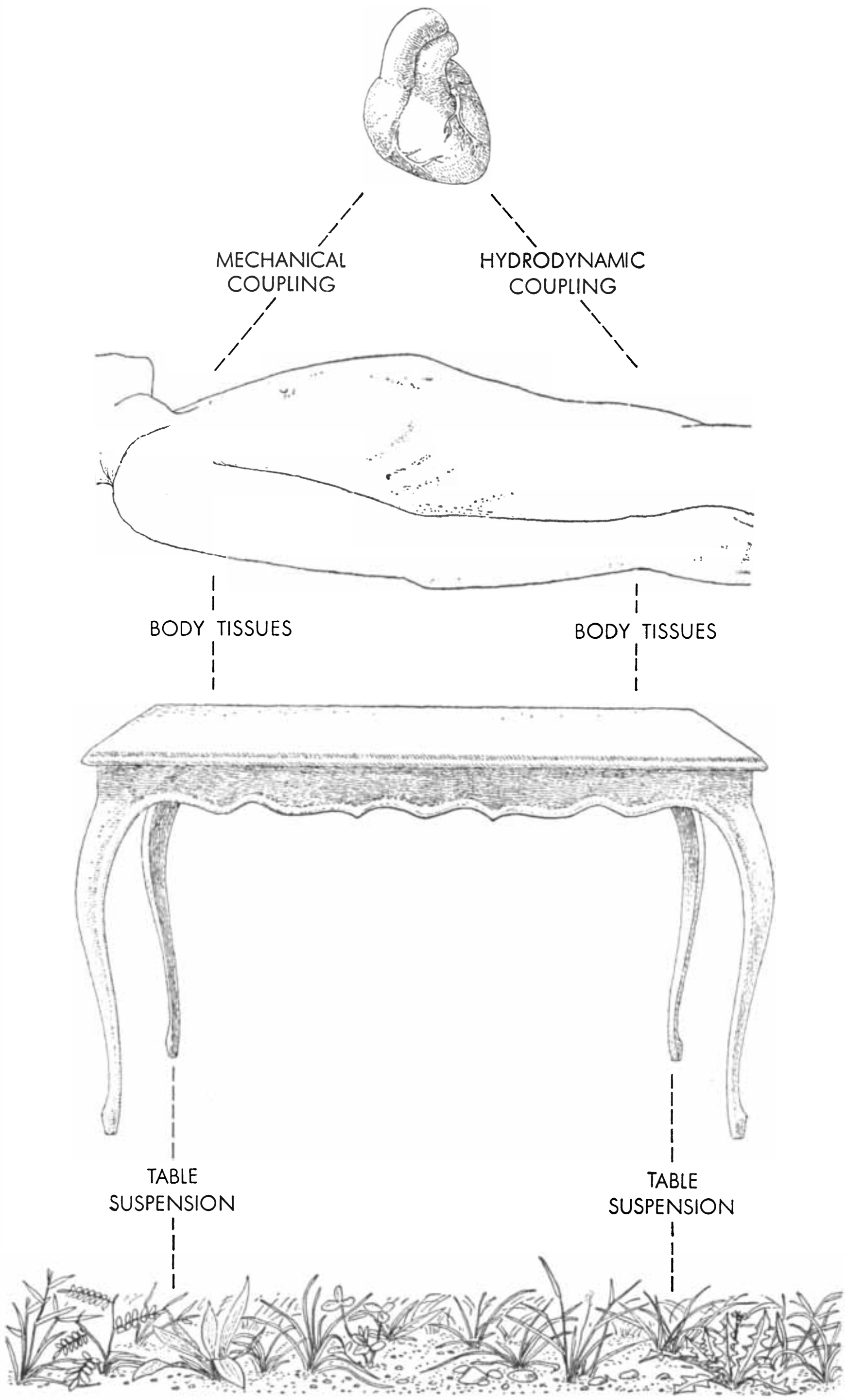
Each company in General Precision Equipment Corporation works close to the frontiers of science in its specific fields. Working together, they have rolled up an impressive record of achievement in new and often uncharted technological areas.

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

should practically disappear. But the fact is that these experiments produce much less effect on the dog's ballistocardiogram than was expected. It seems that the animal's bodily vibrations are associated mainly with movements of the heart, rather than with blood flow.

Does this mean that the dog's system behaves differently from man's? Or that we have been misled by the apparent confirmations of the rifle-and-bullet analogy found in the ballistocardiograms of human subjects? We simply aren't sure at this time. We clearly need more work directed to unraveling the relation of the various events in the heart cycle to the ballistocardiogram. We can echo discoverer Gordon's sentiment that ballistocardiography "yields results of astonishing delicacy." At the same time we could also wish that they were not so bewilderingly "varied."



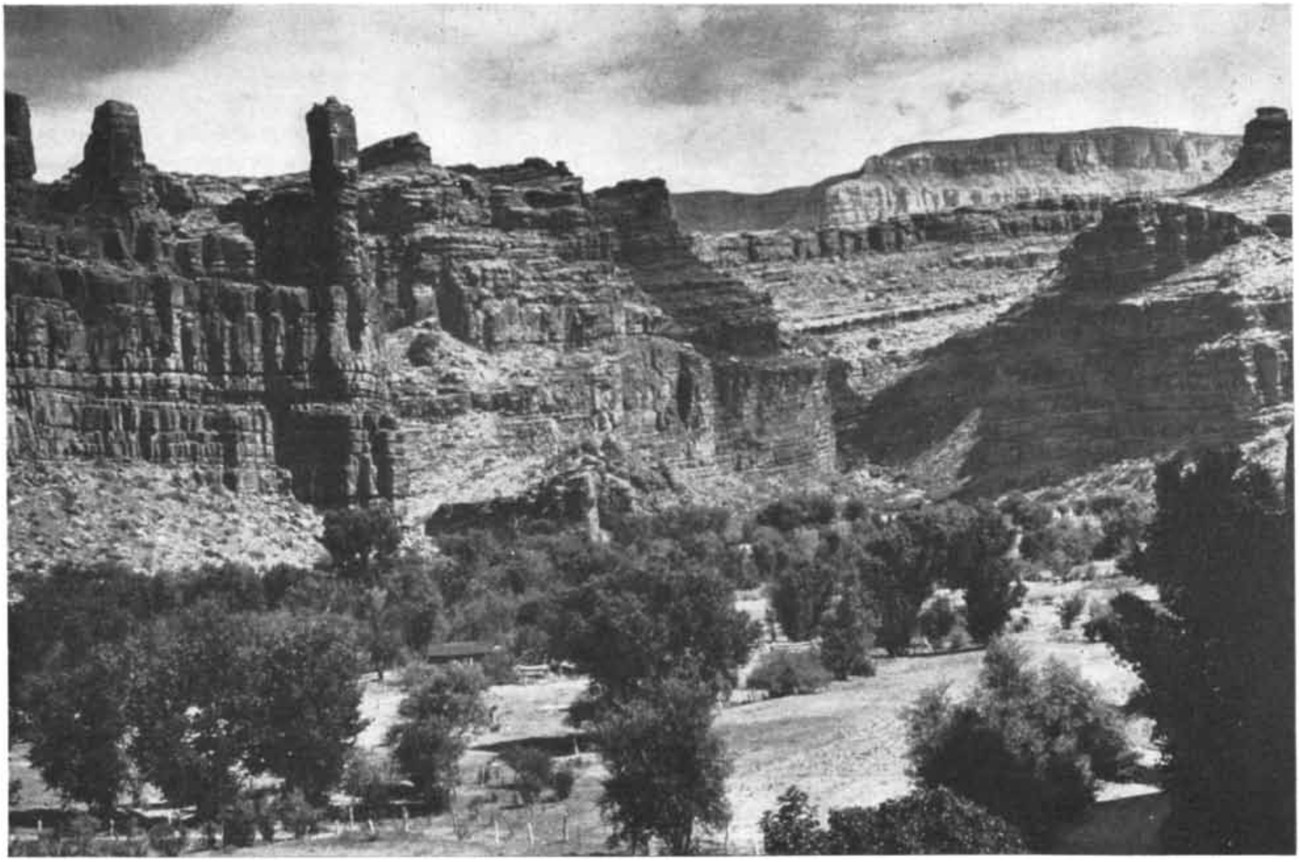
MECHANICAL RELATIONSHIP between heart, body, table and earth is shown in fanciful schematic representation. These varying elastic linkages complicate ballistocardiography.

Prehistoric Man in the Grand Canyon

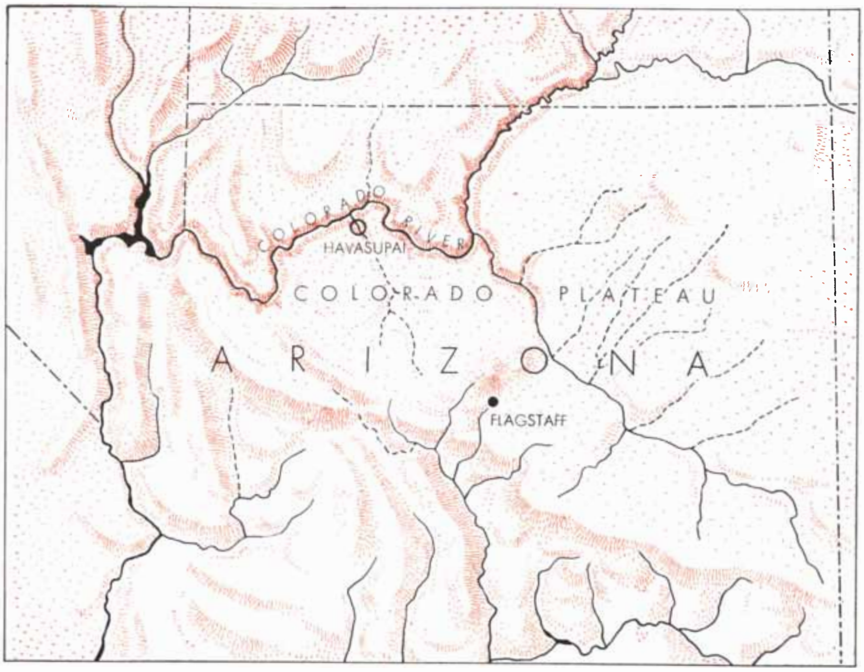
In an oasis at the bottom of the Canyon live the Havasupai Indians, who have now been linked to a vanished people who settled the surrounding plateau in the seventh century A.D.

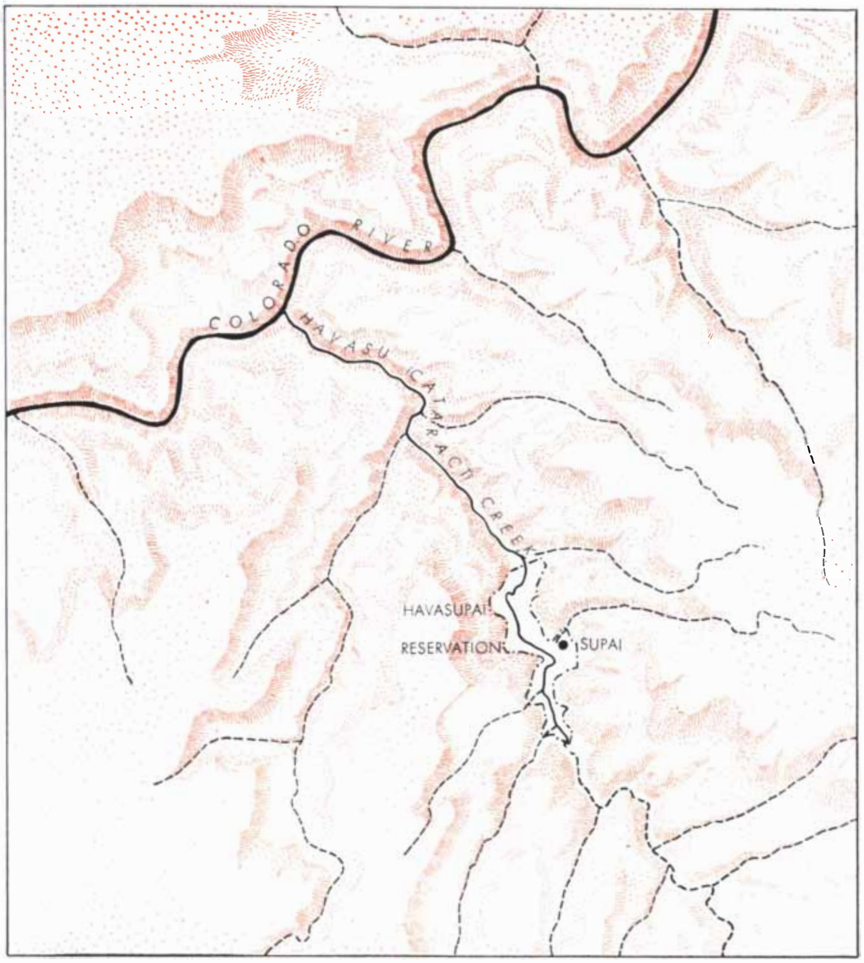
by Douglas W. Schwartz

The Grand Canyon in Arizona was discovered by Spanish explorers in 1540, but so far as is known no white man entered the Canyon itself until two and a half centuries later. In July of 1776 a Franciscan priest, Francisco Thomás Garcés, was traveling on a mission toward the Hopi country, and en route along the Colorado River he heard of an Indian tribe living deep in the Canyon. Since his mission was to convert Indians wherever he found them, Father Garcés asked to be led to the tribe so that he might take them the word of God. With the help of a guide the padre descended by steep trails to a valley almost a mile below the Colorado Plateau, in a small branch of the Colorado River called Cataract Creek. There he found a verdant oasis offering the pleasantest possible contrast to the desert country above. On the canyon bottom, between the bare, brown cliffs, ran a beautiful spring-fed stream,



CATARACT CREEK CANYON is a fork of the Grand Canyon. It is now the home of the Havasupai Indians. On the high ledges of the canyon wall, and atop the sloping rock debris at its base, are the granaries and shelters of an ancient people.





GRAND CANYON of the Colorado River cuts through the Colorado Plateau in northern Arizona. The relation of the Havasupai territory to the Grand Canyon is shown on the map at top. The map at bottom shows the exact location of the Havasupai Reservation in a widening of Cataract Creek Canyon. To the west, on the Coconino Plateau, are the ruins of houses built by the Cohonina people. The author believes they were ancestors of the Havasupai.

creating a green paradise of trees, flowers and luxuriant grass. It was occupied by a village of Indians called the Havasupai—"people of the blue-green water."

Garcés noted that the Havasupai made good use of the life-giving stream. They had developed a system of irrigation ditches to water their hundred or so arable acres, and in their small fields they were growing corn, beans, squash and a few European crop plants—apricots, figs, peaches, alfalfa—which they had obtained from other Indian tribes, who in turn had received them from the Spaniards. Father Garcés also observed a number of other things about the Havasupai's culture during his short stay of several days in the village. At dawn each family went out to work in the fields with digging sticks, hatchets and hoes. But as soon as the sun rose high enough to beat down in the Canyon, generating oven-like heat, everyone retreated from the fields to the huts and shades of the village. The men gossiped at the "sweatlodge," a counterpart of the village drugstore. The women indulged in their favorite sport—gambling with dice made of sticks. The children spent most of their afternoon hours swimming in the fast-flowing stream.

The peripatetic padre moved on, taking away only a momentary picture of these people and knowing little (since he had no interpreter) about their fascinating history and way of life. Not for well over a century was much more heard about the Havasupai. The waves of trappers, prospectors, soldiers, railroad scouting parties and scientific expeditions that overran the Southwest through the 19th century saw little of this shy tribe, which ventured less and less from its canyon retreat. But about 30 years ago Harold S. Colton, director of the Museum of Northern Arizona at Flagstaff, became interested in the history of Indians of the area, for remains going back some 1,200 years had been found on the plateau above the Canyon. He unearthed many old camp sites and houses of a people on the plateau who seemed to have disappeared around 1100 A.D. The mystery of their disappearance, as well as the peculiar isolation of the Havasupai, excited my curiosity when I began to work in the Grand Canyon area eight years ago. I became convinced that the key to the prehistory of the Colorado Plateau and Canyon Indians lay in the Havasupai home at the bottom of the Canyon.

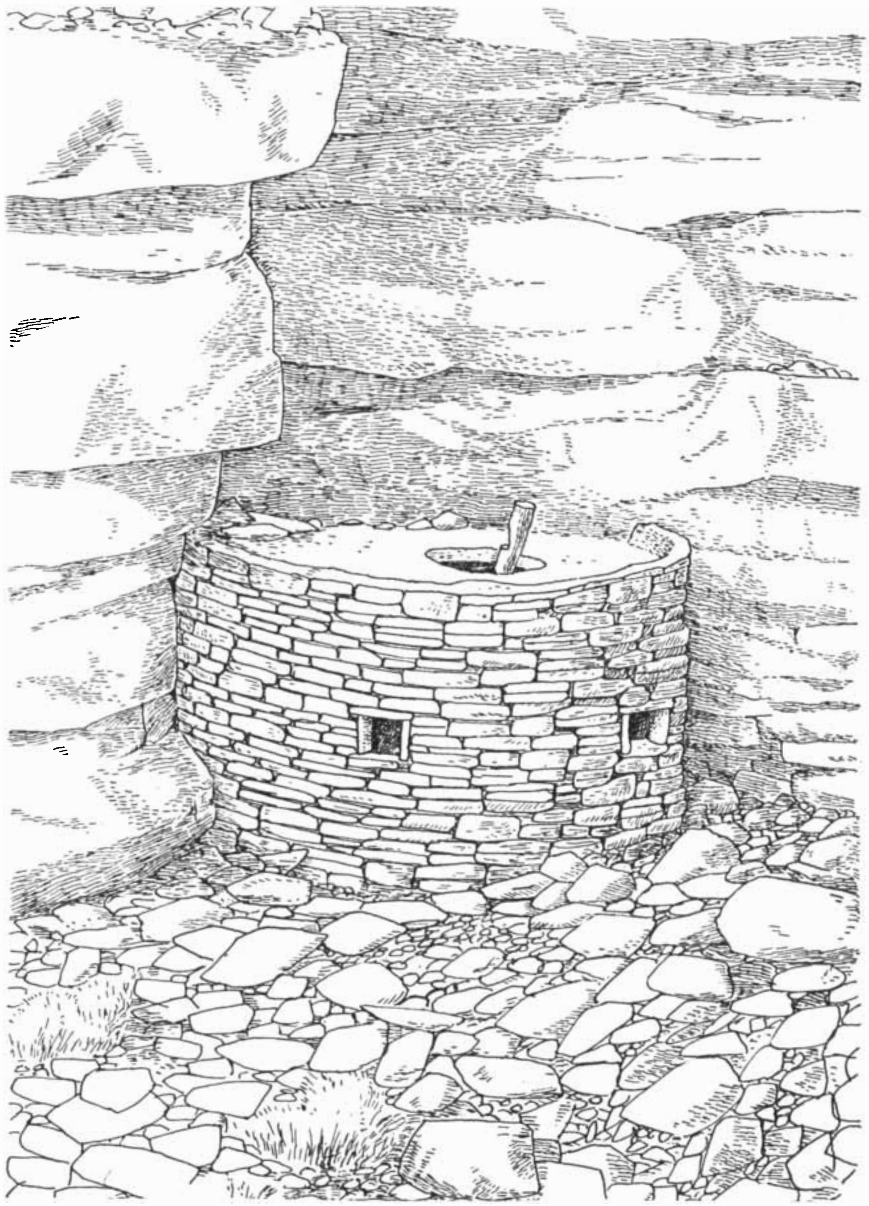
In the winter of 1953-54 I lived with the Havasupai for six months in their canyon village. It was apparent that there was no hope of finding any ancient Havasupai remains in the village area. In early spring and in late summer floods as high as 40 feet often rush down the narrow canyon of Cataract Creek. The Havasupai villages have repeatedly been washed away by these floods. But at such times the Indians have taken refuge, as far back as they can remember, in rock shelters at the base of the cliff walls. We therefore excavated these shelter sites, hoping to find cultural remains of the Indians going back to the beginning of their occupation of the Canyon. The excavations were so successful that, combining information from the diggings in the Canyon and on the Plateau with our knowledge of the present descendants, and injecting a dash of poetic license (if my professional colleagues will not object), it is now possible to reconstruct the general history of the Havasupai for some 13 centuries.

Some time around 600 A.D. a few small family groups of Indians began to settle in the Colorado Plateau area above the Canyon [*see map on opposite page*]. They came from the west, possibly leaving an overcrowded region. (Colton named them the Cohonina, a Hopi word meaning "those who live to the west.") For a century they lived a frontier life, depending heavily on game and berries for food, searching for water sources, trying out the land for farming and settlement possibilities. After about 100 years they had learned to live off their new land so well that the population began to increase and settlements spread to all parts of the plateau. In the winter months they supplemented their farm crops by hunting near their plateau homes and in the great canyons that bordered them on two sides. It is possible that the Cataract Creek Canyon oasis was discovered during one of these early expeditions and thereafter served as a hunting base.

By 700 or 800 A.D. the plateau settlers had developed an efficient agriculture, were building some stone houses, and were making pottery with designs and decorations borrowed from their Indian neighbors in the Little Colorado and San Juan country to the north and east. In another century or so they had progressed to constructing granaries for their crops and were adopting a new style of house with what looks like a patio at one end. They also built a large, thick-walled structure which may have been a fort or a ceremonial building.

Meanwhile the population had overflowed into Cataract Creek Canyon. The canyon pioneers developed their own way of life, clearing the heavy brush, using the creek to irrigate their patches of land, and developing trails to the plateau a mile above. Possibly the tribe might eventually have split into two groups, one living primarily in the canyon, the other on the plateau. But as Colton observed, around 1100 A.D. the plateau population began to disappear, and within 100 years its settlements were deserted. Our excavations suggested a likely explanation. It seems that the plateau dwellers, as well as some Indians from other areas, were driven into the canyons by wandering tribes of raiders. The archaeological remains show that the Cataract Creek Canyon population increased greatly at this time. The valley floor became so overcrowded that people took up residence in the rock shelters at the base of the cliffs. Furthermore, they began to build cliff dwellings in the face of the cliffs, no doubt to defend themselves against the raiders. Every available ledge became a home, and on the large ledges the canyon people erected elaborate structures.

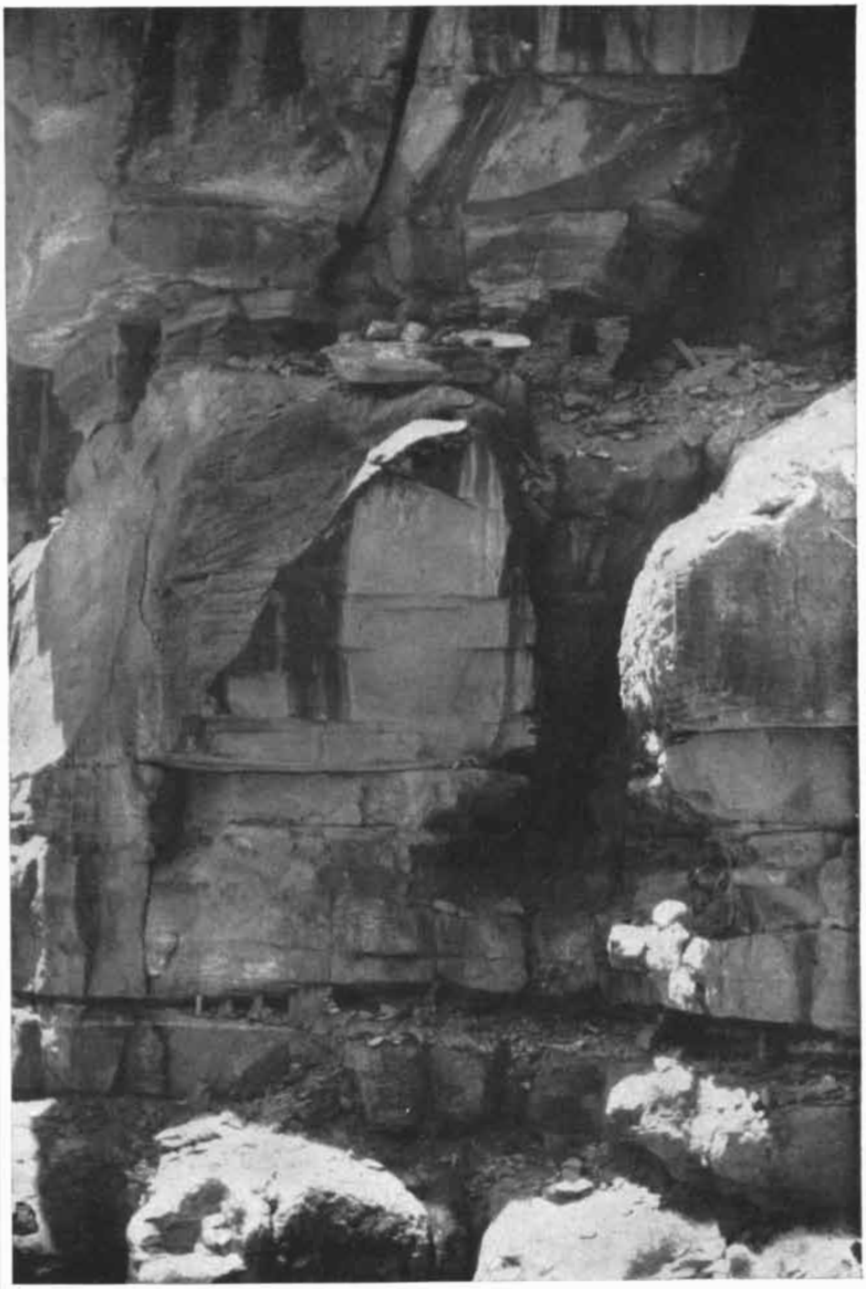
Apparently by the middle of the 13th century the raiding of the area by outside bands had subsided. The Canyon people abandoned their cliff dwellings. By this time they had evolved a new way of life. To find enough food for the large valley population they had had to organize frequent hunting parties



CLIFF SHELTER on a high ledge of the canyon wall is shown according to the author's reconstruction. Now a ruin, it was used as a refuge from floods or enemy raiding parties.

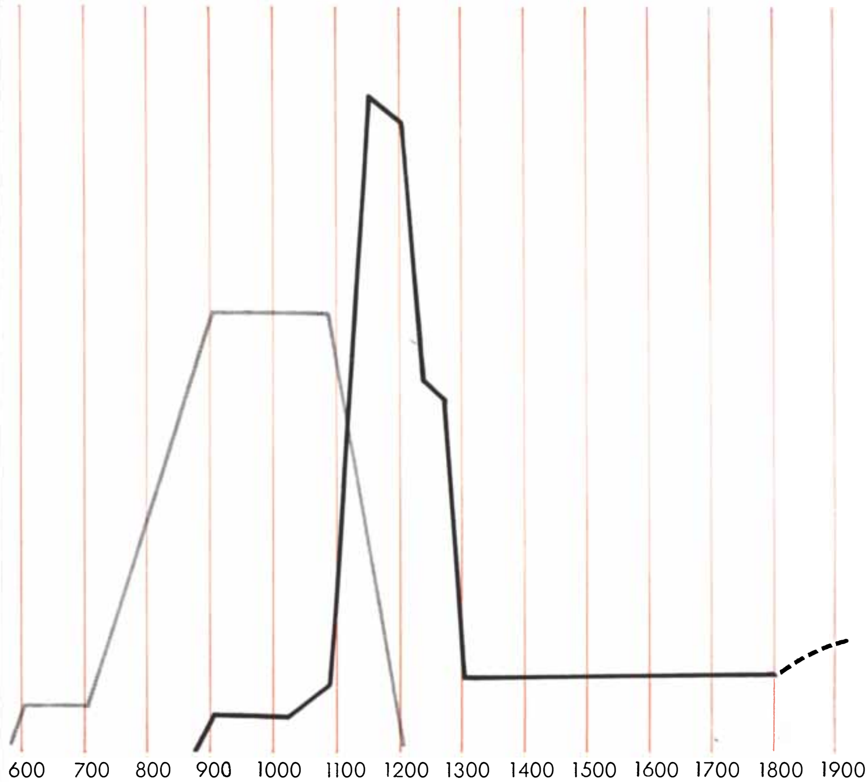
to go up on the plateau. Now these hunting and food-gathering expeditions to the top, particularly in winter, became a fixed feature of Havasupai life. The canyon refugees could not go back to living on the plateau again, even if they had wanted to. Conditions on the old plateau had changed, as the old men may have remarked. The annual rainfall had diminished. The vegetation was no longer as lush; the flowers were not as bright. Farming on the plateau had become impossible.

So the Havasupai developed a double life: summer in the canyon, winter on the plateau. All summer they led a sedentary existence in the valley, watching the crops grow. After the harvest, when the days grew cool, they moved up to the plateau and pitched camp in the cedar thickets. But they could not stay long in any one place: the winter life of hunting and gathering wild fruits and nuts kept them on the move over the great expanses of the plateau. Their rather precarious winter existence gained some security, however, from the crop reserves they were able to bring with them from the canyon. In the spring the Havasupai went back to the canyon



SHELTERS AND GRANARIES on high ledges illustrate the near-inaccessibility of the sites in which the author excavated early Havasupai remains. A stone house with a window can be seen (*upper right*) and, below it, a row of granaries on a narrow ledge (*bottom*).

NEW DEPARTURE
NEW DEPARTURE



CHANGES OF POPULATION on the Coconino Plateau (*gray line*) and in Cataract Creek Canyon (*black line*) are shown schematically. The plateau population began to decrease in the 12th century, probably because of enemy raids followed by climatic change. The raids filled the canyon with refugees. When the raiders left, canyon population fell.

village to take up their sedentary farming life again.

For 300 years, until early in the 17th century, the Canyon Indians passed a tranquil existence. They had friendly relations with the Navaho, Hopi, Walapai and other neighboring tribes. Each August the Havasupai invited their neighbors to their annual harvest dance—a five-day feast of eating, dancing, trading and gambling which is still the highlight of Havasupai life today. The Havasupai culture changed little in the three centuries.

But this stability began to break down in the early 1700s. Long before Father Garcés arrived, the coming of the white man was heralded in Cataract Creek Canyon by new goods which filtered to the Havasupai from other tribes. The Spanish settlers themselves did not come near the canyon; the land of the Havasupai was of no use to them. The fact that the little canyon was well hidden from the plundering hands of the conquistadors saved the Havasupai from the fate that overtook many other Southwestern Indian tribes. They retained most of their aboriginal culture: their pottery, clay pipes, stone knives, fire drills, bone tools, bows and arrows, basketry and skin clothing. But through the Hopi they began to receive crockery, metal pans, guns, plants and cloth. When the first white man, Father Garcés, laid eyes on them, they already had horses, cattle and some Old World plants.

Although they have continued to have less contact with white people than almost any other Indian tribe, their culture has gone on adapting itself to the white man's ways. In the middle of the 19th century the unaggressive Havasupai accepted a reservation of only about 500 acres in the bottom of the Canyon. Secluded in their deep valley, the "people of the blue-green water" have nevertheless, by diffusion from the Hopi and other Indian neighbors and by deliberate education through Federal Government workers, moved rapidly toward immersion in American culture in recent decades. Each year several hundred tourists descend the Canyon to see their blue oasis, with beautiful waterfalls that tumble down the creek bed, and to see the gentle, cheerful Havasupai, now a small group of some 35 families. Their village, Supai, has a post office and a schoolhouse, and on occasion the villagers are treated to Hollywood movies of the "Wild West."

Can you find the fabric in these pictures?

Concrete storage houses built on pneumatic forms, fabricated by Goodyear Tire and Rubber Company, using a Wellington Sears nylon base fabric.

Compressed blocks of Wellington Sears duck are used in Divine Bros. Canvas Cushion Tired Wheels on this factory truck.

Flaps of Wellington Sears fabric, coated with abrasive, form the "spokes" of the "PG" Wheel made by Minnesota Mining and Manufacturing Co.

Polishing off a tough grinding job . . . moving tons indoors without noise or damage . . . putting up a concrete building in 24 hours . . . these are some of the jobs turned over to *fabric!* And the lengthening list of specially engineered textiles indicates that every day more and more industries are making available to themselves the variety and versatility of modern-day fabrics. Which means that more and more industrial planners are turning to Wellington Sears—as their first source of dependable help, backed by over a century of experience in industrial fabrics. If you have any problem related to fabrics, call us.

And for an informative booklet illustrating many other industrial uses of fabric, write Department F-2 for "Fabrics Plus".

Wellington Sears

FIRST In Fabrics For Industry

For the Rubber, Plastics, Chemical, Metallurgical, Automotive, Marine and Many Other Industries

WEST POINT TEXTILES

WEST POINT MANUFACTURING CO

Wellington Sears Co., 65 Worth St., New York 13, N.Y. • Atlanta • Boston • Chicago • Dallas • Detroit • Los Angeles • Philadelphia • San Francisco • St. Louis

MATHEMATICAL GAMES

Concerning the game of nim and its mathematical analysis

by Martin Gardner

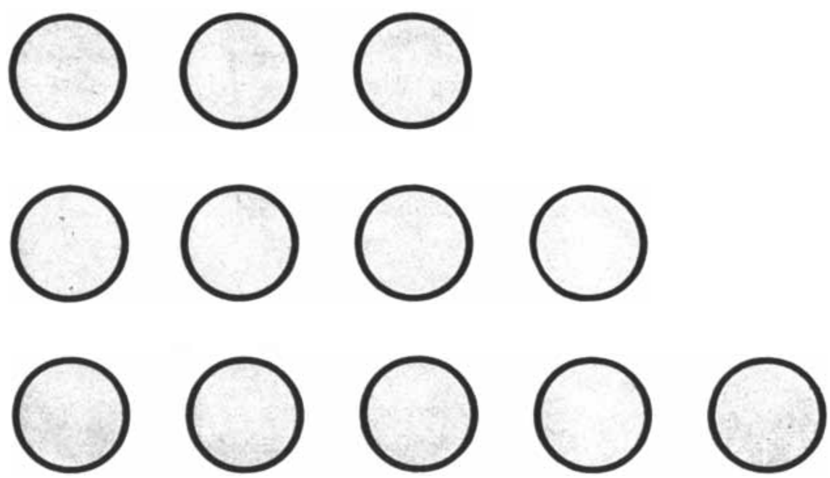
One of the oldest and most engaging of all two-person mathematical games is known today as nim. Possibly Chinese in origin, it is sometimes played by children with bits of paper, and by adults with pennies on the counter of a bar. In the most popular version of the game 12 pennies are arranged in three horizontal rows as shown in the illustration at the bottom of this page.

The rules are simple. The players alternate in removing one or more coins from any one of the three rows. Whoever takes the last penny wins. The game can also be played in reverse: whoever takes the last penny loses. A good gamester soon discovers that in either form of the game he can always win if one of his moves leaves two rows with more than one penny in a row and the same number in each; or if the move leaves one penny in one row, two pennies in a second row and three in a third. The first player has a certain win if on his first move he takes two pennies from the top row and thereafter plays "rationally."

There is nothing startling about the foregoing analysis, but around the turn of the century an astonishing discovery was made about the game. It was found that it could be generalized to any number of rows with any number of counters in each, and that an absurdly simple strategy, using binary numbers, would enable anyone to play a perfect game. A full analysis and proof was first published in 1901 by Charles Leonard Bouton, associate professor of mathematics at Harvard University. It was Bouton, incidentally, who named the game nim, presumably after the archaic English verb meaning to take away or steal.

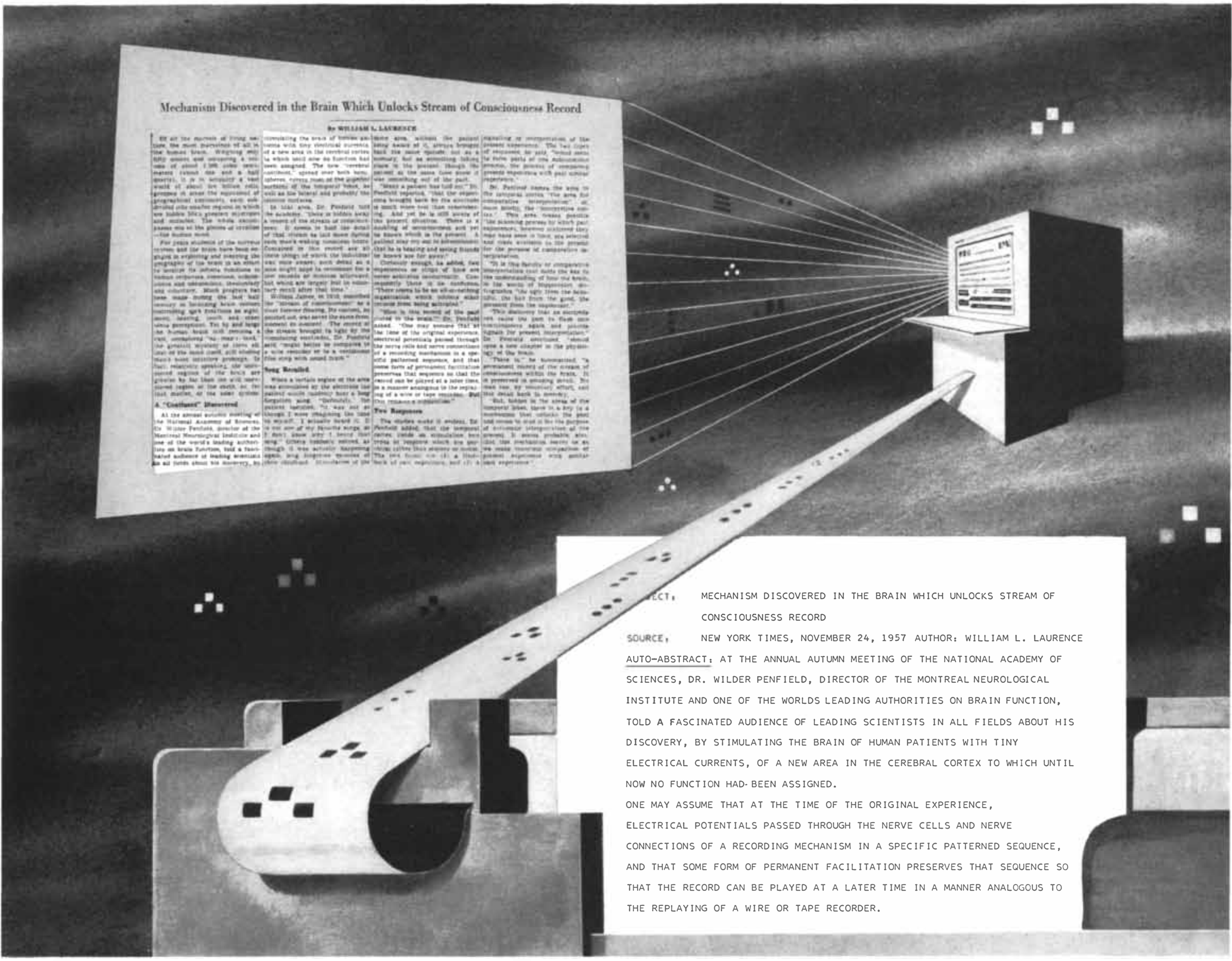
In Bouton's terminology every combination of counters in the generalized game is either "safe" or "unsafe." If the position left by a player after his move guarantees a win for that player, the position is called safe. Otherwise it is unsafe. Thus in the "3, 4, 5" game previously described the first player leaves a safe position by taking two pennies from the top row. Every unsafe position can be made safe by a proper move. Every safe position is made unsafe by *any* move. To play rationally, therefore, a player must move so that every unsafe position left to him is changed to a safe position.

To determine whether a position is



Twelve counters are arranged for a "3, 4, 5" game of nim

REPORT FROM IBM — YORKTOWN RESEARCH CENTER, NEW YORK



Scientific articles—electronically abstracted

The significant meaning or "auto-abstract" of the news article illustrated above was achieved by a successful experiment in scoring key sentences in the original article to produce the abstract—all electronically. The project was originated and managed by H. P. Luhn at the IBM Yorktown Research Center.

First, the article must be in machine-readable form, using either punched cards or tape. The data processing machine then computes the relative significance first of the words and then of the sentences contained in the article. It does this on the basis of statistically derived criteria involving both word frequency and distribution. The sentence or sentences scoring highest in significance become the "auto-abstract."

This research experiment demonstrated the feasibility of automatic abstracting. By extending the current techniques, it may be possible to scan the whole of printed knowledge on a given subject and to make "auto-abstracts" of articles in an incredibly short time. This new exploration may assist in breaking down the barriers imposed by the current mass of printed material between the researcher and the further development of his ideas.

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.

safe or unsafe, the numbers for each row are written in binary notation. If each column adds up to zero or an even number, then the position is safe. Otherwise it is not.

There is nothing mysterious about the binary notation. It is merely a way of writing numbers by sums of the powers of two. The chart on this page shows the binary equivalents of the numbers 1 through 20. You will note that each column, as you move from right to left, is headed by a successively higher power of two. Thus the binary number 10101 tells us to add 16 to 4 to 1, giving us 21 as its equivalent in the decimal system, based on the powers of 10. To apply the binary analysis to the 3, 4, 5 starting position of nim, we first record the rows in binary notation as follows:

	4	2	1
3		1	1
4	1	0	0
5	1	0	1
Totals	2	1	2

The middle column adds up to 1, an odd number, telling us that the combination is unsafe. It can therefore be made safe by the first player. He does so, as explained, by taking two pennies from the top row. This changes the top binary number to 1, thereby eliminating the odd number from the column totals. The reader will discover by trying other first moves that this is the only one which makes the position safe.

An easy way to analyze any position, provided there are no more than 31 counters in one row, is to use the fingers of your left hand as a binary computer. Suppose the game begins with rows of 7, 13, 24 and 30 counters. You are the first player. Is the position safe or unsafe? Extend all five fingers of your left hand, palm toward you. The thumb registers units in the 16 column; the index finger, those in the 8 column; the middle finger, the 4 column; the ring finger, the 2 column; the little finger, the 1 column. To feed 7 to your computer, first bend down the finger representing the largest power of 2 that will go into 7. It is 4, so you bend your middle finger. Continue adding powers of two, moving to the right across your hand, until the total is 7. This is of course reached by bending the middle, ring and little fingers. The remaining three numbers—13, 24 and 30—are fed to your computer in exactly the same way except that any bent finger involved in a number is raised instead of lowered.

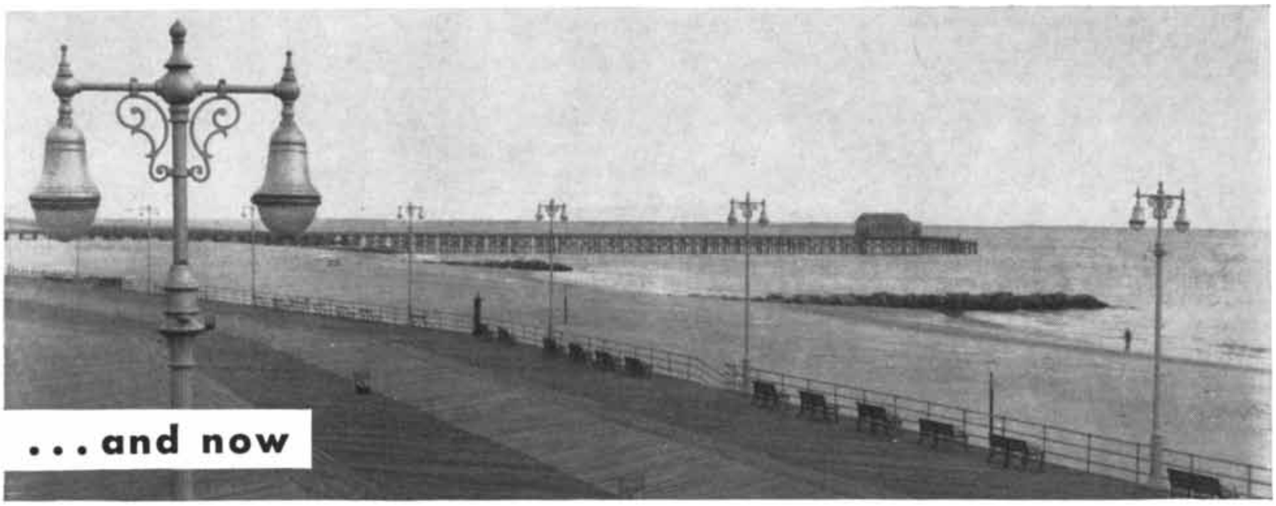
Regardless of how many rows there are in the game, if you finish this procedure with all your fingers raised, then the position is safe. This means that your move is sure to make it unsafe, and that you are certain to lose against any player who knows as much about nim as you do. In this example, however, you finish with first and second fingers bent, telling you that the position is unsafe, and that you can win if you make a proper move. Because there are many more unsafe combinations than safe ones, the odds greatly favor the first player when the starting position is determined at random.

	16	8	4	2	1
1					1
2				1	0
3				1	1
4			1	0	0
5			1	0	1
6			1	1	0
7			1	1	1
8		1	0	0	0
9		1	0	0	1
10		1	0	1	0
11		1	0	1	1
12		1	1	0	0
13		1	1	0	1
14		1	1	1	0
15		1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1
18	1	0	0	1	0
19	1	0	0	1	1
20	1	0	1	0	0

Table of binary numbers to analyze nim

Now that you know that 7, 13, 24, 30 is unsafe, how do you find a move that will make it safe? This is difficult to do on your fingers, so it is best to write

N. Y. Daily News photo



SAFE BY THE SEA. Although New York's famous Coney Island boardwalk has undergone many changes in the last 34 years, its old-time lampposts are still there. Corrosion-resisting Monel fastenings have held them securely for a generation.

What keeps Coney Island lampposts standing up to 34 years of storm, salt and sea?

One of the lampposts on Coney Island's popular boardwalk was taken down a few years ago . . .

Inside its base, the work crew found a thirty-year accumulation of soggy rust flakes.

And under that? Four Monel* nickel-copper alloy nuts and bolts holding the post tightly to the boards. Threads as clean and sharp as new. An easy twist with a wrench and out came each Monel alloy fastening — as fit and fine as the day it had been put in!

Anchoring lampposts to stand firm through 30 years or more of seaside duty may be a far cry from *your* metal problem. But whatever that problem is — corrosion, stress, fatigue, high or low temperature — its solution may very well be found in an Inco Nickel Alloy.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Remember, when you buy
INCO NICKEL . . . you also get
INCO+SERVICES

Whenever you are looking for answers to your metal problems, all the information and help we can give you are yours for the asking. For instance . . .

- **Corrosion Service**
- **High Temperature Service**
- **Fabrication Help**
- **Foundry Service**
- **Field Information Centers**
- **Convenient Sales & Service**
- **Technical Publications**

*Registered trademark

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER

down the four binary numbers as follows:

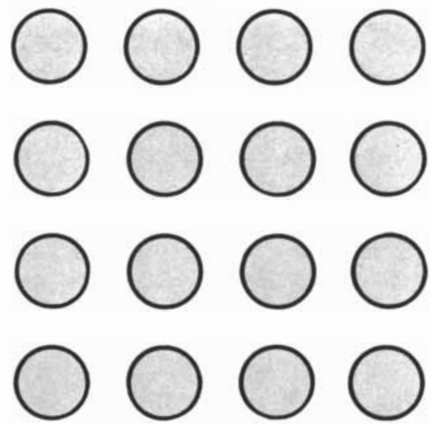
	16	8	4	2	1
7			1	1	1
13		1	1	0	1
24	1	1	0	0	0
30	1	1	1	1	0
Totals	2	3	3	2	2

Note the column farthest to the left that adds up to an odd number. Any row with a unit in this column can be altered to make the position safe. Suppose you wish to remove a counter or counters from the second row. Change the first unit to 0, then adjust the remaining figures on the right so that no column will add up to an odd number. The only way to do this is to change the second binary number to 1. In other words, you remove all counters except one from the second row. The other two winning moves would be to take four from the third row or 12 from the last row.

It is helpful to remember that you can always win if you leave two rows with the same number of counters in each. From then on, simply move each time to keep the rows equal. This rule, as well as the preceding binary analysis, is for the normal game in which you win by taking the last counter. Happily only a trivial alteration is required to adapt this strategy to the reverse game. When the reverse game reaches a point (as it must) at which only one row has more than one counter, you must take either all or all but one counter from that row so as to leave an odd number of one-unit rows. Thus if the board shows 1, 1, 1, 3, you take all of the last row. If it shows 1, 1, 1, 1, 8, you take seven from the last row. This modification of strategy occurs only on your final move, when it is easy to see how to win.

Since digital computers operate on the binary system, it is not difficult to program such a computer to play a perfect game of nim, or to build a special machine for this purpose. Edward U. Condon, the former director of the National Bureau of Standards who is now at Washington University of St. Louis, was a co-inventor of the first such machine. Patented in 1940 as the Nimatron, it was built by the Westinghouse Electric Corporation and exhibited in the Westinghouse building at the New York World's Fair. It played 100,000 games and won 90,000. Most of its defeats were administered by attendants demonstrating to skeptical spectators that the machine could be beaten.

In 1941 a vastly improved nim-playing machine was designed by Raymond



A variation of nim called Tac Tix

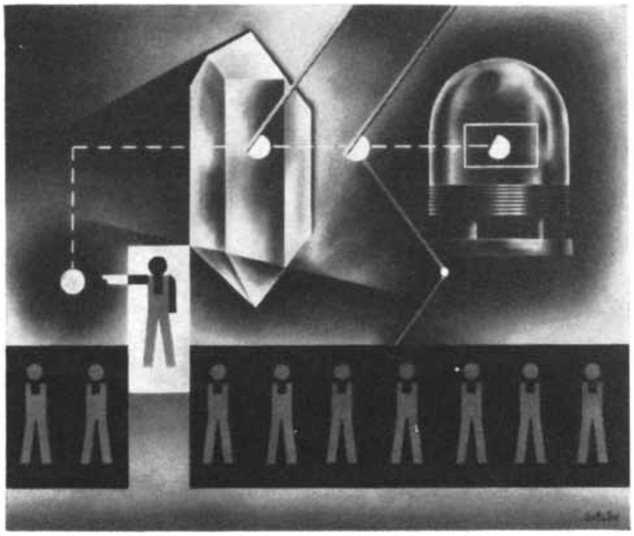
M. Redheffer, now assistant professor of mathematics at the University of California at Los Angeles. Redheffer's machine has the same capacity as Condon's (four rows with as many as seven counters in each), but where Nimatron weighed a ton and required costly relays, Redheffer's machine weighs five pounds and uses only four rotary switches. More recently a nim-playing robot called Nimrod was exhibited at the Festival of Britain in 1951 and later at the Berlin Trade Fair. According to one newspaper account, the machine was so popular in Berlin that visitors "entirely ignored a bar at the far end of the room where free drinks were available, and it was necessary to call out special police to control the crowds. The machine became even more popular after it had defeated the economics minister, Dr. Erhard, in three games."

Several interesting variations of nim have been fully analyzed. To my mind the most exciting variation, and one that has not yet been analyzed, was invented about 10 years ago by Piet Hein of Copenhagen. Hein is the inventor of Hex, a topological game discussed in this department for July, 1957.

In Hein's version, called Tac Tix in English-speaking countries and Bulo in Denmark, the counters are arranged in square formation as shown at the top of this page. Players alternately take counters, but they may be removed from any horizontal or vertical row. They must always be adjoining counters with no gaps between them. For example, if the first player took the two middle counters in the top row, his opponent could not take the remaining counters in one move.

Tac Tix must be played in reverse form (the player who takes the last counter loses) because of a simple strategy which renders the normal game

MISSILE COMPONENTS Bulova's infra-red seeker cell—the Sidewinder's eye — locks this missile on target; Bulova fuzing systems do the rest. Powder-driven gyros, timers, safety-and-arming systems and other electronic and electro-mechanical devices, designed and made by Bulova, play vital roles in the Dart, Talos, Sparrow... in all, 18 key missiles.



AUTOMATION Bulova R&D designed mechanized plant and equipment for Signal Corps goal of 10,000 perfect quartz crystals per 8 hour shift —with 1/10th the manpower. From systems analysis through equipment development, Bulova engineers devise industrial and military facilities for automatic production of electronic components and ordnance items.

Bulova precision helps to solve today's most challenging problems

Time, mass, length... the age-old concepts man relies on as he enters the Age of Space.

Time alone is unique. Its accurate measurement demands the highest order of precision in the design and manufacture of electro-mechanical devices.

Bulova, leader in measurement of time, has become master of the very combination of abilities that holds practical solutions to the growing challenges of miniaturization.

Miniaturized systems and components by Bulova are now working for our nation's defense and automated industry. The same vision and experience that developed them are available to assist you... from concept to reliable mass production.

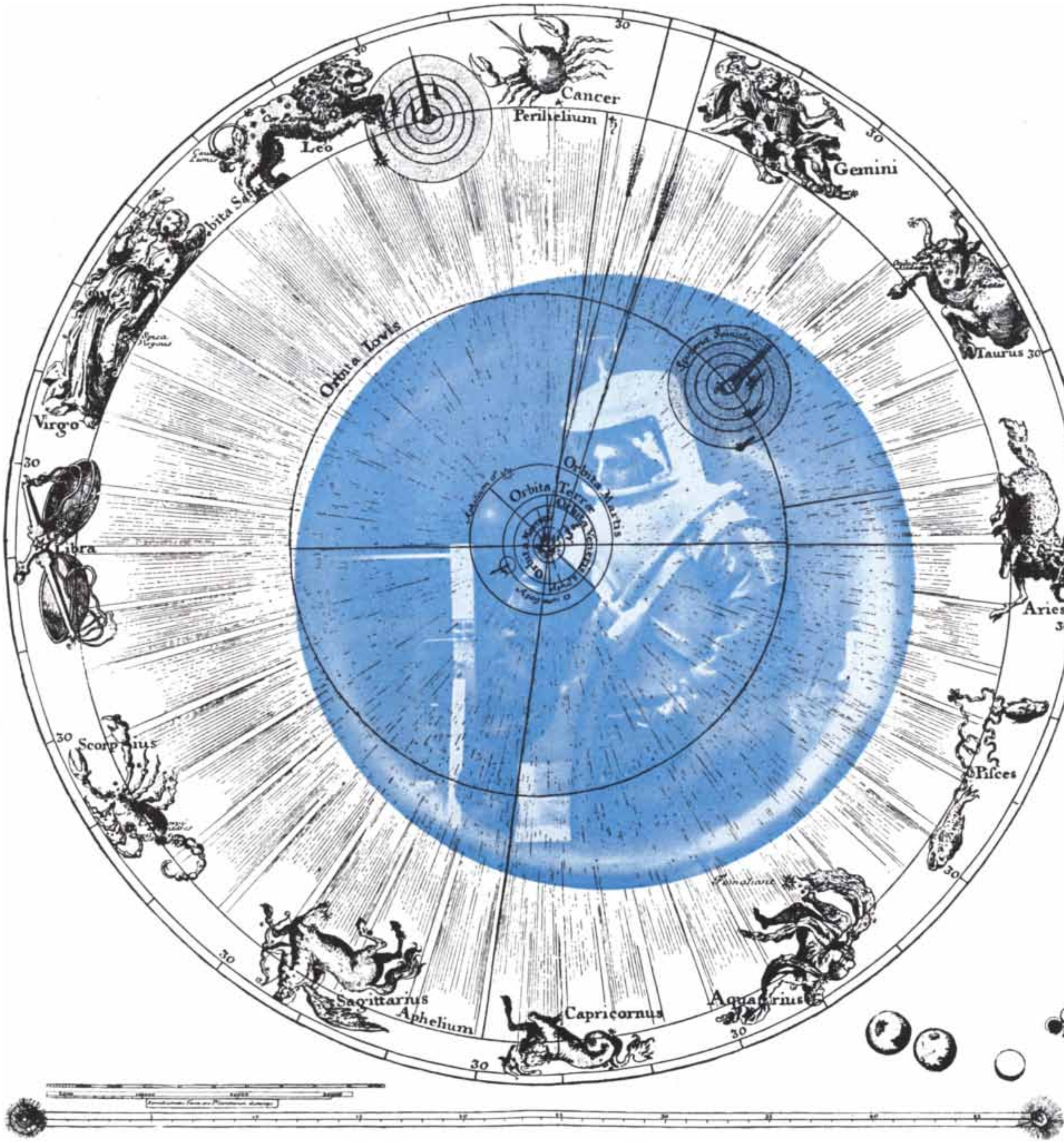
For further information, write Department G.I.S.-1.

BULOVA
watch company

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

PRECISION MANUFACTURING Bulova-built servo muscles steer our nation's first ballistic guided missile — the Corporal. When critical tolerances demanded uncompromising accuracy, Bulova solved tooling and assembly problems on a crash basis. Bulova experience and facilities are unexcelled where precision, reliability and capacity are vital.

AIRCRAFT INSTRUMENTS Bulova's new Servo Altimeter combines unsurpassed sensitivity and accuracy with direct-reading tape presentation. Special pressure devices created by Bulova include transducers for air data computers... remote pressure sensors for weather stations and airports... climb and dive indicators... and autopilot altitude controls.



Routine Flight...

THE WORLD'S AGE-OLD DREAM of exploring the universe is nearing reality. Daily we are gaining new knowledge—knowledge of the physical effects of outer space upon equipments, and of the physiological and psychological effects upon Man. Placing Man himself within the atmosphere of outer space is now routine procedure in Litton Industries' Space Research Laboratory.

LITTON INDUSTRIES BEVERLY HILLS, CALIFORNIA
Plants, Laboratories & Offices in the U.S., Canada, Europe, and South America

DIGITAL COMPUTERS & CONTROLS RADAR & COUNTERMEASURES INERTIAL GUIDANCE MICROWAVE POWER TUBES AUTOMATIC DATA PROCESSING
AIR NAVIGATION & COMMUNICATION MONROE OFFICE & BUSINESS MACHINES SPACE RESEARCH PRECISION COMPONENTS & TRANSFORMERS

trivial. On squares with an odd number of counters on each side the first player wins by taking the center counter and then playing symmetrically opposite his opponent. On squares with an even number of counters on each side the second player wins by playing symmetrically from the outset. No comparable strategy is known for playing the reverse game, although it is not difficult to show that on a 3×3 board the first player can win by taking the center counter or a corner counter, or all of a central row or column.

The clever principle behind Tac Tix, that of intersecting sets of counters, has been applied by Hein to many other two- and three-dimensional configurations. The game can be played, for example, on triangular and hexagonal boards, or by placing the counters on the vertices and intersections of a pentagram or hexagram. Intersections of closed curves may also be used; here all counters lying on the same curve are regarded as being in the same "row." The square form, however, combines the simplest configuration with maximum strategic complexity. It is difficult enough to analyze even in the elementary 4×4 form, and of course as the squares increase in size the game's complexity rapidly accelerates. Perhaps some industrious reader can answer the tantalizing question: Who has a win on the 4×4 reverse game, the first or second player?

Among analyzed variations of nim one proposed in 1910 by the American mathematician Eliakim H. Moore is of special interest. The rules are the same as they are for regular nim except that players are permitted to take from any number of rows not exceeding a designated number k. Surprisingly the same binary analysis holds, provided a safe position is defined as one in which every column of the binary numbers totals a number evenly divisible by k plus 1.

Many readers have improved upon the answers, given in this department for December, to the problems published here in November. It develops that not only six but also seven cigarettes can be so placed that each touches all the others; that there are a large number of equally simple solutions to the match problem; and that there are procedures by which the efficient electrician can label any number of wires (except two) in one round trip between top floor and basement. In the drawing for the sphere problem, the six-inch hole was incorrectly labeled, but the text should make the solution clear.

THE AMATEUR SCIENTIST

How a gas-discharge tube was made and applied in diverting experiments

Conducted by C. L. Stong

John Armstrong, a high-school student in Springfield, Ill., has demonstrated once again that neither inexperience nor limited facilities can discourage the determined amateur experimenter. Two years ago Armstrong's physics teacher at Cathedral Boys' High School came across an old gas-discharge tube in the school storeroom. When the tube was tested it did not work too well, and the teacher challenged Armstrong to find the trouble. Armstrong promptly broke the tube, but this only stimulated him to make a new one. Within a few months he not only wound up with a successful gas-discharge tube but also made a set of unusually good photographs of gas-discharge effects, learned that electron bombardment has peculiar effects on the germination of seeds, and walked off with first prize in the annual science competition conducted by the Illinois Junior Academy of Science.

Armstrong's tube does not differ essentially from the one invented in 1752 by the English physician William Watson, who pumped air out of a glass bulb containing a pair of electrodes in an attempt to learn whether air is a conductor of electricity. As the air was pumped out of the tube, the amount of electricity conducted between the electrodes increased. After a time Watson was astonished to observe that the tube was filled with a pink light. Experimenters have been pumping the tube ever since, and it has still not been emptied either of gas or strange effects. From it have come a large number of advances in modern electronics and experimental physics.

The amateur can easily join in this kind of experimentation. A gas-discharge tube is about as simple to make as a piece of electrical apparatus can be. With a little ingenious scrounging it can be set up for less than $10.

"The glass for my tube," writes Armstrong, "came from the scrap pile of a nearby college. It is 14 inches long, an inch in diameter, and has a wall thickness of an eighth of an inch. The ends of the tube are closed by rubber stoppers. Sixpenny nails pushed through the stoppers serve as electrical connections. The point of one nail is the cathode; a cup-shaped copper disk, soldered to the head of the other nail, is the anode.

"One stopper was perforated to take a short length of quarter-inch glass tubing. This serves as an exhaust port. It is connected by flexible plastic tubing to a piston-type vacuum pump. Incidentally, a dealer in second-hand electric refrigerators is a good source of such a pump. The compressor of an old refrigerator can be converted into a vacuum pump simply by hooking it up backward. A good compressor (converted, of course, into a vacuum pump) can evacuate an air-tight vessel until the pressure inside is only 25 microns of mercury, or one 30,000th the pressure of the atmosphere at sea level.

"Experiments with gas-discharge tubes require a vacuum gauge of some sort. A simple gauge made of plastic tubing and mounted on a board as shown in the illustration [*see page 114*] is adequate. Although it is not shown in the drawing, a metric ruler is mounted beside one arm of the U-shaped tube of the gauge. The tube is filled with mercury to the 38-centimeter mark and connected to the vacuum system by means of a T-shaped fitting. Both the tubing and the mercury can be ordered through most drugstores. The price of mercury is about 30 cents an ounce; a pound will more than fill a gauge made of eighth-inch tubing.

"All joints in the vacuum system, including those between the nails and the stoppers, must be sealed. A good wax for this purpose can be made by melting together equal parts by weight of vaseline and paraffin. The compound is easy to apply at room temperature and its vapor pressure is not high enough to contaminate the system.

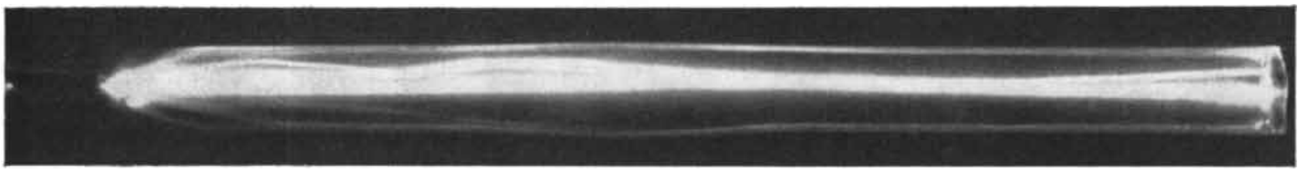
"My tube is energized by an induction coil of the vibrator type, capable of producing a spark about an inch and a half long in air. Ideally one should use a source of pure direct current. However, the output of the coil is adequate for this work, because the voltage pulse induced in the secondary winding of the coil when the vibrator contacts open is always of the same polarity, and it is much stronger than the pulse of opposite polarity induced when the contacts close. Hence the output may be regarded as pulsating direct current. Coils of this type were used in Model-T Fords, and some are still around. Those from modern automobiles will work just as well if they are equipped with an external vibrator. The power for my coil is derived from a transformer which steps the 110-volt alternating house current down to 12 volts. This output is then converted to direct current by a selenium rectifier. High-voltage connections between the coil and the tube are made by high-tension cable of the type used for connecting automobile spark-plugs.

"The apparatus should be set up in a dimly lighted room. Allow a few minutes for your eyes to become adapted to the darkness; then start the coil and the pump. A faint glow will appear at the point of the cathode nail and at the edge of the anode. The glow will spread appreciably by the time the pressure has dropped to 2.5 centimeters of mercury. The electrical field in the vicinity of the electrodes has become so intense that electrons are knocked from molecules colliding with the metal parts. In the process energy is absorbed by the fragments. Some dismembered molecules then recombine and emit the absorbed energy as light. Few of the excited particles migrate far before colliding with other molecules of gas. Hence the glow is largely confined to the surface of the electrodes [*top photograph on opposite page*].

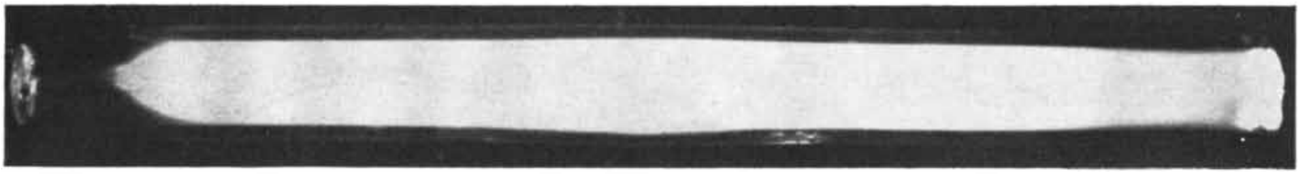
"When the pressure has dropped to

An amateur's photograph of the corona discharge in a gas-discharge tube at atmospheric pressure

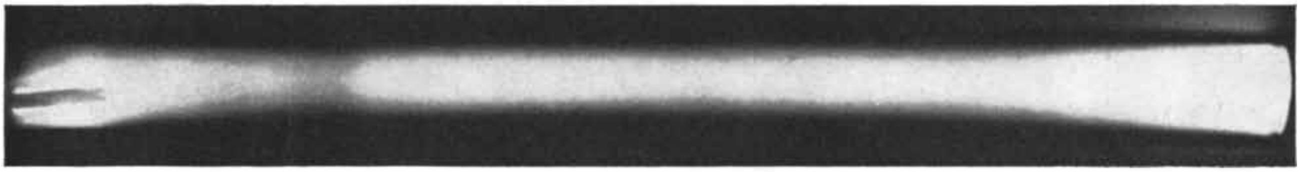
Erratic spark discharge at a pressure of 1.5 centimeters of mercury



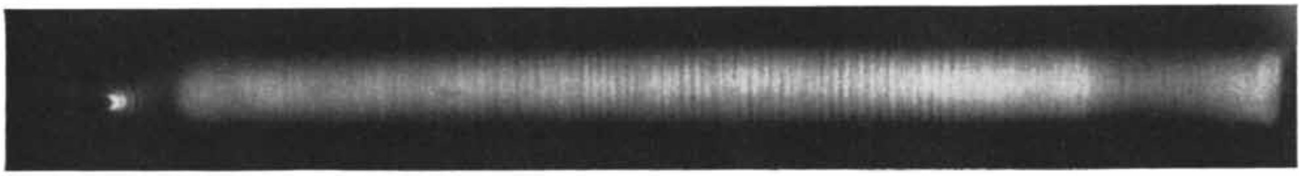
Steady spark discharge at a pressure of 1 centimeter of mercury



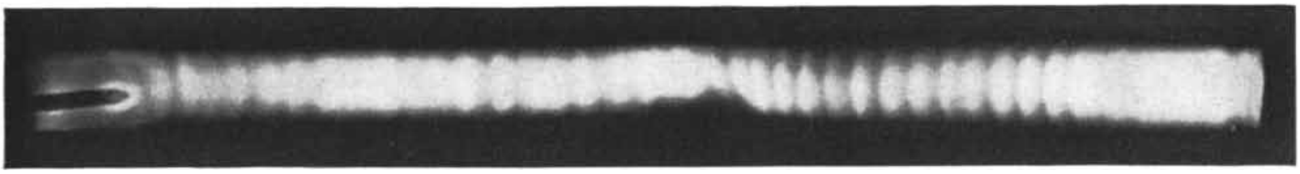
Full glow discharge at a pressure of .75 centimeter of mercury



Faraday dark space at a pressure of .2 centimeter of mercury



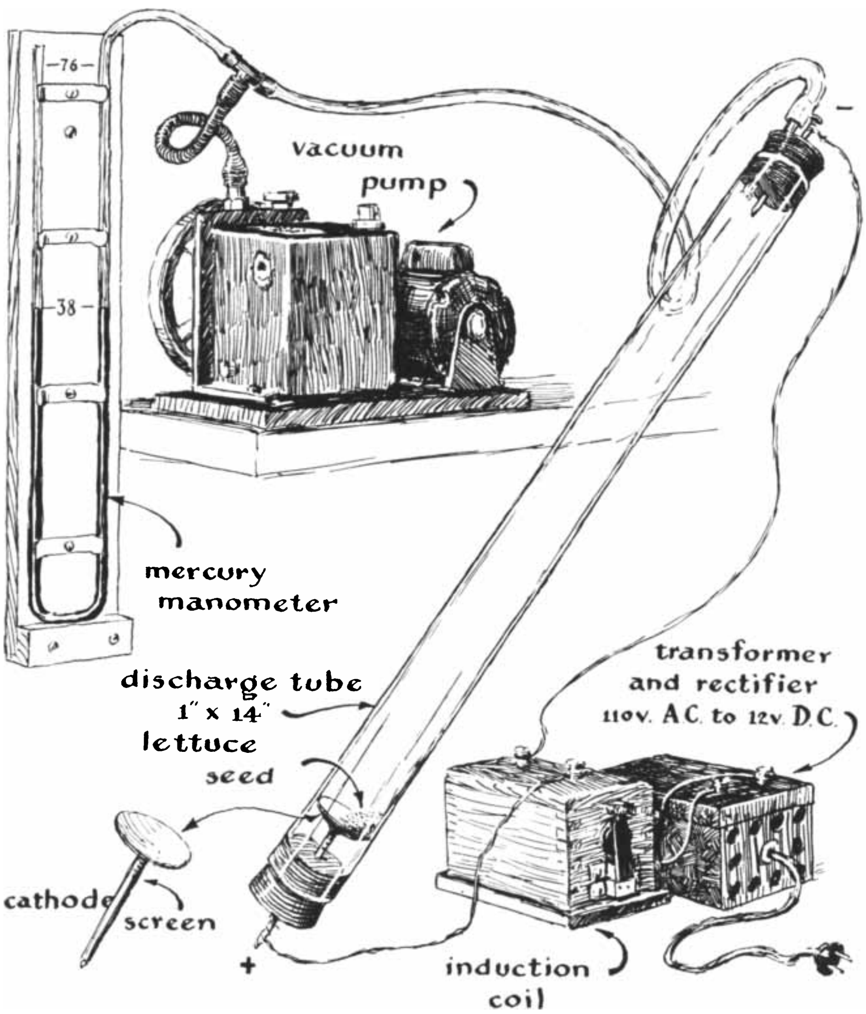
Thick disks at a pressure of .1 centimeter of mercury



Disks are distorted (center) *by the application of a magnetic field* about 1.5 centimeters, electrons and ionized molecules or atoms can occasionally travel the full length of the tube. Some of these charged particles collide with other molecules and ionize them. As the molecules recombine, they emit light and trace the path of the charged particles. These intermittent discharges can be photographed by time exposure [*second photograph on preceding page*]. When the pressure is reduced to 1 centimeter, the discharge is continuous [*third photograph*].

"At a pressure equivalent to about .75 centimeter of mercury the tube abruptly fills with Watson's pink glow. The space has been emptied to the point where many particles reach high speed before colliding with gas molecules. However, the tube still contains so many gas molecules that ionizing collisions occur with great frequency; recombination takes place throughout the space. Hence the tube emits a uniform glow similar to the aurora polaris, commonly known as the Northern or Southern lights [*fourth photograph*].

"With a further reduction of pressure to about .2 centimeter of mercury a number of subtle effects appear in the discharge, although only a few show in my picture [*fifth photograph*]. The broad dark region near the cathode end of the tube is called the 'Faraday dark space' because Michael Faraday first observed it in 1753. An intense blue glow now surrounds the cathode. With a slight further reduction in pressure the color of the tube changes from pink to white and, although the glow appears solid, it actually consists of a series of fine disks of light somewhat like a stack of coins. The disks are so thin and closely packed that one must study them a while before they can be seen. I have not yet succeeded in photographing them. Nor have I found a clear explanation of the effect in any reference text. As F. H. Frantz pointed out in his discussion of electrical discharges ["The



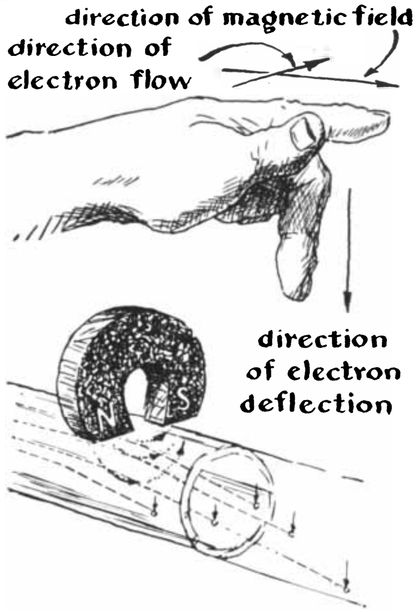
A gas-discharge tube with high-voltage supply and vacuum system

Amateur Scientist," February, 1956], a number of phenomena associated with electrical discharges through gas at low pressure are not understood. The apparent narrowing of the glow toward the middle of the tube in my photographs is an optical distortion caused by the glass. The tube I used had been heated to the softening point during a previous chemical experiment and the glass in the middle of the tube had become thicker.

"At still lower pressures the Faraday dark space expands toward the anode at the expense of the disks, which become thicker and less numerous. A second dark region, the Crookes dark space, appears between the Faraday dark space and the cathode. Like the Faraday space, the Crookes dark space also expands toward the anode with the decrease of pressure. When the pressure drops to about a millionth of its initial value, the Crookes dark space expands to the anode and the glow vanishes. Collisions between the relatively few remaining gas molecules and electrons, now rushing to the anode at speeds measured in thousands of miles per second, are so infrequent that no perceptible light is emitted. At about this point, however, the walls of the tube begin to glow a pale green. The glow is due to X-rays generated when high-energy electrons crash into the nuclei of silicon atoms in the glass. My pump does not exhaust the tube to this pressure. The thicker disks, Faraday dark space and bright cathode glow are evident in my sixth photograph [*page 113*].

"Photographing these effects is an interesting project. I have been unable to locate pictures of them in any reference text. The work is not easy, particularly at the lower pressures, because the glow tends to flicker and blur the image unless the voltage and pressure are held constant. I used Eastman Kodak Royal Pan sheet film, which has an A.S.A. speed rating of 400. My first five pictures [*page 113*] were made with a lens opening of *f*/16. The first was made at a shutter speed of 1/200 second. The next three were time exposures of 15 seconds. The fifth was made at 1/200 second. The sixth picture was made at *f*/3.5 and 1/400 second. Many of the effects are rich in color. So far as I can learn they have never been reproduced in color, although color photographs of them have doubtless been made.

"Because electrons are charged they can be deflected by a magnetic field. If you know the polarity of the field, you can determine whether the charge is positive or negative. Everybody knows that the charge of ordinary electrons is



The "left-hand rule"

negative, but the experiment is interesting nonetheless. You can identify the north pole of a magnet simply by suspending it at the middle with a piece of heavy thread. The magnet will doubtless spin until the thread untwists, but finally it will come to rest in a north-south direction. The north pole is then marked. During this procedure the magnet should not be hung near a large mass of iron, which may cause it to give a false indication. The magnet (one of the Alnico semicircular type works best) is now put across the discharge tube so that the lines of magnetic force cut through the electron stream at a right angle. Electron flow obeys the so-called 'left-hand rule.' Hold the left hand so that the index finger points away from the body, the thumb points up and the middle finger points to the right [*see illustration above*]. Without changing the relative position of the fingers turn the hand until the thumb points in the direction of the current flow (current is assumed to flow from anode to cathode although the electrons flow in the opposite direction) and the index finger points in the direction of the magnetic field (north to south). The middle finger will then point in the direction toward which the electron beam is deflected, if the electrons are negatively charged. The upward distortion of the striations in the middle of my seventh picture [*page 113*] shows the effect.

"Having built the tube and photographed some of its effects, I looked into the possibility of using it for other ex-

perimental work. I had read somewhere that the rate at which seeds germinate is influenced by electron bombardment at the business end of a linear accelerator. My tube scarcely qualified as a linear accelerator; on the other hand, it seemed to me that if seeds were put inside the tube, where they would receive the full impact of the electron beam, some effect might be observed.

"Lettuce seeds were selected for the test because they are large enough for easy counting. The seeds were divided into five groups of 100 each. One of the groups was set aside to serve as a control. The remaining four were put into the tube, one group at a time. The cathode stopper was simply pulled out and the seeds poured into the tube. The electric field tends to concentrate at the edge of the cup-shaped anode; since I wanted bombardment of maximum intensity, the tube was operated in an inclined position so that the seeds would collect at this edge.

"In the case of three test samples the tube was exhausted to the pump's limit and the vibrator of the coil was adjusted to produce maximum secondary voltage. One sample was exposed to maximum bombardment for five minutes, another for 10 minutes and the third for 15 minutes. In the case of the fourth sample the tube was pumped to lower pressure (about .75 centimeter of mercury); consequently this sample was subject to less intense bombardment. The time of exposure was five minutes.

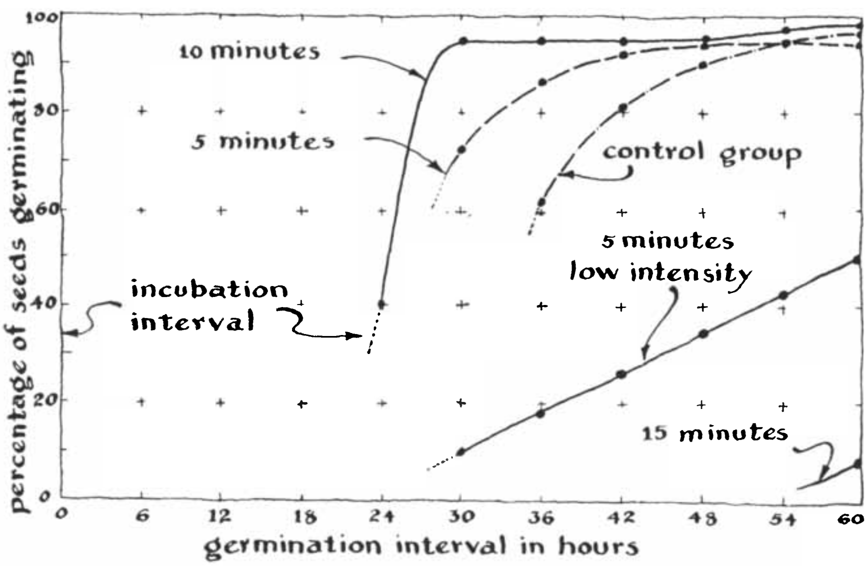
"The seeds were made to germinate by placing them on a disk of blotting paper kept moist with a wick. Each group of seeds was labeled and exposed to light from a north window in a room where the temperature was a reasonably constant 70 degrees. The results are shown in the accompanying graph [*below*]. Note the remarkable contrast between the germination rate of seeds in the control group and that of seeds exposed to high-intensity bombardment for 10 and 15 minutes. At the end of 24 hours, 40 seeds of the 100 exposed for 10 minutes had germinated. Six hours later the figure was 94; ultimately it reached 99.

"No seeds of the control group had germinated at the end of 30 hours and only 62 had germinated at the end of 36 hours. At the end of 60 hours 97 had sprouted. This was two less than the group irradiated for 10 minutes. Even the sample exposed at high intensity for five minutes showed a marked gain over the control group. It is interesting that a few seeds from the group irradiated for the same time at low intensity germinated early but only half showed signs of life at the end of 60 hours.

"Following the germination experiment a few of the sprouted seeds from each group were kept under extremely moist conditions. Mold promptly attacked the control group. But seeds which had been irradiated showed no evidence of mold or bacterial growth even at the end of several days."

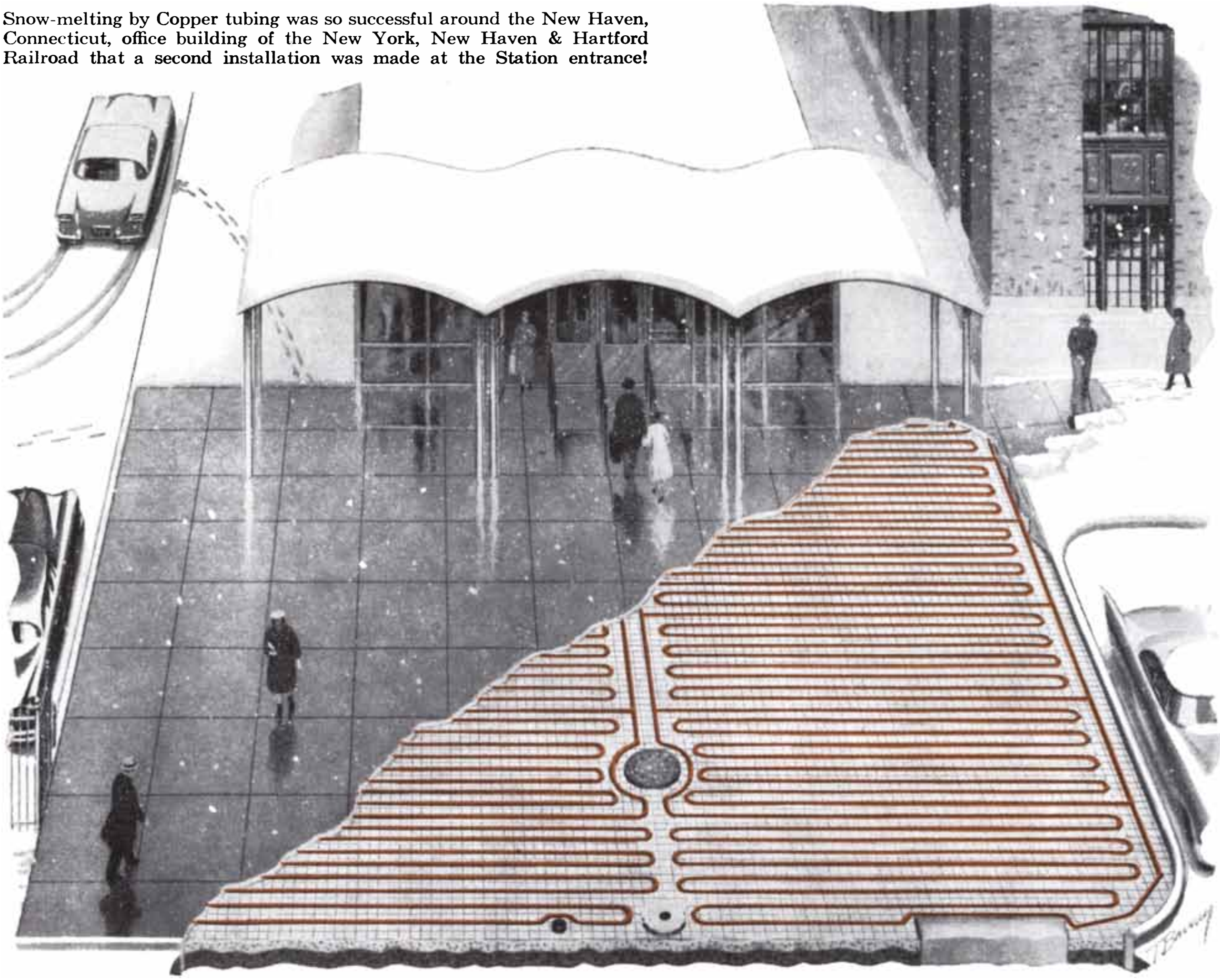
F. P. Hughes of Wausau, Wis., submits a tip for those about to embark on the making of their first telescope mirror.

"When you start to build a telescope,"



A graph showing the effects of electron bombardment on the germination of lettuce seeds

Snow-melting by Copper tubing was so successful around the New Haven, Connecticut, office building of the New York, New Haven & Hartford Railroad that a second installation was made at the Station entrance!



Add COPPER

...and stop shoveling snow!

In New Haven at the railroad station, snow is removed by melting. Hot water, circulating through Copper tubes embedded in the pedestrian pavement, keeps the whole area clear!

Installing a snow-melting system . . . in front of a store or bank or office building or along residential sidewalks and driveways . . . *is easiest with Copper.* For Copper tube comes in 60 and 100 foot lengths, minimizing the number of joints needed. These joints are quickly made too . . . by soldering or brazing. Also, the flexibility of Copper tube makes most of the bending something a mechanic can do with his two hands and a knee!

And the life of the completed, continuous heating coil? Just about *unlimited.* For Copper means virtual absence of corrosion and consequently a smooth, free flow of the heating medium at all times. No clogging with rust or other matter.

For other applications, Copper offers other superior properties, too. It's the best conductor of electricity commercially available. It is easy to machine, draw, form, stamp, polish, plate. And you can count on an ample supply of Copper to meet all your future needs.

COPPER · BRASS · BRONZE

in over 40 Standard Alloys!

For other examples of Copper tube's lower cost of installation, write the Copper & Brass Research Association, 420 Lexington Avenue, New York 17, N.Y.

Hughes writes, "do not make a mirror. Make two. Buy two mirror blanks and one blank for a tool. For the first 'wet' and all odd wets thereafter grind the first mirror blank on the tool. For the second wet and all even wets thereafter grind the second mirror blank on the tool. Continue alternating this way through polishing. Submit both polished mirrors to the knife-edge and other conventional tests. Take the better-looking mirror of the two and figure it by the method described in Albert G. Ingalls' book, *Amateur Telescope Making.* By definition this is your first mirror and it will not be very good.

"Never mind the quality. Silver it, slip it into a mounting and have a look. When your curiosity has been satisfied, set to and figure the other mirror. This time you will be under no overpowering compulsion to look through your new telescope (the principal reason why first mirrors are bad) because you already have one in use. The second mirror will accordingly show a much better figure. You have been through the mill once. When the second mirror is as good as you can get it, silver and swap.

"Now refigure the first mirror (regrinding it if pits show). It will doubtless come through the process in excellent shape. Silver, swap and continue in this way until you have two perfect mirrors. Leave one mirror unsilvered for solar work, use both mirrors to make a binocular telescope or sell one of them. The beauty of this procedure is that there is always a mirror in usable condition on hand, so the novice does not hesitate to touch a fault for fear of making things worse.

"I do not claim credit for this idea or take responsibility for its unaccountable omission from Ingalls' celebrated books on telescope making. It was dreamed up a couple of centuries ago by a fellow named William Herschel."

C. A. Rambow, a graduate student at the California Institute of Technology, submits the following suggestion for an inexpensive source of the voltage required for the production of high-energy sparks described in this department last November.

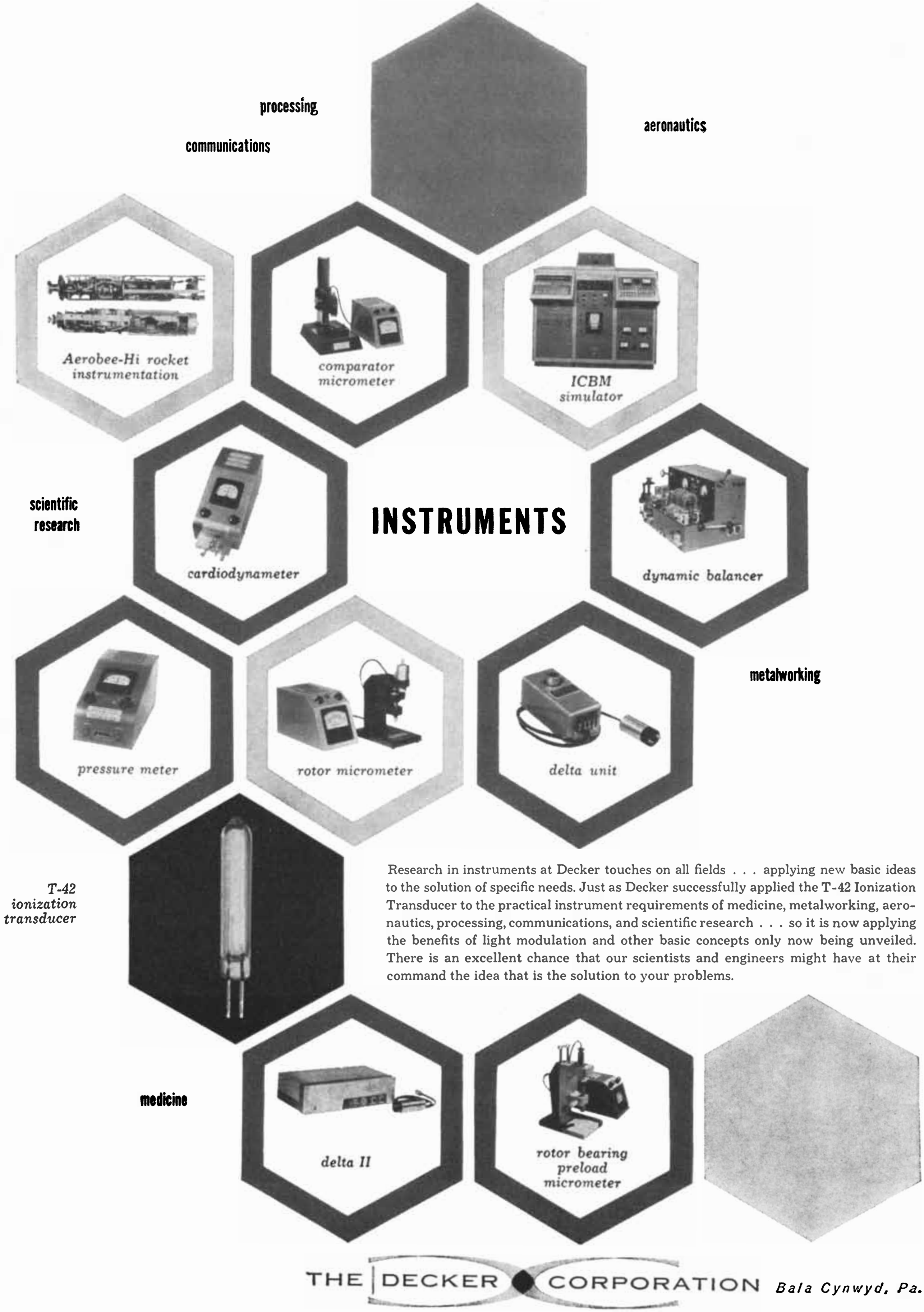
"A much cheaper power supply for charging the capacitors than those you described," Rambow writes, "can be made from an old Model-T Ford spark coil. Experimenters will have just cause for sorrow when the last of these wonderful devices has passed, but fortunately they can still be got in junk yards and even in a few auto-parts stores. To charge capacitors, connect the high-voltage terminal of the coil to the filament circuit of a 1B3 tube, and the anode of the tube to the ungrounded side of the capacitor. The rectifier filament will, of course, be at high voltage, but the required current is small enough so that a single flashlight cell will last for several hours of experimentation. A small amount of resistance is needed in the filament circuit to drop the battery voltage of 1.25, and this is most easily obtained by cutting a little nichrome wire from a replacement coffee-pot element. If you put a switch in this circuit, be sure it can be operated by a long and well-insulated extension to the handle.

"Since the output wave-form from the coil is not a pure sine wave (or for that matter pure anything), the polarity of the battery supplying the coil will influence the delivered voltage. However, if a transformer is used to supply the coil, the peak voltages will be of both polarities. In most cases this is also cheaper and easier than providing a battery. It is also important to keep the vibrator points on the coil bright and well-adjusted; failure to do so can cost you half the maximum voltage available.

"The voltage to which a condenser can be charged can be measured by a pair of needle points. These can be mounted on metal brackets attached to standoff insulators. One of the needles should be fastened to a long bolt which runs in a nut mounted atop the insulator, so the spacing between the two can be varied. A table of voltages for various spacings will be found in most handbooks. Spheres may be used in place of needles if available.

"Using this system of charging and measuring, I found I could charge a war-surplus Pyranol capacitor of .1 microfarad capacity to its 16,000-volt rated voltage in a few seconds. I don't know how high the power supply would go, but I do know that it will go up to 40,000 volts, which was enough to ruin the capacitor. However, the capacitor had served for many discharges of 30,000 to 35,000 volts prior to this.

"I would like to include a final word of warning in regard to these high-voltage capacitors. If they remain charged for any length of time, the dielectric becomes polarized. A quick discharge of the capacitor doesn't allow the dielectric to return completely to its former state, and although you throw a dead short across the capacitor, you can come back in an hour or two and find enough voltage to knock you flat. This is best avoided by leaving the short across the capacitor terminals after the capacitor has been used."


processing
communications
aeronautics
Aerobee-Hi rocket instrumentation
comparator micrometer
ICBM simulator
scientific research
cardiodynameter
INSTRUMENTS
dynamic balancer
pressure meter
rotor micrometer
delta unit
metalworking
T-42 ionization transducer
Research in instruments at Decker touches on all fields . . . applying new basic ideas to the solution of specific needs. Just as Decker successfully applied the T-42 Ionization Transducer to the practical instrument requirements of medicine, metalworking, aeronautics, processing, communications, and scientific research . . . so it is now applying the benefits of light modulation and other basic concepts only now being unveiled. There is an excellent chance that our scientists and engineers might have at their command the idea that is the solution to your problems.
medicine
delta II
rotor bearing preload micrometer
THE DECKER CORPORATION Bala Cynwyd, Pa.

New positions in

MISSILE SYSTEMS THERMODYNAMICS

Expanding missiles programs at Lockheed create thermodynamic problems of a most advanced nature. Projects at the Palo Alto, Sunnyvale and Van Nuys organizations present unusual opportunities for achievement in thermodynamics areas including: Boundary layer and heat transfer analyses in hypersonic flow fields such as pressure gradient and real-gas effects; analysis of thermodynamic performance of missiles in continuum flow, slip flow and free-molecular flow; calculation of transient structural and equipment temperatures resulting from aerodynamics heating and radiation; specification of ground tests and flight tests required to verify and improve thermodynamic design of missile and weapon systems; analysis and interpretation of thermodynamic ground test and flight test data. Inquiries are invited. Please address the Research and Development Staff, Sunnyvale 4, Calif.

Research and Development Staff members discuss heat flux during reentry of a hypersonic vehicle with Dr. C. H. Wilson, Manager Reentry Body Department (right). Others left to right: J. I. Osborne, R. G. Wilson, W. E. Brandt.

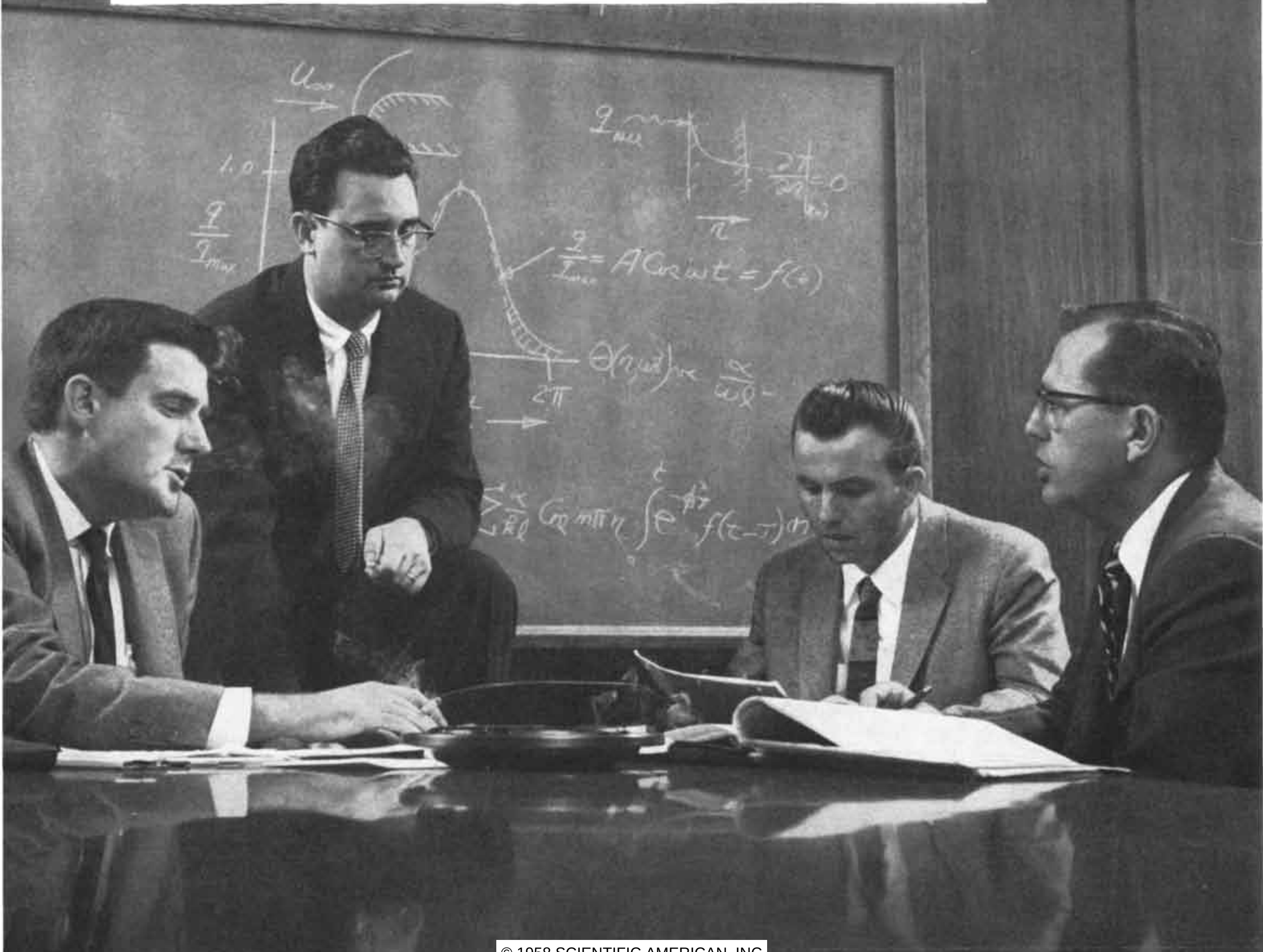
Lockheed

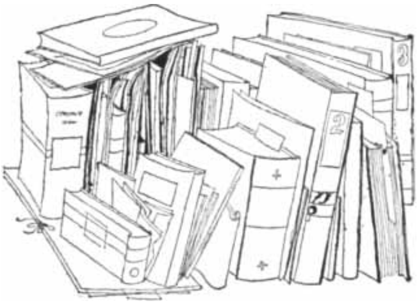
MISSILE SYSTEMS

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PALO ALTO • SUNNYVALE • VAN NUYS

CALIFORNIA





BOOKS

A new introduction to the social sciences which stresses social facts and problems

by M. Brewster Smith

THE FABRIC OF SOCIETY: AN INTRODUCTION TO THE SOCIAL SCIENCES, by Ralph Ross and Ernest van den Haag. Harcourt, Brace and Company ($10).

The title and subtitle of this compendious but readable textbook reflect a conflict between two conceptions of how to acquaint the interested layman with the study of man in society. One approach examines the social fabric with a focus on the social problems and alternatives of policy about which a well-educated person should be informed. The other takes more seriously the novelty of scientific inquiry into human social conduct. In the latter view an introduction to the social sciences should convey the spirit of this audacious study: its hopes and pretensions, its limitations and disappointments, its working methods and disciplines.

A really satisfactory book of either kind is hard to find—or to write. Both must cope with the extraordinary variety of fact and method over the range from psychology and anthropology to sociology, economics and political science; from problems of child-rearing to those of mass culture, depression, war and peace. Both must somehow steer a course between superficiality and overspecialization. Either kind of book has its own distinctive choices and dilemmas. The fact-and-problem-oriented book must reckon with our sketchy understanding of man in society. Thus it must blend knowledge with wisdom and judgment, which may obscure the distinction between thoughtful speculation and knowledge that stands up to scientific scrutiny.

A book that gives priority to introducing the reader to the social sciences, on the other hand, must take into account the fact that as academic disciplines the several social sciences reflect in different degree the scientific spirit, and that within any particular social science traditionally important bodies of theory may be only tenuously rooted—if at all—in procedures of scientific verification. Should such a book introduce the reader to social science as the disciplined inquiries in which contemporary social scientists are engaged —or to the characteristics, root notions and conclusions of the several social sciences as fields of knowledge?

The present authors have written a fact-and-problem-oriented book. They say: "In this book we have tried to avoid both shallow survey and unduly specialized elaboration by discussing rather fully a number of topics selected for their importance in contemporary society. Some of these topics are keenly felt to be important. These are 'social' problems (for instance, discord, 'abnormal' behavior such as crime, or change). Other topics do not directly impinge as 'problems' on people's consciousness but are of equal scientific significance (for instance, concord, 'normal' or law-abiding behavior, or stability). Though each topic conventionally lies in a field worked by one of the several social sciences, the methods of all the social sciences are brought to bear whenever they are relevant.... There are no economic or sociological subjects, we maintain, but there are economic or sociological aspects of most subjects—and the concepts of economics or sociology with which to tackle them. The methods and main concepts of each of the several social sciences are outlined, and we hope that philosophical and humanistic awareness has tempered our writing."

The Fabric of Society is properly the title of the book. Yet the subtitle belongs, too: a serious, though subsidiary, attempt is made to introduce the reader to the nature and leading concepts of the various social sciences. How compatible are these dual objectives? How much faith can the interested reader place in this book as an orientation to contemporary society and as an introduction to social science? Interested readers there will be, for the authors avoid the musty aroma of the textbook and write with a verve that heightens the fascination of their material.

Before we can answer these questions, we must consider the organization of the book. The first of the four parts into which it is divided is called "Persons, Groups and Culture." For reasons that are not sufficiently apparent, the authors begin the book with an account of personality and its development under social influences. They seem to be saying: "People are the starting point for any account of the social fabric"; but they make little reference thereafter to the psychological hypotheses introduced at the outset. The psychologist may wonder at the authors' decision to select for exclusive attention the Freudian version of personality development. By and large their simplified rendition of psychoanalytic doctrine is accurate. But to grant Freud's clinical hypotheses such easy acceptance is to disregard the current strenuous efforts of psychologists and others to bring these potent but undisciplined insights into the domain of scientific knowledge.

The ensuing chapters of Part I provide an array of concepts and facts (drawn primarily from sociology) for the description and analysis of society, and apply them to the American scene. Particularly capable and provocative is the discussion of social mobility—the extent to which persons move up or down in the hierarchy of class and privilege. To replace the Horatio Alger myth, which identified rags-to-riches as a peculiarly American trajectory, the authors lead the reader through a close consideration of the conditions under which upward or downward movement is theoretically possible. The final chapter of the first part—on popular culture in an era of mass communication—like most current writing on the topic strikes a note of social criticism rather than of science. The authors deplore the shallowness of the popular arts, and have many perceptive things to say about the loss of values in an industrial society.

The second major part, "Science and Symbols," begins with a highly abstract introduction to the nature of logic and of science. This part of the book is notable for an unusually lucid yet sophisticated discussion of the relations of science and moral values, and the compatibility of science with free will. Those who find in the physicist's principle of indeterminacy a refuge for belief in arbitrary free will (as if chance could provide a suitable basis for moral responsibility) will be disabused by an apt interpolation from Bertrand Russell, one of many selections from relevant writings that are interspersed to good effect throughout the text. The groundwork is laid, if not fully developed, for a view in which relative freedom (as opposed to constraint and not to determinism) finds a place in the sort of world known to science.

In what is probably the most successful section of the book, Part III on "Economic Aspects of Society," the authors give a clear and interesting account of the operation of our economic system, with thoughtful attention to such problem areas as depression, the farm surplus, labor unions, foreign aid and monopoly. The Soviet system and its Marxist ideology is subjected to informed scrutiny. One nine-page selection from R. A. Radford stands out as a gem of enlightening exposition. It is a description by a participant of the development and operation of a cigarette-based price system in a German prisoner-of-war camp. As the fish would be the last creature to discover the water, our very familiarity with ordinary economic practices handicaps our understanding of the economics of price, which are suddenly projected in bold relief by this description of a wartime microcosm.

If Part III fairly represents the concerns of economics, the final part ("The Organization of Power") does less justice to the newer, more scientific trends in political science. Here, as in most introductory courses in government, the emphasis is on political philosophy and the analysis of political institutions, rather than on the recent empirical interest in political process and behavior that gives promise of a study of politics that is scientific in more than name or claim. Among the topics considered are international politics and foreign policy, democracy, civil liberties, political parties and bureaucracy. For the most part the discussion, while thoughtful, does not involve the scientific enterprise of putting questions to nature.

In sketching the scope of *The Fabric of Society* I have rather freely interspersed my own evaluations. Fairness to the authors requires a more explicit look at what they set out to do. In introducing a series of chapters on controversial economic problems, they write:

"Few of us look upon these matters dispassionately. There are three ways of dealing with them. The first is to confine oneself to pure description.... Such information is useful because it furnishes the factual materials necessary for an analysis of policy. But it is not itself an analysis. A second way is to adopt the 'adversary' procedure familiar to the courtroom. Readers, like a jury, are asked to consider the pleas presented by employer and union spokesmen, then to make up their own minds.... Yet the analogy between a courtroom and a book—particularly one addressed to nonprofessional readers—is feeble.... Were we to present just the pleas of spokesmen for contending interests, the reader would have to act as a jury unassisted by a judge and bereft of law. The authors feel that their task is to analyze the issues.... In choosing this third way—analysis—the authors do not claim for themselves greater detachment or objectivity than is given to other mortals. Their only claim is that they have presented their views candidly. The reasons that led to these views are given in the hope that the readers will be stimulated to reasoned assent or dissent."

This reasonable statement throws us back to the choice of emphasis noted at the beginning of this review. For the enlightenment of the citizen the authors have elected to emphasize the analysis of policy. To do so goes beyond the conditional attitude of science, as the authors are well aware. But, as the authors are also correct in holding, there is no necessary incompatibility between propositions in the scientific framework (given such-and-such conditions, such a consequence will ensue) and evaluative analysis of policy (given the desirability of certain social ends, and also given such-and-such conditions, a particular policy should be followed which has these advantages that outweigh those disadvantages). So long as matters of descriptive fact, of contingent relationship and of evaluative standards are kept distinct, science need not lose its purity in being put to service in the criticism of policy.

While one cannot gainsay the authors'

objections to an uninterpreted description or to a forensic contest as approaches to the intelligent consideration of policy, their own approach of candid advocacy has drawbacks that may not appear at first reading. Underlying their position on a number of issues is an ideological preference that is not explicit: a stance that can best be identified as neo-conservatism, since its urbane, sophisticated defense of the established order betrays roots in disillusionment with the left-liberalism of the 1930s. Witness the following, which form a pattern that the authors share with other writers in journals of opinion and social criticism. They are positively enthusiastic about American capitalism, devoting to it what amounts to an extended apologia. They tend to be critical of labor unions and collective bargaining. They are dubious about the wisdom of the Supreme Court decrees requiring desegregation. They are cynical about the accomplishments and potentialities of the UN, measuring it against the ideal requirements of a world government. They pooh-pooh the nationalist indictment of colonialism, making an impressive but selective case on economic grounds in neglect of its psychological and social consequences. They are skeptical about the potentialities of foreign aid to underdeveloped countries, and generally favor a course of hardheaded *Realpolitik*. They make a point of limiting their definition of democracy to the strictly political sphere, excluding the social and economic. In all these cases their reasoning is explicit, and the reader cannot help but find it stimulating to follow their argument.

But for the "nonprofessional reader" whom they have in mind is not "reasoned assent" more likely than dissent? How indeed is he to dissent except through prejudice and wrongheadedness? The authors stand as judge and jury, and marshal their own witnesses. The reasoning is good; the authors are not easily to be exposed in simple fallacies of the sort they lay bare for the benefit of the reader. And the facts, where they are available, are usually summarized with accuracy and clarity.

But must we not agree with the authors if they are right? Of course it isn't that simple. The large issues with which they are concerned involve judgments too far removed from the realm of accepted fact and confirmed hypothesis for certainty—or what is next best but attainable on some matters, provisional scientific acceptance. Necessarily the authors select their ground. Their conclusions follow. We admire their forthrightness, and we learn from the reasoned discourse by which they reach their conclusions; but we are hardly freed to arrive at different conclusions of our own. The very candor of the authors disarms *us*, not them.

Their candor is genuine, all the same. The authors are honest with the reader, and the book can therefore be recommended as an introduction to social thought—most heartily recommended to readers whose biases run counter to those of the authors. Social criticism and philosophy have always been tendentious; wisdom, if not knowledge, has advanced by the free interplay of divergent attitudes. But as an account of social science the book is hardly satisfactory. One wants more sensitivity to the criteria by which scientific hypotheses are accepted or rejected; a firmer sense of standards as to what is admitted as evidence. One wants more examples of the *process* of discovery in the social sciences, so that the reader can envision the direction in which firmer answers can be sought to questions where conjecture must presently suffice. One wants, in other words, more of the kind of book suggested by the subtitle *An Introduction to the Social Sciences*.

The danger is that the reader of a book like this may identify able criticism and advocacy of social policy with social science, even though the authors themselves may be clear about the distinction. Such a confusion is fostered when the reader senses, as he will, that the real enthusiasm of the authors is for a rational approach to the human predicament (they are humanists at heart, and good ones) and to social problems; they give little evidence of familiarity with the patient, often disappointing process by which modest conjecture about relationships among social facts are confirmed or rejected, or qualified and refined. The confusion is regrettable on two counts. Some may attribute unwarranted weight to the authors' more speculative conclusions, thinking them to be legitimized in the name of science. Others, and I find this more to be regretted, will reject social science out of hand as being little different from the old speculative social philosophy. One is reminded of the old confusion of social science with socialism, to which it must be said that some social scientists of an earlier day contributed. Their ideology was opposed to that of the present authors, but the parallel is striking.

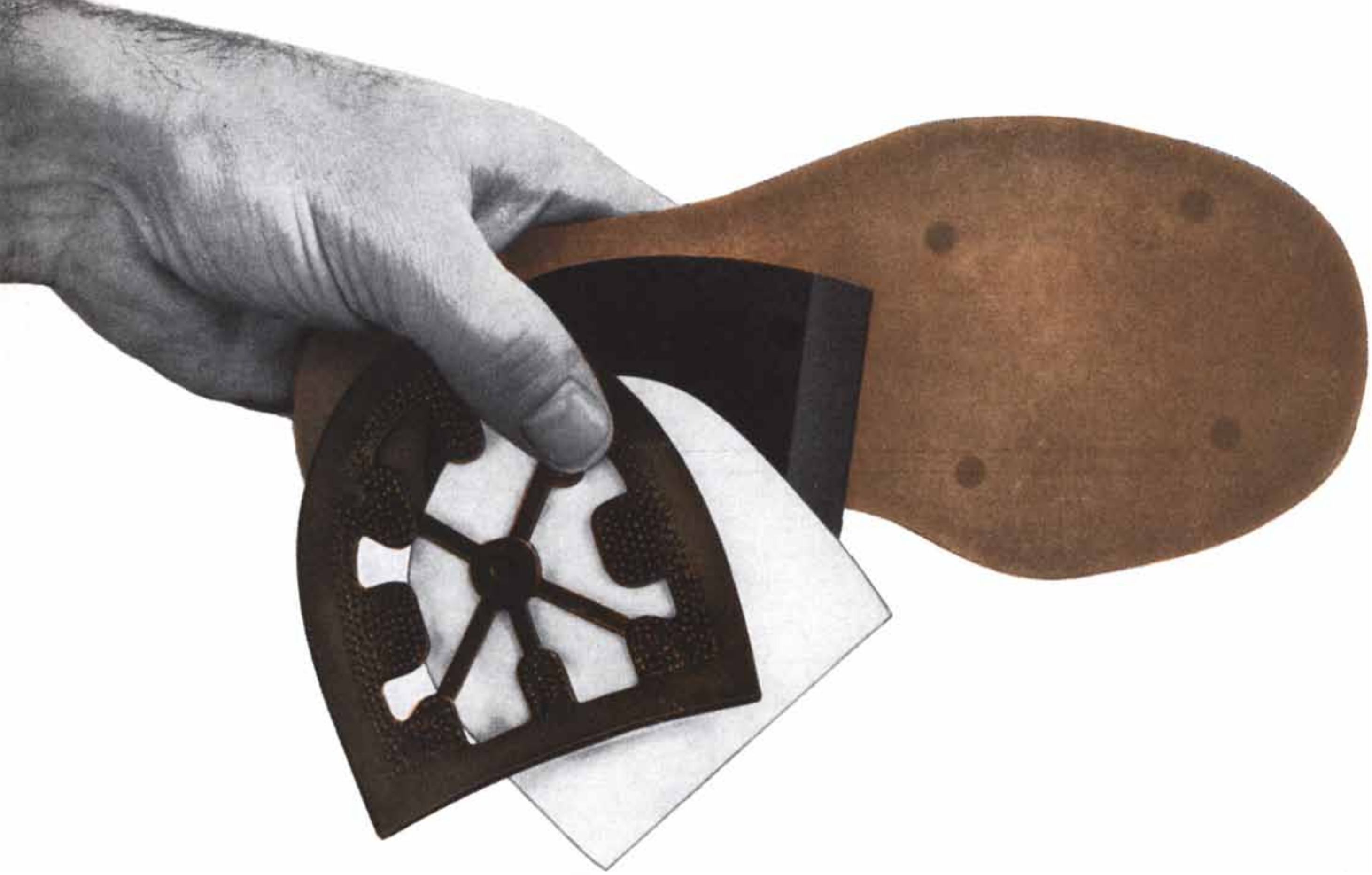
The Fabric of Society is a good book for stimulating thought about the problems of society in the light of current knowledge, but it would be a better one

if it said more about the process of social science. For the person who may later develop a specialized interest in the social sciences, a different sort of introduction might be preferable. A book that led the reader himself to discover the nature of discovery in the social sciences, and to appreciate the difficulties that hamper it, would perhaps attract to social science some of the hardheaded souls who in an age of sputniks may flock too unanimously in the direction of the physical sciences. Lacking this book (unless one counts Stuart Chase's *The Proper Study of Mankind*, which is too enthusiastic to attract the really critical reader), the person who suspects he harbors a serious interest in such matters might do better to turn to any of several good popular introductions to the separate disciplines of social science. An example is Clyde Kluckhohn's introduction to modern anthropology: *Mirror for Man.*

Short Reviews

SCIENTIFIC INFERENCE, by Sir Harold Jeffreys. Cambridge University Press ($4.75). This well-known book, which first appeared in 1931, has been substantially rewritten and a new chapter added on statistical mechanics and quantum theory. But the general standpoint, as the author states it, remains unaltered: namely, that a theory of epistemological probability must be provided to explain how it is ever possible to make inferences and predictions which go beyond the actual data of experience. This process is of course not confined to science. It occurs in ordinary affairs, as for example when we expect day to follow night, or count upon a can labeled tomato juice not to contain pickled eels or cyanide. All predictions, whether scientific or everyday, rest upon confidence which derives from repeated observations. To be sure, this confidence is sooner or later betrayed, and the "laws" of science, which embody it, require periodic renovation. Yet, as Jeffreys maintains, this patchwork of successive approximations, of confidence placed, betrayed and reborn, is the only possible method of scientific progress. In his book he discusses such topics as logic and scientific inference, Gödel's proof, the pretensions of science, probability, sampling, measurement, Newtonian dynamics, light and relativity. Few scientists or philosophers are likely to agree with him in all his opinions (he is, for example, strongly opposed to the frequency theory of probability, and regards probability as an *a priori* notion of partial proof not belonging to deductive logic); but he is a sharp, saucily elegant thinker whose views, whether or not one accepts them, are as stimulating as they are cogently expressed.

FORD: EXPANSION AND CHALLENGE, 1915-1933, by Allan Nevins and Frank Ernest Hill. Charles Scribner's Sons ($8.95). The second volume of this massive work carries to 1933 the story of one of the most unlikable and influential men of modern times. The opening scene is of the crowd filling the Palace of Transportation at the Panama-Pacific Exposition in San Francisco one afternoon in 1915. The chief attraction was the unveiling of mass production in a Ford Motor Company exhibit—a replica of the assembly line for Model-T cars at Highland Park near Detroit. As the authors remind us, the world in 1915 was the world of the Curies, Ernest Rutherford and Einstein; of Benedetto Croce and Henri Bergson; of Henri Matisse, Paul Klee and Picasso; of Gerhart Hauptmann, Bernard Shaw and Maxim Gorki; of Maurice Ravel, Igor Stravinsky, Jan Sibelius and Puccini. But it was also the world of wireless, the airplane, the automobile, the suspension bridge, the electric light and the skyscraper; a world of technology and large-scale production in which Americans had taken leadership. With its vast reserves of raw materials, great plants, ingenious inventors, energetic venturers and huge labor force, the country "was the happiest of all environments for the growth of mechanistic enterprises." And in this environment no single man shot up so quickly and flourished so wildly as Henry Ford. His personal qualities and his insights made a formidable amalgam for success. He was single-minded, tireless, bold, sometimes gentle, sometimes ill-tempered, ambitious and without scruple. He was stubborn, weak, uneducated, suspicious, disloyal and cunning. He was cynical, sentimental, sententious, inward and self-anointed. He was also extraordinarily skilled as an engineer. He "read" engines; "he combined some of da Vinci's creative quality in mechanics with James Watt's superb practicality"; he had designed in the Model T an incomparably useful and durable vehicle, which he recognized millions of people needed and would buy if it was cheap. During the 18 years recorded in this book Ford engaged in bitter struggles, committed enough blunders to bring him to the edge of ruin, surmounted serious crises and transformed the ways of our society. The well-intentioned peace ship; the unsuc-



Shoe parts of **TENITE POLYETHYLENE**
offer better flexibility
easier workability
improved moisture resistance
longer life

Plastics are becoming more important every day in shoe construction. The midsole, Dutchman heel pieces, and heel base shown above, for example, illustrate new uses of Tenite Polyethylene by Endicott-Johnson Corporation, a leading name in the shoe industry.

Tenite Polyethylene is a plastic with properties useful to shoe manufacturers. It is light in weight and resists chemical attack, aging and moisture. It is easy to form; parts can be molded, or cut from extruded sheet. It can be supplied in colors.

Endicott-Johnson cite numerous benefits from their use of Tenite Polyethylene. Dutchman heel pieces, they report, formerly were made of fibre and leather. By using Tenite Polyethylene, they now have a material more adaptable to rounding and skiving, which permits production of better-fitting shoes. The new heel pieces also have greater flexibility and moisture resistance—two important considerations for any heel piece.

Their heel bases formerly were made of rubber. By switching to plastic, Endicott-Johnson feel that their new bases are more serviceable and that quality control has been made more precise.

Midsoles formerly were made of leather. Here again, the change to polyethylene has meant improvements in workability, flexibility and moisture resistance.

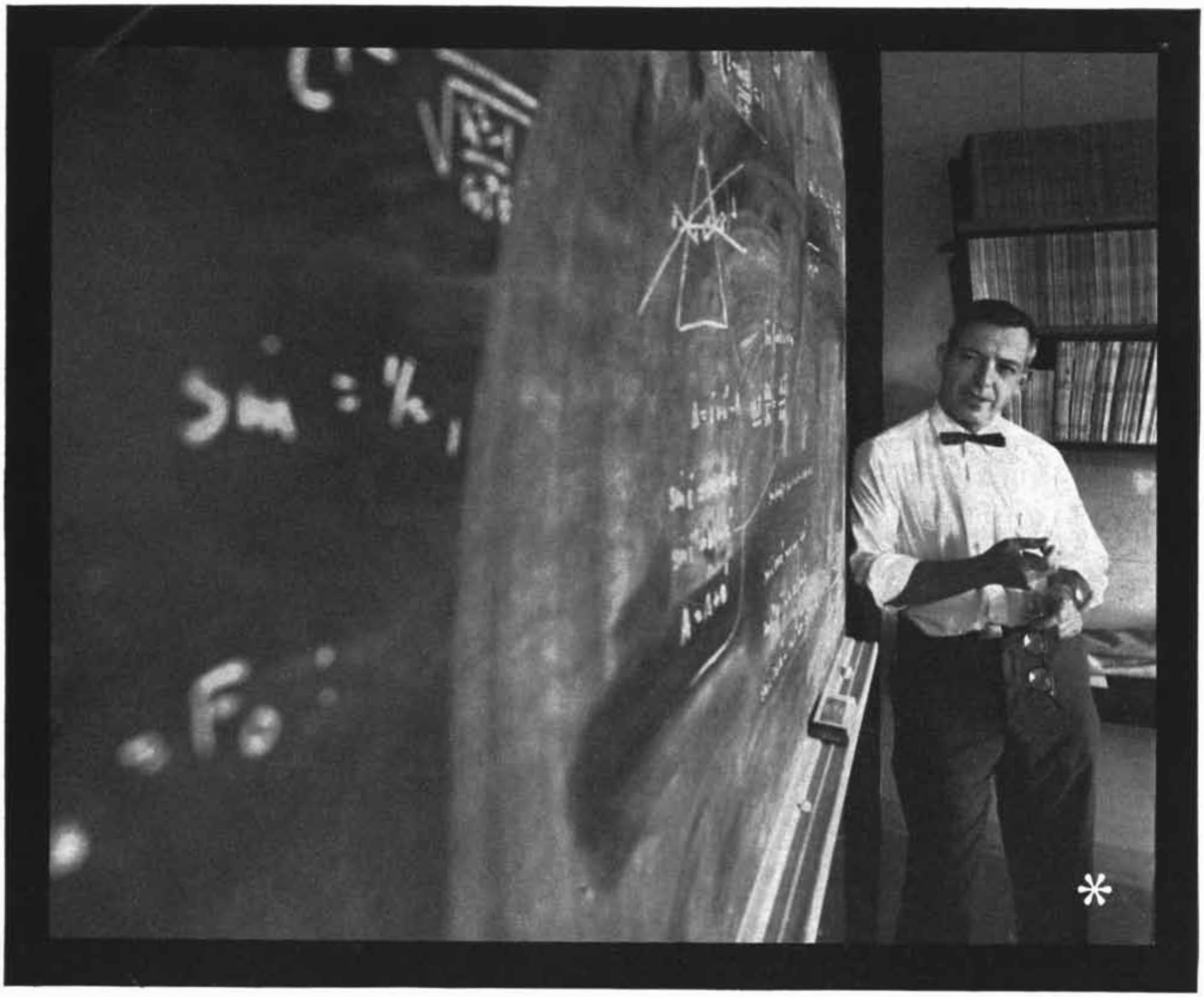
Today, many industries are using Tenite Polyethylene in place of traditional materials. Perhaps you, too, have a product that could be given improved performance or longer life if made of this versatile plastic. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
POLYETHYLENE
an Eastman plastic

cessful campaign to be senator; the shameful Dearborn *Independent* crusade for anti-Semitism; the Chicago *Tribune* libel suit (in which Ford on the witness stand ventured the date 1812 for the American Revolution and identified Benedict Arnold as a man "who used to write for us"); the buying out of the other stockholders (the Dodge brothers, for example, in addition to millions in dividends already received, got $25 million for stock that had cost them $10,000) and the acquisition of sole control of a $500 million industrial corporation; the building of the vast River Rouge plant; the Muscle Shoals affair; the Brazilian rubber plantation; the experiment in aircraft manufacture; the brilliant exploitation of the D. T. & I. Railroad; the imagination and the tyranny of the company's labor relations (it was the introduction of Stakhanovite methods, as one reviewer has observed, which probably accounts for Ford's popularity in the U.S.S.R.); Ford's ruthless method of meeting the economic depression of the early 1920s; his relations with the higher-ups in his organization and the cruel treatment of his son; the final scrapping of the Model T: these are among the highlights of an engrossing story. This could not have been an easy book to write; to be fair to Henry Ford calls for nothing less than divine charity and understanding.

THE BUILDINGS OF ENGLAND. LONDON, VOL. I: THE CITIES OF LONDON AND WESTMINSTER, by Nikolaus Pevsner. Penguin Books, Inc. ($3). A volume in a splendid series by a noted historian of art and architecture. When Pevsner, head of the department of the history of art at Birkbeck College, University of London, completes his extraordinary survey, there will be available a detailed description of the architectural features of "all ecclesiastical, public and domestic buildings of interest" in each town and village of every county of England. This work (like others in the series) is based upon the author's own "perambulations"; he walks, when engaged in his researches, a dozen miles a day, looking at everything and making careful notes. Besides skillful word pictures of the various buildings, inside and out, information on structural points, materials, decorations and a mass of interesting historical data, there are included in the present volume 96 pages of plates. Even at $3 this paperback is a bargain.

A HISTORY OF MECHANICS, by René Dugas. Central Book Company, Inc. ($15). The writing of a history of mechanics is a very difficult task. Mechanics is one of the oldest of the sciences. It engrossed the ancients; for more than two millennia it was cultivated by the foremost scientific thinkers, who succeeded in erecting an amazing structure from a mere handful of principles; it was brought to seeming perfection in the 19th century. Then within a few years two remarkable and wholly unanticipated developments—relativity and quantum theory—which did not arise out of classical mechanics itself but rather from the study of electromagnetic and atomic phenomena, showed that the subject was neither perfect nor closed. Now we have quantum and wave and relativity mechanics, and no physicist would dream of asserting that these are the last word. Mechanics is not finished like chess. Obviously the historian of mechanics must be many-sided. He must be a versatile scholar, at home both in the ancient and the modern texts, and he must possess a wide and thorough knowledge of physics. Also, if his account is to be more than a chronology yet less than an encyclopedia, he must be guided by principles of selection which, while keeping his work within reasonable bounds, will help him give a fair and full picture of the major themes and their interconnections. René Dugas, of the Ecole Polytechnique in Paris, has in earlier writings demonstrated his considerable capacity as a historian of science. One of his studies in the history of dynamics was reviewed two years ago in these columns; it exhibits his learning and his critical faculties. The present survey runs from Aristotle to Dirac, from levers to tensors. Thus in a single book are collected "the stammerings of the early students, the creation and organization of the classical science and the rudiments of the new mechanics." This is a large order; indeed, it was necessary in reviewing 19th- and 20th-century mechanics to limit the discussion to certain questions of special importance. Dugas acknowledges his indebtedness to the labors of Pierre Duhem, Emile Jouguet, Paul Painlevé; and of course to Ernst Mach, whose famous *Mechanics*, for all its bias and special pleading on behalf of positivism, was a deep and original work that gave a light to all later critics, philosophers and historians of science. Dugas has his own opinions and does not hesitate to depart from the views of others on the basis of his sifting of the evidence. It is not possible in a short notice properly to appraise his achievement. Louis de Broglie in an interesting foreword describes the book as a "document of the



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; also other senior scientists with operations research experience.

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, experiences in operations research or related fields.

MONTEREY, CALIF.: Senior scientist to direct operations of field experiment group.

(Please indicate location preference.)

tech/ops

** Dr. Eric Clarke, tech/ops vice president, takes a look at a problem in his office at Burlington, Mass.*

first rank for the historian of mechanics." A clear style stands out (this despite clumsy translation), a remarkable sweep and a sureness of touch. The work deserves and will undoubtedly draw the absorbed attention of specialists.

AUBREY'S BRIEF LIVES, edited by Oliver Lawson Dick. The University of Michigan Press ($5.95). This enchanting book, which scholars have known and looted for centuries, consists of a superb collection of biographical portraits of 16th- and 17th-century English celebrities. Poets, philosophers, soldiers, statesmen, clerics, whores, merchants, great ladies, scientists are sketched in their appearance, their actions, their sayings, their humors. Aubrey was a hanger-on but not invariably a respecter of personages. Nothing pleased him more than to record foibles and scandals; he was a brilliant observer of intimate details and an avid collector of gossipy trinkets. Two specimens from Dick's ably edited selection: Robert Hooke is "of midling stature, something crooked, pale faced, and his face but little belowe, but his head is large, his eie full and popping, and not quick; a grey eie. . . . [The letter he sent Newton giving the inverse square principle of gravitational action] is the greatest discovery in Nature that ever was since the World's Creation. It never was so much as hinted by any man before. I wish he had writt plainer, and afforded a little more paper." William Harvey "wrote a very bad hand"; "did delight to be in the dark, and told me he could then best contemplate"; "was far from Bigotry"; "was wont to say that man was but a great, mischievous Baboon"; said of Bacon to Aubrey "He writes Philosophy like a Lord Chancellor"; observed "that the Turks were the only people [who] used [women] wisely"; "was very Cholerique and in his young days wore a dagger [which he was] apt to draw-out upon every slight occasion"; and once said that "after his Booke of the *Circulation of the Blood* came-out, that he fell mightily in his Practize. . . ."

THE TROPICS, by E. Aubert de la Rüe, François Bourlière and Jean-Paul Harroy. Alfred A. Knopf ($12.50). This richly illustrated, rewarding book deals mainly with the plant life of the tropics. Tropical flora are as varied as the land and climate of the hot countries. The conventional notion is that the landscape is made up entirely of great rain forests and of "exuberant vegetation." But this describes only the regions ruled by heavy, humid heat and abundant rains. Besides such scenes there are the parklike savannahs with their scattered trees, the grassy savannahs and great open areas, the deciduous forests, the thorny scrubs, the desert steppes, the quaint mangrove forests of the muddy coasts, the "alpine meadows of the high equatorial summits," the "misty moss-grown mountain forests." Each region nurtures its own vegetation, each breeds strange and beautiful and fantastic forms of plant and animal life. De la Rüe, a geologist with extensive experience in the tropics, ably describes the plants; Bourlière, known for his excellent popular books on mammals, adds a succinct chapter on tropical animals. A final section by Jean-Paul Harroy discusses the devastation of these natural wonders: the cutting of the forests, the erosion of the soil, the destruction of big game. Some important scientific advances have accidentally injured the land: for example, as a result of the control of epidemic diseases, herds of domestic animals have increased to the point where they threaten the cover of vegetation. And in most instances the technological blessings of civilization—from power saws to firearms—are responsible for the gradual ruin of the tropics.

Notes

NEW LIGHT ON THE MOST ANCIENT EAST, by V. Gordon Childe. Grove Press, Inc. ($1.75). A reprint of one of the best books for the general reader on the archaeological discoveries which have afforded us an understanding of the birth of civilization in the Near East.

DIRECTORY OF AMERICAN SCHOLARS, edited by Jaques Cattell. R. R. Bowker Company ($20). Third edition of a standard compilation of reference data about those working in philosophy, history, literature, the languages and related disciplines.

ARCHAEOLOGY AND ITS PROBLEMS, by Siegfried J. De Laet. The Macmillan Company ($4.50). A succinct, clear presentation by a noted teacher and field worker of the methods, techniques, problems and purposes of archaeology.

SIMPSON'S HISTORY OF ARCHITECTURAL DEVELOPMENT. VOL. I: ANCIENT AND CLASSICAL ARCHITECTURE, by Hugh Plommer. Longmans Green and Co. ($6.75). A thoroughgoing revision, incorporating the results of the many archaeological discoveries of the present century, of the first volume of a noted work originally published in 1905.

INDEX OF ADVERTISERS

FEBRUARY, 1958

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful.

THE MORTALITY OF MEN AND WOMEN

HUMAN CONSTITUTION IN CLINICAL MEDICINE. George Draper, C. W. Dupertuis and J. L. Caughey, Jr. Paul B. Hoeber, Inc., 1944.

THE ROLE OF TESTICULAR SECRETIONS AS INDICATED BY THE EFFECTS OF CASTRATION IN MAN AND BY STUDIES OF PATHOLOGICAL CONDITIONS AND THE SHORT LIFESPAN ASSOCIATED WITH MALENESS. James B. Hamilton in *Recent Progress in Hormone Research*, Vol. 3, pages 257-322; 1948.

WOMEN AND MEN. Amram Scheinfeld. Harcourt, Brace and Company, 1944.

STRONG MAGNETIC FIELDS

THE DESIGN OF POWERFUL ELECTROMAGNETS. Part IV: THE NEW MAGNET LABORATORY AT M.I.T. F. Bitter in *The Review of Scientific Instruments*, Vol. 10, No. 12, pages 373-381; December, 1939.

FURTHER DEVELOPMENTS OF THE METHOD OF OBTAINING STRONG MAGNETIC FIELDS. P. Kapitza in *Proceedings of the Royal Society*, Series A, Vol. 115, No. A772, pages 658-683; August 2, 1927.

PRODUCTION AND USE OF HIGH TRANSIENT MAGNETIC FIELDS: I. H. P. Furth and R. W. Waniek in *The Review of Scientific Instruments*, Vol. 27, No. 4, pages 195-203; April, 1956.

PRODUCTION AND USE OF HIGH TRANSIENT MAGNETIC FIELDS: II. H. P. Furth, M. A. Levine and R. W. Waniek in *The Review of Scientific Instruments*, Vol. 28, No. 11, pages 949-958; November, 1957.

THE METABOLISM OF RUMINANTS

DIGESTION IN THE RUMINANT STOMACH. H. H. Dukes in *The Physiology of Domestic Animals*, pages 352-391; 1955.

FAT METABOLISM. H. H. Dukes in *The Physiology of Domestic Animals*, pages 580-612; 1955.

PRECURSOR—PRODUCT RELATIONSHIP FOR MILK FORMATION IN THE INTACT DAIRY COW. Max Kleiber in *Revue Canadienne de Biologie*, Vol. 13, No. 4, pages 333-348; November, 1954.

A RESPIRATION APPARATUS FOR C^{14} STUDIES WITH COWS. Max Kleiber and Melvin Edick in *Journal of Animal Science*, Vol. 11, No. 1, pages 61-71; February, 1952.

RUMINANT DIGESTION. S. R. Elsden and A. T. Phillipson in *Annual Review of Biochemistry*, Vol. 17, pages 705-726; 1948.

ANCIENT TEMPERATURES

DEPTH HABITATS OF SOME SPECIES OF PELAGIC FORAMINIFERA AS INDICATED BY OXYGEN ISOTOPE RATIOS. Cesare Emiliani in *American Journal of Science*, Vol. 252, No. 3, pages 149-158; March, 1954.

GLACIAL AND PLEISTOCENE GEOLOGY. Richard Foster Flint. John Wiley & Sons, Inc., 1957.

OLIGOCENE AND MIOCENE TEMPERATURES OF THE EQUATORIAL AND SUBTROPICAL ATLANTIC OCEAN. Cesare Emiliani in *The Journal of Geology*, Vol. 64, No. 3, pages 281-288; May, 1956.

PLEISTOCENE TEMPERATURES. Cesare Emiliani in *The Journal of Geology*, Vol. 63, No. 6, pages 538-578; November, 1955.

TEMPERATURES OF PACIFIC BOTTOM WATERS AND POLAR SUPERFICIAL WATERS DURING THE TERTIARY. Cesare Emiliani in *Science*, Vol. 119, No. 3,103, pages 853-855; June 18, 1954.

THE JUVENILE HORMONE

INSECT METAMORPHOSIS. R. E. Snodgrass. Smithsonian Miscellaneous Collections, Vol. 122, No. 9; April, 1954.

THE JUVENILE HORMONE OF INSECTS. Carroll M. Williams in *Nature*, Vol. 178, No. 4,526, pages 212-213; July 28, 1956.

MORPHOGENESIS AND THE METAMORPHOSIS OF INSECTS. Carroll M. Williams in *The Harvey Lectures*, Vol. 47, pages 126-155; 1953.

THE PHYSIOLOGY OF INSECT METAMORPHOSIS. V. B. Wigglesworth. Cambridge University Press, 1954.

THE DISCOVERY OF FISSION

NUCLEAR FISSION. Louis A. Turner in *Reviews of Modern Physics*, Vol. 12, No. 1, pages 1-29; January, 1940.

BALLISTOCARDIOGRAPHY

CLINICAL BALLISTOCARDIOGRAPHY. Herbert R. Brown, Jr., Vincent deLalla,

Jr., Marvin A. Epstein and Marvin J. Hoffman. The Macmillan Company, 1952.

THE BALLISTOCARDIOGRAM: A DYNAMIC RECORD OF THE HEART BEAT. John R. Braunstein. Charles C Thomas, 1953.

BALLISTOCARDIOGRAPHY: THE APPLICATION OF THE DIRECT BALLISTOCARDIOGRAPH TO CLINICAL MEDICINE. William Dock, Harry Mandelbaum and Robert A. Mandelbaum. The C. V. Mosby Company, 1953.

PREHISTORIC MAN
IN THE GRAND CANYON

THE ABANDONMENT OF THE SAN JUAN REGION. Erik K. Reed in *El Palacio*, Vol. 51, No. 4, pages 61-74; April, 1944.

CLIMATE CHANGE AND CULTURE HISTORY IN THE GRAND CANYON REGION. Douglas W. Schwartz in *American Antiquity*, Vol. 22, No. 4, pages 372-377; April, 1957.

THE COHONINA CULTURE OF NORTHWESTERN ARIZONA. John C. Mc.-Gregor. The University of Illinois Press, 1951.

DEMOGRAPHIC CHANGES IN THE EARLY PERIODS OF COHONINA PREHISTORY. Douglas W. Schwartz in *Prehistoric Settlement Patterns in the New World*, pages 26-31; 1956.

HAVASUPAI ETHNOGRAPHY. Leslie Spier in *Anthropological Papers of the American Museum of Natural History*, Vol. 29, Part 3, pages 81-408; 1928.

MATHEMATICAL GAMES

A MACHINE FOR PLAYING THE GAME NIM. Raymond Redheffer in *The American Mathematical Monthly*, Vol. 55, No. 6, pages 343-350; June-July, 1948.

NIM, A GAME WITH A COMPLETE MATHEMATICAL THEORY. Charles L. Bouton in *Annals of Mathematics*, Series 2, Vol. 3, pages 35-39; 1901-1902.

THE NIMATRON. E. U. Condon in *The American Mathematical Monthly*, Vol. 49, No. 5, pages 330-332; May, 1942.

THE AMATEUR SCIENTIST

GASEOUS CONDUCTORS: THEORY AND ENGINEERING APPLICATIONS. James Dillon Cobine. McGraw-Hill Book Company, Inc., 1941.

THEORY OF GASEOUS CONDUCTION AND ELECTRONICS. Frederick A. Maxfield and R. Ralph Benedict. McGraw-Hill Book Company, Inc., 1941.