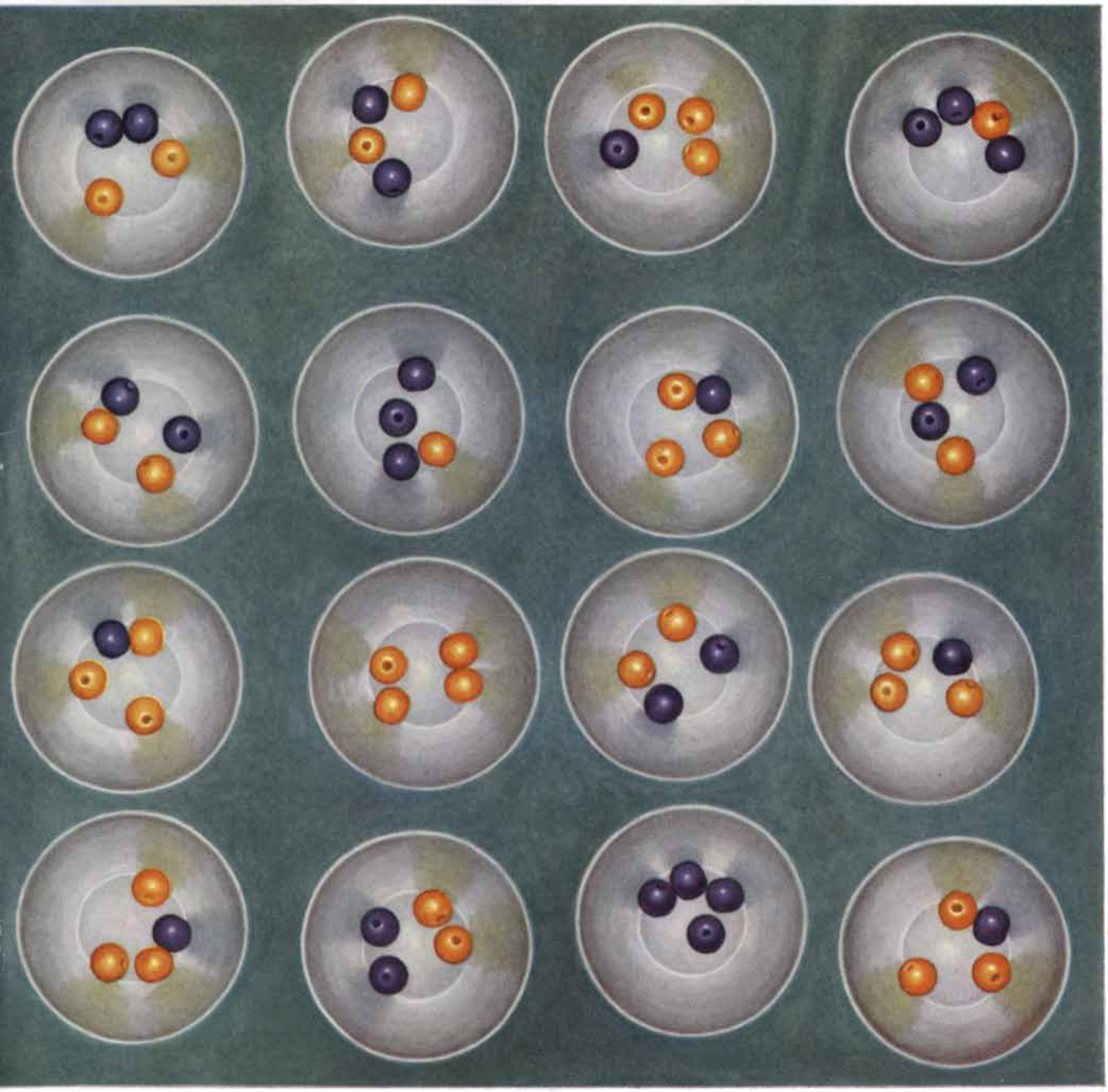
SCIENTIFIC AMERICAN



SUBJECTIVE PROBABILITY

FIFTY CENTS

November 1957

What is Atomized Aluminum?

Interesting characteristics lead to wide industrial demand

ALCOA® Atomized Aluminum is a finely divided, granular powder produced by blowing molten aluminum through fine atomizing nozzles into a dust collector. Particles are more or less spherical, or tear shaped, with a relatively low surface area.

Widely used in explosives during and since World War II, atomized aluminum has found important (and increasing) use in peacetime industry. Potential uses have not been fully exploited. New markets are opening every day.

Atomized aluminum is a highly effective reducing agent. As such, it is used successfully as a substitute for zinc.

Atomized aluminum has high fuel value. It increases the explosive force of TNT by 100%. With an oxidizing agent such as barium nitrate, it burns hot—up to 4500°. Moreover, by varying the degree of oxidation, burning can be controlled —from an explosion down to a flare.

Conversely, atomized aluminum disperses heat in other industrial applications, for example in grinding wheels.

Some of the more interesting current uses:

PLASTIC SHAPES (such as metal-forming dies)—Mixed with synthetic resins (like the epoxies) to produce stamping or forming dies. Advantages: better heat transfer, which increases dimensional stability, lessens shrinkage; better appearance and increased resistance to shock.

EXOTHERMIC REACTIONS—Reacts with various metallic oxides to produce intense heat. Typical uses: in hot tops to permit smaller diameter risers in castings; specialized welding applications.

PYROTECHNICS—Burning rate of atomized aluminum is changed by varying the strength of the oxidizing agent. Example: candle power and burning time of signal flares can be controlled.

EXPLOSIVES—Used commercially (mining) and by the military, atomized aluminum has high fuel value, serves as a booster to explosive compositions. Intense heat expands explosive gases, greatly increasing force. Atomized aluminum is economical because it can be substituted for a percentage of the explosive. It's cheaper, for example, than nitroglycerine.

CHEMICAL USES—Atomized aluminum is a strong reducing agent and readily replaces metals from other compounds and solutions. Used in the recovery of gold and silver from cyanide solutions and in the production of alum to reduce ferric iron to the ferrous state.

CERAMICS—Gives added strength to ceramic forms. Enables refractory saggers to withstand higher temperatures (extends service life).

COLD SOLDERS—Mixes with resins to form a plastic compound. Advantages: Tough metallic surface, machineable, adheres well, good appearance, can be painted.

HOT SOLDERS—Used in filling solders requiring less heat than regular tin alloy solders.

POWDER METALLURGY—A whole new field has been opened here. Extrusions, forgings and sheet demonstrating exceptional strength and stability at high temperatures have been produced.

CATALYSTS—Provides raw material in production of aluminum alkyls, extremely active catalysts. (One end product: polyethylene.)

Atomized aluminum contributes to many everyday products —high purity aluminum chloride for the cosmetics industry, drain cleaning compounds, iron-free paper makers' alum. It's even used in metal spray guns in place of wire.

WRITE FOR SAMPLES. It's likely that versatile ALCOA Atomized Aluminum Powder can be used profitably in *your* products or processes. We will be happy to send complete data on various grades available and supply your technical staff with experimental samples.

Write today to ALUMINUM COMPANY OF AMERICA, PIGMENTS DIVISION, 1714-L Alcoa Building, Pittsburgh 19, Pennsylvania.

NEW!
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Pete Marenholtz discusses **PREFLIGHT MISSILE CHECKOUT**

Prior to launching a missile, a full-scale dress rehearsal is conducted in order to enact every predictable contingency which might occur during flight. Considering the multitude of intricate and remotely controlled actuations which must be checked within a very short time interval, and the speed with which the corresponding decisions must be made, it is easy to recognize the need for the faster-than-human, more-reliable-than-human capabilities of the equipment monitoring this dress rehearsal. The possibility of human errors can not be tolerated, not only out of concern for the safety of personnel, but in order to avoid damaging the expensive missile itself.

The preflight missile checkout system incorporates all operations necessary for the final preparation of the missile for flight. To meet the requirements of unfailing high-speed repeatability, the use of electronics is mandatory. The electronic checkout equipment must:

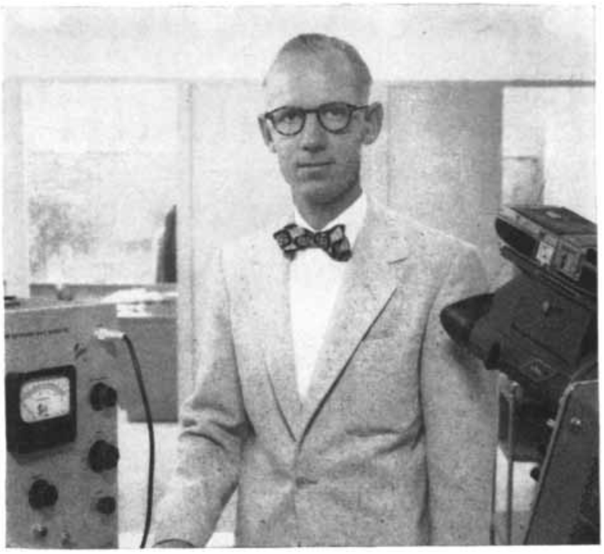
1. Position missile controls for flight and precess inertial guidance elements for a predetermined flight plan. This involves making decisions which may be changed again during the final seconds prior to the moment of launching. Errors in judgment or of actuation must be eliminated.
2. Actuate all controls on the missile and sense correct functioning.
3. Provide an immediately available record of all tests for evaluation and making of final decisions relating to the missile's readiness for firing.

The mechanics of performing the above checkout functions falls into the realm of logical decisions. More specifically, the decisions are made more reliable and accurate by resorting to electronic decision elements. One technique is to store into a memory device all the necessary commands, off-limit conditions, and sequencing instructions required for the checkout.

The type of memory device required for a particular missile depends upon the speed with which checkout operations must take place. For instance, present-day missile checkout time scale requirements may be satisfied with punched paper tape programs. Faster access time, if required, may be achieved by employing magnetic tape or magnetic cores.

In a typical system the selection of controls to be actuated and electrical points to be instrumented is accomplished by positioning stepping switches in response to signals generated by the program memory device. The signal from the instrumented point is converted to a digital signal and compared in an automatic comparator with predetermined limits likewise stored in the memory device. This comparator operates as a time-digital comparison and comparisons therefore can be made at high speed and with digital accuracy.

A prime requirement for an automatic checkout system is absolute reliability. The time and the money at stake are enormous and reliability of the ground station system should, if possible, exceed that of the missile itself by at least an order of magnitude. In the case of equipment carried on board the missile it is often necessary to compromise between reliability and weight. But ground station equipment is invariably designed for reliability regardless of weight.



Pete Marenholtz, engineer, specializing in transistor digital circuitry, discusses automatic preflight missile checkout.

Redundancy is used (over and above conservative design and quality components) in achieving this extreme degree of reliability. Each internal operation of the system is performed twice and the results are compared before initiation of a main missile system function. A malfunction anywhere in the checkout which could not otherwise be avoided, is therefore immediately detected and measures are taken to protect the overall missile system. In the binary portions of the system parity checks are employed for added reliability insurance.

In developing such systems as the preflight missile checkout system, the progressive nature of military research has advanced automation techniques to their present high level and has paved the way for their counterpart in industrial applications.

By applying the latest proven techniques. our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write to Dept. 14.

DAYSTROM SYSTEMS

Division of Daystrom, Inc., 5640 La Jolla Boulevard
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Established 1845 **SCIENTIFIC AMERICAN** November, 1957 Volume 197 Number 5

ARTICLES

DEPARTMENTS

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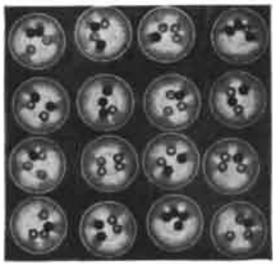

THE COVER

The painting on the cover shows 16 cups of the kind used in an experiment on subjective probability (*see article on page 128*). The subject is shown a bowl of blue and yellow beads and told that it contains the same number of each. The experimenter then draws beads from the bowl and places four in each cup. The subject is asked to guess how many of the cups contain each of the possible combinations of beads.

THE ILLUSTRATIONS

Cover painting
by John Langley Howard

Page	Source
45-49	Irving Geis
50	Anton F. Bruun
51	John Langley Howard
52	Anton F. Bruun
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105	National Audubon Society
106-108	René Martin
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112-113	René Martin (*top*); Prentice Bloedel (*bottom*)
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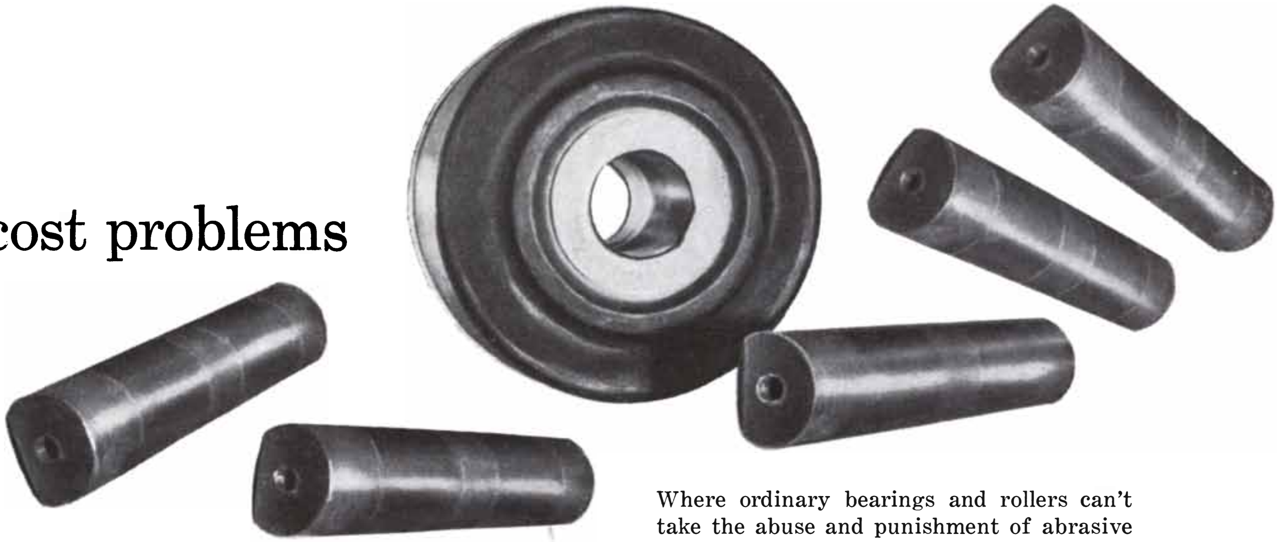
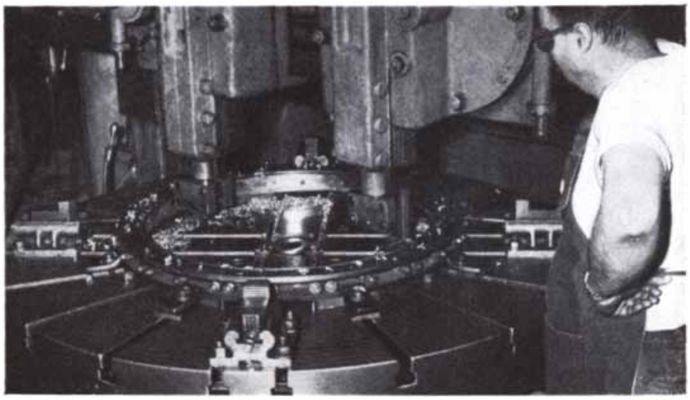
cost problems



ABRASION

Where ordinary bearings and rollers can't take the abuse and punishment of abrasive rock and acid sludge, such as in mining operations, they are hard-faced with HAYNES STELLITE Alloy No. 6 and last for years instead of weeks! HAYNES Alloys reduce maintenance and replacement costs by giving long service.



MACHINING

HAYNES STELLITE 98M2 alloy tools remove metal fast in machining jet engine diaphragm rings. These tools take a ½-in. cut and remove 55 cubic in. of metal in 15 minutes. About six rings now are machined per grind where other tools failed to finish even one. And tool service life has jumped over 600 per cent. Fast, precision machining with long tool life makes a big difference in production costs.

Wherever you have a *tough* cost problem due to maintenance or replacement expense caused by excessive wear, heat, or corrosion, or where there is a complex design or production problem—investigate the use of HAYNES Alloys.

In practically every industry, you will find HAYNES Alloys helping to increase production and reduce maintenance—doing an efficient job at low cost. For information on HAYNES Alloys, contact our nearest sales office or write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana. Sales Offices in Chicago, Cleveland, Detroit, Houston, Los Angeles, New York, and San Francisco.

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ALLOYS
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UNION CARBIDE

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Progress with TITANIUM

New Titanium alloys

developed by Mallory-Sharon for the missile age

Two remarkable titanium alloys developed by Mallory-Sharon's Research Laboratory further extend the usefulness of the metal in hot environments. This development promises more and more applications in rockets and missiles for titanium—strongest metal per pound of weight in its temperature range.

Commercial introduction of these new alloys culminates research and development over a two year period. In the intensive evaluation of both laboratory and production ingots, thousands of individual tests were made and analyzed. The results:

The first new alloy (MST 821) is a weldable sheet and bar material which offers strengths equivalent to similar titanium alloys—*at temperatures two hundred degrees higher*. This exceptional advantage is maintained in the range of 400 to 1000 degrees F.

The second new alloy (MST 2.5Al-16V) offers remarkable ease of fabrication for a high strength material. Sheet metal parts can be readily formed while the alloy is relatively soft, then can be heat-treated to high strengths. Heat treatment *more than triples* the strength level of this alloy.

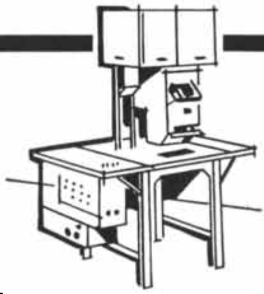
As titanium's future in our air defense grows, it is likewise proving its economic advantages in new industrial applications. Let Mallory-Sharon, technical leader in titanium, help you *design ahead* with this new metal.

MALLORY Ti SHARON

MALLORY-SHARON TITANIUM CORPORATION · NILES, OHIO

Producers of titanium and titanium alloy sheet, strip, plate, rod, bar, billets

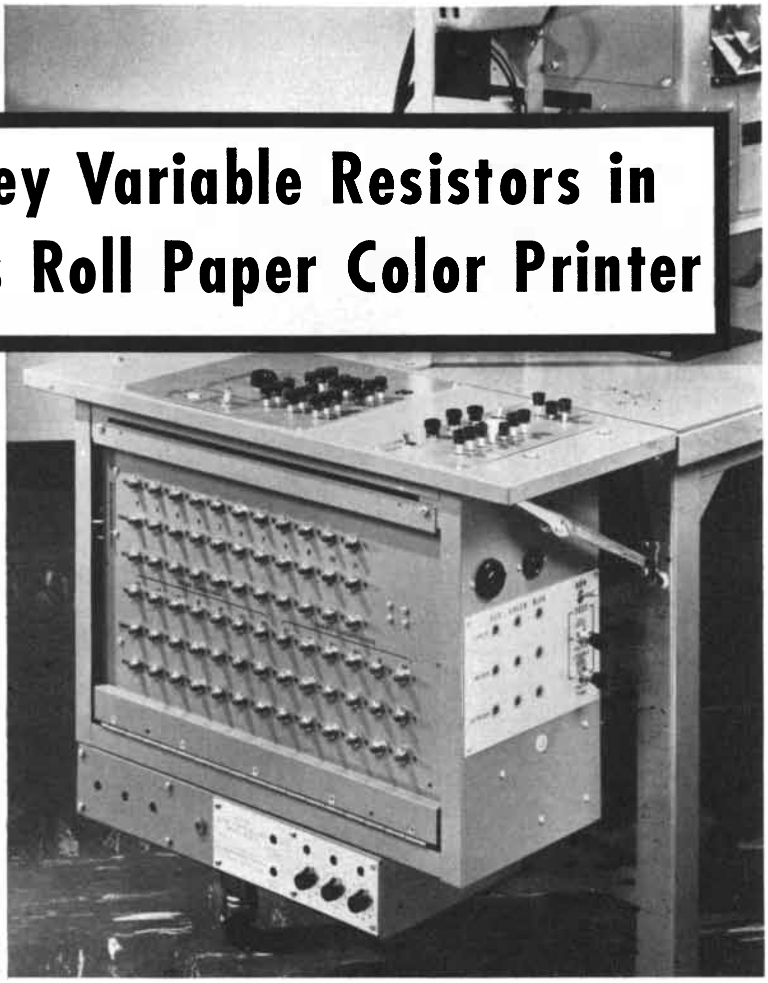
86 Allen-Bradley Variable Resistors in Eastman Kodak's Roll Paper Color Printer



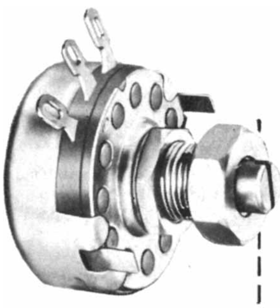
In the cycling control and timing circuits of this Eastman Kodak printer, there are actually 86 Allen-Bradley Type J variable resistors! Nine of them constitute the major controls. All the resistors are adjusted and set at Kodak.

The Allen-Bradley Type J variable resistor is hot molded with the solid resistor element being integral with the base. The reliability of the resistor makes an important contribution to the efficient operation of the printer. This is typical of the industrial use of Allen-Bradley electronic components.

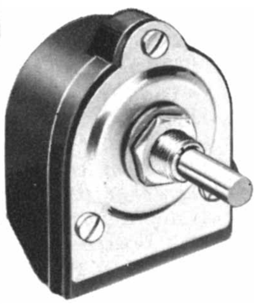
Allen-Bradley controls are available in the several basic types shown below.



Control box on the Eastman Kodak Roll Paper Color Printer. The machine makes color prints from Kodacolor negatives.



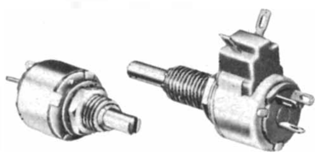
TYPE J—rated 2 watts at 70°C ambient. Total resistance values from 50 ohms to 5 megohms. Available in single, dual, and triple units with various types of adjusting shafts, and with built-in line switch.



TYPE H—rated 5 watts at 40°C ambient. Total resistance values from 50 ohms to 2.5 megohms. Good for over 100,000 cycles with no appreciable resistance change. Max. voltage 750 v, d-c.

TYPE T—rated ½ watt at 70°C ambient. Plastic cover serves as actuator, making unit extremely flat. Total resistance from 100 ohms to 5 megohms.

TYPE F—rated ¼ watt at 70°C ambient. Diameter ½". Standard tapers. Slotted shaft. Designed for printed circuits.



TYPE G—rated ½ watt at 70°C ambient. Diameter ½". Plain or lock-type bushings; plain or slotted shaft. Available with line switch (right).

A-B QUALITY

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Solvay Process
International

- *facts on food colors*
- *new aerosol mold release*
- *chromium chemical data books*

Facts on food colors

What about those headlines on food colors? And the stories that some certified food colors are toxic? Is there anything to the Food and Drug Administration's recent delisting of three previously acceptable colors?

Here are a few facts behind the headlines.

The practice of coloring food is centuries old. Though the early colors were of natural origin, they have been replaced in the coloring of many foods by superior synthetic colors — the certified "coal-tar" colors. The Food and Drug Administration has been certifying a number of these colors for use in food since the early 1900's.

You're probably aware of some of the foods commonly colored today: ice cream, soft drinks, baked goods, candies, processed cheese, gelatin desserts, orange skins, margarine, butter.

Why then have some food colors been "delisted" and why are others being considered for delisting?

The controversy centers on the meaning of a single word in the Federal Food, Drug and Cosmetic Act: "harmless."

The Food and Drug Administration's definition: incapable of producing harm in any quantity or under any circumstances.

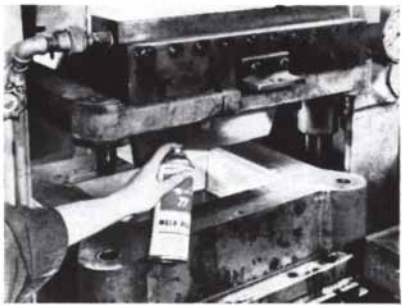
The food color industry's: incapable of producing harm under normal conditions of use.

It is the industry's view that FDA animal tests of certified colors have made use of quantities of color unrelated to — and far in excess of — quantities normally ingested by humans. A newspaper interview quoted the Commissioner of Food and Drugs as saying that he "conceded that three coal-tar dyes recently banned were harmless as used, but explained that their use was [a] technical violation of the law as now worded."

The absolute FDA standard seems to find support in the popular tendency to regard synthetics as inherently inferior to natural products. Yet, many fresh vegetables we eat every day contain small but tolerable quantities of naturally occurring poisons which, if judged as food colors are now being judged, would lead to the elimination of a large part of our vegetable diet.

What the food color industry asks is an amendment to the present law which would clearly grant power to the FDA to set quantitative limits on the use of colors in food. Such limits would safeguard public health, permit maintenance of our food color supply, and encourage research in the field.

Two articles — one supporting the industry's position, the other detailing manufacture and quality control of food colors — have been prepared by Allied's National Aniline Division, the leading food color producer. You can get them by checking the coupon at right.



Aerosol mold release

Remember the line that went, we could have some ham and eggs if we had some ham . . . and some eggs. Stretch your imagination a good deal, and it has some relevance in the business of molding.

Low-molecular weight polyethylene is a superior mold release.

There's hardly a more convenient way to dispense liquids than with an aerosol spray.

Ham and eggs: POLY-LEASE 77, a low-molecular weight polyethylene in a mixed solvent system, supplied in aerosol form. The spray's push, by the way, is from Allied's GENETRON propellants.

Here's how it works. When hot or cold mold cavities or other objects are sprayed, a smooth, relatively hard film forms quickly on the surface. This film provides efficient release with a minimum number of spray applications, resulting in faster cycle time, reduction of rejects and consequent lowering of production costs.

POLY-LEASE 77 will be of interest to molders of rubber, plastics (epoxies, polyesters, phenolics, alkyd, urea, melamine), powdered metal.

Chromium chemicals

The authoritative collection of chromium chemical technical bulletins has been published, appropriately enough, by the leading producer of chromium chemicals.

The books describe Allied's MUTUAL chromium chemicals and their applications in leather tanning, corrosion control, and anodizing of aluminum.

We'd be pleased to send either a brochure describing 49 bulletins available, or the bulletins in your field of interest.

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Please send me further information:

- ☐ Facts on food colors
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LETTERS

Sirs:

Like many meteorologists, Joanne Starr Malkus ["The Origin of Hurricanes," Scientific American, August] appears to have her head somewhat in the clouds. More and more evidence points to the fact that the secret of hurricane origin lies in the ocean water beneath the forming storm. It now appears that "hot spots" on the ocean surface "cook" the tropical atmosphere like a pancake on a griddle until a vast area of squalls is developed. How do these hot spots form? Most probably they are loops of tropical current that have become separated from the parent streams. These cut-off loops (perhaps 100 miles in diameter) radiate heat into the atmosphere as they dissipate and spread out on the ocean's surface. Once the tropical air is "boiling" in this manner, all that is needed is the passage of a pressure-lowering wave in the atmosphere to generate the spiraling winds of a hurricane.

Joseph E. O'Hare

U. S. Navy Hydrographic Office
Suitland, Md.

Sirs:

Mr. O'Hare's suggestion of a relation between hurricane formation and the existence of warmer regions in the ocean surface layers is an interesting one, and

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Now a circle 5 inches in diameter can be read to 1 second of arc . . . directly . . . with Gurley's new UNISEC®

Helping to master the minuscule

Now that the industrial micromanipulator and the binocular microscope have been drafted from the laboratory—to help master the minuscule in industry—the ever-growing emphasis is on ultra-precision.

Each day there are increased industrial demands for tolerances so close that a reading microscope is needed to observe and check them. The success of many critical operations depends upon extreme tooling accuracy. But, as allowed tolerances grow vanishingly small, the cost of attaining specified precision tends to skyrocket. So too, as any modern precisionist can tell you, do the problems and frustrations!

Tooling accuracy, of course, is founded on the flat plane, a true perpendicular to it, and a linear measurement standard. *Now, an ingenious new instrument brings optics to the aid of industrial precision at a point in tooling operations where costly error can be forestalled—in initial positioning.*

Extraordinary precision . . . with optics

A new device—called UNISEC—from W. & L. E. Gurley, makes extraordinary precision in angle reading conveniently available. It thus helps cut the costs that soar when initial inaccuracy reproduces its errors in ensuing work.

UNISEC consists of an Optical Coincidence Reading System and a Precision Glass Circle. The device actually reads the 5-inch circle to *one second of arc*—directly. It uses the principle of reading both sides of a circle at once to remove eccentric error.

Precision through image coincidence

The latest of a long Gurley family line of ultraprecision equipment, UNISEC will read the angular position of a rotatable shaft at rest *with a degree of precision obtainable otherwise only with an optical reading theodolite.* It can be attached to any stationary shaft where highly precise positioning is desired. Turning the sighting device from base point to an object indicates the amount of angle between. On a clinometer, for example, it measures deviations from the horizontal.

Readings from the optically flat crown glass circle with its 2160 graduations are viewed through a microscope eyepiece which swivels 360 degrees to allow reading from any stance. The images of graduations taken from opposite sides of the glass circle are made to coincide in the reading microscope. Movement of a deviating prism system makes this possible. Measuring the position of the deviating prism makes possible the highly accurate angular reading.

Special eyepieces and units for screened projection at high magnification may be obtained. Special Coincidence Reading Systems, using larger circles and housings, add versatility to this device. UNISEC is one of a host of products studied, developed and manufactured by Gurley for science and industry. It has been widely welcomed at a time when the amount of permissible variance from a standard has already become vanishingly small.

Gurley's 113 years of experience

During 113 years of experience in optics the Gurley group have developed and made precision instruments ranging from surveying instruments to modern hydrological, meteorological and other engineering equipment; analog-digital converters; components produced by high precision photographic methods; as well as lenses, prisms, reticles and divided circles of the highest accuracy. (Also, though commonly thought of as surveyors' tools, Gurley transits and levels perform optical tooling in aircraft jig construction and solve many other difficult industrial aligning problems.)

A bulletin illustrating the how and why of UNISEC *is yours for the asking.*

W. & L. E. GURLEY
DEPT. UNI-SA, INDUSTRIAL DIVISION
TROY, NEW YORK

one which has received considerable attention from meteorologists. Although there is not yet sufficient evidence to abandon the connection which Mr. O'Hare suggests, it is certain that it is by no means so simple as he proposes. Second, no positive evidence of the type he cites is in existence, even concerning the presence of oceanic hot spots of the scale he mentions, except in the Gulf Stream area, in which only a few, if any, hurricanes form. The studies made to date of ocean temperature anomalies and activity of a hurricane-formation area have had rather disappointing results. Smaller-scale hot spots may be important in breeding ordinary trade cumulus-cloud groups, but these form over the ocean daily, and hurricanes are so rare that many steps must intervene before their growth into the runaway cumulo-nimbi of a hurricane. Finally, the fundamental point remains: that the energy source for hurricanes lies in latent heat of water vapor. The sensible heat transport in most of the hurricane-breeding area is both small and downward, so that any simple "cooking" mechanism has been rather surely eliminated as a possibility. In the season of deep moist layer, the tropical atmospheric "gun" seems to be nearly always loaded with moisture and instability, and the right combination of triggers producing convergence appears to be required to set it off. The evidence to date suggests that these are upper-level disturbances.

JOANNE S. MALKUS

Woods Hole Oceanographic Institution
Woods Hole, Mass.

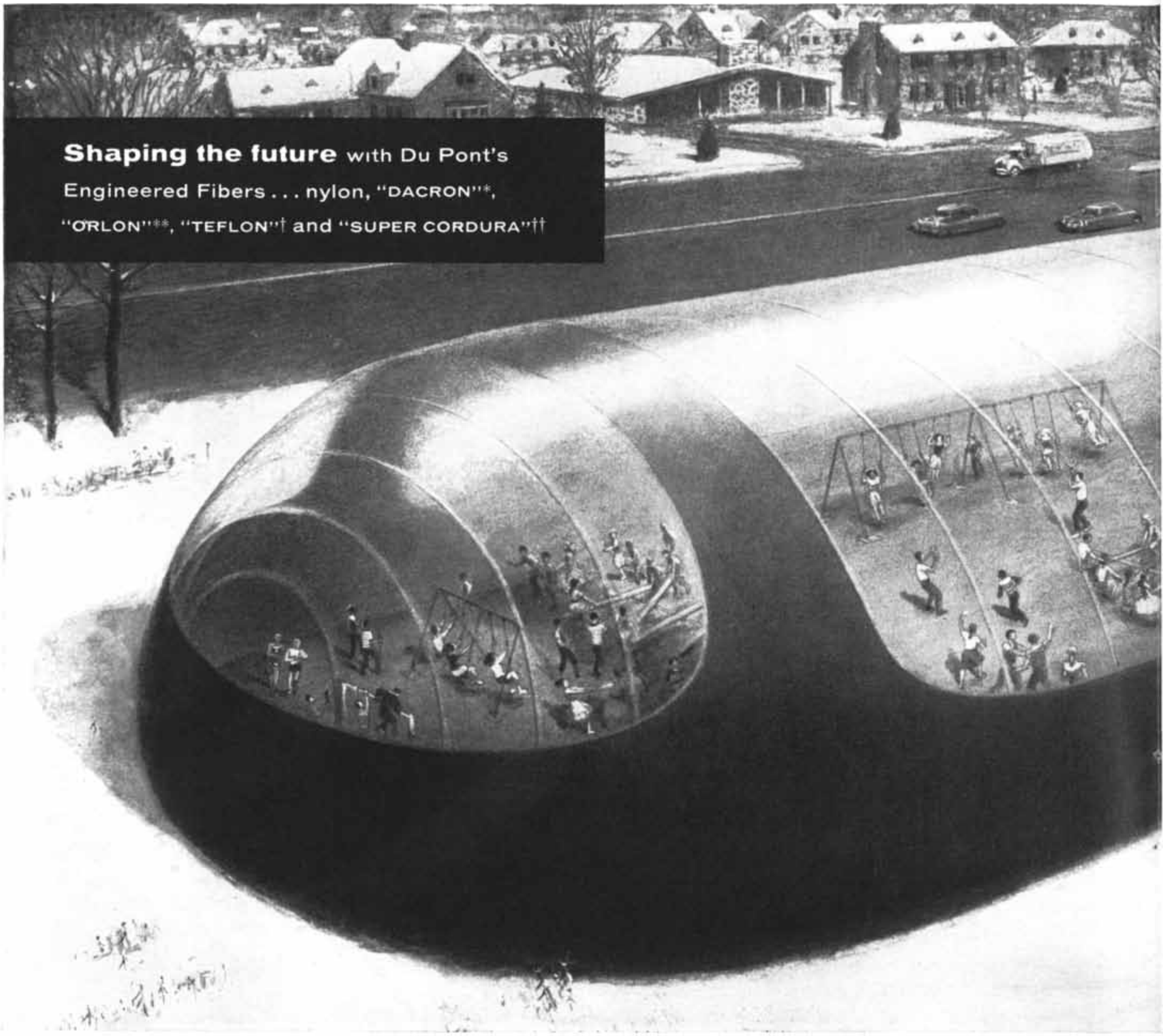
Sirs:

Allow me to put in a good word for *Hypericum perforatum* which, in your article "Weed Control by Insect" [SCIENTIFIC AMERICAN, July], is called a pest.

In northern Europe this plant is called *pericon*. It is a wildflower confined to dikes, hedges and ditches along picturesque country roads. The people certainly do not allow it to cover hundreds of thousands of acres. Far from being a pest, it is considered rather benign. The buds of the yellow flowers are picked just before they blossom, dried in attics for a few weeks and steeped in aquavit or gin to produce a beautiful deep-red cordial of delicate bouquet.

CARL F. CLAUSEN

Evanston, Ill.



TOMORROW'S ALL-WEATHER SCHOOL PLAYGROUND

. . . using the engineered properties of a Du Pont fiber

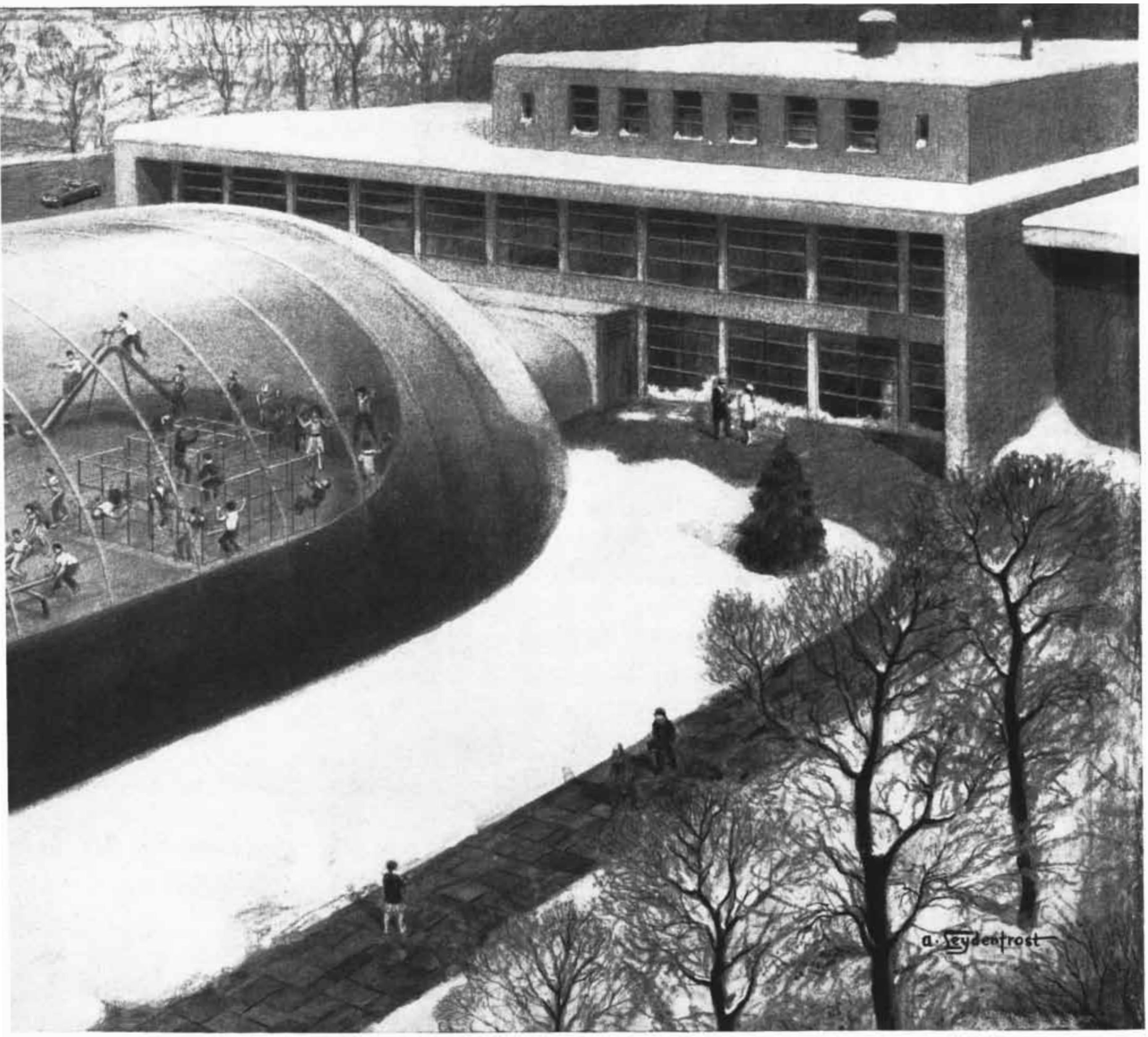
Covering large areas at low cost has plagued architects since ancient times. Inflatable structures are an ingenious answer to this long-felt want. They are made possible by tough, thin, lightweight coated nylon fabrics. The projected all-weather playground shown here is "roofed" by a transparent-topped pneumatic dome made with coated nylon fabric. It is kept inflated by pressures little higher than atmospheric, yet can withstand the buffeting of high winds.

Present uses of pneumatic structures include warehouses, hangars, fair buildings, radomes. Nylon is used because it is strong and weather-resistant, does not stiffen in severe cold, does not stretch too much, yet yields when necessary. If desired, it can be stored for long periods of time without deteriorating. Cost is about half that of conventional temporary buildings.

Nylon fibers offer many outstanding design characteristics. Weight for weight, they are stronger than steel wire. They have the best shock-absorption factor of any fiber, and their toughness provides high resistance to wear and abrasion. Nylon fabrics are transparent to high-frequency waves and are, therefore, used to make radomes. They have excellent abrasion resistance and resist rot, mildew, insects and many common chemicals.

As you can see, Du Pont nylon fibers offer a unique combination of properties. Engineers seeking design characteristics outside this range can often find them in a different Du Pont industrial fiber or combination of fibers. For example:

DO YOU KNOW that Du Pont "Dacron"* polyester fiber provides exceptionally high wet strength and high stretch resistance . . .



that it withstands oxidizing agents and bleaches? (Low-stretch cordage of "Dacron" is twice the strength of manila rope.)

DO YOU KNOW that Du Pont "Orlon"** acrylic fiber has outstanding resistance to weathering and ultraviolet light . . . produces staple which equals wool in bulking power, high thermal insulation and wrinkle resistance? (Acid-resistant clothing of "Orlon" protects workers in industry.)

DO YOU KNOW that Du Pont "Teflon"† tetrafluoroethylene fiber is virtually unaffected by the most violent corrosives known to man, can act as a dry lubricant, can be used at temperatures of 500°F. and higher? (Filter fabrics of "Teflon" defy heat and corrosive chemicals.)

Chances are that somewhere in your field of interest there is a place where Du Pont fibers can make a substantial contribution to your products. The experience, production facilities, and testing and research activities at Du Pont all combine to offer you an authoritative source of industrial textile information and development cooperation. If you're searching for the answer to a materials problem, check with Du Pont.

WRITE FOR YOUR COPY:
"DU PONT FIBERS IN INDUSTRY"

The 80 pages of this fact book are edited especially for the engineer and designer. The properties of Du Pont fibers are described in detail. Technical and performance data are presented for most basic industrial fiber applications—including fabrics, felts, laminates, etc. For your copy, write to: E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Department, 5518 Nemours Building, Wilmington 98, Delaware.

DU PONT

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

"Dacron" is Du Pont's registered trademark for its polyester fiber.
***"Orlon" is Du Pont's registered trademark for its acrylic fiber.*
†"Teflon" is Du Pont's registered trademark for its tetrafluoroethylene fiber and its fluorocarbon resins.
††"Super Cordura" is Du Pont's registered trademark for its high tenacity rayon yarn.

something of your future was on our minds yesterday

Who can gauge the portent of things like jet and rocket flight, gas turbines and guided missiles? Electronic computers and automation, television and radar? Fission products and atomic power?

Already some of them are giant industries. They affect your personal life, your business planning, your entire world outlook. Yet each would still be an improbable dream except for the electrical alloys, special steels, and other corrosion and heat-resistant and special-property metals (such as titanium and zirconium) that will do today what could not be done yesterday.

It is Allegheny Ludlum's continuing job to pioneer, research and perfect such metals—and more important, make them available in the commercial shapes, forms and sizes that you need. ● Call on us for *any* engineering assistance. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

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Take a look at the record... FOR RESEARCH REACTORS

Active since the very beginning of the civilian atomic energy program, AMF Atomics has steadily grown in stature as one of the world's leaders in the peaceful application of the atom. Within that time, AMF has built a stockpile of experience in nucleonics that is unique.

It is, today, the world's leader in the design, development and construction of research reactors. Several AMF reactors are already in operation—a number are nearing completion—and there are many others in the fabrication stage, both home and abroad. Of the pool type, heavy-water, and light-water tank types, these AMF reactors offer a maximum of economy as well as inherently safe design and great experimental flexibility.

In the field of training reactors, AMF, working together with Dr. Zinn and GNEC, has developed an advanced version of the Argonaut reactor. Called the "Educator", it offers universities everywhere a thorough yet economically practical training facility.

In power and marine propulsion, too, AMF Atomics has played a leading role, with several variations of a closed-cycle, boiling-water reactor now in the process of development for both government and industry.

Aside from its reactor design and construction activities, AMF Atomics has also taken the lead in development of reactor control-rod drives, remote material-handling equipment, and a number of other specialized nuclear devices. Such AMF equipment is now in actual service at government and industrial installations in many parts of the world.

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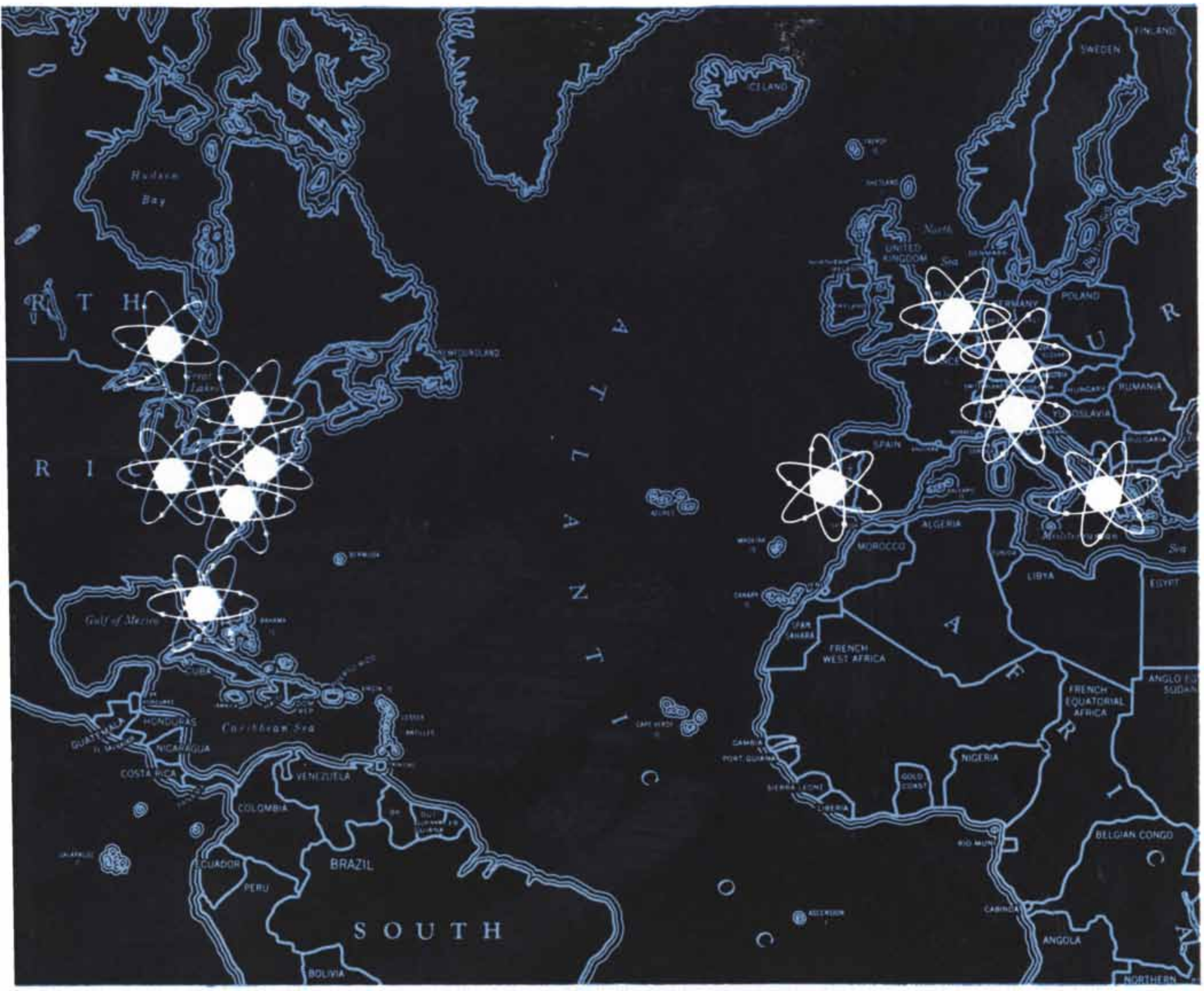


—LOOK TO AMF ATOMICS

AMF RESEARCH REACTOR PROJECTS

CUSTOMER	REACTOR TYPE	POWER LEVEL
*Battelle Memorial Institute, Columbus, Ohio	Pool-Type	1000 KW
Industrial Reactor Laboratories, Inc., Plainsboro, N. J.	Pool-Type	5000 KW
University of Buffalo, Buffalo, New York	Pool-Type	1000 KW
*Technical University of Munich, Munich, Germany	Pool-Type	1000 KW
*International Exhibition, Het Atoom, Amsterdam, Netherlands	Tank-Type, Demonstration	10 KW
Japanese Atomic Energy Research Institute, Tokai-Mura, Japan	Heavy Water, Tank-Type	10,000 KW
McMaster University, Hamilton, Ontario	Pool-Type	1000 KW
Greek Atomic Energy Commission, Aghia Paraskevi, Greece	Pool-Type	1000 KW
Union Carbide Corp., Sterling Forest, New York	Pool-Type	5000 KW
Societa Ricerche Impianti Nucleari, Milan, Italy	Pool-Type	1000 KW
AMF-GNE Educator, University of Florida, Gainesville, Florida	Training	10 KW
Portuguese AEC, Lisbon, Portugal	Pool-Type	1000 KW

*In operation

AMF ATOMICS

AMF ATOMICS
A Division of AMERICAN MACHINE & FOUNDRY COMPANY
AMF Building • 261 Madison Ave. • New York 16, N. Y.

50 AND 100 YEARS AGO

SCIENTIFIC AMERICAN

NOVEMBER, 1907: "'The determination of the atomic weight of radium which I published in 1902 was carried out with 9 centigrammes of radium chloride. Fresh processes having since then furnished some decigrammes of practically pure chloride, I have subjected them to purification, which enabled me to obtain 4 decigrammes of perfectly pure radium chloride, and to determine the atomic weight of radium under far better conditions than before. The weighings were performed with a Curie aperiodic balance which is accurate to one tenth of a milligram, and takes only ten seconds to reach its position of equilibrium. I conclude from these experiments that the atomic weight of radium is 226.2 (Ag = 107.8, Cl = 35.4) with a probable error of less than half a unit.'—*Mme. Curie*"

"A report that Count Zeppelin's airship has been sold to the German Government is denied by the Count himself. He states, however, that the balloon shed has been sold to the Government, to be used as a harbor for military airships. It is reported that the German Government has commissioned Count Zeppelin to build an airship capable of carrying 18 passengers and having motors of 285 horse-power. The Germans have advanced to the stage where they now have special field guns for shooting directly upward at balloons or airships. The German Emperor's optimistic view of aeronautical matters augurs well for the success of the Wright brothers in disposing of their aeroplane to the German Government. Our own Government should take steps immediately to forestall any foreign nation's getting this invention."

"In presenting the SCIENTIFIC AMERICAN Flying Machine Trophy to the Aero Club of America, the publishers have recognized that the conquest of the air may not come through dirigible gas bags but through the perfection of aeroplanes, machines that are heavier than air. The cup is offered for competition among

A GREAT AMPLIFIER TUBE IS PERFECTED FOR TELEPHONY

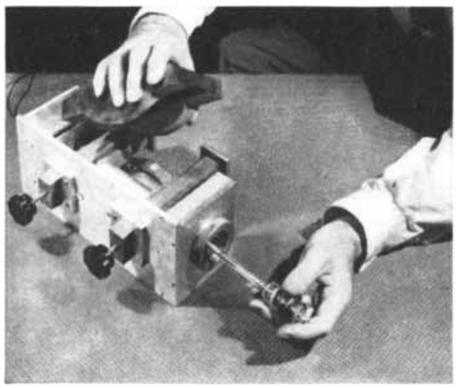
A new transcontinental microwave system capable of carrying four times as much information as any previous microwave system is under development at Bell Laboratories. A master key to this development is a new traveling-wave tube of large frequency bandwidth.

The traveling-wave amplifying principle was discovered in England by Dr. Rudolf Kompfner, who is now at Bell Laboratories; the fundamental theory was largely developed by Labs scientist Dr. John Pierce. Subsequently the tube has been utilized in various ways both here and abroad. At the Laboratories it has been perfected to meet the exacting performance standards of long distance telephony. And now for the first time a traveling-wave tube will go into large-scale production for use in our nation's telephone systems.

The new amplifier's tremendous bandwidth greatly simplifies the practical problem of operating and maintaining microwave communications. For example, in the proposed transcontinental system, as many as 16 different one-way radio channels will be used to transmit a capacity load of more than 11,000 conversations or 12 television programs and 2500 conversations. Formerly it would have been necessary to tune several amplifier tubes to match each channel. In contrast, a single traveling-wave tube can supply all the amplification needed for a channel. Tubes can be interchanged with only very minor adjustments.

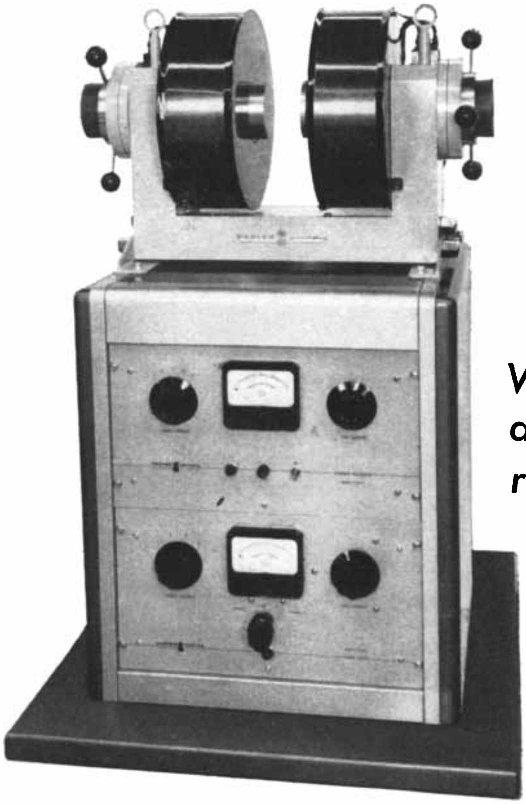
The new amplifier is another example of how Bell Laboratories research creates new devices and new systems for telephony.

Left: A traveling-wave tube. *Right:* Tube being placed in position between the permanent magnets which focus the electron beam. The tube supplies uniform and distortionless amplification of FM signals over a 500 Mc band. It will be used to deliver an output of five watts.



BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



the heavier-than-air machines and, year by year, as aeroplanes are developed, the conditions governing the contest will be readjusted. The cup stands 32 inches high and is a magnificent trophy of wrought silver mounted on a pedestal of onyx. It is of American manufacture, and is valued at $2,500."

"In a paper read before the Academy of Sciences on Prof. Bordas's discoveries, based on the observation of the late Prof. Curie that glass acted upon by radium acquires a magnificent azure tint, it was stated that Prof. Bordas placed a small quantity of corundum in contact with radium for a period of a month. At the end of the time, he found that uncolored corundum acquired the yellow of the topaz, blue corundum became an emerald-green color, while violet corundum took a sapphire blue. Corundum is an oxide of aluminum, and when colored is known as sapphire, Oriental ruby, Oriental topaz and Oriental amethyst, according to the tint. Upon repeating the experiment with various shades of the mineral, one that became ruby-colored was appraised by a jeweler at from $100 to $160 a carat."

"The U. S. Government spends $1,500,000 a year on its weather bureau, which is more money than all the governments of Europe combined spend for similar service. It has a staff of many hundred skilled experts and trained observers, who in all parts of the country are constantly on the watch to see what the heavens will bring forth. Recently it has been estimated that on an average the people of the U. S. save $30,000,000 every year because of their weather service. As the people contribute $1,500,000 every year to its support, this means that they get annually a dividend of 2,000 per cent on the investment."

SCIENTIFIC AMERICAN

NOVEMBER, 1857: "Captain Paulding, who was sent out by our Government to examine into the feasibility of a canal across the Isthmus of Darien, has recently made a report (to the Navy Department) which appears to be highly favorable to the enterprise. On the whole route most, if not all, of the hills through which the canal would pass would be required for embankments over the plains and swamps. The length from shore to shore is 45¾ miles. The

U. S. Air Force Photo

"Moby Dick" high altitude research balloon being launched from a special protective trailer at AFMDC. This balloon carries instruments up many miles. Small sized balloon alongside provides launch crew with information on surface wind velocity and direction.

SCIENTISTS ARE OPENING DOOR TO OUTER SPACE AT AIR FORCE MISSILE DEVELOPMENT CENTER

Almost 4000 square miles of desert comprise the rocket and missile test range at the Air Force Missile Development Center at Holloman AFB, near Alamogordo, New Mexico. In another sense, the test range is limitless, extending upwards to the reaches of space. It is one of AFMDC's missions to extend our knowledge of these extreme altitudes, to prepare man for life above the atmosphere—this in addition to extensive development and test work with missiles and similar weapons.

AFMDC is one of the centers of the Air Research and Development Command. In addition to its basic mission, it works with other ARDC centers, government agencies and industrial contractors in electronics, weapons, and upper atmosphere research.

Undergoing tests at AFMDC are surface-to-air and air-to-air supersonic missiles for intercepting hostile aircraft; air-to-surface missiles; surface-to-surface guided missiles, and many similar weapons.

Instruments and biological specimens are carried skyward in experimental rockets and balloons at AFMDC for studies of radio wave propagation at high frequencies; investigation of electrical characteristics of the ionosphere and composition and acoustical properties of upper atmospheres; studies of the intensity of radiation from the sun, from nocturnal space, and from the earth; studies of high altitude winds, and studies of the biological effects of cosmic radiation and reduced gravity. This high altitude research is useful in the development of missiles, aircraft, and associated equipment.

Gleaning this useful information is a long and difficult business which draws upon the skills of thousands of civilian and military engineers and their many counterparts in private industry. The efforts of this small army of technicians will not only determine America's ability to meet potential aggressors, but bring ever closer the coming Age of Space.

This is one of a series of ads on the technical activities of the Department of Defense.

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prism of water is to be 150 feet wide at the bottom, 270 feet wide at the surface, and 31 feet deep; the locks to be 400 feet in clear length of chamber, and 90 feet in clear width. The summit level will be 150 feet above mean tide of the Atlantic and Pacific oceans. The summit cut will be about four miles long. The deepest cutting on this level will be 136 feet, and the average depth of the cut will be 49 feet."

"Under favorable circumstances the wind is sometimes a better locomotor than steam. A late passage of the ship *Lord Raglan* from England to India, with troops, is a good illustration. This vessel, propelled only by canvas, made the passage to Bombay in 12 days less time than the royal mail steamer. The season was the most favorable for prosperous breezes. In the fall of the year it is said that the winds are contrary, and that the steamers can go in half the time occupied by the fleetest sailing vessels."

"The amount expended by American travelers in Europe is estimated at $10,000,000 annually. This is no small amount to be emptied into the pockets of European hotel keepers and railway companies."

"John Lane, Senr., the inventor of the steel plow, died at his residence in Lockport, Ill., on the 5th of October, after a brief illness. Mr. Lane emigrated to Illinois in 1833, and in that year invented the steel plow, which is now in general use throughout the West."

"*The Atlantic Monthly* is the title of a new magazine just commenced by the eminent publishing house of Phillips, Sampson & Co., of Boston, Mass. The first number contains ably written articles superior, in fact, to the ordinary run of contributions to magazine literature. In reference to the merits of articles every reader must judge for himself."

"On the morning of October 3rd an attempt was made to launch the *Great Eastern* into the river Thames, London. It was the first and only trial, and the effort to move her beyond a few feet totally failed, and the gigantic vessel, which ere this should have been a 'monster of the deep,' remains as firm, if not firmer, than ever upon the river's bank. For another month at least, if not for a longer period, the launch has been postponed, and the 2d of December has been fixed as the earliest period on which the next effort can be made."

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For example, the IBM 610 features single-instruction square root, simultaneous division and multiplication, highly flexible tape units, and requires only a minimum of instruction to learn to operate the machine. The 610 has been designed with reliability as a prime consideration—built-in self-checking provides assurance of accurate results.

Quickly, conveniently, and economically—the new 610 Auto-Point Computer helps you solve a wide variety of engineering and scientific problems. And this mobile desk-side computer does not require air conditioning—another cost-saving advantage. For complete details, simply call your local IBM representative.

A few applications of the 610 Auto-Point Computer

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•

Formulae Evaluations

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Calculation of Aeroelasticity

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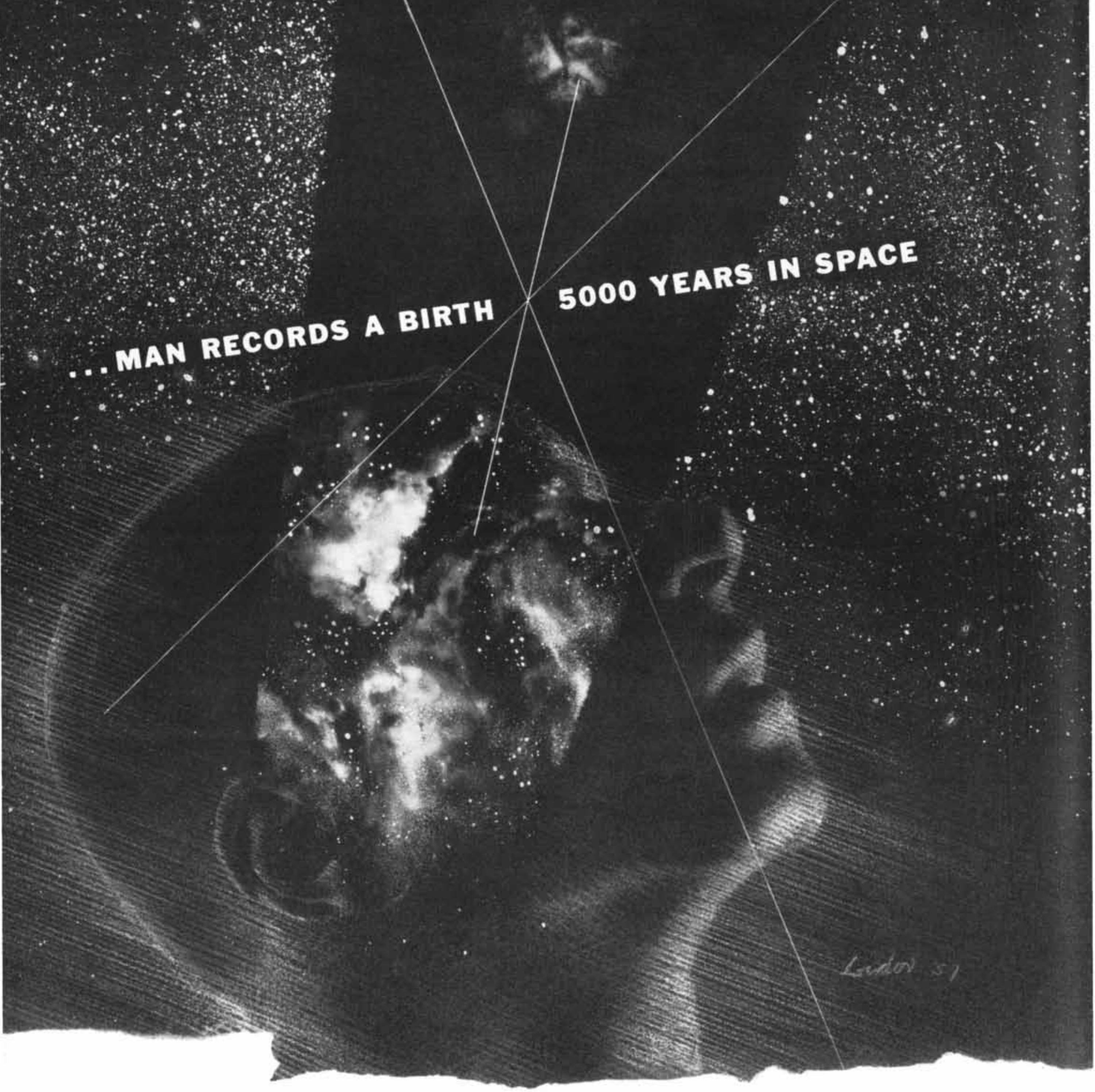
Data Reduction

IBM TIME EQUIPMENT

TIME EQUIPMENT • DATA PROCESSING • ELECTRIC TYPEWRITERS • MILITARY PRODUCTS



Five thousand light years away, in one of the spiral arms of our galaxy, clouds of cosmic dust are condensing to form new stars. Through optics of the great Baker-Schmidt ADH telescope, designed and built by Perkin-Elmer, astronomers have been able to obtain the first photographic proof of the process by which these stars are being born.

Perkin-Elmer has been assisting at another birth, too—the birth of a new age of instrumentation. Through a unique combination of optical, mechanical and electronic skills, Perkin-Elmer is pioneering in the development and manufacture of new infrared spectrometers for chemical analysis, instruments for process control, automatic zoom lenses for industrial television, special optical and infrared systems for a growing list of industrial and military applications. For information on Perkin-Elmer's products and facilities, write us at:

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ND FACTS

New Departure split inner ring bearings are made in a range of sizes with and without inner ring puller grooves indicated in the exploded view above.

LOADS GET A LIFT with THIS BALL BEARING

Whether in helicopters or jet engines, New Departure ball bearings of split inner ring type provide very high load capacity. That's because the separable rings permit high race shoulders and a greater number of balls of large size.

These split inner ring *ball* bearings not only carry heavy thrust loads in either direction in addition to radial loads (with thrust predominant), but they have important application advantages.

Since both the inner rings and separator-ball assembly are removable from the outer ring as individual parts, the bearings are easily inspected or cleaned. In addition, installation is greatly facilitated.

Send for Folder TB listing sizes.

GM FORWARD FROM FIFTY

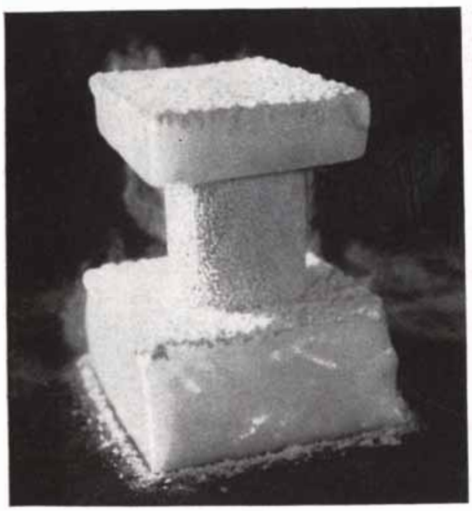
NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

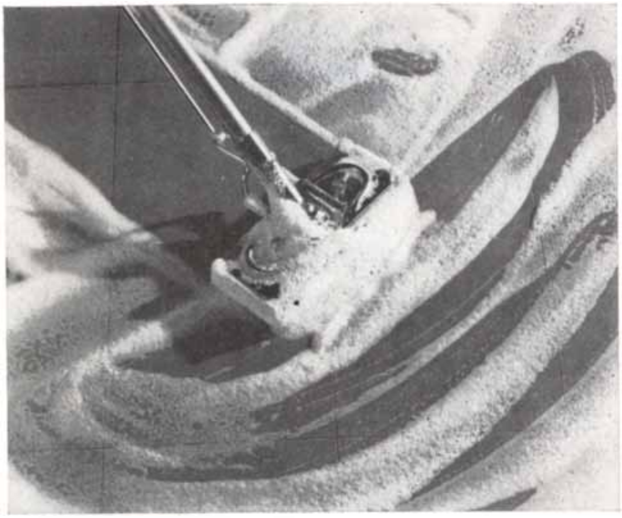
NOTHING ROLLS LIKE A BALL

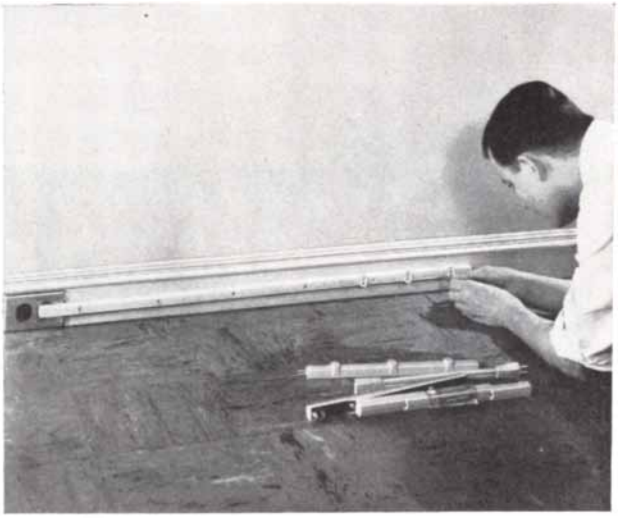
Life on the Chemical Newsfront

FIFTY PUREBRED HEIFERS are offered in a current Cyanamid program to help improve the nation's dairy herds. Any dairy farmer can participate and if he is one of the winners he will receive a calf of his own breed choice. The program, which ends January 31, 1958, is part of a promotion for AUREOMYCIN® *chlortetracycline* mastitis treatment—an important factor in maintaining dairy herd health. This is one of many chemicals and drugs offered for farm and home use by Cyanamid's recently formed Farm and Home Division.



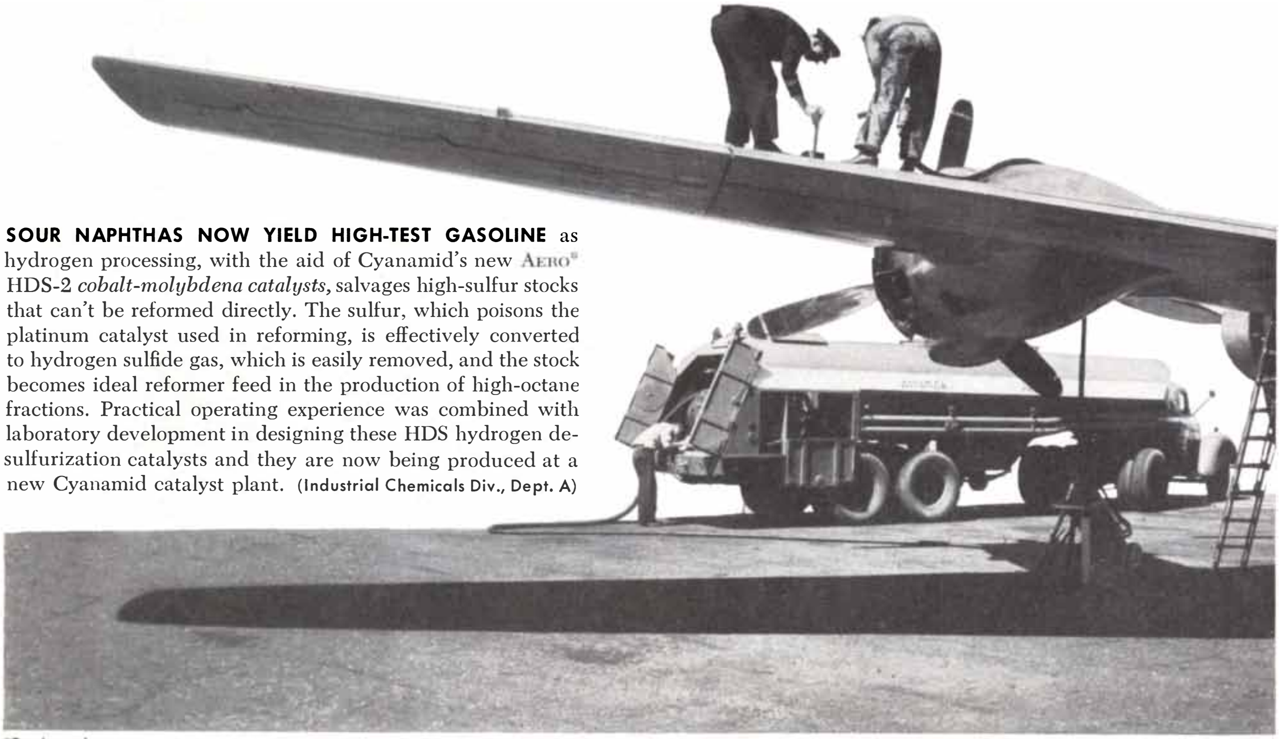
FREEZE-THAW STABILITY IS ADDED to vinyl latices prepared with PAM *polyacrylamide* as the protective colloid. A water-soluble polymer, PAM protects latex particle size and dispersion through multiple freeze-thaw cycles, keeps viscosity stable through a range of application conditions and provides excellent salt tolerance where required. The improved storage characteristics of dispersions stabilized with PAM will mean wider application possibilities for paints, adhesives and other vinyl latex products. (New Product Development Department, Dept. A)





RED PIGMENTS NOW STAY RED in vinyl floor tile in spite of exposure to acids, alkalis and harsh cleaning methods. The pigment is Clarion Red 20-7150, a vivid red "on the yellow side" that was particularly designed to withstand the attack of household chemicals. As a result, Clarion Red 20-7150 is finding application in a wide range of plastic products where bright permanent reds are called for. **(Pigments Division)**

RELIEF FROM THE "WIRE JUNGLE" is provided by the new Snapit Inter-Link system made by Cable Electric Products Inc. Molded of BEETLE® *urea molding compound,* these interlocking units provide low-cost, easily installed electrical outlets that have Underwriters Laboratories' approval and meet building codes. The strength and excellent insulating properties of BEETLE assure safe, dependable service. **(Plastics and Resins Division)**



SOUR NAPHTHAS NOW YIELD HIGH-TEST GASOLINE as hydrogen processing, with the aid of Cyanamid's new AERO® HDS-2 *cobalt-molybdena catalysts,* salvages high-sulfur stocks that can't be reformed directly. The sulfur, which poisons the platinum catalyst used in reforming, is effectively converted to hydrogen sulfide gas, which is easily removed, and the stock becomes ideal reformer feed in the production of high-octane fractions. Practical operating experience was combined with laboratory development in designing these HDS hydrogen desulfurization catalysts and they are now being produced at a new Cyanamid catalyst plant. **(Industrial Chemicals Div., Dept. A)**

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Tomorrow . . . vehicles at sea, in the air, and out in space will be guided by inertial navigation systems—systems that will lean heavily on contributions of the American Bosch Arma Corporation through its ARMA Division. For ARMA is an acknowledged leader in inertial navigation, as shown by the selection of ARMA to design and produce the guidance system for Titan: the newest intercontinental ballistic missile. ARMA . . . Garden City, N. Y. A Division of American Bosch Arma Corporation.

There are unlimited employment opportunities in inertial navigation at ARMA.

AMERICAN BOSCH ARMA CORPORATION

THE AUTHORS

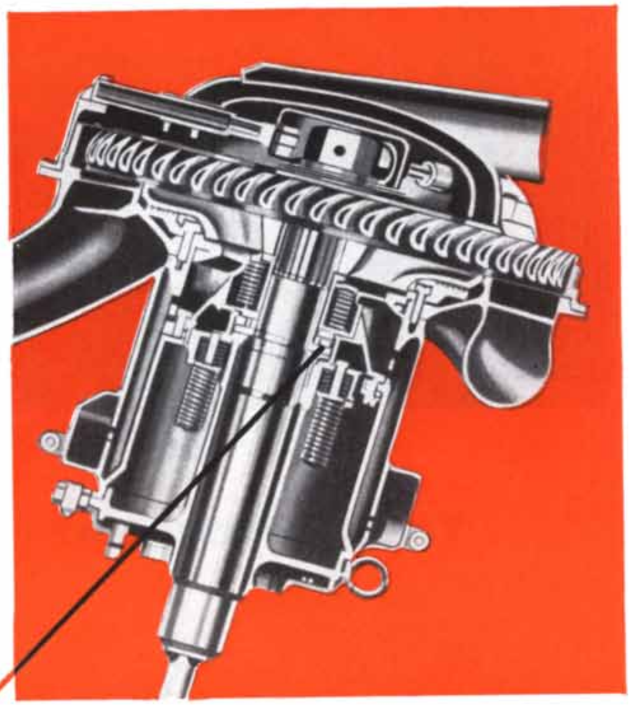
CHESTER I. BARNARD ("A National Science Policy") is a former president of the Rockefeller Foundation (1948-1952) and chairman of the National Science Foundation (1952-1954). Born in Malden, Mass., in 1886, he left Harvard College while still an undergraduate in order to become first a statistician and then an engineer with the American Telephone and Telegraph Company. From 1927 to 1948 he was president of the New Jersey Bell Telephone Company. During World War II Barnard was president of U.S.O., Inc., and director of the National War Fund, for which services he was honored with the Meritorious Civilian Service Award of the U. S. Navy and the President's Medal for Merit. He is the author of *The Functions of the Executive* and *Organization and Management.*

ANTON F. BRUUN ("Animals of the Abyss") was leader of the round-the-world expedition of the Danish oceanographic vessel *Galathea,* during which he and his colleagues gathered much of the information on which his article is based. The cruise of the *Galathea* might never have come about had not Bruun, as a five-year-old child on a farm in Denmark, contracted poliomyelitis. Judging that he would never be strong enough for agricultural work, the Bruuns sold their farm and bought another near a preparatory school, at which they hoped their son would learn to live by his wits. Bruun avidly collected butterflies, beetles, fossils, minerals, cactus plants and tropical birds and fishes. By his second year at the University of Copenhagen, he had given up his childhood ambition of becoming a schoolteacher and begun a career of zoological research. In May, 1923, he embarked on the first of several cruises on the Danish fisheries research vessel *Dana.* The *Dana* cruised around the world in 1928-1930; it was on this trip that Bruun and S. Greve, a young naval lieutenant, first conceived of an expedition of their own. After 20 years of hoping and planning, their ambition was finally realized in October, 1950, when the *Galathea* set sail with Bruun as scientific leader and Greve as skipper. Bruun, who is married and has one child, is lecturer in oceanology at the University of Copenhagen and curator of mollusks at the University's Zoological Museum. Much interested in the prospects

GRAPHITAR® OIL SEALS PLAY IMPORTANT PART IN DEPENDABLE PERFORMANCE OF NEW POWERFUL CURTISS-WRIGHT TURBO COMPOUND ENGINES

Increased demand for faster non-stop service has placed great demands on the engines that power modern airliners. Helping to meet this need is the powerful EA Series Turbo Compound engines built by the Wright Aeronautical Division of the Curtiss-Wright Corporation, Wood-Ridge, New Jersey. In each of these 18-cylinder giant engines, 3 GRAPHITAR oil seals play an important part in maintaining the dependability, efficiency and power. Three power-recovery units are employed on the Turbo Compound to utilize normally wasted exhaust gases and provide still additional thrust. The GRAPHITAR seals are used on the turbine shaft in each of these units and must withstand continuous high speeds and high temperatures. These seals prevent hot gases from reaching the shaft bearings and carbonizing the lubricant. Low coefficient of friction, and the excellent wear and sealing properties of GRAPHITAR make it ideally suited for this demanding installation.

Compacted under extreme pressure, and fused at heats to 4500° F., GRAPHITAR can be formed into relatively complex shapes, ground to tolerances as close as .0005″. Since it is entirely self-lubricating, GRAPHITAR can be used where only steam or water are present. GRAPHITAR is lightweight, durable, chemically inert and virtually unaffected by extremes of vibration, pressure, or temperature.



Get the fact-filled GRAPHITAR engineering Bulletin No. 20. Write today for your copy. If you have design questions on problems, our engineering staff will be happy to assist you in any way possible.

R-248-1

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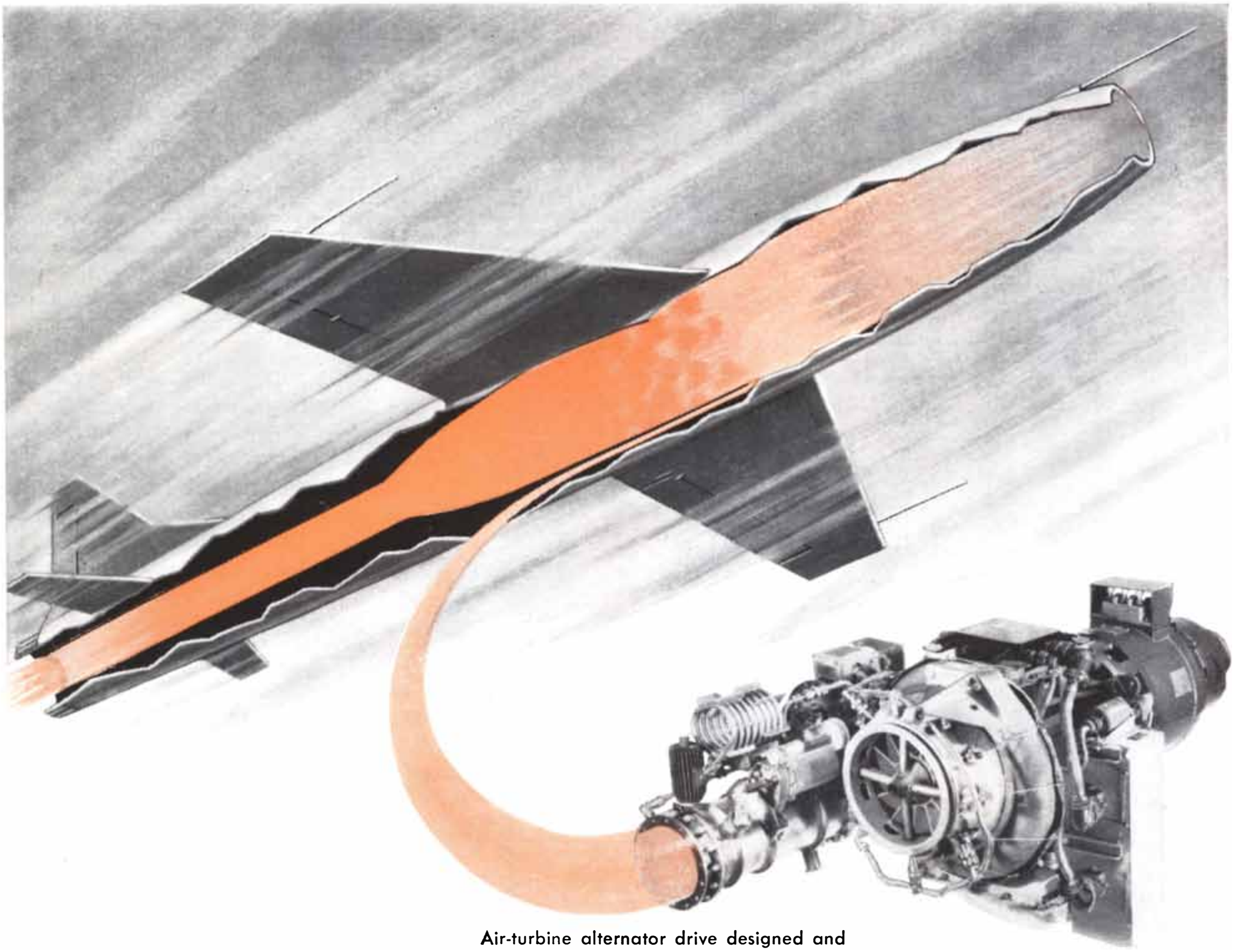
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES for international cooperation in marine studies, he serves on the oceanographic committees of UNESCO and the International Council of Scientific Unions.

RALPH S. SOLECKI ("Shanidar Cave") is a graduate student at Columbia University who has organized and directed three archaeological expeditions to Iraq. He is also associate curator of archaeology in the Smithsonian Institution, with which he has been connected since 1948. Solecki has done research for the Smithsonian in West Virginia, the Great Basin area and the arctic slope of Alaska. His article entitled "How Man Came to North America" appeared in SCIENTIFIC AMERICAN for January, 1951.

GEORGE W. GRAY (" 'The Organizer' ") has contributed nearly a score of articles to SCIENTIFIC AMERICAN, the most recent being "The Lamont Geological Observatory" in the issue of December, 1956. A member of the staff of the Rockefeller Foundation for many years, he has recently retired.

B. T. MATTHIAS ("Superconductivity") is a member of the technical staff of Bell Telephone Laboratories at Murray Hill, N.J. He was born in Germany, studied physics at the University of Rome and spent the years of World War II in Switzerland, where in 1943 he earned a Ph.D. from the Federal Institute of Technology in Zurich. Until 1947 he worked as a scientific collaborator of the Federal Institute. He then came to the U. S. to join the staff of the Division of Industrial Cooperation of the Massachusetts Institute of Technology. Now a naturalized citizen of the U. S., Matthias has been with the Bell Laboratories since 1948, except for a two-year period during which he taught physics at the University of Chicago.

WILLIAM A. WIMSATT ("Bats") is a Cornell-educated histologist who has been professor of zoology at Cornell University since 1950. He is currently acting chairman of Cornell's zoology department. Wimsatt is also a research collaborator in the biology department of Brookhaven National Laboratory. "My preoccupation with 'wild' mammals," he writes, "rather than with the usual laboratory and domesticated species has amused some of my colleagues, but my reasons are, I think, sound. Like all biologists, I am interested in fundamental problems, but I am especially interested in differences between ani-



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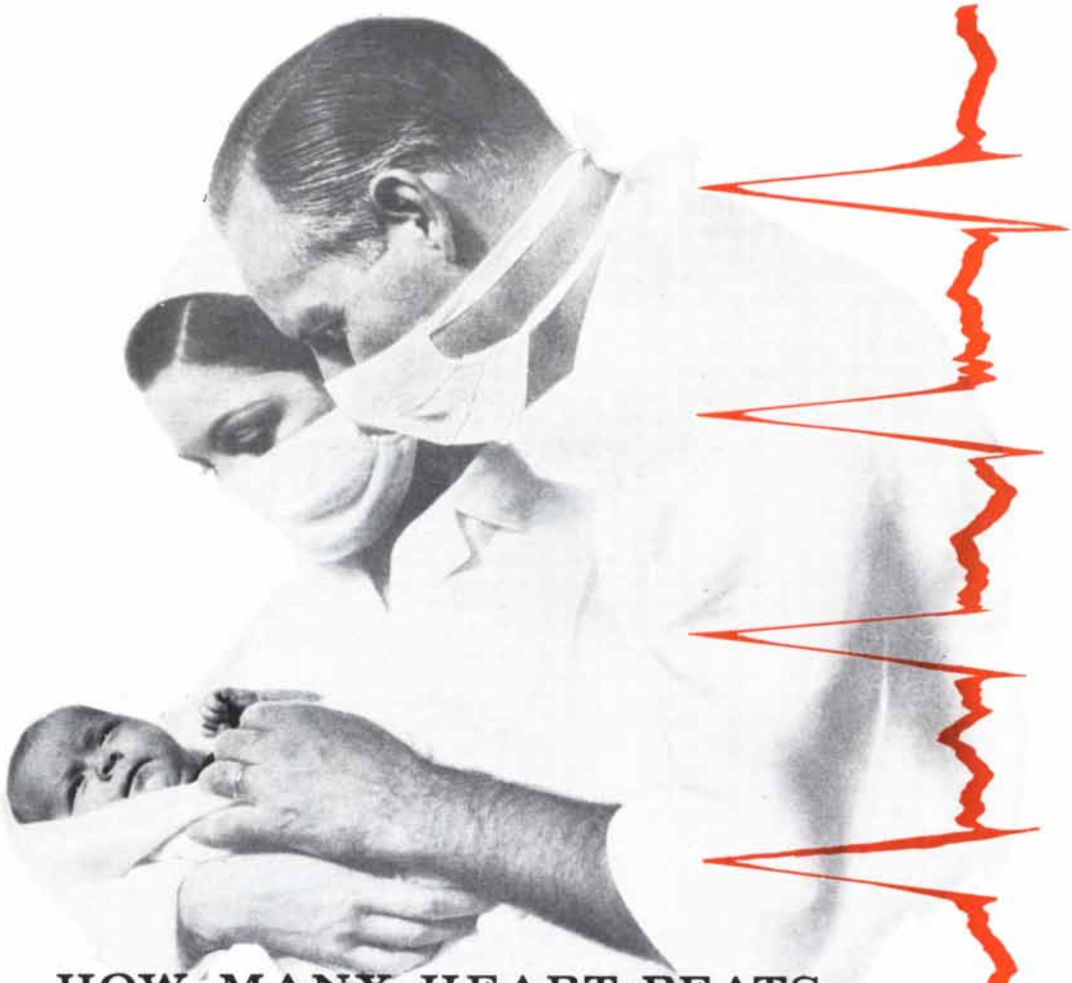
mals, particularly the specializations by which they have become adapted to different ways of life." Wimsatt took to studying bats because they were little known but easy to catch. He feels that bat-hunting has provided him with many valued human contacts as well as exposing him to beautiful cave scenery. The father of five children, he is currently building a log-cabin cottage near Ithaca, N. Y. The rest of his spare time is taken up by big game hunting with bow and arrow: in nine years he has bagged five deer.

JOHN D. ROBERTS ("Organic Chemical Reactions") is professor of organic chemistry at the California Institute of Technology. Born in Los Angeles, he attended the University of California at Los Angeles and received his Ph.D. there in 1945. He then did research at Harvard University as a National Research Council postdoctoral fellow, and became an instructor (ultimately associate professor of chemistry) at the Massachusetts Institute of Technology. A Guggenheim Fellowship took Roberts to Cal Tech in 1952, and he was appointed professor in the following year. Roberts has received a number of honors in chemistry, most recently the Harrison Howe award.

JOHN COHEN ("Subjective Probability") is a mathematically-minded professor of psychology in the University of Manchester. He received his training at University College London, where from 1933 to 1940 he did research under Cyril Burt on the application of factor analysis to human intelligence, physique and temperament. A resourceful experimentalist, Cohen has interests in psychology which are anything but narrowly technical. He collaborated with R. M. W. Travers and R. B. Cattell on works called *Human Affairs* and *Educating for Democracy*. World War II and its aftermath provided Cohen with many opportunities to apply statistical methods to social questions. For UNESCO he studied the tensions arising at international congresses, and for the British Government he reported on the usefulness of psychologists and psychiatrists in the services and the proper allocation of nurses. Later, studying the distribution of personnel in various professions, he discovered that Britain's seventh largest industry is gambling, employing more than 300,000 persons with 10 million customers. Cohen since then has delved deeply into man's gaming instinct, and with C. E. M. Hansel he wrote a book entitled *Risk and Gambling*.



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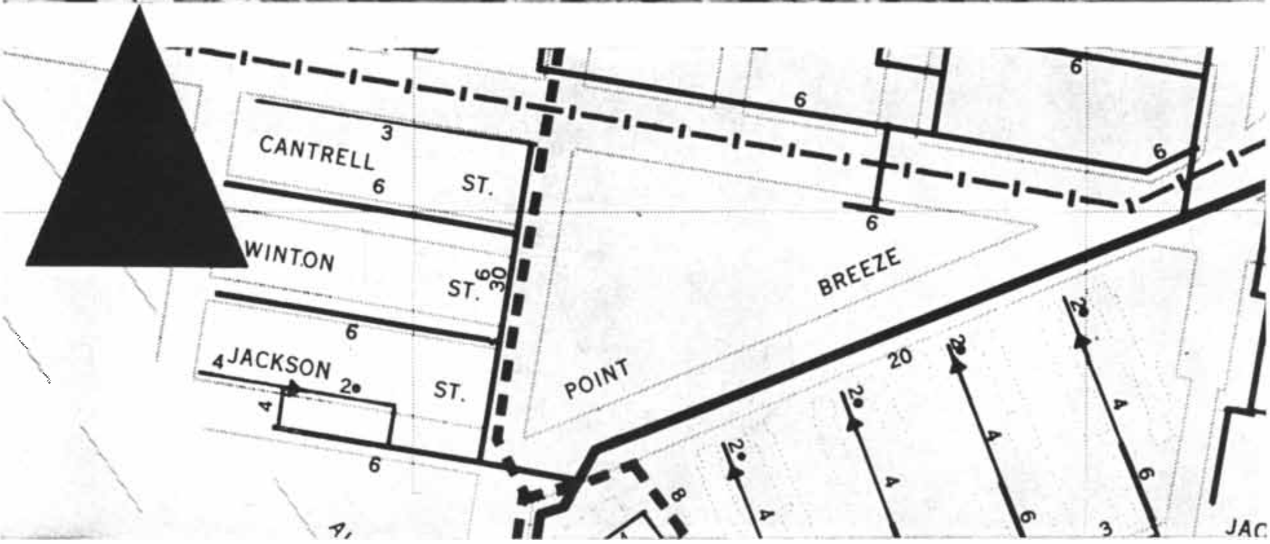

Photograph and *Map* courtesy Philadelphia Gas Works

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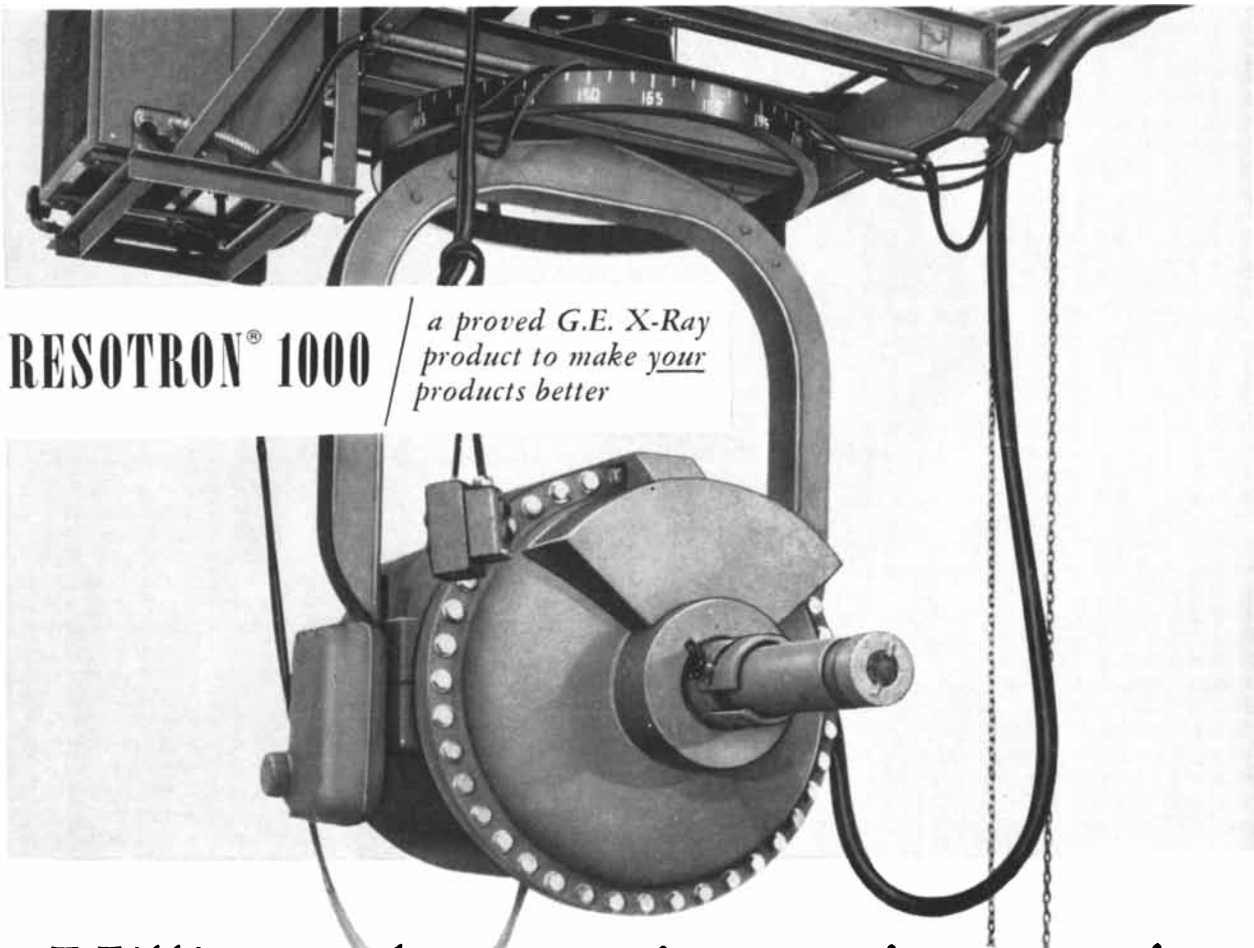

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A National Science Policy

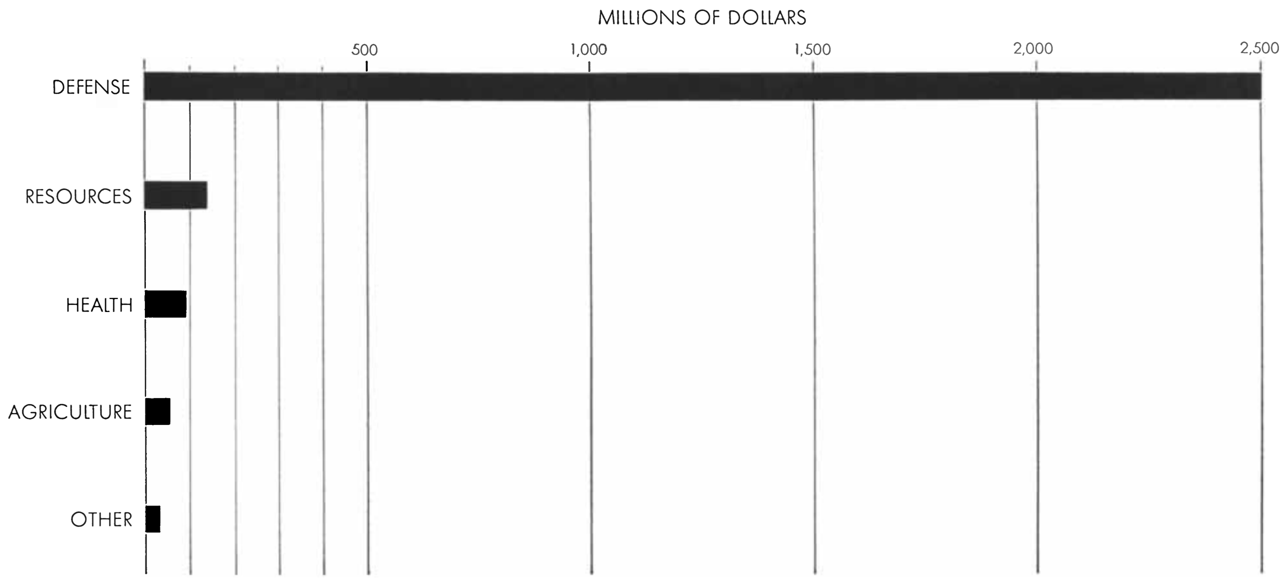
A report to the public from the National Science Foundation shows basic research needs greater public support. It now gets less than 10 per cent of $5,400 million spent for research and development

by Chester I. Barnard

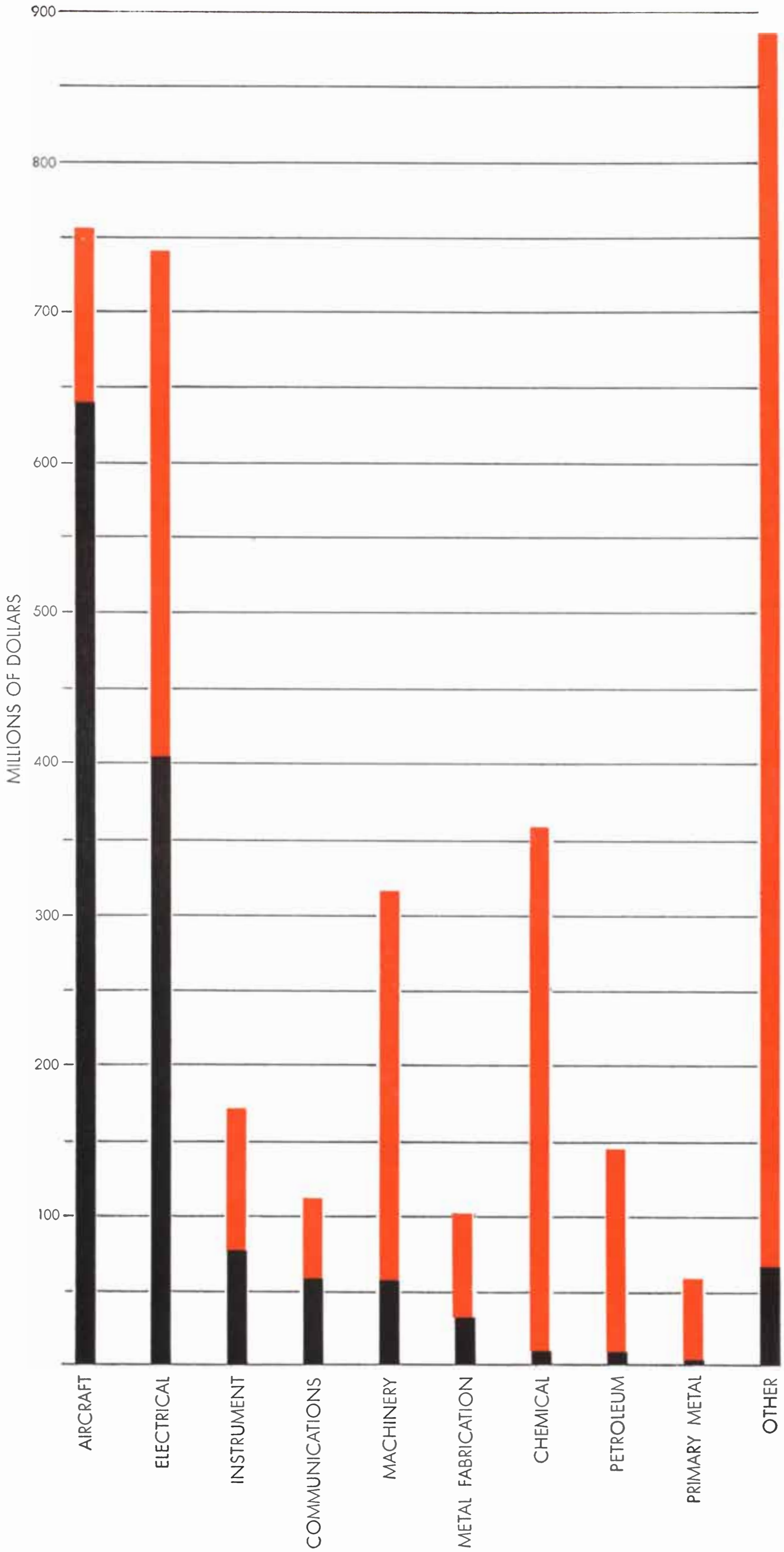
There was a time in the not-distant past when science was regarded as primarily a branch of learning, an enterprise of university professors. Like the arts and letters, it depended for support on the tuition fees of students and the gifts of benefactors. But the great harvest of practical results from science in the past two decades has radically altered the environment of science in this country. Government and industry are appropriating astronomical sums of money to research and development each year. Public officials and businessmen have come to see that the investment of manpower and resources in the advance of scientific knowledge will ultimately pay in practical application. Science is now established in the public mind as a wellspring of national security and prosperity.

In this new climate how does science fare? Is its public support as wise as it is apparently generous? Do our policy-makers distinguish between research that advances knowledge and the research projects that yield immediate and spectacular technological results? Can science successfully assert its own aims and objectives against the pressing demands of the national defense and the general welfare?

An occasion for reflection on such questions is provided by the publication of a report to the public on the state of science by the National Science Foundation. The report, called "Basic Research: A National Resource," is issued in accord with the Foundation's statutory direc-



FEDERAL EXPENDITURES for research and development go nearly 90 per cent to military purposes. "Resources" include $75 million for civilian applications of atomic energy. Included in "other" is $40 million budget of the National Science Foundation. The figures in this chart and those on the following pages are for 1953-54, the years covered by National Science Foundation report.



INDUSTRIAL EXPENDITURES include $1,520 million on account of the Federal Government (*black bars*) and $2,350 million on industry's own account (*colored bars*). The aircraft, missile and atomic energy programs account for most of the Government's expenditures.

tive "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." The Foundation itself, expending its increasing appropriations each year since 1950, has been making policy in important ways. Now, with the present report, it invites the electorate to consider the condition of the country's scientific establishment and to join in the task of framing the terms of its support. This article will summarize the report and present one voter's views on how well it meets the serious issues with which it is concerned.

The picture presented is the product of a comprehensive survey, involving 15,000 questionnaires, 10,000 of them filled out by industrial concerns. Covering the year 1953-54, it is the most complete investigation of its kind ever conducted in this country. Since the sole measure of activity is dollars spent, however, the picture is somewhat one-dimensional. Such figures ought to be combined with those for man-hours and capital equipment, and the report expresses the hope that future surveys will do this.

In the fiscal year 1953-54 our nation's total expenditure for research and development was $5,400 million, about 1.5 per cent of the gross national product. Of this sum more than half was supplied by the Federal Government and nearly half was devoted to national defense. Industry invested only a little less money than the Government, and for itself and for the Government it conducted more than two thirds of the research and development activity of the nation. The universities and their professors held a minority interest in this immense enterprise, conducting less than $500 million worth of work.

In view of the junior position of the universities, it is apparent that basic scientific work must constitute only a small part of the total research and development effort. Indeed, most of the $500 million that even they expended came from government and industry for contract research. The universities had only $70 million of their own funds for scientific work.

The report goes to considerable lengths to estimate how much of the nation's research effort is "basic" and how much "applied." It encounters a difficulty at the outset, however, in attempting to lay down an objective basis for telling one from the other.

The first attempt to settle this philosophical question is made on historical

FINANCE \ PERFORMANCE	GOVERNMENT	INDUSTRY	UNIVERSITIES	INSTITUTES	TOTAL	PER CENT
GOVERNMENT	970	1,520	280	50	2,810	52
INDUSTRY		2,350	20		2,370	44
UNIVERSITIES			130		130	3
INSTITUTES			30	20	50	1
TOTAL	970	3,870	460	70	5,370	
PER CENT	18	72	9	1		100

INPUT-OUTPUT TABLE shows source of research and development funds (in millions of dollars) across the rows, and users of funds down the columns. "Government" means the Federal Government; "universities" include their associated research institutes.

lines. But the discussion of "The Rise of Basic Research" seems to me inadequate and misleading. The unspoken premise of the authors is that until recently Americans were interested only in technology and practical matters. It is said that "the frontiersman had no time for refinement or subtleties" and "the pioneer nation did not have the reserves of labor, wealth and time for a long-range view." Accordingly, the nation's "technical developments had their origin in basic science provided by Europeans." This strikes me as an unsound substitution of legend for history. The Puritans with their elaborate theological doctrines were men of great "refinement and subtleties," and they endeavored to take a long-range view which included science as one of the means of obtaining an adequate picture of the world. Increase Mather and Cotton Mather, two of the leading theologians of the early 18th century, were very interested and well informed in contemporary science. Certainly by the time of the American Revolution the country was well supplied with farsighted men—Thomas Jefferson, John Adams, James Madison and Alexander Hamilton, to name a few.

The report makes much of the fact that "of 90-odd scientific journals founded before 1815 only one was American." To say this and not mention Benjamin Franklin's founding of the American Philosophical Society in 1748, the founding of the American Academy of Arts and Sciences in 1780, or the later founding of the American Association for the Advancement of Science in 1848, distorts the picture. In the 18th century the population of the Colonies was less than three million, scattered over 1,500 miles of Atlantic seaboard. It is the small size of the Colonial population, rather than the imputed proclivities of its members, that explains the modesty of their early ventures in science. No one today regards the small population of Scandinavia as being of lesser quality merely because other countries with larger populations do more and publish more in science. For our country's size and wealth, in the 18th and 19th centuries, it contributed its share to science—considering the work of Benjamin Franklin, Joseph Henry and Josiah Willard Gibbs, to mention only the men of first magnitude. More study of the history of science will eventually correct our sentimental view of our past.

The report's contention that our technological advances had their foundations in Europe is equally misleading. The fact is that many of the most important developments of early industrial technology, in Europe as well as America, had little or no connection with science. There is no particular scientific content in Henry Maudslay's invention of the lathe, nor in James Watt's steam engine, which was made possible by that lathe. It was Eli Whitney's ingenuity, not his incidental culture in science, that led to the concept of interchangeable parts. A notable exception in the early days was Samuel Morse's telegraph, but he got most of the scientific knowledge he needed from another American, Joseph Henry. The work of these early inventors was very different from that of the scientists and engineers who are engaged today in the exploitation of scientific knowledge for practical ends. Perhaps this whole section of the report is mislabeled. Our history in basic research goes back to our beginnings. The new element in the picture is the rise of applied research.

The distinction between basic and applied research is not sharpened by the examples of allegedly basic research discussed in the next section of the report. One of these, the machine translation of language, seems in itself to involve nothing more basic than the adaptation of a computer to the task, though it is doubtless true that the project has inspired some basic research in the nature of language itself. In another example we have Karl Jansky's discovery of radio signals from outer space. Jansky, according to the report, was not engaged in basic research; he merely made a basic discovery. Here the confusion arises from labeling research according to the motives for which it is carried on; there is an element of snobbery involved which ought not be encouraged. After all, Louis Pasteur made his great contributions to the foundations of bacteriology in trying to find solutions for the practical problems of the French silk and wine industries. The whole discussion demonstrates that the dichotomy between basic and applied research can be overemphasized. The authors of the report are anxious to have it recognized that basic research carried on for no practical purpose involves results of great usefulness. No one will disagree, but the suggestion that basic research must have no practical motive or immediate application creates a dilemma which is going to plague the National Science Foundation more and more. The full story would require display of the interdependence between basic and applied research and would not minimize the fact that the traffic in inspiration, ideas and technique moves in both directions.

Whether a given research project deserves to be classified as basic or applied must ultimately be a matter of personal opinion. The opinion will inevitably reflect the bias of the person giving it. This is well illustrated by the report, which relates that university administrators estimated they received about $85 million for basic research from the Federal Government, while the public officials who disbursed these same sums calculated they provided barely half that amount to the universities for the same purpose. The report explains the human quality of this discrepancy: "Basic research enjoys high status in universities, while Federal agencies generally have to justify their programs in applied terms."

Since the report's estimate of the nation's expenditures for basic research is the sum of a whole series of such personal judgments, it must be used with caution. The figure arrived at is $435 million—about 8 per cent of the total research and development expenditure. Discounted for the "high status" that basic research enjoys and for the consequent tendency to inflate the estimate of what is spent on it, the actual figure, if "basic" research can really be defined, comes closer to $350 million.

Whether this is enough or too little it would be difficult to say. The report would be more helpful on this point if it gave us figures for earlier years and showed us at least whether the situation is better or worse today for basic research. It must be admitted that we have no figures as reliable as those produced by the survey for 1953-54. However, we can turn to the authoritative report "Science, the Endless Frontier," prepared under the direction of Vannevar Bush in 1945. There we find some significant round numbers. Before World War II, according to that report, basic research got $40 million. This was a much smaller figure than today's $435 million. But it was 15 per cent of the total national research and development expenditure, which ran about $260 million in those days. The percentage going to basic research was thus twice as great as it is today. Furthermore, according to the Bush report, basic research got 70 per cent of the $30 million expended on research and development in the nation's universities.

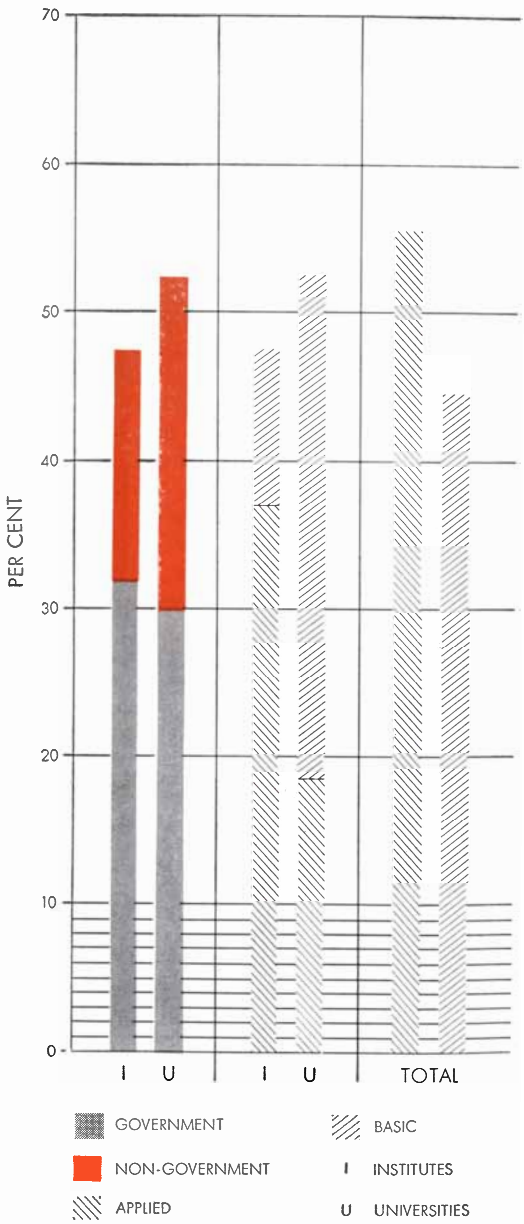
The figures in the present report suggest that basic research gets no more than 35 per cent of the total funds expended by our universities today.

In the report, it is true, university officials claim that of $240 million spent by their institutions on research and development $160 million, or two thirds, went to basic research. These figures, however, cover only the expenditures of the universities "proper." The universities spent another $220 million via the many affiliated research institutes which they have set up to handle contract research for the Federal Government, most of it military, much of it secret. These *ad hoc* institutes presumably insulate the universities from the taint of commerce. But since they offer the talents of the same professors and graduate students for hire, the insulation would appear to be largely symbolic.

That basic research now engages less than half the energies of our university science faculties should be the cause of grave concern. In the words of the present report: "The true functions of American institutions of higher education have tended to become clouded since World War II. Endowment and tuition income have lagged far behind rising financial needs. . . . The situation has come at a time when the Government itself, particularly the Department of Defense, needs scientists and facilities for large-scale projects in applied research and development. . . . [The universities] have come to depend increasingly on Federal support. This trend could have extremely unfortunate results, if allowed to develop."

It may be that the trend has already been allowed to develop too far.

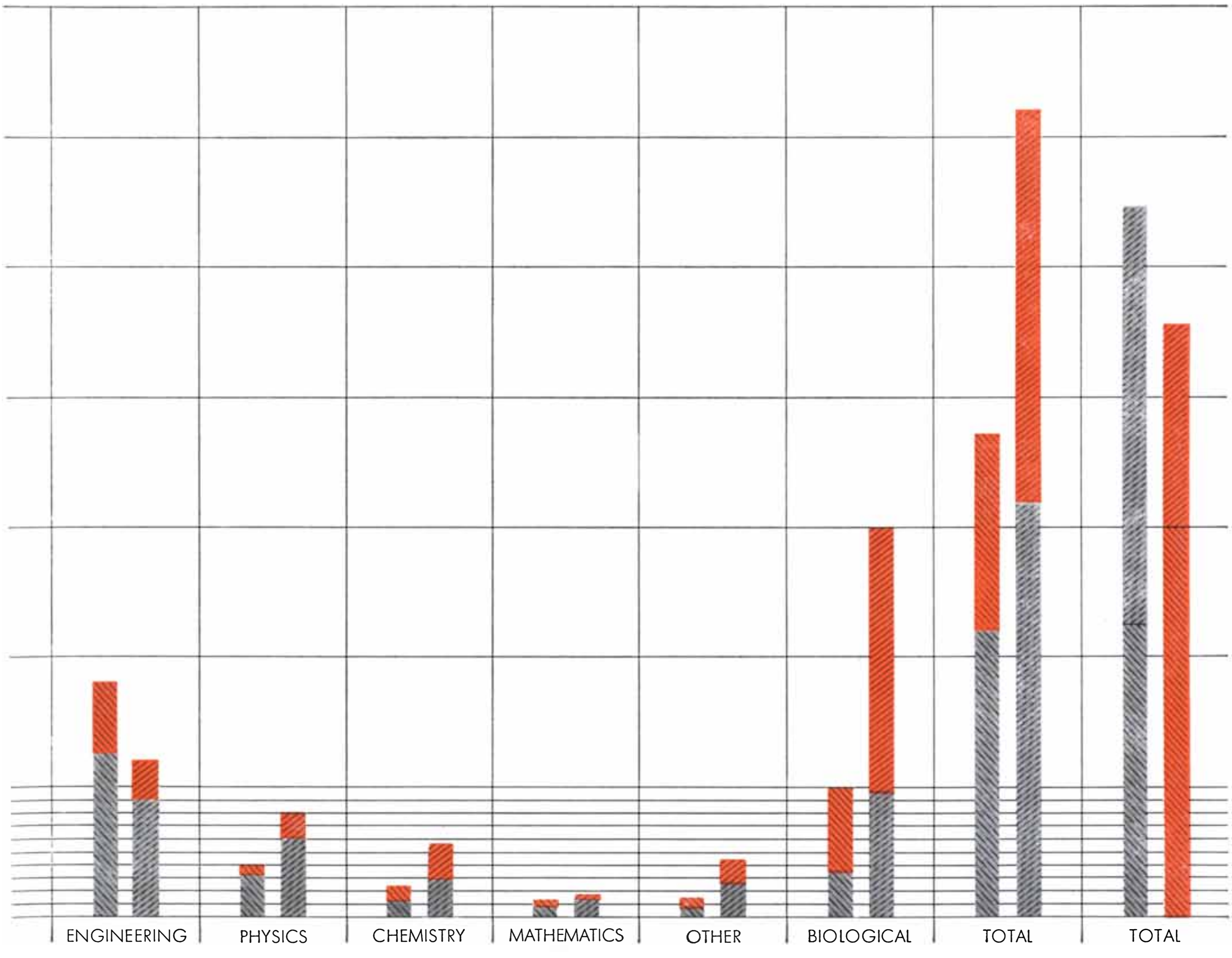
In its discussion of corrective measures, the report urges increased outlays for basic research from state governments, industries, private foundations and private donors, so as to limit the amounts that must be sought from the Federal Government. To encourage private financing the report suggests that some modification of income tax laws



would be appropriate. These proposals seem to turn on the fear of governmental interference, and they seem quite unrealistic to me. I have no doubt that industry can and will spend more funds in support of basic research, but it seems rather obvious that there are limitations on what corporations can do. Some degree of relevance to its business is required if a corporation is to spend its funds. It also seems a bit naive to assume that Government is not providing the funds if it is providing special tax benefits for private donors. As a practical matter this depends on the magnitude of the relief sought and of the funds required. If they become very large, the issue must be faced.

The fact is that the funds supplied by the Government are already very large, representing more than half of the $500 million expended on all research in the universities. Most of this money goes to applied research and generates the major portion of the economic and political pressures that tend to divert university resources away from their proper objectives. Some of this pressure could be removed by spending that money in other institutions where applied research is appropriately carried on. The report is gingerly in dealing with this possibility, because some universities "may feel that a drastically reduced level of applied research and development funds may seriously affect their income." Since there is apparently no escape from this dependence upon Federal funds, it would seem the wise course to redress the balance by a steady increase in the budget of the National Science Foundation.

However and wherever the increased funds for basic research are to be obtained, some criterion of economy will be required. We have reached the stage where the maintenance of an expanding pool of tested scientific knowledge is not only good economics but the only possible economics. We must push on rapidly if we are to use natural resources effectively for the needs of the increasing world population and if we are to maintain the competitive position of this nation. But we cannot, either from the standpoint of dollars or personnel, try to compress into one or two generations the broad range of work which in the end must be carried on over a number of generations to come.



UNIVERSITY RESEARCH AND DEVELOPMENT expenditures are charted by source and distribution in accord with key at left. More than half of the grand total of $460 million expended by the universities and their affiliated institutes goes to applied research, as shown at left in chart. One third of $240 million expended by the universities "proper," charted above, goes to applied research.

Animals of the Abyss

When the Danish oceanographic vessel "Galathea" sailed around the world, its investigators sampled the life of the greatest depths with a cable seven and a half miles long

by Anton F. Bruun

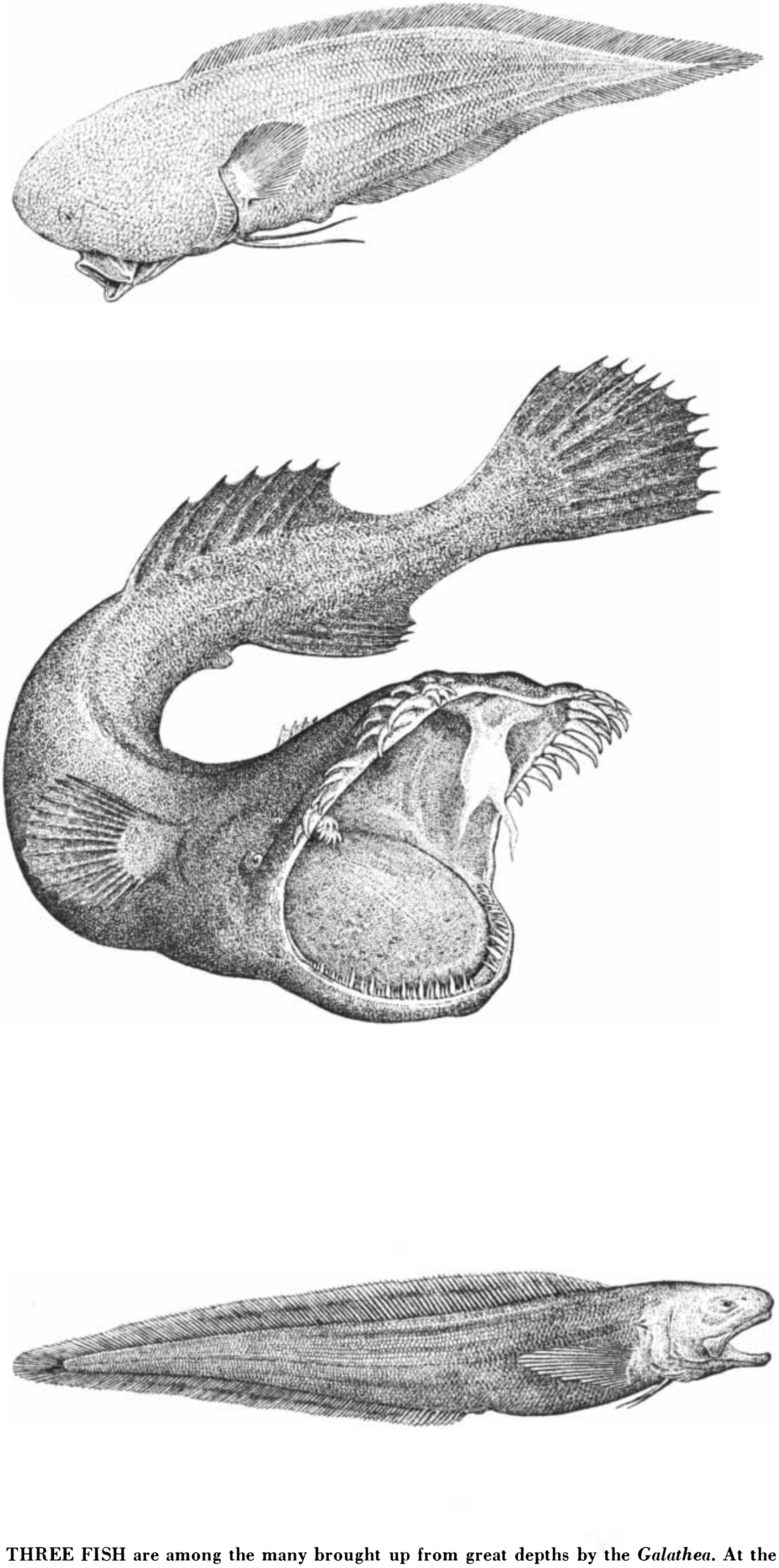
The oceanic abyss of our planet is an immense region. Below 4,000 meters (two and a half miles) of water lies an area as great as all the continents put together. The deepest deeps—under 6,000 meters—amount to an area half as large as the U. S. This vast world is in many ways as strange and remote as another planet. It is a world of total darkness and eternal cold, never more than a few degrees above freezing. The pressure is enormous—up to 1,000 atmospheres and more. As Charles Wyville Thomson remarked when he first sounded the great ocean depths in the famous *Challenger* expedition, it is almost as hard to imagine life existing in these conditions as in fire or in a vacuum. But we know today that there are forms of life—strange forms, to be sure—which thrive in the very deepest

"GALATHEA" is photographed at anchor off Kondul in the Nicobar Islands of the Indian Ocean. Originally the New Zealand vessel H.M.S. *Leith*, she was purchased after World War II by the Danish Navy. Her length is 266 feet; her displacement, 1,600 tons.

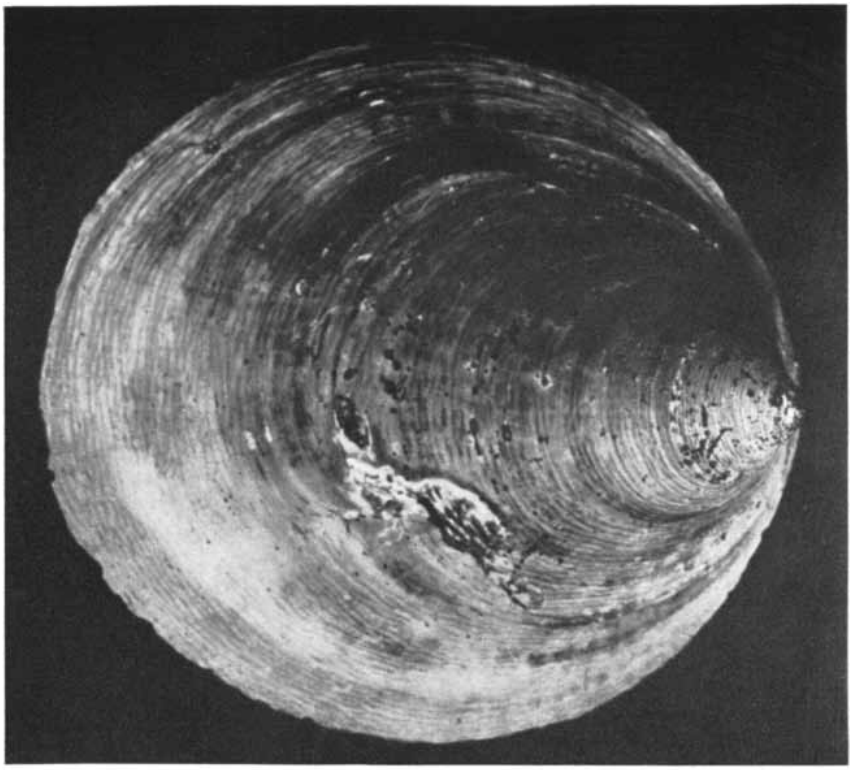
trenches of the ocean bottom. From these "hadal" regions (to borrow a word from the Greek Hades) scientific expeditions of the last few years have dredged up a considerable array of living creatures.

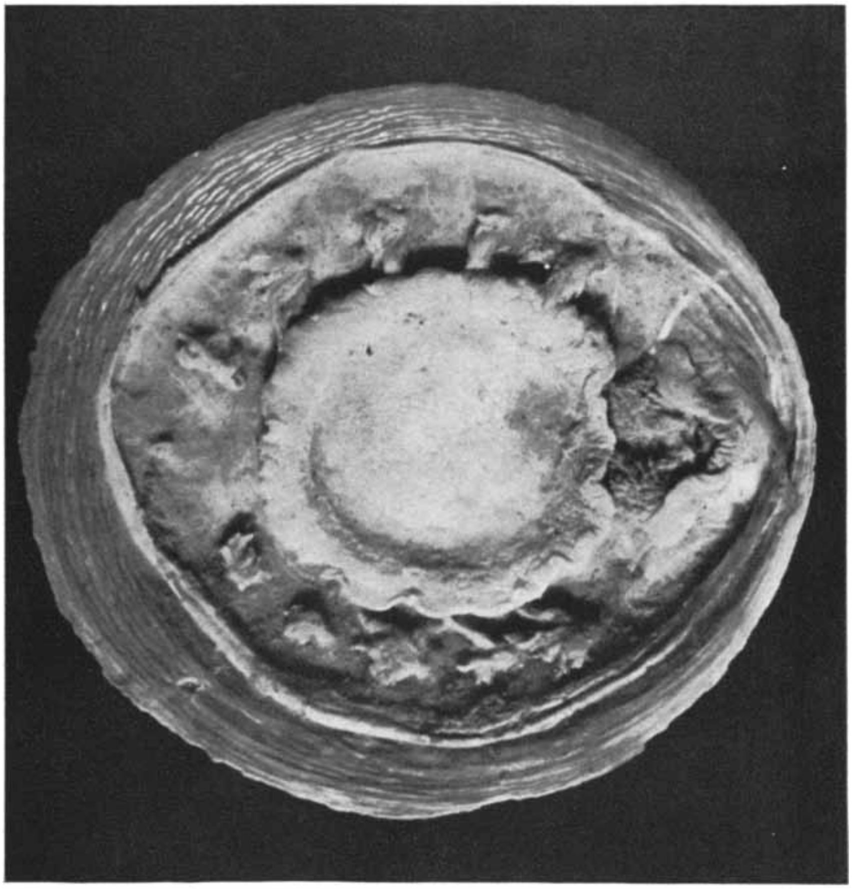
It is less than a century since scientists began to explore the deep ocean bottoms. In the 1870s several British and U. S. ships set forth with long ropes to fish at depths of thousands of feet along the sea floors. The round-the-world expedition of the British *Challenger* brought to light an amazing variety and abundance of life in the deep oceans [see "The Voyage of the 'Challenger,'" by Herbert S. Bailey, Jr.; SCIENTIFIC AMERICAN, May, 1953]. Since World War II, elaborately equipped ships have plumbed depths never reached before, and we have now sampled the deepest trenches in the oceans. In 1948 the Swedish *Albatross* expedition fished down to 7,900 meters in the Puerto Rican Trench; in 1949 the U.S.S.R. ship *Vitiaz* reached 8,100 meters in the Kurile-Kamchatka Trench. And on August 21, 1951, the Danish *Galathea*, on its round-the-world deep-sea expedition, brought animals to the surface from the bottom of the Philippine Trench. This is the deepest haul so far: it came from the great depth of 10,190 meters (about 33,600 feet, or more than six miles below the sea surface).

It is not a completely accidental coincidence that the deepest abyss in the oceans and the highest mountain on the earth—Mount Everest—were conquered at the same time. Both achievements required highly developed techniques and equipment which were brought forth by the war. To appreciate what exploring the great ocean deeps involves, you must keep in mind that if Mount Everest were dropped into the Philippine Trench its peak would be a mile and a half below sea level. From the water's surface atop this fantastically deep chasm the ship drops a long, thin line to grope blindly for organisms in the ooze at the bottom of the trench. It is comparable to flying in an airplane six miles up and trying to snag animals on the ground with a grappling hook hung from a miles-long drag line. Naturally, fishing at this distance, we cannot be sure that what our line happens to drag up is a really fair sample of what lies on the bottom. An airplane explorer who pulled up a mouse on his line might conclude that the earth's surface was largely inhabited by tiny rodents. But fortunately the en-



THREE FISH are among the many brought up from great depths by the *Galathea*. At the top is *Typhlonus*, a blind fish with a mouth that can be protruded like a shovel; it was caught at 5,090 meters in the Celebes Sea. In the middle is *Galatheathauma axeli*, a fish with a large luminous organ in its mouth; it was caught at 3,590 meters in the Pacific off Central America. At the bottom is *Bassogigas*, the fish caught at the greatest depth: 7,130 meters.





MOLLUSK DISCOVERED BY THE "GALATHEA" was *Neopilina galatheae*. It is a relative of the ancient mollusk *Pilina*, which has been extinct for 350 million years. At the top the mollusk, which has only one shell, is shown from above; at the bottom, from below.

vironment in the deep ocean is so uniform that we can be fairly confident our samples are representative.

I should say a few words about the equipment that makes this fishing possible. First of all, echo-sounding apparatus allows us to locate a deep-sea trench and explore its topography. Without such a survey we would have little chance of fishing successfully along its bottom, for the trenches are narrow furrows with steep, rugged sides. If you imagine trying to drag a net through Yosemite Valley from an airplane six miles above without tearing the net on its rocky sides, you will understand the difficulty. With the echo-sounder we locate the bottom of the trench and check the depth continually during the towing. For dragging the bottom the *Galathea* used either a dredge or a trawl net. We had the benefit of powerful winches and high-quality steel wire for the line, in contrast to the hemp ropes and primitive winches used by the pioneers. Our line was a single steel wire about seven and a half miles long, tapering from a thickness of nearly two thirds of an inch at the upper end to a little over a quarter of an inch at the bottom end. The wire could bear a load up to four and a half tons, and the weight and drag of our gear was only one and a half tons. Very complicated calculations are required to find out how much wire must be paid out to reach the bottom, what the drag of the gear and the friction between the long wire and the water will be at a given towing speed, and so on. Here we had the invaluable help of B. Kullenberg, who had taken part in the round-the-world expedition of the Swedish *Albatross* in 1947 and 1948.

Before I describe the animals we found, let us consider a few facts about their deep-sea environment. In the sea the pressure increases by about one atmosphere (roughly 14.7 pounds per square inch) for every 10 meters of depth. Thus at 4,000 meters the pressure is about 400 atmospheres; at 10,000 meters, 1,000 atmospheres. It is almost impossible for us to conceive what living under such pressures must entail. The human body gets into serious difficulties at pressures of only three or four atmospheres (corresponding to a depth of 100 to 140 feet in the water). The deep-dwelling sea animals—worms, mollusks, crustaceans and so forth—have no air bladders, but the great pressure imposes other serious physiological problems. We know very little about what these problems really are; all we know is that a number of animals have somehow managed to evolve mechanisms which enable them to live comfortably under the enormous pressure of 1,000 atmospheres or more.

Next, these animals have to live in complete and eternal darkness. Sunlight does not penetrate more than a few hundred meters below the ocean surface. In the dark regions lower down there are some luminous fishes and other animals, but even this chemical light largely disappears below 1,500 meters.

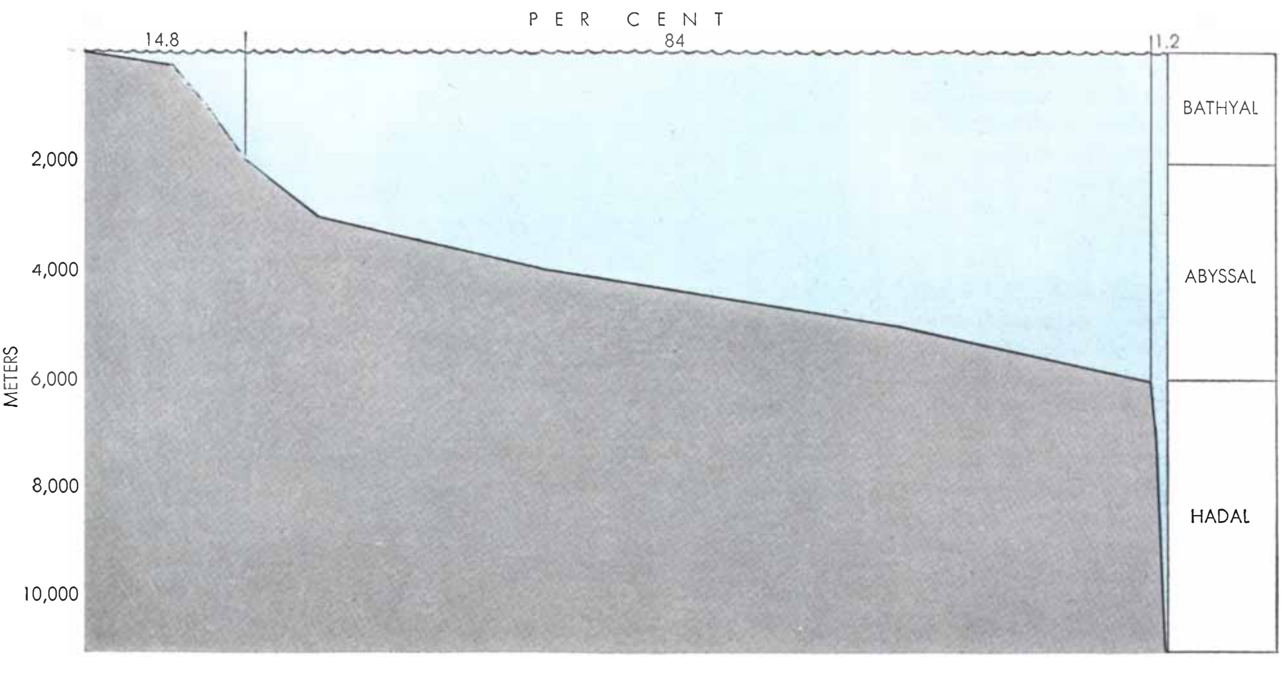
At great depths it is not only uniformly dark but also uniformly cold—at the Equator as well as near the poles. The salinity of the water also is uniform. Its content of oxygen seems to be quite sufficient to support life for breathing animals. As for food, the deep-sea animals must depend on organic matter falling from the surface levels of the ocean, because the lack of light excludes any manufacture of organic substances by photosynthetic plants. Contrary to a common impression, there is no rain of animal carcasses from above: these are devoured long before they reach the bottom, except for an occasional dead whale or giant shark. What does come down is excrement, the cast skins of crustaceans, the horny beaks of squids, water-logged driftwood, fragments of plants and the like. All this organic matter serves as food for bacteria, which in turn become nutritious eating for bottom animals.

So the darkness is uniform; the temperature is more or less uniform; similarly the salinity, the food (though it varies in quantity) and the habitat (mainly a soft, clayey ooze). Moreover, at the level around 2,000 meters the animals have unhindered mobility from ocean to ocean, because of the lack of physically different zones or topographical barriers. It is not surprising, therefore, to find the animals more or less alike in a general way. Whereas the surface animals of the sea may vary all the way from coral organisms to arctic seals, the deeper bottom dwellers are mostly small burrowing forms: bristle worms, bivalves, various other crustaceans, sea cucumbers, brittle stars and so on. Many of these middle-level animals are not very different from their surface cousins, except that they are blind and rather colorless—like the pale, blind inhabitants of caves, another dark habitat.

From the depths between 2,000 and 6,000 meters the *Galathea* fished up thousands of specimens of animals, many of which had previously been considered rare. Except for the fact that they were more abundant than had been thought, most of these species had little novelty. But occasionally we caught a new species that had never been brought up before. The most peculiar fish we netted was a luminous angler fish, taken at a depth of 3,590 meters in the Pacific off Central America. Like certain other deep-sea anglers, this fish had a luminous organ to attract its prey, but its organ was inside the mouth [*see middle drawing on page 51*]!

Far more interesting was another species of animal caught for the first time by the *Galathea* expedition. It was a small, limpet-like mollusk which turned out to be a living relative of an ancient mollusk, *Pilina*, that has been extinct for some 350 million years. The discovery was no less surprising than if we had brought up a living trilobite—the ancient and extinct arthropod that is believed to have been one of the earliest animal inhabitants of the earth. Our mollusk (named *Neopilina galatheae*) is so different from the present-day mollusks that it must be placed in a special class of its own. As a living fossil it may be as important a clue to the evolution of mollusks as the egg-laying duck-billed platypus is for studying the origin of mammals.

Below about 6,000 meters, what we usually think of as fishes (fishes with backbones) practically disappear. Very few such fishes have been found at greater depths—only six by the *Galathea* and two by the *Vitiaz*. The deeper bottom-dwellers therefore are secure from



AREA OF THE OCEANS less than 2,000 meters deep (bathyal) is 14.8 per cent of their total area; area between 2,000 and 6,000 meters deep (abyssal), 84 per cent; area deeper than 6,000 meters (hadal), 1.2 per cent. The abyss is thus the world's largest ecological unit.

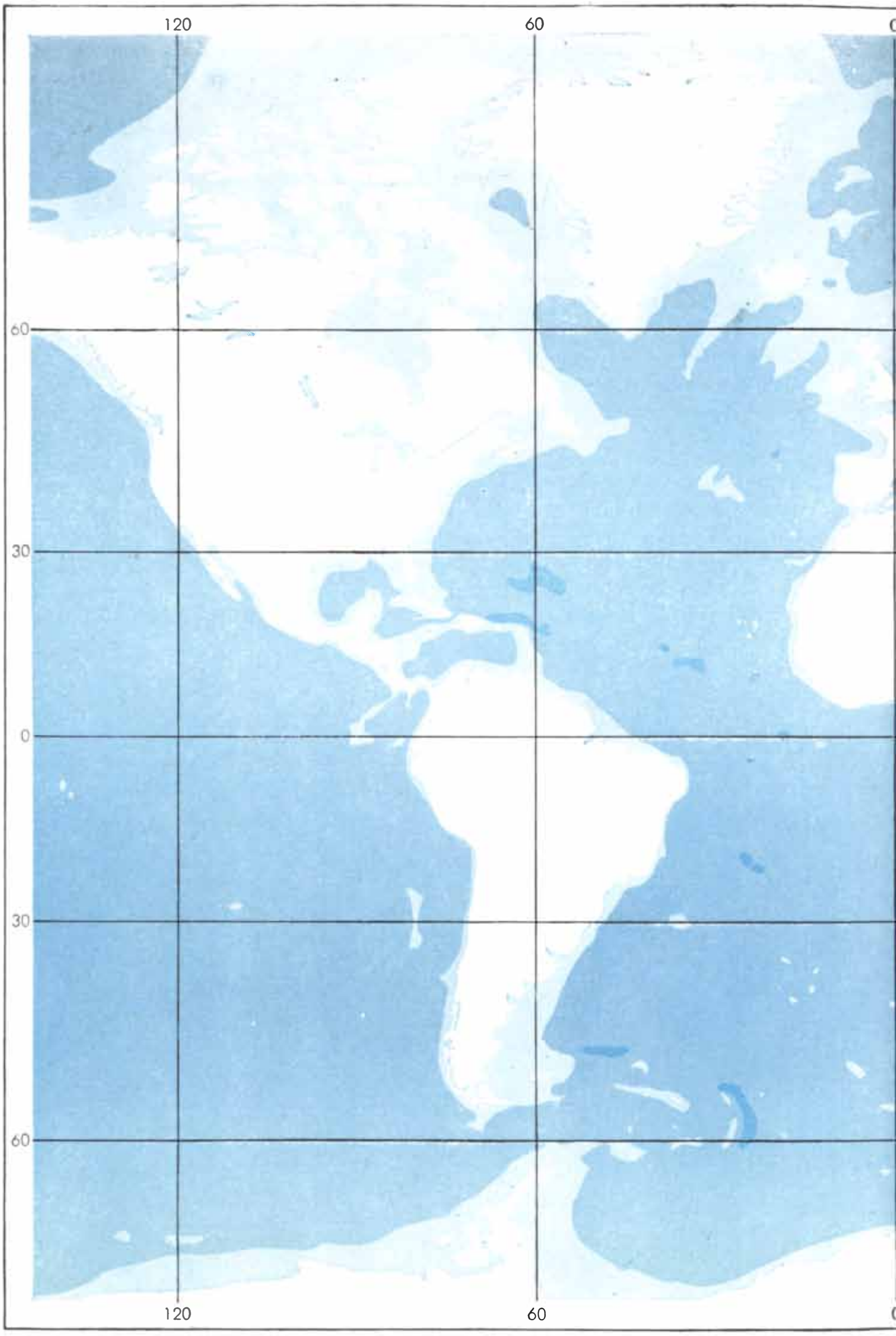
predaceous fish. Indeed, the great pressure shelters them from invaders of any sort. Since only animals adapted to the extreme pressure can live there, they enjoy a protected niche undisturbed by competition from newcomers.

In the very deep trenches the isolation of the inhabitants is practically perfect. Once an animal has become adapted to the trench-bottom pressure (from 700 to more than 1,000 atmospheres), it cannot rise to a higher level and therefore cannot migrate out of the trench. It lives, in effect, on an island as remote as a mountain peak from contact with the rest of the world. And just as unique species of plants and animals evolve on islands and on mountain peaks, we should expect each trench to have its own peculiar population. That is exactly what we find.

After the *Galathea* had surveyed the Philippine Trench and defined the bottom, it lowered its 12,000-meter line and made a pass along the trench at a speed of two knots. When the trawl was finally pulled up, the explorers were delighted to see clay on the framework and stones in the net, sure evidence that the trawl had reached the bottom. The first animal noticed in this haul was a sea anemone—a whitish growth on a stone. At first glance it looked like a typical sea anemone, but on closer analysis it proved to be so unusual in some properties that it represents an entirely new family. Altogether we found eight species of animals in the Philippine Trench: sea anemones, sea cucumbers, bivalve mollusks, amphipod crustaceans and bristle worms. And from the 8,200-meter Kermadec Trench (off the Kermadec Islands of New Zealand) we fished up 18 different species. In all cases the species were different from their relatives at higher levels of the ocean, and they also differed from trench to trench.

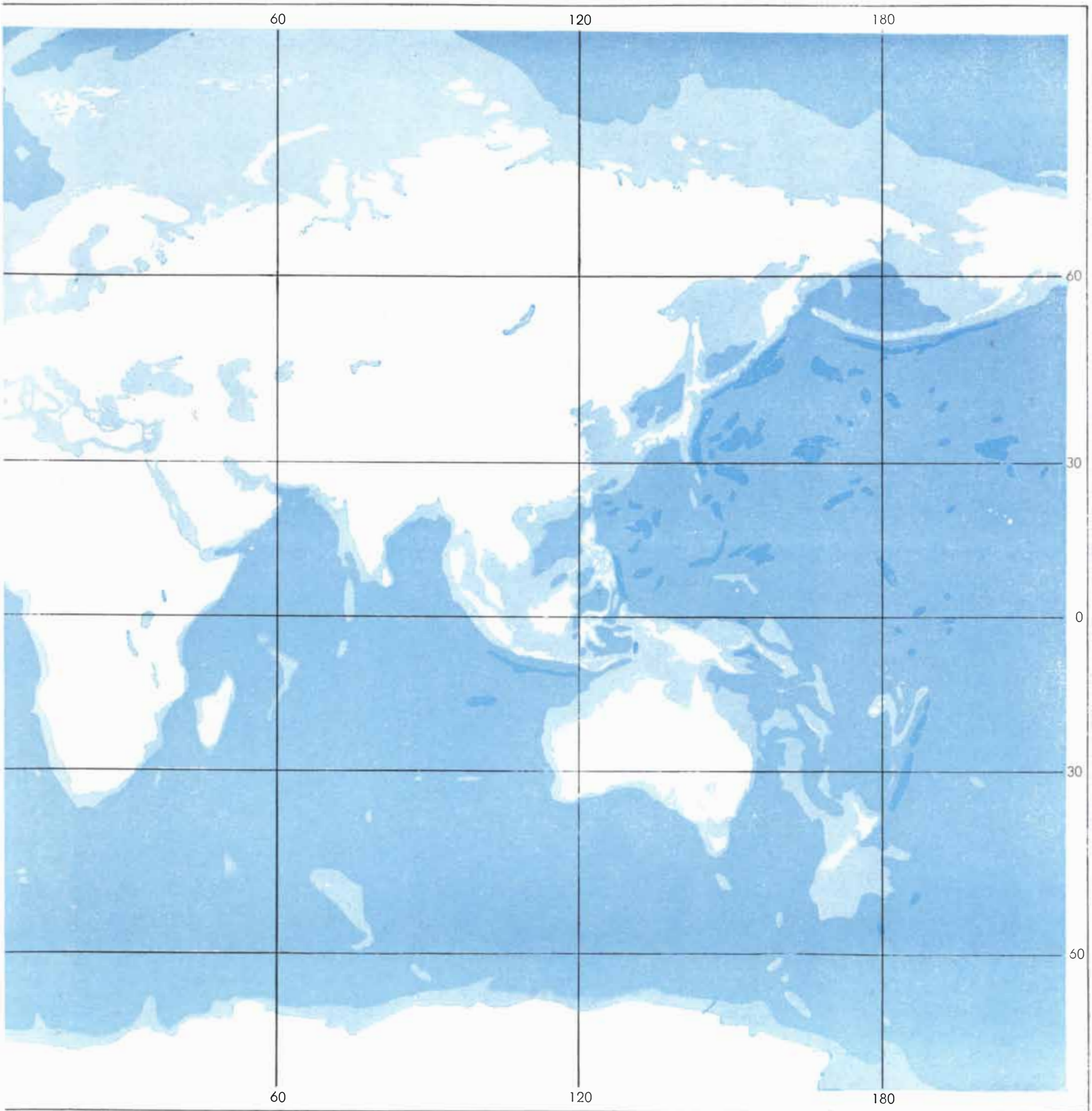
What I have described so far would not greatly have surprised the pioneers on the *Challenger*. Superficially the animal inhabitants of the deep trenches do not look very different from the types living somewhat higher up. Nor do the bacteria that we found on the floor of the Philippine Trench. But their make-up certainly must be unusual. The bacteria are truly pressure-loving organisms, unable to exist at all at pressures of less than 1,000 atmospheres. Somehow they are constructed in a particular way to live at these pressures. Their structure must be very different from that of organisms at sea level. Claude E. ZoBell and Richard Y. Morita of the Scripps Institution of Oceanography, who took part in our expedition, have been cultivating these bacteria in high-pressure chambers, and we can expect very important results from their studies.

I should mention two other important facts that have been learned from the explorations of the deep sea. The *Galathea* expedition investigated the production of organic food in the oceans. For this a new measure devised by E. Steemann Nielsen of Copenhagen was used. It estimates productivity by the amount of carbon dioxide assimilated by sea



DEPTH OF THE OCEANS is roughly indicated by this map of the world. The waters less than 2,000 meters deep (bathyal) are indicated by the lightest colored area. The waters be-plants. Using radioactive carbon 14 as a tracer, Steemann Nielsen measured the plant assimilation of carbon dioxide in samples of water drawn from several depths all along the route of the expedition. He found that organic production varies greatly from region to region but that no area is completely barren: there are no "deserts" in the sea. Steemann Nielsen estimated from his measurements that all the seas together produce about 40 billion tons of organic matter per year—about the same amount as the total annual production by plants on land. This finding is an important step toward answering the question about how much food we may eventually get from the sea [see "Food from the Sea," by Gordon A. Riley; SCIENTIFIC AMERICAN, October, 1949].

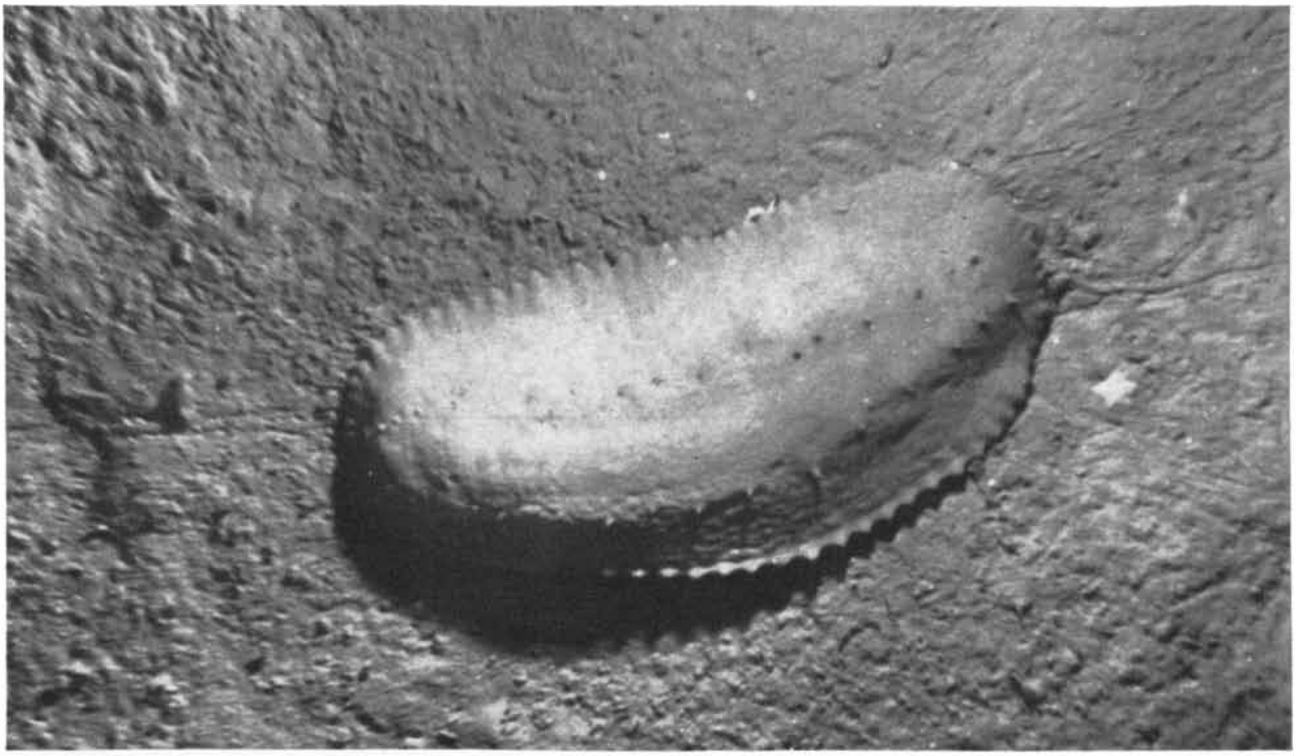
The other interesting finding is that

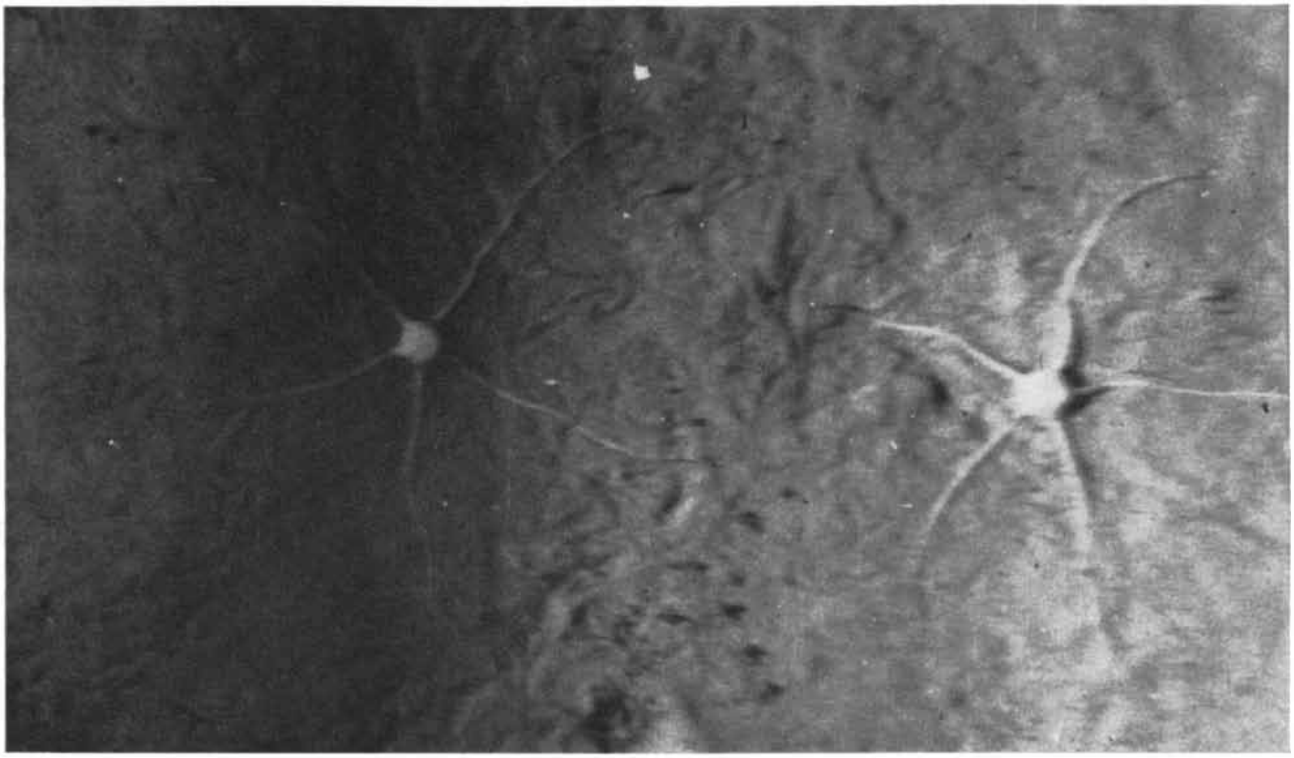


tween 2,000 and 6,000 meters deep (abyssal) are indicated by the darker colored area. The waters deeper than 6,000 meters (hadal) are indicated by the darkest colored area. The deepest haul made by the *Galathea* was at depth of 10,190 meters near the Philippines.

with the coming of the ice ages on the earth, the temperature in the deep seas dropped sharply. The average temperature of the water at great depths seems to have fallen from about 10 degrees centigrade to two degrees. In other words, life in the deep sea must have been subjected to what amounted to a cold-shock treatment. Undoubtedly this had catastrophic effects, destroying all deep-sea life except the species that could resist the cold or escape to warmer levels of the ocean.

Those of us who are interested in studying the undersea world have some concern just now about the possibility that man may soon start dumping radioactive wastes from atomic energy plants in the deep sea. Such deposits on the ocean bottom might change its living population as drastically as the cold of

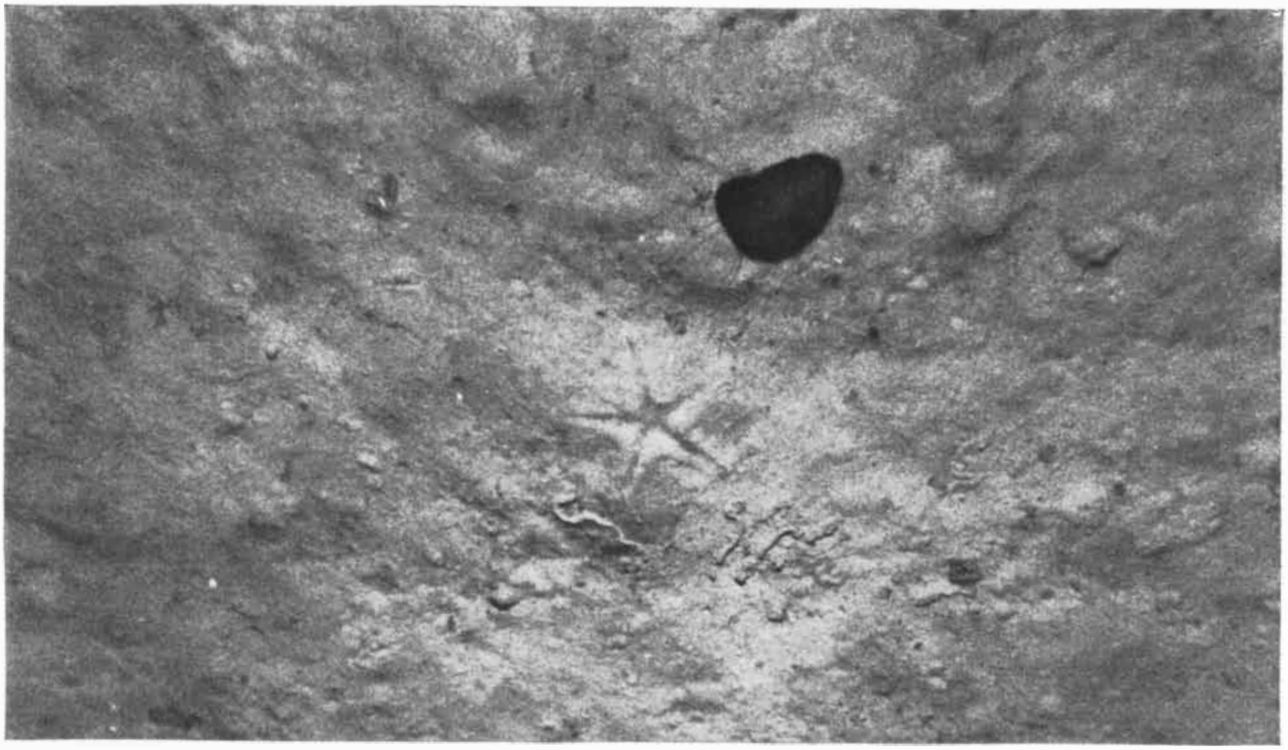




ABYSSAL ANIMALS were photographed, not from the *Galathea*, but by investigators of the Lamont Geological Observatory of Columbia University. At upper left is a sea cucumber, photographed at a depth of 2,000 meters. At upper right is another sea cucumber

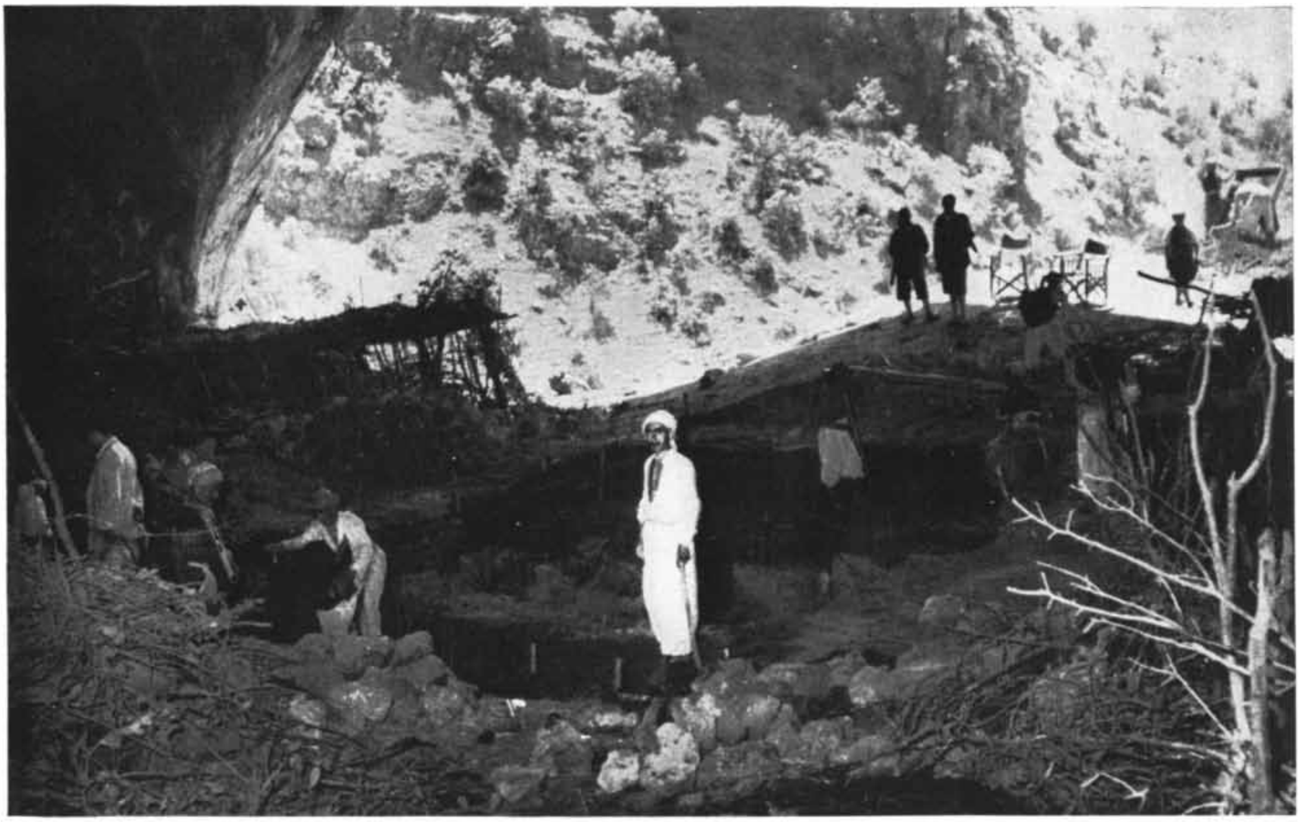
the ice ages. We should very much like to get a good look at the animals before that happens.

We have literally only scratched the surface of the world of fabulous life and pressure at the bottom of the deep sea trenches. To go further in that costly exploration we shall need international cooperation. The oceans are international, and so is oceanology. The nations of the world should collaborate in this science, through an agency set up on the same plan, say, as the new European Organization for Nuclear Research in Switzerland. People everywhere will benefit from studies of the sea, for we shall learn much about the oceans' food resources, about our long-term climate and about the remarkable ability of organisms to live under fantastic pressure.



and a buried starfish, photographed at a depth of 3,904 meters. At lower left are two brittle stars, photographed at 2,100 meters. At lower right is a fish swimming above the bottom, photographed at 1,600 meters. All the photographs were made in the North Atlantic.

MOUTH OF SHANIDAR CAVE is an opening in the flank of Baradost Mountain, some 250 miles from Baghdad. The cave is 130 feet deep; its mouth is 26 feet high and 82 feet wide. From November to April it is inhabited by Kurdish goatherds (*see photograph below*).



FLOOR OF SHANIDAR CAVE is covered with simple shelters for its Kurdish inhabitants and corrals for their animals. In this photograph Kurdish workmen have just begun the excavation of the earthen floor of the cave. Bedrock was reached at a depth of 45 feet.

SHANIDAR CAVE

This rocky shelter in Iraq has been inhabited by man for 100,000 years. Digging down through the earth of its floor, archaeologists have even uncovered the remains of the predecessors of Homo sapiens

by Ralph S. Solecki

In a mountainside in the Zagros Mountains of northern Iraq is a human dwelling place known as "The Big Cave of Shanidar." It is a high-vaulted natural cave about the size of four tennis courts—capacious enough to house a considerable band of people. The cave has a warm southern exposure and is well protected from winter winds. Nearby are springs and a stream to supply water. Remnants of wild game and the few stands of still-undisturbed virgin forest on the hillsides testify that the place has long had a fertile and livable climate. Today the Cave of Shanidar is inhabited by a clan of Kurdish goatherds and their animals. It is not hard to imagine that men have lived in this commodious, sun-warmed shelter for generation after generation. Out of scientific curiosity we have dug into the floor of the cave, and found to our delight that this conjecture is a feeble understatement. The inhabitation of the Shanidar Cave apparently goes back at least 100,000 years! Remains unearthed from deep beneath its trampled floor give evidence that Neanderthal man once lived here, and that the cave has been a home of man more or less continuously for something like 3,000 generations.

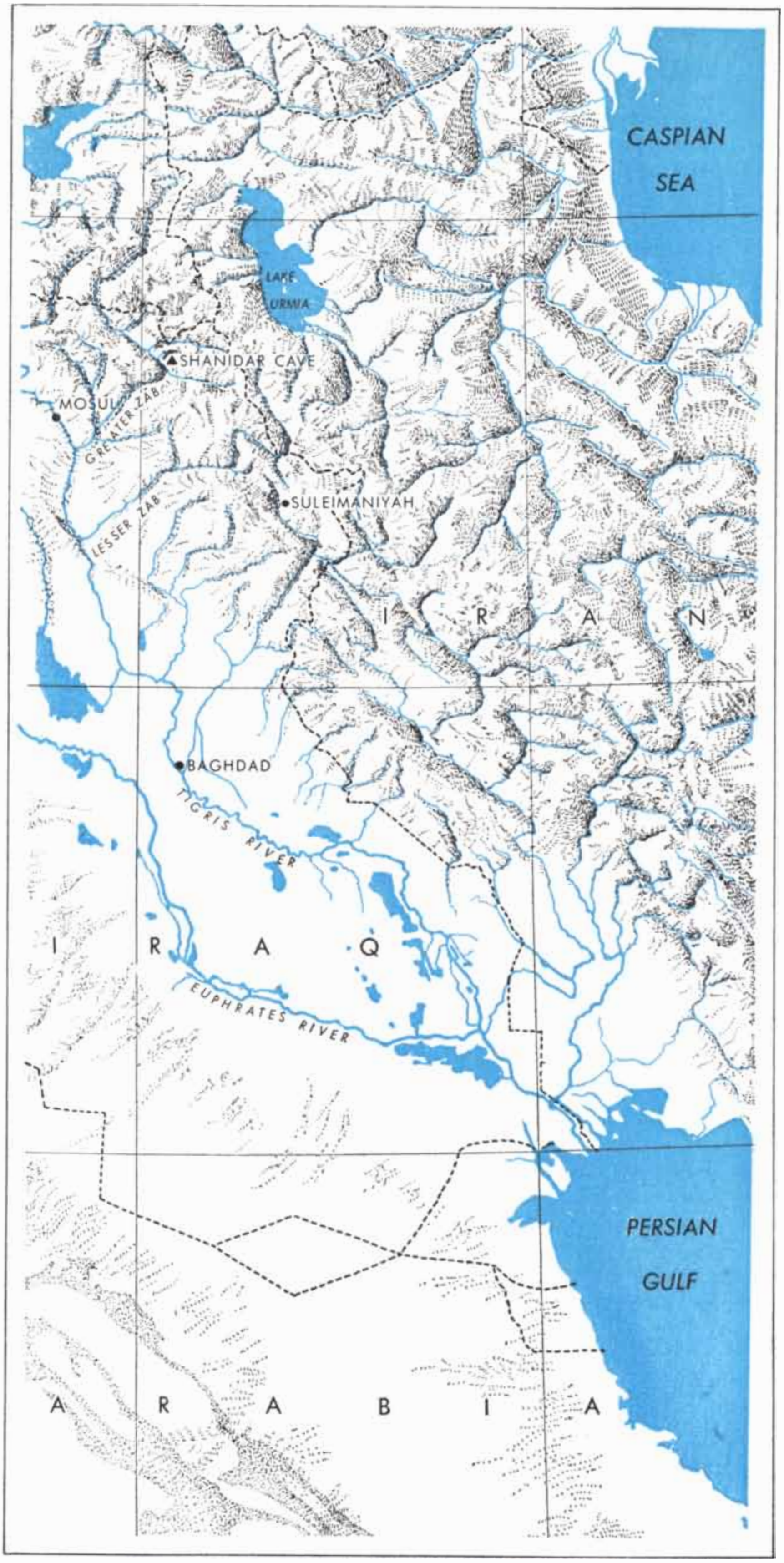
Needless to say, the Shanidar Cave has become one of our most important and fruitful sites for tracing the early history of mankind. Rarely do archaeologists have a chance to see so clear a succession of man's development over so long a period as we have in the layers that make the pages of the story of Shanidar. The story is not lessened in interest by the fact that Shanidar Cave is close to the birthplace of the first great civilizations in Mesopotamia [see "The Sumerians," by Samuel Noah Kramer; SCIENTIFIC AMERICAN, October].

Mesopotamia itself is a poor place to look for the Stone Age cultures that preceded its ancient civilizations. A hunting and foraging people would have found little food in its marshes and deserts; moreover, it would be difficult to discover or to date any of their camp sites in this sea-flooded and river-washed plain. Archaeologists have long realized that the best chance of finding Stone Age human remains lay in the foothills and mountains north of the Tigris and Euphrates. In 1928 a small party led by Dorothy Garrod of the University of Cambridge found such remains in two caves near a town called Suleimaniyah in the Zagros foothills [*see map on next page*]. There were no other serious excavations until Robert Braidwood of the University of Chicago began his explorations of Stone Age sites in the same vicinity in 1950 [see "From Cave to Village," by Robert J. Braidwood; SCIENTIFIC AMERICAN, October, 1952]. Braidwood discovered evidences of the beginnings of human agriculture and village settlements. But the dream of archaeologists looking into man's distant past is to find a site where the stages of his development are piled layer upon layer so that we can get a consecutive, slow-motion picture, so to speak.

In 1951, while working in Iraq with a University of Michigan expedition, I heard about Shanidar Cave and decided to stay on, after the expedition went home, to do some exploratory digging in the cave. These first soundings were so promising that I returned in 1953, and again in 1956, for two more full seasons of excavation. The investigations have been conducted on behalf of the Iraq Directorate-General of Antiquities and the Smithsonian Institution, with support from several other organizations.

The Zagros Mountains resemble the highlands of Scotland; their foothills look like the hills of the U. S. Southwest. Shanidar Cave is in a mountain called Baradost, overlooking Shanidar Valley. From the cave mouth one can see the Greater Zab River, a tributary of the Tigris. The cave, now some 2,500 feet above sea level, was dissolved out of the mountain's limestone rock, originally laid down by an ancient sea. It has a flat earthen floor, about 11,700 square feet in area, and a high ceiling (45 feet at the highest point) blackened with a centuries-old deposit of soot. The Kurdish goatherds and their families, who live in the cave all winter from November to April, have built individual brush huts inside it, each with a small fireplace, and corrals for goats, chickens, cows and horses [*see drawing on page 61*]. The Kurds are a proud, self-sufficient, but backward people. They make fire with flint and steel and grind wheat by hand with circular stones. The women cut hay in the mountain meadows with short iron sickles and toil barefooted up a mountain trail with goatskins to fetch water from the springs. Compared with modern Baghdad, only 250 miles away, the present dwellers in Shanidar Cave could just as well be living in the days of the Assyrian herdsmen 2,500 years ago.

It was from this level of culture, then, that we began our digging journey into man's early history. We marked off a small area in the center of the cave and started our slow, careful excavation down through the floor. In three seasons of work we have cut through the full depth of the cave's earthen accumulations, down to bedrock at 45 feet, and have sifted about a tenth of the total bulk of its deposits. The excavations have yielded a rich record of human occupation—ancient hearths, tools, animal bones, even Neanderthal skeletons—going back some 100,000 years.



CAVE IS LOCATED on this map of the region north of the Persian Gulf. Suleimaniyah is the site of earlier cave excavations by Dorothy Garrod of the University of Cambridge.

We found four main layers, distinguishable by soil color and the types of artifacts they contained. Each corresponded to a recognizable stage of man's development. I shall first review briefly the general contents of these layers, which are identified, according to an archaeological convention, by the letters A to D from the top down [*see drawing on page 62*].

Layer A, averaging about five feet thick, is a black, greasy soil, compacted by many generations of feet. It dates from the present back to some time in the Neolithic (New Stone) Age, perhaps 7,000 years ago. This layer covers the revolutionary period in man's way of life when he emerged from mere hunting to food gathering, agriculture and animal herding. Throughout Layer A we found ash beds of communal fires, bones of domesticated animals and domestic tools such as stone mortars (which the Kurds still use for cracking nuts). The circular millstones with which they still grind wheat showed up only in the upper part of Layer A; apparently these are a comparatively recent development. About a foot below the surface we found some primitive clay tobacco bowls—mute evidence that the tobacco habit came to this part of Asia about 300 years ago. A little farther down was a bit of burnished pottery similar to the kind known as "Uruk" ware, named for the city of Erech in ancient Mesopotamia. This pottery dates from the time of the invention of cuneiform writing in Sumer.

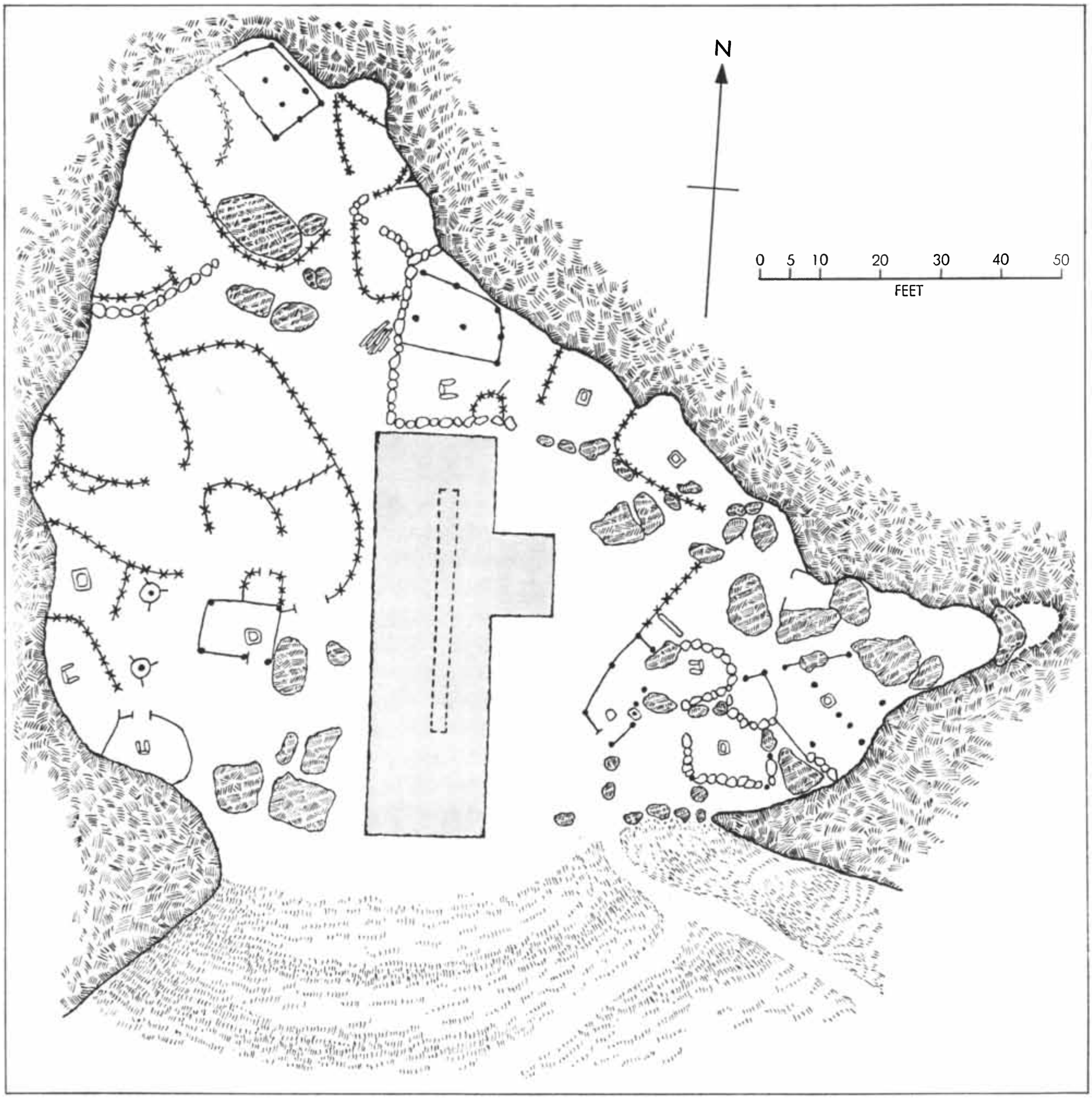
Layer B, just below A, is a fairly thin, brown-stained deposit which, according to carbon-14 measurements, dates back to the Middle Stone Age, about 12,000 years ago. It contains the primitive artifacts of a people who knew neither agriculture nor animal domestication nor pottery making. There is no sign that they even collected edible nuts. Apparently snails made up a considerable part of their diet, for there are heaps of snail shells strewn about. Animal bones are relatively scarce in this layer: there are no domestic animals and few wild ones. Possibly it was a period of game scarcity in Shanidar Valley.

Nonetheless the prehistoric people of Layer B seem to have thrived and even to have had some leisure. They made exquisitely chipped projectile points, and bone awls which must have been used for sewing or lacing. What is more, there are engraved pieces of slate, and also fragments of well-rubbed coloring stones which suggest that these people may have made paintings or decorations.

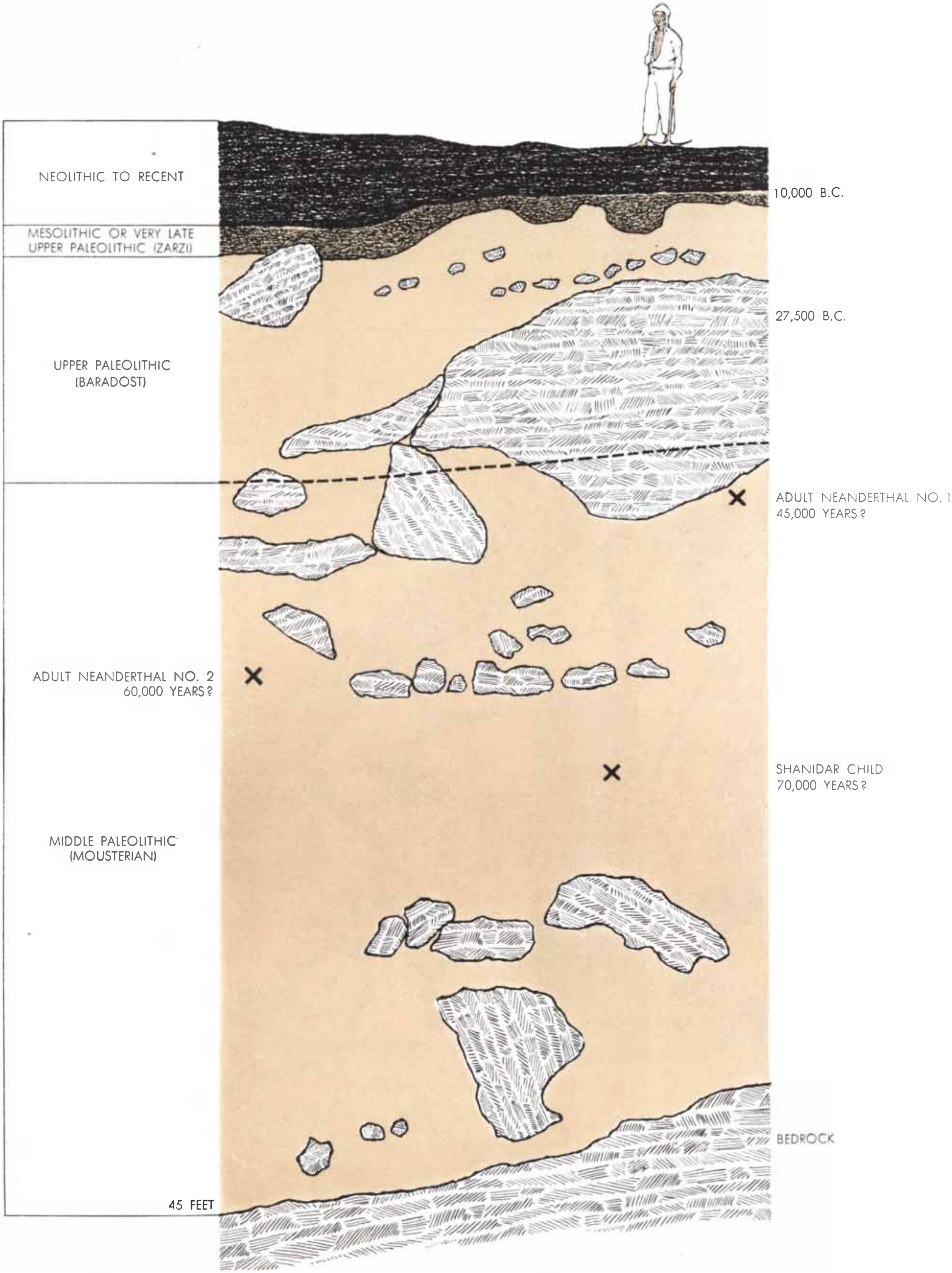
Below Layer B we come to a gap of some 17,000 years during which the cave apparently was not occupied. The next layer, C, dates from about 29,000 to more than 34,000 years ago, according to radiocarbon measurements of charcoal in its firebeds. Near the top of the layer are many boulders, which probably fell from the ceiling during an earthquake and may well have discouraged residence in the cave. The soil layer itself, a yellowish deposit about eight feet thick with the remains of many fires, bespeaks a long occupation by the late Paleolithic (Old Stone Age) people who had lived in the cave in this period.

Now these people are an anomaly in the Iraq region. Their flint tools—so-called "blade tools"—were like the implements of a late Paleolithic culture in Europe known as the Aurignacian (which used to be identified with Cro-Magnon man). But no such culture has been found anywhere in Iraq except at Shanidar, although other sites in the area have yielded earlier and later cultures. To the distinctive culture of Layer C we therefore gave the name "Baradostian," after the name of the mountain on which Shanidar Cave is located.

The people of Layer C, like their counterparts in Europe and elsewhere, must have been good woodworkers, for their deposits contain many flint woodworking tools, including scrapers and



EXCAVATION IS LOCATED by the gray area on this map of the cave. The broken line in the gray area, and its extension toward the mouth of the cave, is the outline of a test trench dug in 1951. The floor of the cave is littered with rocks from the ceiling.



LAYERS IN THE FLOOR of the cave are indicated on this cross section. At the top (Neolithic to Recent) is Layer A; second from the top (Mesolithic or Very Late Upper Paleolithic), Layer B; third from the top (Upper Paleolithic), Layer C; fourth from the top (Middle Paleolithic), Layer D. The location of the Neanderthal finds are marked by crosses. The rocks fell from roof of the cave.

gravers. Of course none of their wood products has survived in the soil of the cave, but we know from the reports of ancient explorers that Stone Age peoples were capable of a wonderful wood technology.

In Layer D of the cave, a 29-foot-thick series of deposits extending from about 16 feet below the surface to bedrock at 45 feet, we arrived at a distinct break in the human line. The peoples above were presumably all *Homo sapiens:* here, some 45,000 years ago and earlier, we discover the extinct *Homo neanderthalensis.* Not only do we recognize his crude tools, but by incredibly good luck the Shanidar Cave yields up no fewer than three skeletons of Neanderthal man, including the first Neanderthal infant!

First, a brief word about his artifacts, of which, naturally, there are not many. The flint implements of Neanderthal man are called Mousterian, after a site in France where typical ones were found. Like those unearthed elsewhere, the Neanderthal tools in Shanidar Cave are simple flakes of flint with one worked face, struck to form a cutting edge or a point. Apparently Neanderthal man was smart enough to make the most of his material, because every flint core we found had been hacked down to the last flake that could be extracted from it.

We have no clue to what clothing he wore, but he must have wrapped himself in some sort of covering, for this was a cold period in the history of Shanidar Cave—the height of the last Ice Age. In Layer D there is a dark, eight-foot stratum with an especially heavy concentration of fire remains, probably representing a period when the cave was continually occupied because of the cold outside. Apparently the occupants kept a constant fire going, for warmth and to repel wild animals. The period was not only cold but also very wet: there is a layer of stalagmitic lime—drippings from the ceiling—which marks the only era of appreciable dampness in the history of this cave.

Although the cave afforded protection from the miserable climate, it was not without its hazards to the Neanderthal occupants. From time to time there were terrific rockfalls from the ceiling, probably caused by earthquakes. We found firebeds and an animal buried under such falls, and the skeletons of both of the Neanderthal adults lay crushed under boulders which may have crashed down and killed them.

Neanderthal man has been found in a number of places in Europe, but he is a rarity in Asia. Shanidar Cave is only the fifth site in Asia where his bones have turned up. (The nearest to Shanidar is Mount Carmel in Palestine.) This alone gives the skeletons in our cave extraordinary interest, for we may learn something about man's evolution by comparing these skeletons with Neanderthals elsewhere. And added to this is the fact that one of the Shanidar finds is a year-old baby, the only infant Neanderthal yet unearthed.

The three skeletons lay at three different levels, separated by thousands of years [*drawing on opposite page*]. The most recent, and best preserved because its bones were least crushed by rocks and the overburden, is that of an adult estimated to have lived in the cave about 45,000 years ago. A rockfall shattered some of its bones badly, but the skeleton is fairly complete, and much of the skull is intact. The second adult skeleton was found about 23 feet below the surface and is believed to be about 60,000 to 65,000 years old. It was considerably more damaged than the first: a rockfall crushed not only its bones but also its skull. The child lay at a still lower level, perhaps 70,000 years old. Its skeleton was found doubled up, with the legs tucked under the chin and the arms folded close to the body. Most of the fragile skeleton, including the head, was crushed under the earth overburden, and only its teeth and the hand and foot bones are in good condition.

Every frequenter of museums is familiar with the classic picture of Neanderthal man of Europe: the low, sloping forehead, the bulging brow ridges, the massive, prognathous jaw, the receding chin, the worn teeth. Our best-preserved specimen, the Shanidar 45,000-year-old, is generally faithful to this picture. He was what anthropologists call a "conservative" type—almost fully Neanderthaloid, with few suggestions of progress toward the features of *Homo sapiens.* But he does show one feature which is more human than Neanderthaloid: his brow bulge is not one continuous ridge running across the forehead but has a depression in the middle between the eyes, and it flares at the sides. This skeleton is about five feet three inches long—the typical height of Neanderthal man. Two of the front teeth are missing, and he evidently lost them while he was alive, because there is some replacement of tissue in the jawbone where they were rooted. The teeth of both of our Neanderthal adults show heavy wear: they were worn quite flat.

It will take time to analyze the skeletons, to relate them to the Neanderthals of Europe and of other sites in Asia, to discover whether the three Neanderthals of different eras at Shanidar differ from one another, to reconstruct their posture and other attributes and to read any clues they may offer to the evolution of early man in the Middle East. It is possible that the still unexcavated part of Shanidar Cave will yield more skeletons; indeed, we have found two human skeletons from the Neolithic Period and one from the time of Mohammed.

Meanwhile the priceless hoard of remains in Shanidar Cave is being studied by archaeologists, physical anthropologists, zoologists, geologists, climatologists and other specialists. With the combined insights of all these investigators we can hope to translate the scraps of evidence into a comprehensive account of the peoples who lived in the cave and of how they wrested a living from nature in various times and conditions. The Kurdish families who still live at Shanidar are, of course, a vivid and illuminating part of the picture. Stone Age archaeology would be a vague and frustrated science were it not for the assistance that anthropologists and their living subjects are able to give in enriching the meaning of artifacts. As a prehistorian once put it, in anthropology "one catches one's archaeology alive." We see an excellent illustration of what this may mean when we look at the remarkable products made by "primitive" tribes with seemingly crude and limited tools. An archaeologist unearthing a prehistoric wood-scraper made of stone or a shell has no idea of what its users manufactured with it, for the wood objects have long since decayed. But when we discover what living aborigines have done with similar tools, we begin to realize that prehistoric man may well have been far more resourceful, and capable of more exquisite workmanship, than his tools suggest.

We still know comparatively little about the history of the Big Cave of Shanidar. But standing before the deep cut that we have sliced into its floor, we can see the general outlines of that history. We see Neanderthal man crouching over a fire nearly 100,000 years ago, and looking out from the cave mouth at a valley landscape not too different from the one today. He goes forth to hunt tortoises, wild goats and wild pigs (which still roam the valley but are now untouched by the Kurds because of a religious taboo). Apparently he does not try to catch the swift deer or tackle the dangerous bear, wolf or leopard (at least their bones are practically absent in the deposits of Shanidar Cave). The splintered bones of his game show that he cracked open the bones to suck out every bit of marrow.

For tens of thousands of years Neanderthal man hangs on at the cave, surviving the Ice Age, rockfalls and unremitting rains. Although he is a backward type, he lingers on in this mountain fastness for thousands of years after physically more "progressive" Neanderthals have died out in Palestine, only 600 miles away. Century after century his life continues with a monotonous sameness; even his flint tools do not change. Eventually he is succeeded by *Homo sapiens*. Now the curve of culture begins to rise gradually: the new men improve their hunting weapons, fashion tools for woodworking and sit around a communal fire. Thousands of years later the inhabitants of the cave have advanced to finely chipped tools, sewing and painting. But the curve of progress still clings low on the horizon. Then, some 7,000 years ago (only yesterday in the long history of the cave), the curve suddenly begins to shoot up with a burst of power. The people of Shanidar Cave learn to domesticate animals, till the soil, grind wheat, make pottery, spin thread. They remain, however, an isolated, pastoral people, in spite of the successive Sumerian, Babylonian, Assyrian and Persian civilizations that rise and fall in nearby Mesopotamia.

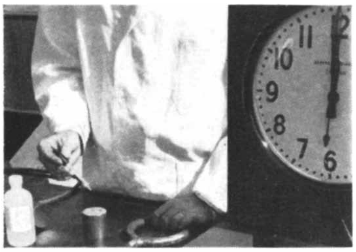
So the story of Shanidar Cave ends just a little beyond the Stone Age. Soon, it seems, its story will come to a final end, because the Iraq Government plans to build a dam on the Greater Zab which will flood Shanidar Valley and cut off access to the cave. Fortunately it was discovered in time to tell us its history.

NEANDERTHAL SKELETONS were exposed by an extension of earlier soundings in the spring of this year. The first adult Neanderthal to be discovered is at lower right. The arrow on the rear wall points to the location of the second adult Neanderthal.

Kodak reports on:

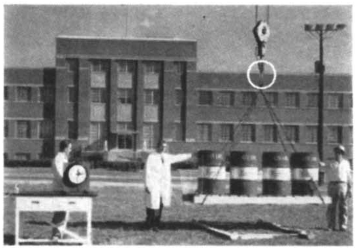
how to stick fast, rapidly . . . a high level of aberration correction at popular prices . . . the expensive pencil

It polymerizes

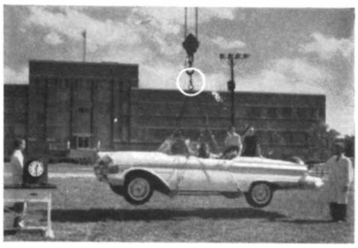


1. At high noon we put one drop of something on the end of a clean 2″ steel rod.

2. We butt it against another such clean rod, pressing firmly with the fingers.

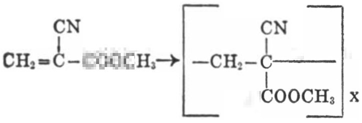


3. By 12:15, our single drop has formed a bond of considerable tensile strength.



4. And by 12:30 it is even stronger. (Tests show it to be over 5,000 psi.)

The liquid in the dropper is a chemical invention we call *Eastman 910 Adhesive.* Its major ingredient is a thin, watery liquid which polymerizes as follows:



With very few exceptions, polyethylene and silicone grease among them, it sticks all materials together—like and unlike, organic and inorganic, metallic and non-metallic. Temperatures above 100 C or continuous high humidity above 80 C eventually spoil the bond.

For a one-ounce sample of Eastman 910 Adhesive *send $5 to Eastman Chemical Products, Inc., Kingsport, Tennessee (Subsidiary of Eastman Kodak Company). Part of the reason for the price is the high attrition rate of the production equipment. The manufacture of this product can suddenly turn into the most awful mess you ever saw in your whole life. Nevertheless, the cost should decline some when the production volume rises.*

The boon of lanthanum

Our former research vice president, Dr. C. E. Kenneth Mees, one of a few men who shortly before World War I conceived the novel idea that science had a place in industry, has suggested to us from his retirement in Honolulu that the public ought to be told more about rare element glass. He is right.

Before photography itself was invented, a way was found to overcome the fact that a lens is stronger for blue light than for red. Combine a positive lens with a weaker negative lens and make the latter out of a glass which has more dispersion, i.e. rate of change of index with wavelength. The net result will still be positive power, but the negative element will lengthen the focus more for the wavelengths where the positive element is cutting it too short. This is called color correction and works fine.

Besides chromatism, nature and the laws of mathematics impose other impediments on man's strivings for perfect optical imagery. Each surface in a system contributes its own load of these aberrations, both plus and minus. The art of lens design consists of playing them off against each other. The more surfaces, the better the attainable correction. Another truism in the business has it that the deeper the curve, the bigger its load of aberrations.

Very well. Along about 1934, as a result of some rather deep studies in glass chemistry, we found that by replacing certain traditional glass ingredients with such oddities as lanthanum oxide, one could make a glass of very high index but with a dispersion low enough for use in positive elements. The higher the index, the shallower the curves can be and therefore the lighter the load of aberrations to be balanced out. Before long, Kodak lenses demanding the best possible performance were being put out with elements of such glass, regardless of the cost of lanthanum and of 10-pound batch production in pure platinum crucibles.

As the years rolled by, a new philosophy on using our rare element glass took shape among our lens designers. It goes like this: Shallow curves not only introduce less aberration, but geometry permits more of them on a single block for grinding and polishing. This economy can pay for a pretty high glass cost. At the same time, the customer gets a level of aberration correction superior to what the same number of components could have bought him before lanthanum.

Doctor Mees and we hope that when next you shop for a personal camera, you give particular consideration to the Kodak Pony 135, *the* Kodak Pony IV, *the* Kodak Signet 30, 40, *and* 50 Cameras, *and the fixed f/1.9 lens of the* Kodak Medallion 8 Movie Camera. *They've got it. Lanthanum, that is.*

Emancipation in the drafting room

One way to judge how near tangibility a big proposal stands is to count the draftsmen committed to it. Should you be forced by circumstances to use drafting manpower for effectiveness rather than effect, you ought to be informed of some wrinkles developed in the past couple of years whereby the intelligent use of photographic materials replaces the simple wearing down of fabric in the seat of draftsmen's pants. The two basic tenets of this movement are: 1) "If it's been drawn once, why draw it again?" 2) Camera and film are cheaper than the drawing pencil when you need a representation of existing equipment on which engineering changes are to be indicated.

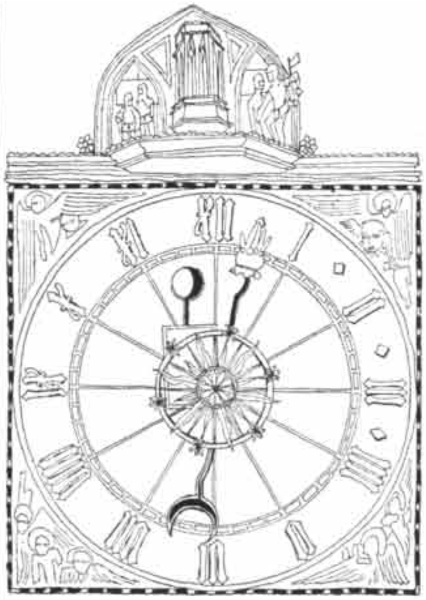
Just so they can't say you didn't try, send to Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y., for literature on short cuts in the drafting room, or on the "photo drawings" method, or both. If it's not the sweeping generalities but some vital specifics that interest you, we're prepared to answer questions.

Price quoted is subject to change without notice.

Kodak
TRADE MARK

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

SCIENCE AND



Sputnik

The earth's first man-made satellite, called *sputnik* (Russian for "fellow traveler"), became spaceborne around midnight (Moscow time) on October 4. The U.S.S.R. gave no advance notice of the launching, and in the first days of sputnik's flight little specific information about the satellite was released to the rest of the world. In the U. S., where for several days the only means of tracking the satellite was its radio signals, it took observers a week to find its orbit. As this issue of SCIENTIFIC AMERICAN went to press, the available facts were:

Launching. Moscow radio announced the launching shortly after midnight on October 5 (late afternoon of October 4 in the U. S.). The site of the launching was not announced: the first guesses were that it was near the Caspian Sea.

Rocket. The satellite was shot straight up in a three-stage rocket. The Soviet announcement said the rocket's total power equaled that of the world's largest hydroelectric station; rocket experts in other countries estimated the take-off weight to be somewhere between 150,000 and 300,000 pounds. After the satellite was fired into its orbit by the third-stage rocket, it was trailed by the rocket shell and the dropped nose cone, also traveling in round-the-earth orbits.

Satellite. The "bird" itself was a sphere with a diameter of 58 centimeters (about 23 inches) and a weight of 83.6 kilograms (about 184 pounds). Enclosed in an aluminum-alloy shell filled with nitrogen, it carried two radio transmitters sending signals alternately, one at 20.005 megacycles and one at 40.002 megacycles. Batteries for the one-watt transmitters made up most of the satellite's load. Whether the bird carried other instruments was not at first clear: Soviet scientists said the satellite was recording temperature, and U. S. scientists were certain that it was transmitting coded signals recording observations.

Orbit. The satellite was fired into an orbit at an angle of 65 degrees to the Equator; this deprived it of the accelerating effect of the earth's rotation and made it harder to track than if it had circled the earth near the Equator, but the orbit had the advantage of sending the satellite far enough north and south to cover most of the inhabited world. The satellite circled the earth in 96.02 minutes. Its speed was about 18,000 miles per hour, and its elliptical orbit had a maximum altitude of about 600 miles above the earth; estimates of the minimum distance from the earth (perigee) ranged at first from about 150 to more than 400 miles. The orbit apparently wobbled (precessed) slightly, because of the earth's equatorial bulge and possibly variations in air resistance.

Tracking. Soviet observers presumably were able to sight the satellite from the beginning because it passed over the Soviet Union a number of times at dawn and twilight—the only times it could be seen. In the U. S. the bird at first could only be followed by "minitrack" radio receiving stations, hastily adjusted from their prepared high frequencies to the lower 20- and 40-megacycle frequencies of the satellite. The somewhat fuzzy radio fixes of positions, plus a few visual sightings in Australia and Alaska and finally in the U. S., enabled U. S. scientists to calculate the orbit precisely. "Moonwatch," whose headquarters are at the Smithsonian Astrophysical Observatory in Cambridge, Mass., called its large organization of observers into action as soon as the launching was announced.

Results. Although the first satellite is in a sense only an initial trial shot, it is expected to yield valuable information about the density of the outer atmosphere, about the ionosphere, about the shape of the earth and possibly about the temperature and meteors at the borders of space.

Next. U.S.S.R. scientists said they

hoped to launch larger sputniks soon. The U. S. planned to fire a small bird in December and a fully instrumented one by March or April. By the end of the International Geophysical Year a whole flock of satellites may be flying around the earth.

In Less than 100 Years

The first to suggest sending up a man-made satellite, it appears, was Edward Everett Hale, author of *The Man Without a Country.* In 1871 he published in the *Atlantic Monthly* a piece of science fiction called "The Brick Moon." It described a large brick vehicle which was prematurely catapulted into space with some unwilling passengers; the brick moon took a permanent orbit around the earth and became a marker for ocean navigators.

Hermann Oberth, the German father of modern rocketry, was the first to give serious study to the possibility of a satellite. In 1923 he proposed a manned station to serve as an observatory in space.

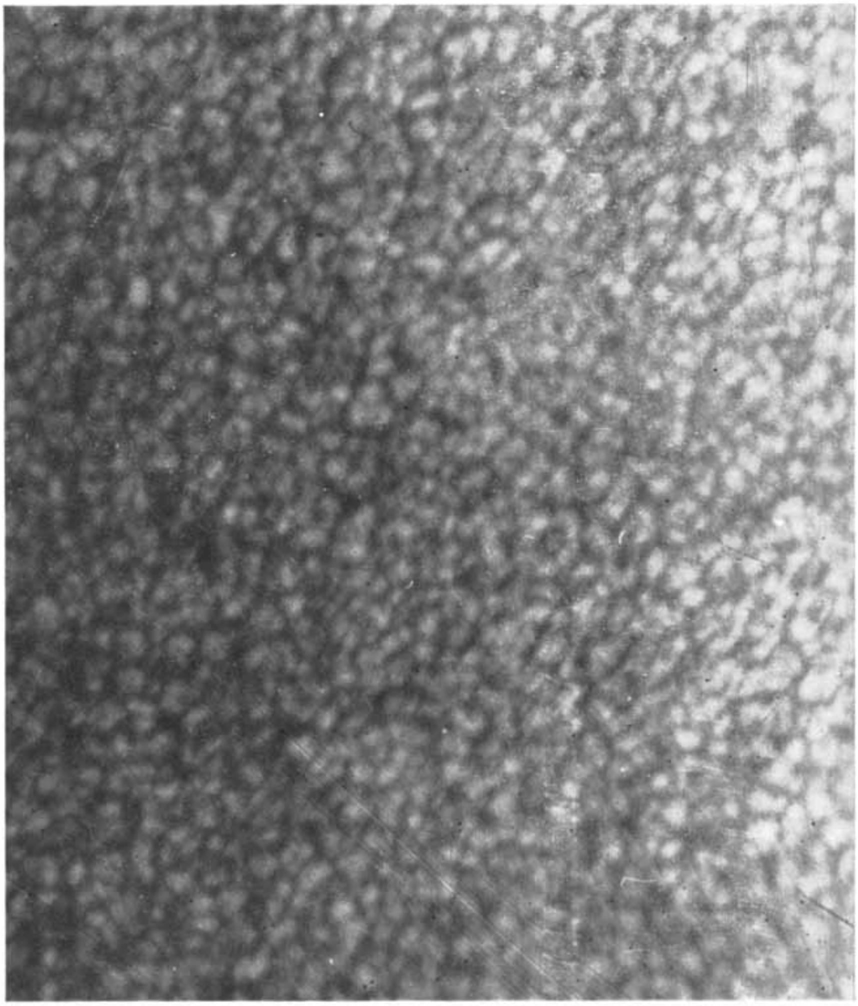
The satellite idea was brought into the realm of practical consideration and support by the development of telemetering techniques in World War II. It then became possible to think of sending up small satellites which could collect information without human observers and radio it to the ground. A number of experts outlined concrete projects. In 1949 Willy Ley, a former member of Oberth's group, proposed shooting up a 200-pound satellite by means of a 220,000-pound rocket. In 1953 S. Fred Singer, the University of Maryland physicist, suggested an instrumented satellite which he named "Mouse." In 1954 the U. S. Office of Naval Research actually set up a satellite project, called "Orbiter," which was to use a military rocket as the first stage. In 1955 the Government divorced satellite rocket research from the military missiles program and created "Vanguard" as a separate scientific project for the I.G.Y.

Meanwhile the U.S.S.R. had quietly been pursuing rocketry for many years. As early as 1925 the Soviet Government published a voluminous report by the "Rocket Subsection of the Committee for the Exploration of the Stratosphere." Apparently its rocket research remained a unified project, for its launching of the first satellite was achieved with military rockets. Contrary to a common impression, German rocketeers cannot have played a large part in this achievement, for the U.S.S.R. obtained no top-notch V-2 engineers after the war, according to Ley.

Sputnik's ancestry actually goes back to the invention of rockets by the Chinese in the 12th century. The physical principle was not understood until near the end of the 19th century, when a Russian, Konstantin E. Tsiolkovsky, developed the theory of the reaction effect. The chronological sequence of advances in rocketry in the 20th century is marked by these highlights: In the 1920s Oberth's group in Germany fired a number of rockets and Robert H. Goddard in the U. S. launched the first liquid-fueled rocket. Near the end of World War II the Germans unleashed the V-2, which reached a height of 50 miles and traveled 118 miles overland. In 1949 the U. S. Army fired a two-stage rocket, combining the V-2 and the Wac Corporal, to a height of 250 miles. In 1956 a three-stage rocket composed of the Army Redstone and two smaller stages went to 680 miles; with a directed booster at the end, this rocket could have been fired into a satellitic orbit. This year a test three-stage rocket fired by the Lockheed Aircraft Corporation rose to a height of 1,000 miles—thanks to an error in firing. The late stages of the rocket were supposed to fire the missile downward, to test the heating effect of its high-speed re-entry into the atmosphere; instead, they fired upward.

The Sun from 80,000 Feet

Out of the sky and into a Wisconsin field last month dropped hundreds of the best photographs of the sun ever made. They were in a camera which had photographed the sun's surface



SURFACE OF THE SUN is shown in unprecedented detail by this photograph made at 80,000 feet with a 12-inch telescope suspended from a Project Stratoscope balloon. The brighter spots in the photograph are eddies of hotter gas; darker spots, eddies of cooler gas.

SILICONE NEWS

"Make it Better" with Silicones

- Longer lasting cosmetics made with water repellent silicones
- Silicones improve appliance finishes
- Better packaging with silicone coated papers

SOMETHING OLD, SOMETHING NEW, *something familiar but different, too... this is the range of products being improved with Dow Corning Silicones. Why make it better with silicones? Lower production costs for one reason. But as these current examples indicate, silicones also help create more customer satisfaction, more sales.*

LONGER LASTING LOTIONS — Yesterday: no matter how often Mrs. Consumer applied hand lotions, her skin was still vulnerable to household detergents and cleaners.

Today: the cosmetic industry is marketing longer lasting and more protective beauty preparations made with Dow Corning Silicones. Already an accepted ingredient in sun-tan oils, hand creams and baby lotions, the silicones turn back water like an invisible glove . . . help keep the soothing ingredients on the skin longer.

Latest survey found most name cosmetic houses evaluating silicones for products ranging from hair sprays to foot ointments. And they're telling their customers about silicones, too. More and more, at cosmetic counters everywhere, you hear Mrs. Consumer say, "I'll take the one with silicones."

NEW APPLIANCE "SALESMAN"— The familiar refrigerator display cases in our supermarkets have long had a coating equally familiar . . . porcelain. Now, there's something new under the fluorescents . . . chip resistant silicone enamels.

A major producer of these display cases, Scherer-Gillett of Marshall, Mich., reports that their silicone finished cabinets stay new looking longer . . . do a better job. The silicone enamel—Nubelon S, made by Glidden — has excellent color retention; withstands more abuse from shopping cart impacts, food stains, and abrasive cleaning compounds. Available in several attractive colors, the silicone enamels enable Scherer-Gillett to produce cabinets that weigh less, cost less to ship, and are easier to handle and install.

Next major area of application for enamels made with silicone resins? Right now they're rapidly gaining favor in the home appliance market.

PACKAGING STICKY PRODUCTS? Then consider the new silicone coated papers and paperboards now available. Virtually nothing will stick to these new packaging materials, thanks to the anti-adhesive silicone coating developed by Dow Corning. Applied at the mill, the silicone coating makes it possible for users of paper bags, boxes and wrappers to get even the stickiest products out of containers without waste. Producers of rubber, asphalt, adhesives, sticky foods . . . all can now offer their customers greater convenience and ease of handling at little or no extra cost. In the

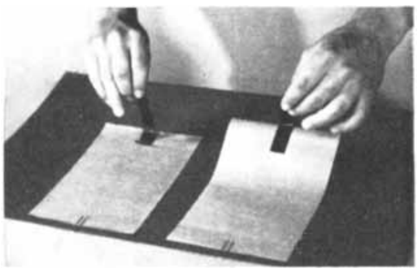


photo you can see how adhesive tape flicks off a silicone coated interleaving paper while clinging to an untreated paper.

FOR MORE INFORMATION **on any of these silicone products or applications, write Dept. 9823**

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 while suspended from an unmanned balloon at a height of 80,000 feet, above most of the earth's turbulent atmosphere.

A first glance at the developed films showed details of the sun that had never been seen before. Chief among these were eddying gas storms ranging from 200 to 600 miles in diameter [*see photograph on page* 68]. Only the largest solar storms can be photographed from the ground, and they are so poorly resolved that their detailed structure cannot be made out. The new photographs from the stratosphere show that small eddies on the sun's face grow into large ones. According to Martin Schwarzschild, the Princeton University astronomer who is directing the balloon project, a cursory examination of the pictures indicates that the small eddies originate deep in the sun's atmosphere. They are bright and hot, with a temperature of about 12,000 degrees Fahrenheit. As they rise, they cool and expand. Then they may cool further and sink back into the sun's atmosphere.

The balloon photography, planned for many months [see "Science and the Citizen," September], went off as well as its planners could have hoped. A 12-inch telescope was kept trained on the sun by automatic equipment while the camera snapped 8,000 pictures. Only one in 20 of these is sharply focused, because the camera was designed to shift its focal adjustment continually to compensate for the effects of unforseeable temperature changes on the optical system. When all the film was exposed, the telescope and camera were automatically detached from the balloon and parachuted safely to the ground.

Up in the Air

There were still other reports last month of discoveries in the upper air made by research projects of the International Geophysical Year.

Rocket shots showed that winds in the high Arctic air blow as fast as 335 miles per hour. A rocket flight during a magnetic storm disclosed bands of intense electric current at a height of 56 miles. Geophysicists had predicted such currents, with strengths up to 10 million amperes, to explain certain features of the aurora.

At a meeting of the International Union of Geodesy and Geophysics in Toronto physicists reported that an atomic-bomb test temporarily reduces the electrification of our atmosphere. Apparently the ionization of the air by radioactive debris conducts electricity from the electric layers to the ground, and this short-circuiting cuts the potential difference between the air and the ground from the normal 100 volts per meter to 15 volts. The voltage returns to normal in a few days, however.

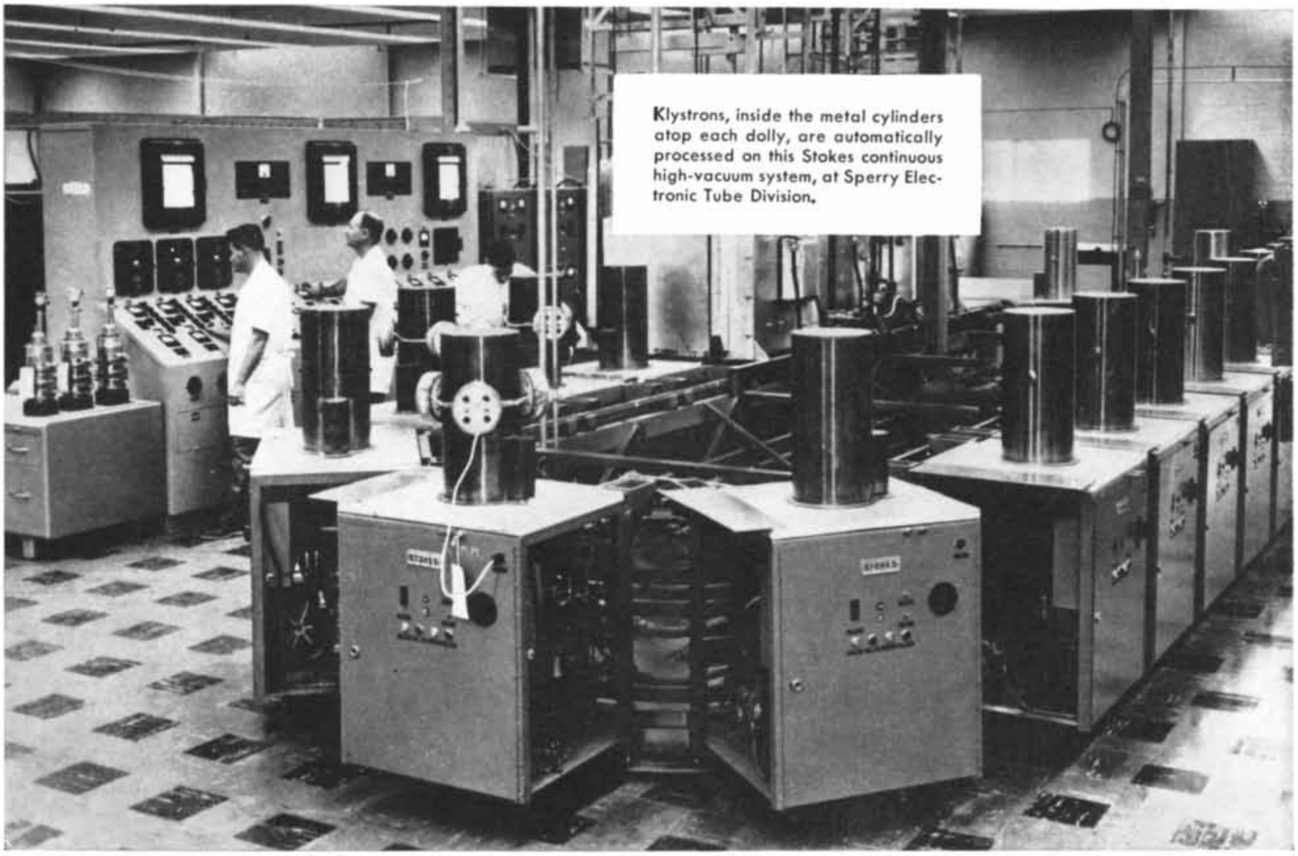
A more lasting effect of bomb tests has been discovered in New Zealand. T. A. Rafter and G. J. Fergusson reported in *Science* that the carbon-14 content of the New Zealand atmosphere has increased 4.8 per cent since 1953. They conjecture that the increase in radioactive carbon is even greater in the Northern Hemisphere, where most of the nuclear explosions have taken place. If so, a measurement of the difference should give valuable information about one of the most important unknowns of meteorology—the rate of mixing of the air of the Northern and Southern Hemispheres.

Chemical Society Meets

A record-breaking number of 15,047 chemists attended the annual meeting of the American Chemical Society in New York last month. More than 1,500 papers were delivered before its 22 sections.

The division of medicinal chemistry heard workers from Eli Lilly and Company report on a theory of the action of tranquilizing drugs and on a number of new compounds they have synthesized. The theory, as explained by Jack Mills, is that tranquilizers interfere with the action of adrenaline in certain centers of the brain. It had been noticed that agents which block adrenaline action in other parts of the body produce tranquilizing effects in animals if given in very large doses. Mills and his group suspected that if these agents could be modified to penetrate the brain more effectively they would be powerful tranquilizers. Working on this hypothesis, the Lilly chemists have synthesized four chemicals which are more effective than reserpine or chlorpromazine in tranquilizing experimental animals.

A new theory about the action of enzymes was suggested. One of the big problems is to discover what part of the large enzyme molecule is responsible for its activity. Daniel E. Koshland, Jr., and his co-workers at the Brookhaven National Laboratory located the active sites on several enzymes by means of radioactive tracers. He concluded that the enzyme molecule is flexible and shapes itself to the substance on which it works; in other words they are not fitted like a rigid lock and key. If the enzyme's active group falls into the right position on the substrate, the enzyme



Klystrons, inside the metal cylinders atop each dolly, are automatically processed on this Stokes continuous high-vacuum system, at Sperry Electronic Tube Division.

Klystron production automated with Stokes high-vacuum system

THESE Sperry Klystrons have *got* to be rugged and stable . . . they're the heart of transmitters for precision, all-weather navigation systems. Producing Klystrons requires extremely high vacuum and elevated temperatures to completely de-gas and dry the tubes internally. These conditions must be attained on a high-production, automatic basis.

Stokes, pioneer in high-vacuum processing equipment for the electronic industry, designed and built a continuous evacuating and conditioning system that performs these functions and eliminates the need for duplicate accessory equipment for each of the separate units formerly used. The system consists of an endless loop of evacuating stations, each housed in an individual dolly. As the dollies index around the loop, the tubes are successively degassed, evacuated, aged, conditioned and sealed.

Each Klystron is enclosed in a stainless steel bell in which a reducing atmosphere is maintained to prevent oxidation of the copper tube body during the heating cycle. All operations are automatically sequenced and controlled, with interlocking circuits and limit switches giving added protection. Any dolly can be removed and replaced without shutting down the system.

This Klystron production system is an example of how another major manufacturer is benefiting from Stokes' long experience in high vacuum engineering and automatic production techniques. For a consultation on your specific needs, call your nearest Stokes office.

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

STOKES

is active; if not, it does not perform its function, even though the two molecules may "fit."

Louis D. Moore, Jr., of the Tennessee Eastman Company, reported evidence that polyethylene molecules grow to molecular weights of 40 million or more—far larger than the previously recognized size of synthetic giant molecules.

Among the new products reported at the meeting were strain-free synthetic sapphires, transparent to infrared and ultraviolet, which may be useful for lenses and prisms; a powerful and versatile new insecticide with very low toxicity for human beings; an all-purpose lubricating grease made of lithium.

New Glue

Polyethylene has been given a wider range of uses by a new adhesive that bonds it to rubber and brass. The glue, developed at the Bell Telephone Laboratories, will make polyethylene-covered telephone cables cheaper and easier to manufacture. It will also serve to protect any metal surface exposed to corrosion: the surface can be brass-plated and then covered with polyethylene.

The adhesive, discovered by Henry Peters, is made of polybutadiene. It is applied as a liquid or a solid sheet between the surfaces to be joined. These are then pressed together and heated.

Vaccines

Winston H. Price of the Johns Hopkins University last month announced a vaccine which prevents some colds, but he believes it has "received much more publicity than it warrants."

The vaccine is a preparation of killed JH (for Johns Hopkins) virus, which proved responsible for about 30 per cent of the colds studied in Price's Baltimore laboratory over a two-year period. In experimental trials the preparation decreased susceptibility to the infection eightfold. But it is effective only against this one organism, and no one knows how common the JH virus is.

Isolating the virus was much more difficult than making the vaccine. It was isolated by special culture techniques. Since discovering the virus, Price and his colleagues have spent most of their time studying its habits and distribution. Now they are beginning to look for other cold viruses.

While U. S. citizens pestered their physicians and scrambled in black markets for a shot of the Asian flu vaccine, a panel of experts from the University of

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Maybe you could do it right in your own plant—any time you like—with a Picker HOTPOT, one of Picker's "packaged" radiation fluxes. The HOTPOT compacts millions of roentgens of high energy radiation in a shielded cabinet no bigger than a desk . . . and so safe you can keep it in your office. Ask us about this and other Picker irradiators.

need radiographic or fluoroscopic inspection of your components, assemblies, welds, castings, forgings or what have you?

We probably have just the machine to do the job for you. The Picker spread of equipment embraces units spanning a radiographic range from 10 KV x-rays (for paper-thin materials) to 3 MEV equivalent Cobalt 60 which can penetrate solid lead inches thick.

looking for fine isotope instrumentation backed by a national service hookup?

Look into Picker-built scalers, ratemeters, well counters, probes. These (all other Picker equipment, too) are sold and serviced by a far-flung network of service engineers with local warehouses and service depots at strategic points. There's probably a Picker District office near you (see your local 'phone book).

got any other radiation problem nagging you?

Why not tell us about it?

We'll be glad to help you if we can (chances are good)

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y.

boils down to this...

if it has to do with RADIATION

it has to do with Picker x-ray

California and Stanford University suggested last month that the "hysteria" was needless. The vaccine is only 50 per cent effective, they said, and it can cause rather severe reactions. Assuming that Asian flu threatens to attack 20 per cent of the population, mass vaccination would help only one person in 10 of those vaccinated, and some of the vaccinees might suffer more from the shot than they would from the flu itself. "If we were to give the vaccine to one million persons across the board right now," said one panel member, "we would have more deaths and illnesses from the vaccine than from the flu."

Electrochemistry of Behavior

New insights into the physics and chemistry of mental activity were reported last month to the American Psychological Association at its meeting in New York. E. Roy John and his colleagues at the University of California at Los Angeles have traced the effects of a psychological conditioning experiment on the physical processes of the brain.

Working with cats trained to avoid certain stimuli, the U.C.L.A. team first observed the changes in learned behavior that could be produced by dosing the animals with a wide variety of chemicals. The substances tested ranged from complex materials such as serotonin and reserpine to potassium and calcium. They were injected either into the bloodstream or directly into the cats' brains through little tubes implanted in their skulls.

Depending on the chemical and the place where it was administered, a number of specific and sharply differentiated effects could be produced. Cats conditioned to jump when they either heard a certain tone or saw a certain light signal were made to ignore the visual signal while still responding to the auditory one. They could be induced to "forget" the significance of a 600-cycle tone to which they had previously responded, while continuing to jump at a 1,200-cycle note. In certain cases the chemical blocked the avoidance reaction but not an emotional response: the cats would cringe or otherwise show fear but would not jump at the signal.

The psychologists then decided to look for specific electrical changes in the cats' brains during the conditioning process. They implanted pairs of tiny electrodes in various parts of the animals' brains and exposed them to a "tracer" stimulus in the form of a light that flashed at the rate of 10 times a

Ruud Water Heaters are widely used in homes to serve automatic dishwashers and clothes washers, in schools and restaurants to meet sanitary code requirements for extra-hot wash and rinse water in dishwashers, and in industry for controlled-temperature applications.

Hotter water for cleaner dishes from Cupro Nickel tanks

Automatic welder joining edges of a formed Cupro Nickel cylinder to produce shell of a Ruud water-heater tank.

THE PROBLEM: To do a superior job of cleaning clothes or washing dishes, water should be *really* hot. For such service, it must be heated and stored well above the usual 140-150 degrees F —and this is tough on ordinary water heater tanks.

The problem faced by Ruud Manufacturing Co., which specializes in high-temperature gas water heaters, was to find a metal readily available at reasonable cost which is highly resistant to attack by many types of corrosive water —at temperatures of 160-180 degrees F. It also had to work out well on the production line.

THE SOLUTION: Ruud talked things over with Anaconda metallurgical specialists. Borrowing from experience in meeting corrosion problems in industrial condensers and heat exchangers, the Anaconda men suggested that Ruud use Cupro Nickel-755. This Anaconda copper alloy, containing 10% nickel, combines exceptional workability and weldability with the strength and resistance to corrosion needed for high-temperature water heater use. Ruud tried it, and is now forming its tanks of Cupro Nickel-755.

THE FUTURE: As the tasks imposed on metals by our ever-changing technology become more numerous and complex, Anaconda and its manufacturing companies — The American Brass Company and Anaconda Wire & Cable Company— constantly seek better ways of doing things with nonferrous metals and products. Whether your problem concerns corrosion, heat exchange, conducting electricity, or better ways of fabricating with metal, see the Man from Anaconda. The Anaconda Company, 25 Broadway, New York 4, N. Y. 57263

ANACONDA®

THE AMERICAN BRASS COMPANY—ANACONDA WIRE & CABLE COMPANY second. At first there was a 10-cycle electrical response in many parts of the brain. This died out as the animal became accustomed to the stimulus. But when the light was coupled with shocks to produce an avoidance reaction, the electrical response of the brain was renewed with greater intensity. Then, as the conditioning became effective, the simple 10-cycle activity dropped off in some sections of the brain and persisted in others. In still other sections there was a new electrical response at some multiple of the outside frequency—5, 20 or 30 cycles. When the conditioning was complete, the 10-cycle signal elicited a distinctive and varied pattern of electrical activity over the brain. Now, if the response was blocked by a drug, the distinctive pattern disappeared and the naive response to the stimulating signal showed up again.

In a continuing series of experiments John hopes to "get a very definite idea of what goes on" in the brain during the learning process.

Mass Media v. Segregationists

The resistance of white Southerners to desegregation seems to weaken in proportion to their exposure to newspapers, magazines and radio and television programs. So concluded Melvin M. Tumin, associate professor of sociology at Princeton University, in a recent issue of *The Public Opinion Quarterly*.

Tumin and his graduate students conducted a study among white male residents in Guilford County, N.C. They found that those who read newspapers and magazines and listened to programs more often were not less prejudiced about Negroes but were considerably milder in the steps they said they would take to maintain segregation. Asked what they would do in specific cases (*e.g.*, a Negro sitting down in the same restaurant), most of the more sophisticated Southerners were not inclined to take aggressive action. To prevent school desegregation the choices of action they thought they would take were in the following order: (1) attempt to amend the Constitution, (2) withhold state funds from desegregated districts, (3) close the public schools, (4) use force if necessary.

Tumin believes that this order of preference shows that informed Southerners are less set against desegregation than is commonly supposed, and that their stereotype as to the Negro's inferiority is likely to disappear after desegregation.

"THE ORGANIZER"

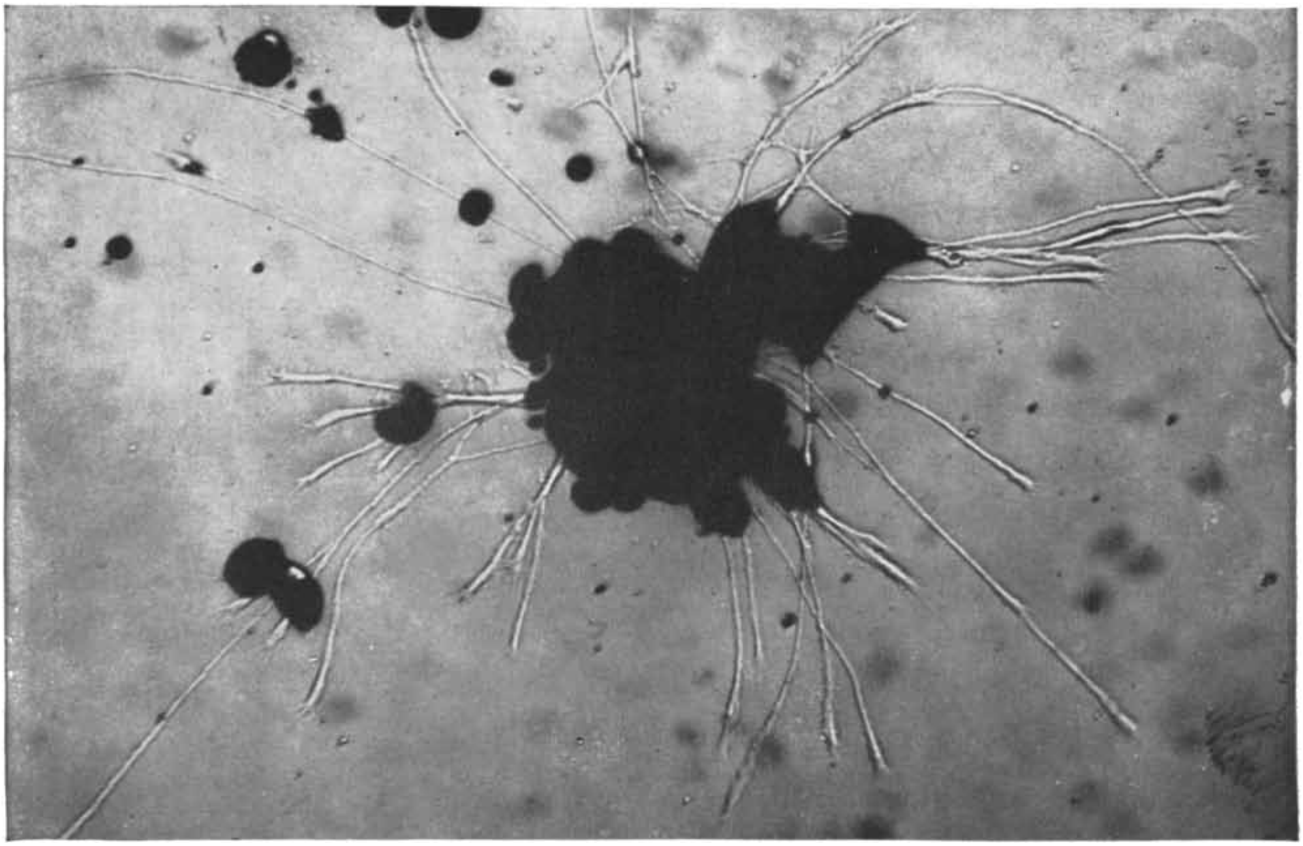
How are the unspecialized cells of the dividing egg organized into the specialized cells of a plant or animal? For 70 years biologists have been searching for the answer by experiments

by George W. Gray

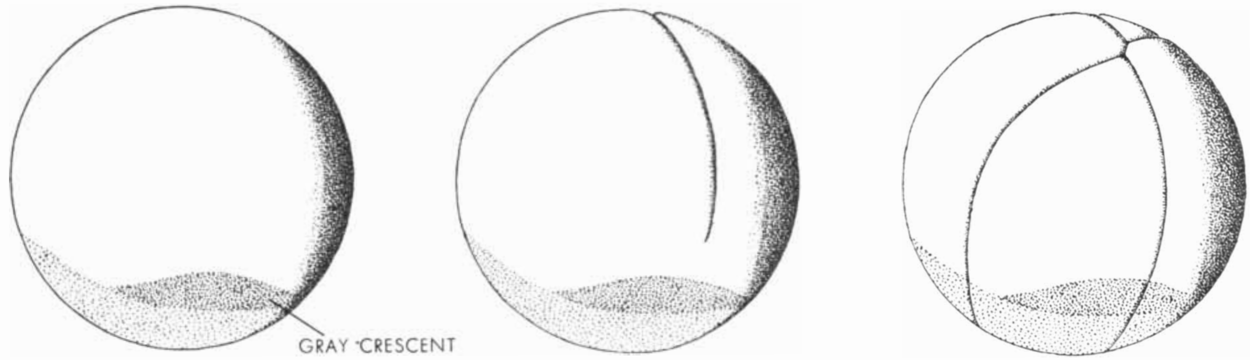
It's a very odd thing—
As odd as can be—
That whatever Miss T. eats
Turns into Miss T.
—Walter de la Mare, *Peacock Pie*

Individuality is the hallmark of life. In the realm of physics and chemistry an investigator must deal with crowds; he can rarely if ever single out one atom or one molecule for study. But a biologist can focus on a single cell, on the nucleus of the cell, on the individual strands of material that make up the nucleus, even, indirectly, on the activity of a single gene. And so he learns that not only is Miss T. unfailingly able to convert steak and potatoes into the unique pattern of the tall, angular, blond woman that is Miss T., but every one of the billions of cells that make up her body carries the individual design that marks it as exclusively her own. The cells are not a crowd but members of an organized community, each serving a special function according to a pre-established plan.

How this organization is brought about is the central problem of biology. If man is ever to understand what life is, he must solve the mystery of how a living thing takes inanimate material and builds it into a germ cell, and how this one cell, after fertilization by merger with another cell, divides into two, and then each into two more, and so on



NERVE CELLS with their typical long fibers were unorganized ectoderm eight days before this photomicrograph was made by M. C. Niu of the Rockefeller Institute. The change was induced by fluid taken from a culture of embryonic "organizer" cells.



DIVISION OF THE EGG of the salamander is depicted in this series of somewhat schematic drawings. The first drawing shows the fertilized egg, with its characteristic "gray crescent." The second drawing shows the first cleavage of the egg, which is perpendicular

through a succession of 40 to 50 cell generations until a human being is born. Everything that is now expressed in the 25 million million cells of the newborn baby was precisely blueprinted in the original germ cell. Not only the architect's plan, but the machinery for building according to the plan was carried in that seed of life not much bigger than the point of a pin.

But how? By the operation of what laws is a single cell able to multiply into such different structures as skin cells, bone cells, muscle cells, blood cells, brain cells and all the rest—and at the same time marshal this wide diversity into a closely coordinated and smoothly working whole?

Epigenesis *v.* Preformation

Embryology dates back to the shadowy dawn of Greek medicine. Two thousand years before there was any knowledge of the biological cell, physicians observed the differences between organs and began to speculate on how the organs were formed. The question was raised by one of the Hippocratic writers, and quite early in history two concepts arose.

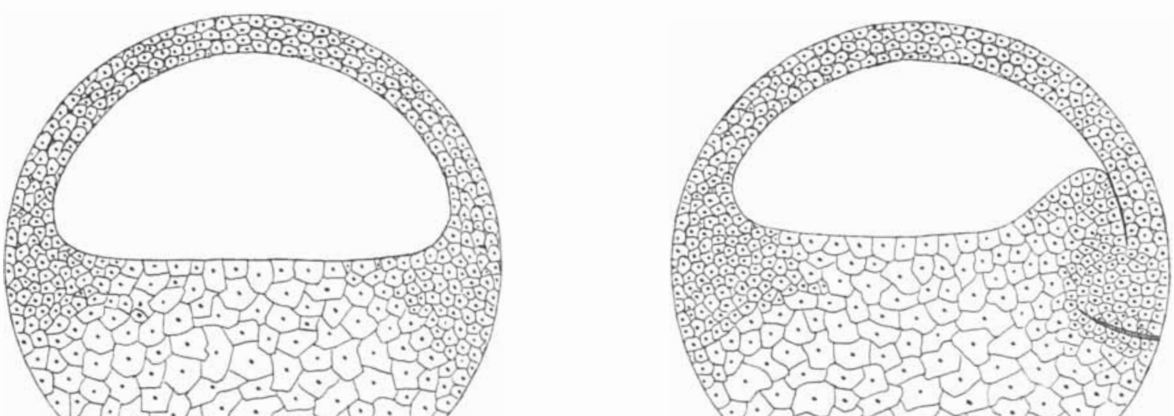
Aristotle argued that the mother contributes the substance and the father the structure of their offspring. He pictured the male's semen as the moving element which organized the substance provided by the female, just as an artist "imparts shape and form to his material." From observations of animals, but mainly of the developing chick in the egg, Aristotle deduced that the first organ to emerge was the heart. He said:

"Either [the organs] are formed simultaneously—heart, lung, liver, eye, and the rest of them—or successively, as we read in the poems ascribed to Orpheus, where he says that the process by which an animal is formed resembles the plaiting of a net. As for the simultaneous formation of the parts, our senses plainly tell us that this does not occur; some of the parts are clearly to be seen in the embryo while others are not."

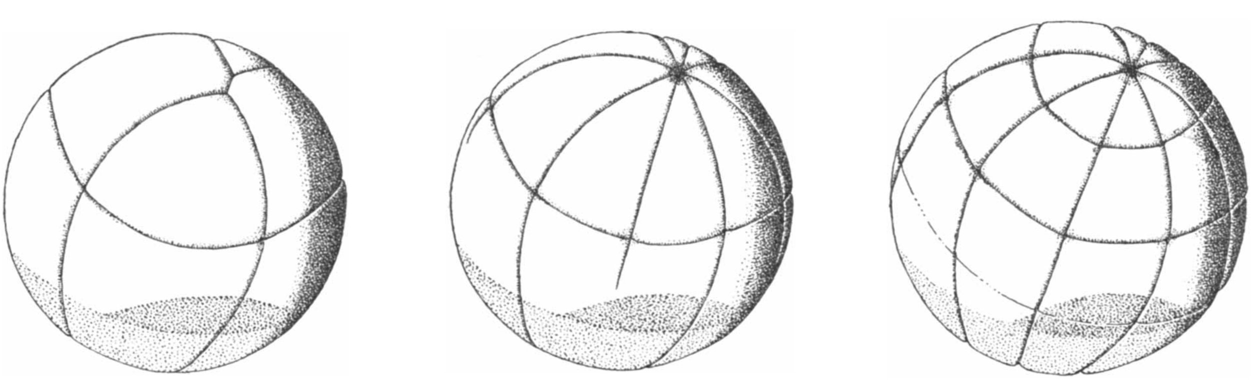
Epicurus held another view. Believing that matter is everything ("there are only atoms and the void"), he contended that both parents contribute material and that a child must be completely formed from conception, though in miniature. The Roman rhetorician Seneca later epitomized the idea in these words:

"In the seed are enclosed all the parts of the body of the man that shall be formed. The infant in his mother's womb hath the roots of the beard and hair that he shall wear some day. In the little mass, likewise, are all the lineaments of the body and all that which posterity shall discover in him."

Here are two strikingly contrasting ideas. In Aristotle's view there was a gradual emergence of form from undifferentiated material—a process which has come to be called epigenesis (from



FORMATION OF THE GASTRULA of the frog, which differs somewhat from that of the salamander, is depicted in cross section. The first drawing shows the blastula, a hollow ball partly filled with yolk cells. The second drawing shows the cells beginning to fold



to the gray crescent. The third drawing shows the egg divided into four cells; the fourth, into eight cells; the fifth, into 16; the sixth, into 32. The region just below the gray crescent later gives rise to the blastopore (*see drawings at the bottom of these two pages*).

the Greek, meaning "ensue upon"). The other view, called preformation, asserted the presence of a full-structured organization from the beginning, so that the development of the embryo was simply an enlargement of what already existed in small scale.

It is interesting that in Renaissance Europe it was the scholastics who accepted Aristotle's theory, while medical men and other biologists turned increasingly to the embryology of the Epicureans. By the 17th century the sway of the preformationists was almost unchallenged, and the concept was pushed to the most absurd extremes. If the embryonic germ is a complete body, it was argued, then the germ must contain all the organs and parts, including the seed of the next generation, and that seed in turn the seed of the next, and on and on, like a series of Chinese puzzle boxes. Mother Eve, it was said, carried in her body the forms of all the people to be born.

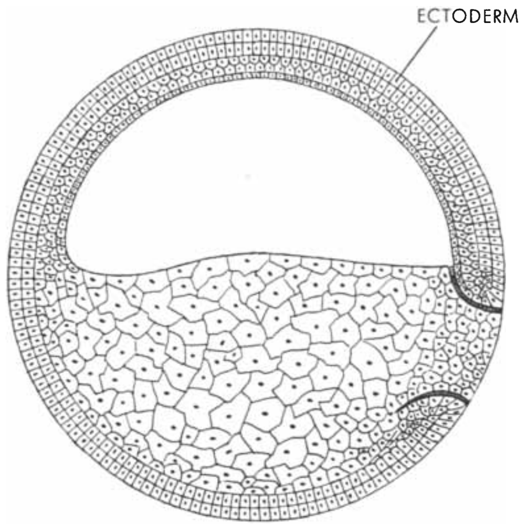
Meanwhile the power of the glass lens had been discovered. The pioneering Dutch microscopist Anton van Leeuwenhoek focused his "optik glass" on a drop of human semen and saw the spermatozoa, which he named "animalcules." Others took up the new instrument, and among them was an ardent preformationist who thought he saw in each animalcule the form of a tiny human being, complete with head, body, hands and feet! This observation led to a great schism among preformationists. For it suggested that Adam, rather than Eve, contained all mankind. Many forsook Eve to espouse the new dogma, and they were called animalculists; those who remained loyal to Mother Eve were ovists.

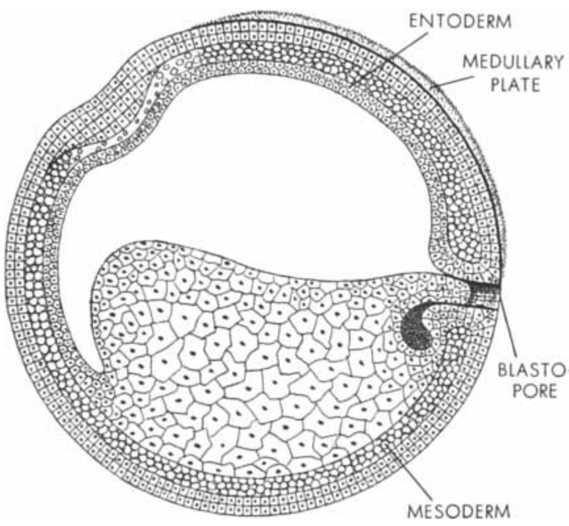
Observations and Experiments

The first breath of fresh air came from Germany. At the University of Halle, Kaspar Friedrich Wolff watched the development of the tip of a growing plant through his microscope and made careful drawings of what he saw. Shoot after shoot showed only homogeneous tissue. There was no sign in this tissue of the leaves, flowers and other organs which later emerged from the shoots. Wolff noticed, moreover, that when the specialized parts did begin to form, each appeared first as an almost imperceptible prominence or swelling in the undifferentiated tissue.

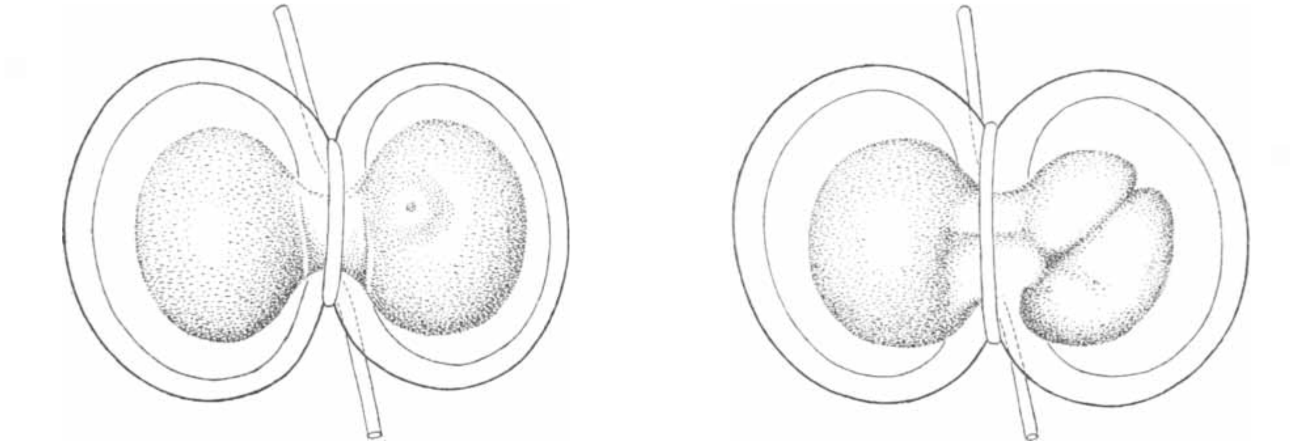
Wolff next trained his microscope on the developing chick in the egg to see what he could learn of animal tissue. He found that the intestine gradually formed from tissue which at the beginning showed no rudiment of the organ that was to come. And so with other organs. Neither in a plant nor in an animal could he see any trace of preformation, and he concluded that in both the developmental process was epigenesis.

Wolff's 18th-century observations inaugurated a rational approach to embry-





inward to form the gastrula. The third and fourth drawings show the formation of the blastopore and the three layers of the gastrula: the ectoderm, the mesoderm and the entoderm. The medullary plate, from which springs the nervous system, grows out of the ectoderm.

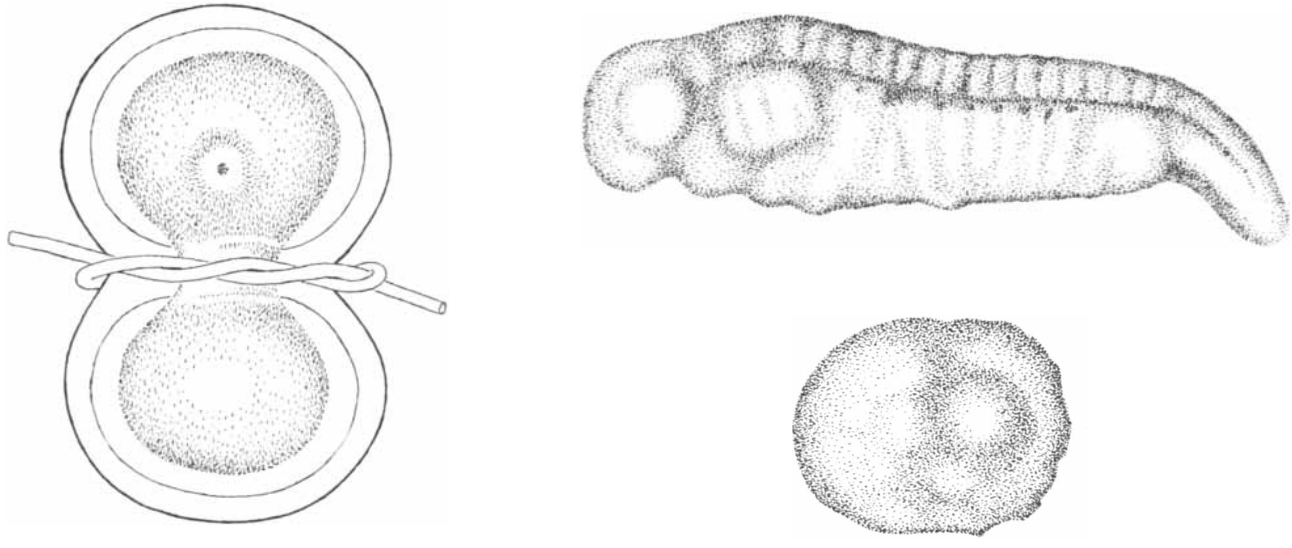


CLASSIC EXPERIMENT performed by Hans Spemann involved tying the salamander egg into two halves across the gray crescent. The nucleus of the egg (*marking at right in drawing at left*) was confined to one half. At first only the half containing the nucleus

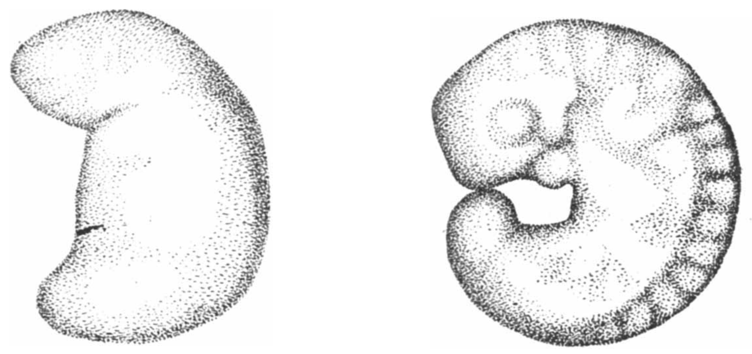
ology, and other advances paved the way: improvement of the microscope, the firm establishment of the cellular theory, the invention of the microtome, the discovery of evolution, of the gene, of proteins and of nucleic acids. Up to the latter part of the 19th century, however, the epigeneticists and the preformationists continued their war of words without direct experimental test, and embryology remained almost entirely a descriptive science. "Take 20 or more eggs," an experimenter of the fourth century B.C. had instructed, "and let them be incubated by two or more hens. Then, each day from the second to that of hatching remove an egg, break it and examine it." This preoccupation with what we may call the natural history of the embryo, paying little attention to causal relationships, continued to dominate embryological research until almost the turn of the century.

In the 1880s the speculations of a German zoologist, August Weismann, precipitated a significant investigation. He developed a germ-plasm theory which pictured the nucleus of the fertilized egg as a mosaic in which "primordia" (starting points of the organs and tissues) "stand side by side, separate from each other like the stones of a mosaic, and develop independently, although in perfect harmony with one another, into the finished organism." If this were the case, then an embryo at the two-cell stage would have one half of the individual in each cell. Wilhelm Roux, an anatomist at the University of Breslau, decided to test Weismann's hypothesis. He figured that if he removed one of the two cells at this stage, the incubation of the remaining cell would provide the needed test. And so in 1888 Roux performed a historic experiment. Taking the two-cell embryo of a frog, he killed one of the cells with a hot needle and let the other develop in its natural water medium. The result was a half-tadpole. This seemed to demonstrate that each cell carried half of the machinery for constructing the frog, and the experiment was hailed as proof of the mosaic theory of preformation.

But there were doubting Thomases. They pointed out that the killed cell had remained attached to the living one and might conceivably have influenced its development. Various attempts were then made to separate embryonic cells, and in 1891 this was accomplished by Hans Driesch, working in a laboratory in Naples. Driesch shook two-cell em-



SECOND EXPERIMENT by Spemann was to tie the egg parallel to the gray crescent. The half of the egg with the gray crescent developed into a normal embryo (*upper right*), but the other half produced only an unorganized "belly-piece" (*lower right*).



divided (*drawing second from left*). Later the other half began to divide. Eventually both halves gave rise to normal embryos, one younger than the other (*drawings at right*).

bryos of sea urchins in a vial of sea water and succeeded in disjoining the two cells without injury. Under incubation each cell developed into a whole sea-urchin larva. In later experiments he separated a four-cell embryo into its components, then an eight-cell, and finally one that had reached the 16-cell stage—and from each he obtained on incubation a complete animal.

This spectacular emergence of the whole from a fragment was so contrary to the popular dogma of the day that it aroused embryologists. There was a rush to the laboratories, and investigators who had been content merely to watch life unfold now became ardent experimenters. By the turn of the century a whole new school of laboratory workers were engaged on problems which the conflicting results of Roux and Driesch had posed. Among them were Hans Spemann, a 31-year-old zoologist at the University of Würzburg, and Ross G. Harrison, a 30-year-old associate professor of anatomy at the Johns Hopkins University. These two became the leaders, builders and teachers of the modern science of developmental biology.

Spemann and Harrison

Both men were superb experimenters. They knew how to ask the right questions of nature. Employing techniques which in some cases had been pioneered by others without definitive results, they had the imagination to strip the problem to its simplest terms, bend the experimental procedures to the new approach and thereby frame a question in such a way that the subject could respond. Spemann used to say that he regarded the embryo as "a conversational partner who must be permitted to answer in his own language"; Harrison had the same attitude. As one reads the papers of these two masters of research, Harrison appears to be more matter-of-fact, more objective, a greater realist, while Spemann seems more philosophically minded, more concerned with symbols, a searcher for wholeness. They never collaborated in investigation but were warm personal friends, frequently consulting each other on speculations and experimental results. Harrison often spent part of his summer vacation visiting Freiburg, where Spemann was professor from 1919 to his retirement in 1935.

Harrison is most widely known, perhaps, for his invention of the tissue-culture technique. It was devised to tackle a problem in embryology, namely, the origin of the peripheral nerves that connect the brain with the end-organs of touch, taste, smell and the rest. The connection is through the spinal column, of course, but how are the lines laid down during development? Some investigators believed that the nerves grew out from the neural tube, the primitive spinal cord of the embryo. Others argued that the fibers originated in the organs and grew toward the cord.

Harrison conceived the idea of trying to culture a minute fleck of tissue from an embryonic neural tube in the nutrient fluid to which it was accustomed, and watching to see whether nerves could grow out of it. He devised the "hanging drop" technique, putting the bit of tissue in a drop of fluid which was then suspended from a glass cover slip laid over a hollowed-out well in the center of a glass slide [*see drawing on page 86*]. The tissue was a particle of neural tube cut out of a frog embryo, and the fluid was a drop of the animal's lymph.

Harrison watched the bit of tissue almost continuously under a microscope, and soon results began to show. After a few hours delicate protuberances began to bud out from the tissue. They grew into filaments which extended into the clotted texture of the lymph. Then, in the same way, Harrison cultured bits of non-nervous tissue—a piece of embryonic muscle, a particle of intestinal wall, other fragments of early organs. All of them grew, but none sent out any nerve fibers. Thus he demonstrated that nerve development is a growth outward from the neural tube, not inward from the organs.

The hanging drop became one of the most powerful tools of experimental biology. In 1917 the Nobel prize committee of the Swedish Karolinska Institute chose Harrison for the Nobel award in physiology and medicine, but for some reason the Institute decided not to give the prize that year, and Harrison never received this honor. But he has had many others, and only last year the Academy of the Lincei in Italy, the world's oldest learned society, sought him out, at the age of 86, to give him its Antonio Feltrinelli prize of $8,000.

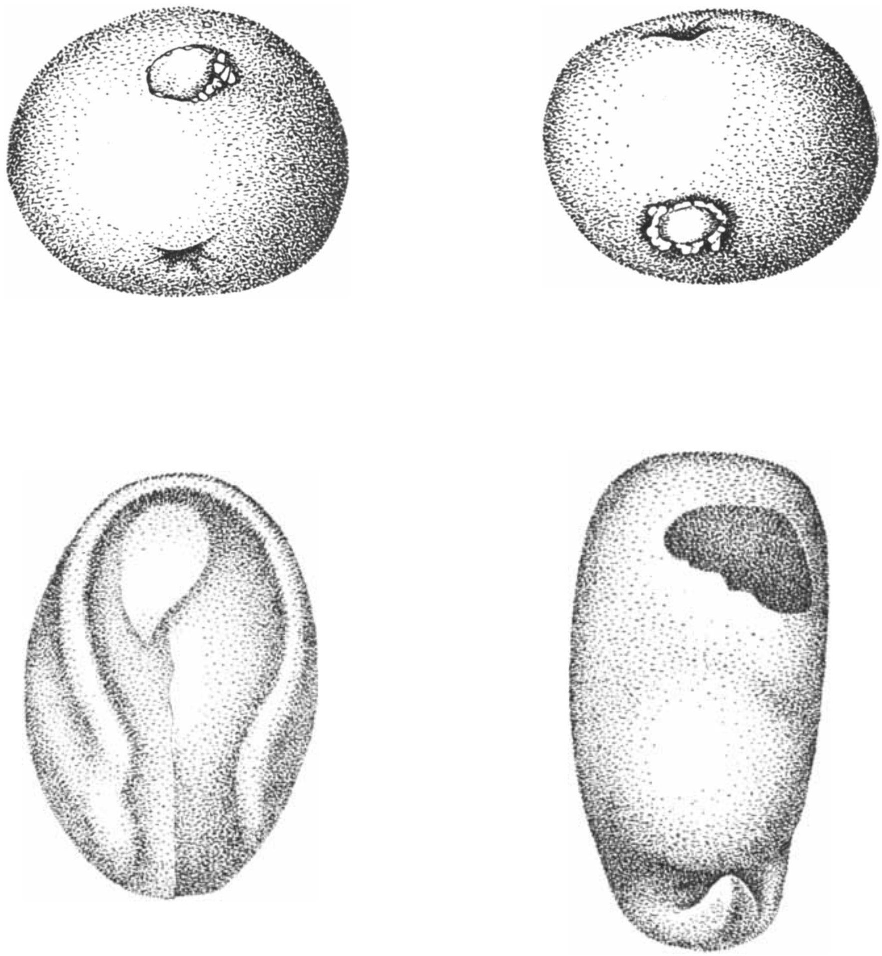
Spemann, too, was the recipient of numerous decorations. In 1935, six years before his death, the committee selected him for the Nobel prize and this time the Karolinska Institute decided to give it. The citation said that the award was for "his discovery of the organizer effect in embryonic development."

The Organization of a Newt

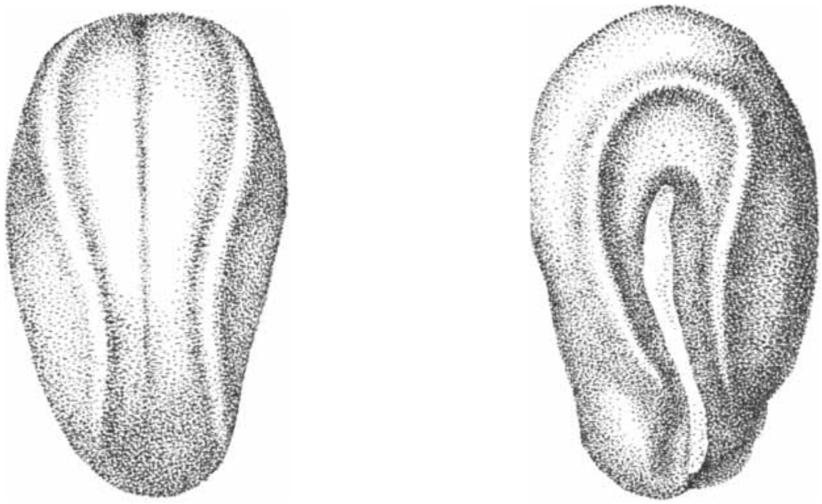
Spemann's discovery was made in experiments with newts, a variety of salamander. These small, lizard-like amphibians originate from eggs whose habitat is water, so it is a simple matter to keep the temperature and other conditions favorable for incubation and nurture. Comparative studies have shown that the development of the salamander egg parallels closely that of other backboned creatures, including man.

A peculiarity of the salamander's egg is that about half of its surface is dark-colored, the other half light or colorless. Immediately after fertilization a small, crescent-shaped segment of the boundary region between the light and dark areas takes a grayish hue. This so-called "gray crescent" is the first visible manifestation of profound changes occurring within the egg. It appears just before the self-duplication of the fertilized cell.

Spemann, like many other biologists of his day, was fascinated by the prob-



TISSUE WAS TRANSPLANTED by Spemann from a region above the blastopore of a salamander egg (where it would normally grow into belly skin) to a region below the blastopore of another egg (where it would normally grow into nerve tissue), and vice versa (*drawings at top*). Later the cells which would have become skin tissue became nerve tissue (*lower left*), and the cells which would have become nerve tissue became skin (*lower right*).



TISSUE WAS REMOVED from the lip of the blastopore of a colorless salamander gastrula and implanted in the ectoderm of a pigmented gastrula. The blastopore tissue of the colorless gastrula induced the pigmented gastrula to make a second medullary plate. At left is the medullary plate of a pigmented embryo; at right, the induced medullary plate on the other side of the embryo. The light area in the induced plate is the implanted tissue.

lem of testing Weismann's mosaic theory of preformation. Suppose, instead of separating the two-cell embryo into its halves as Driesch had done, the egg were simply constricted across its middle just before it cleaved? Spemann procured a strand of baby hair, made a slip noose, looped it over the cleaving egg and drew the strand tight, leaving only a slender bridge of protoplasm between the two halves. The nucleus of the cell was sequestered in one half [*see drawing at top of page 82*]. It began to split and draw apart in two spindles, duplicating itself in the process known as mitosis. The cell on its side of the constricting noose thus divided into two cells, then into four. Meanwhile the cell on the other side of the noose remained just a single cell. Soon, however, it too began to divide, after mitosis had occurred on the other side in a cell close enough to the pinched waist to send nuclear material through the narrow bridge. The net result was two embryos, the one on the side with the original nucleus developing first, but the other finally catching up. Eventually two complete salamander larvae developed. Spemann repeated this experiment many times, once getting 32 cells on one side before nuclear material slipped through and started development on the other.

Suppose the cleaving egg were pinched in a direction at right angles to the first—that is, parallel to the gray crescent instead of across it [*see drawing at the bottom of page 82*]. Would this make a difference? Spemann made the experiment and found the result indeed quite different. The half without the nucleus eventually divided and subdivided, but its final product this time was only an unorganized mass which Spemann called *Bauchstück*—belly-piece. This belly-piece contained liver cells, lung cells, intestinal cells and other abdominal material—but it had no axial skeleton, no nervous system, no unifying pattern.

Why? Why should the unnucleated half of the egg now produce only a crowd of miscellaneous cells? Spemann decided that the distinguishing difference between the experiments must be the fact that in the first, each half of the egg had part of the gray crescent, whereas in the second, one half had most or all of the gray crescent, while the other—the half that failed to develop—had little or none of it.

What was so significant about the gray crescent? Spemann considered its "geographical" relationship to the known facts about development of an embryo.

After the embryo has developed to the

form of a hollow sphere, a dimple begins to form on its surface, and this deepens into a crater called the blastopore. The cells around the lip of the crater suddenly begin to slide in over the brink, as if pushed by an invisible hand. At the end of this process, known as gastrulation, the salamander embryo looks like a rubber ball with half of it pushed in. Now the cells on the concave outer surface, called ectoderm, will become skin, brain, nerves, ears, eye lenses and other sensory organs. A layer of the cells that have migrated to the inside, called entoderm, will develop into lungs, liver, stomach, intestines and certain other abdominal organs. Another infolded layer of cells, the mesoderm, is destined to produce bones, cartilage, connective tissue, muscle, the blood and its vessels, and organs of the urogenital system.

The Organizing Lip

How are all these fates fulfilled? Spemann knew that the lens of the eye is formed by a process of "induction." An eye begins as a tiny protuberance budding off from the embryonic brain; the protuberance grows into a vesicle, and then the vesicle apparently induces the skin overlying it to become a transparent lens. Reflecting on his experiments with pinched eggs, Spemann began to suspect that cells associated with the gray crescent might be the primary inducers of the whole chain of development that produces an organized individual. The gray crescent is merely a surface feature of the egg which soon disappears as the cells multiply. But the blastopore forms just below the area the crescent occupied. For other good and sufficient reasons, Spemann focused his attention on the lip of the blastopore and addressed a series of questions to it.

How would it be if one took a bit of tissue from the specific area of the embryo that is destined to form belly skin and transplanted it to the area behind the blastoporal lip that is to form brain? Spemann did that, using two specimens. From one embryo he cut a microscopic patch from the presumptive flank; from the other he sliced a fragment of equal size from the area that he knew would form brain if left undisturbed. Then he exchanged the two bits, transplanting the presumptive flank tissue into the wound left in the brain area and the presumptive brain into the cut surface of the flank. The grafts grew, the two embryos developed, and lo!—the transplanted flank turned into brain and the transplanted brain into belly skin.

After repeating this and similar experiments many times, and always getting the same answer, Spemann took up a new line of questioning. Suppose, he said, the lip itself were cut out and implanted in another embryo?

The two-story zoology building at the University of Freiburg where Spemann worked was teeming with students, and among them was Hilde Proescholdt. It was her good fortune to be looking for a research project to fulfill the requirements for her Ph.D. Spemann outlined his proposed experiment to the young woman, appointed her his assistant to carry it through, and thus she shared in the great discovery published two years later under their joint authorship.

For this experiment Spemann used two varieties of salamander—one dark-hued, the other colorless. The blastoporal lip was cut from the colorless embryo and grafted into the belly of the pigmented individual. The latter now had two blastoporal lips—its own on its topside, and the implanted lip from the colorless salamander on its underside. Thus there were two centers of organization in a single embryo. And what happened?

Gastrulation occurred at each place: that is, ectodermal cells migrated over each lip into the mesodermal layer beneath. Eventually there developed two axial systems, each complete with a spinal column, head, trunk, legs and tail—two baby salamanders joined like Siamese twins! The extra salamander had whole sheets of tissue made of dark cells, as well as organs and parts built of colorless cells. This showed that the lip transplanted from the colorless embryo had extended its organizing power to multiplying cells of the host embryo.

Here, said Spemann, in the cells that flow around the blastoporal lip, is the primary center of induction. He named this region "the organizer." He did not, however, suppose that it controlled the whole process of development: he saw a succession of organizers at work, one taking up where another left off, each having its part in the sequence which began with the migration of a sheet of epidermal cells over the lip of the blastopore and ended with the birth of a coherent, sentient being.

The New Questions

Spemann's work is one of the great landmarks of biological research. It exemplifies, in the simplicity and directness of its approach, how the mind of a master investigator works. And his experiments and interpretations brought a sense of unity to the science of embryology, leading it sufficiently out of the trees to see the forest and to ask more intelligent questions.

How the organizer and suborganizers work is still a mystery. At first it was thought that the movement of the cells over the lip generated dynamic effects which induced differentiation. But a simple experiment by A. Marx, one of Spemann's students, demonstrated that the primary induction occurred when there was no movement. Next followed tests in which organizer tissue was subjected to crushing, freezing, heating and other injuries, and then implanted into gastrulating embryos—whereupon it induced the emergence of a central nervous system just as undamaged organizer tissue had done. So the conclusion was that induction must be a chemical effect, and a search began for the potent chemical or chemicals released by the organizer cells.

Johannes Holtfreter, who served his apprenticeship under Spemann, found that even after the lip tissue was killed in alcohol it was able to induce development. The same discovery was independently made by C. H. Waddington at the University of Cambridge. Holtfreter went on to try other salamander tissues and then tested both living and dead tissues of other animals—mouse kidney, liver and brain and extracts from chick embryos. Each induced the embryo to form a neural tube. Various efforts were made to analyze these alien substances and blastoporal lip tissue chemically. But all the analyses have been inconclusive, and the situation was further confused when Waddington, Joseph Needham of Cambridge and Jean Brachet of Brussels discovered the astonishing fact that even the synthetic dye methylene blue induced formation of nerve tissue when injected into a gastrulating embryo.

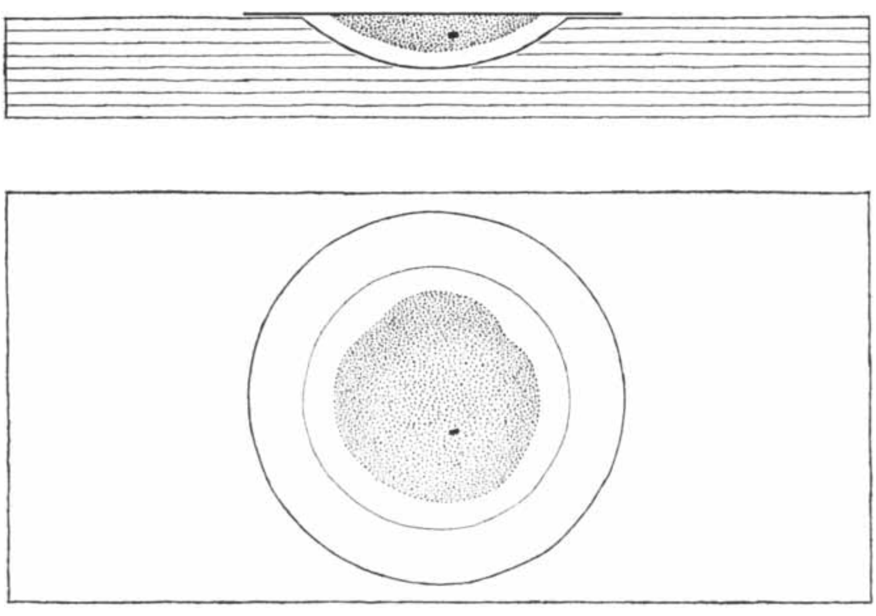
With this medley of causes and effects in the record, and more seeming paradoxes being added almost every month, it would seem that the era of experiment has changed into an era of perplexity. Perhaps that is another way of saying that the embryo is more versatile and complex than anybody dreamed. The situation can be likened to that which arose in biology when it was discovered that an unfertilized egg could be made to develop into an animal by pricking its membrane with a needle; indeed, that virgin birth ("parthenogenesis") could also be induced by heat, electric shock, ether and many other agents. Apparently all that is needed is some impulse to activate the egg. Similarly, while blastoporal lip tissue normally supplies the agent which induces cells to differentiate, the inductive force can also be supplied by various other materials, both living and dead.

Recently Victor C. Twitty and M. C. Niu performed an experiment at Stanford University which demonstrated that the action of the primary organizer is mediated through some diffusible substance which it exudes. They cut a minute piece of blastoporal lip from the early embryo of a salamander and cultured it in a hanging drop. After several days they introduced a bit of ectoderm, consisting of about 15 cells, into the drop. Although the ectoderm fragment was not in contact with the lip tissue, within 10 days it developed into nerve and pigment tissue. They then changed the experiment, this time using not the lip tissue itself but only the fluid in which it had been cultured for several days. As before, the implanted ectodermal cells gave rise to pigment and nerve tissue. Thus it would appear that the organizer is some secreted substance, and Niu (who last year joined the staff of the Rockefeller Institute for Medical Research) is now trying to isolate the active material. He thinks it may turn out to be not just one substance but a group of nucleoproteins, each specific to the induction of a particular tissue. Indeed, embryologists are fairly sure that "the organizer" is not a single substance but a complex of agents and reactions.

The Organizer and the Genes

All that the organizer does, apparently, is to release capabilities already present in the cell but dormant. You cannot force a cell into an alien pattern. You can change the direction of development, but each cell has only a limited "repertory." Its repertory becomes more and more restricted as development proceeds, and this restriction of potentialities is the very essence of embryonic development. It is a restriction under the influence of the genes which reside in the cell's nucleus.

Oscar E. Schotté, now professor of biology at Amherst College, who studied under Spemann at Freiburg and later at Yale University under Harrison, conducted an experiment which brings out beautifully the influence of the genes on development. His project was to transplant an embryonic bit from a frog to a salamander. These two animals belong to different orders and have striking contrasts in structure. The salamander larva has teeth, and on each side of its head are balancers which aid it in swimming. The tadpole of the frog, on the other hand, has no teeth but horny jaws, and the protuberances on the sides of its head are suckers. From the underside of a frog embryo Schotté took a slice of cells which normally would become flank skin and transplanted it to the prospective head area of a salamander embryo. The salamander developed horny jaws instead of teeth, and the



"HANGING-DROP" TECHNIQUE was devised by Ross G. Harrison to grow bits of embryonic tissue *in vitro*. He grew frog tissue in a drop of lymph on the bottom of a microscope cover slip. At the top, the drop and tissue are shown from the side; at the bottom, from above.

head suckers of a tadpole instead of balancers!

From this we conclude that while the organizer determines in general what organs are to be formed, the genes control the details of those organs. It is as if the genes in the frog cells said to the salamander: "You tell us to form a mouth, but we don't know how to make your mouth; we can make only a frog mouth." It is a case of the genes of one animal confronting the alien organizer of a different animal. The fact that they are still able to team up to produce an animal rather than a confused collection of cells is an unsolved puzzle.

This much is sure: development is a business of *both* preformation and epigenesis. The blueprint of the individual is carried in the fertilized egg, but the pattern takes form, organ by organ, as it is called into being by the organizer and is shaped in detail by the genes.

Medical Implications

All these studies, with their changing tactics, have meaning for us. The plastic embryonic cells of sea urchins, salamanders, frogs and chicks are, if not brothers to our own cells, at least cousins. What is learned of them applies to all. And there are many practical problems whose solution may hang on the scientist's fuller understanding of what the organizer is. The cruel malformations that occasionally arise during the development of the embryo—such as Siamese twins or babies born without arms or legs—are failures of organization. Cancer is a lawless crowd of unorganized cells. As we gain in knowledge of the laws of organized growth we may get new clues to the nature of the wild growth that produces malignancy.

Recently, at the Rockefeller Institute, Paul A. Weiss obtained striking evidence of the capacity of cells to organize themselves. From the embryo of a chicken he cut bits of skin tissue, of limb-bud cartilage and of tissue destined to become the coating of the eyeball. He treated all these with an enzyme which dissolves or loosens the "glue" holding the cells together, and so got a mixture of completely dissociated cells of three kinds of tissue. Yet in a tissue culture the cells reassembled themselves according to their kind, and the limb-bud cartilage proceeded to form bone, the eye cells to form eyeball coating and the skin cells to form feathers. "These experiments imply," said Weiss, "that a random assortment of cells which have never been part of any adult tissue can set up conditions—a 'field,' I call it—which will cause members of the cell group to move and grow in concert, following the pattern of a feather in one case, of an eye in another and of a bone in still another."

In a second set of experiments Weiss was able to watch organization at the subcellular level. He cut a salamander and then observed the healing of the wound. The wound cavity filled with a mucus-like liquid. While new skin grew over the cut, connective tissue beneath sent fibrils into the mucus. The tiny fibrils at first were a jumble, like a log jam in a river, but presently they began to assume an orderly arrangement, forming alternate layers like cordwood being stacked crisscross. "Two processes were at work," said Weiss. "The underlayer of connective-tissue cells produced the fibrils, organizing them out of molecules, while the overlying layer of skin cells organized them into a subcellular construction."

Down to the Molecules

Basically, of course, cell differentiation depends on the operation of molecule-forming processes. The molecular building blocks of one tissue (*e.g.*, muscle) differ radically from those of another (*e.g.*, brain). Heinz Herrmann, head of the laboratory of chemical embryology at the University of Colorado Medical School, has called my attention to the fact that investigators of developmental biology have begun to focus on the protein-forming systems of the embryonic cell in their search for the "organizer." Recent experiments in bacteriology are highly suggestive. They show that in a bacterium a new enzyme may suddenly emerge in response to an environmental change. In other words, a new differentiation suddenly appears in one of the molecular building blocks, and as a result the cell acquires a new property, for every feature of its molecular construction of course is controlled by the catalytic action of enzymes.

Herrmann points out that embryology, having arrived at the protein-forming systems as the center of its search, now joins forces with other branches of biology—physiology, immunology, microbiology—which likewise are seeking ultimate answers to their basic questions in the hidden mechanisms by which cells make proteins. Thus the mystery of the development of an organism emerges from its long isolation as a separate study and becomes an integral part of the many-sided inquiry into the nature of life itself.

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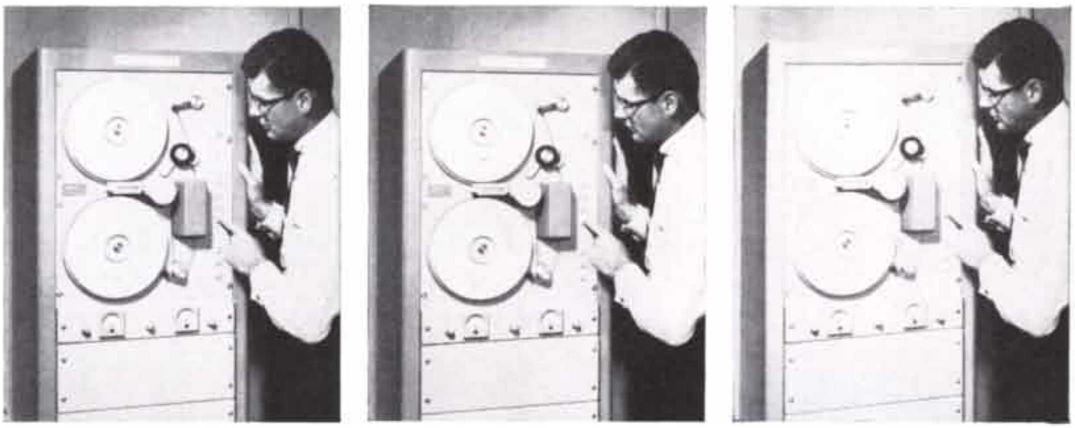

FAXTAPE records its own photograph and provides a revealing comparison. Left photo was printed directly off the facsimile wire. Center is the photo after being received on tape and retransmitted. Right is the same photograph after being retransmitted the conventional way off a facsimile print.

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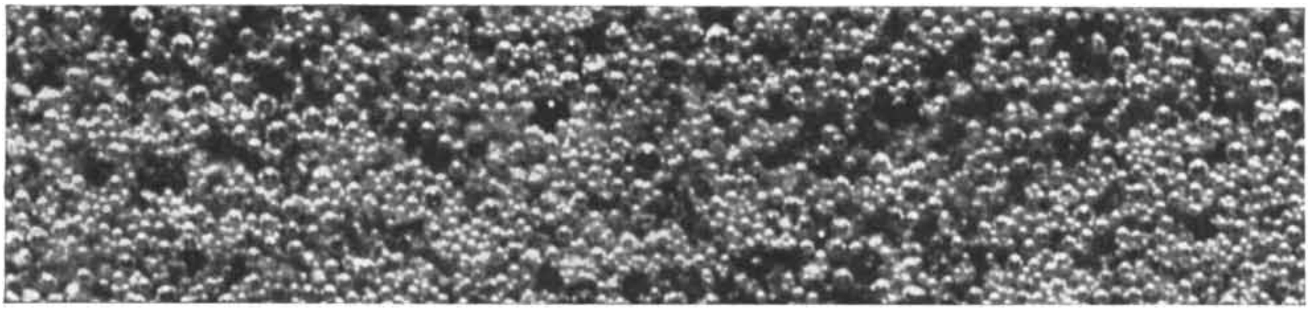

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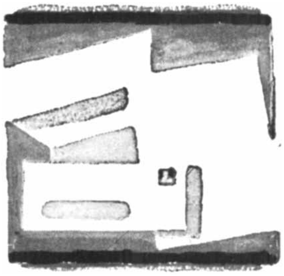

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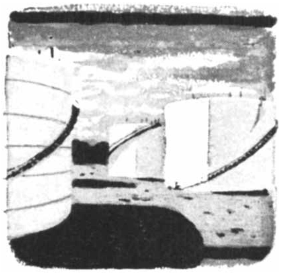

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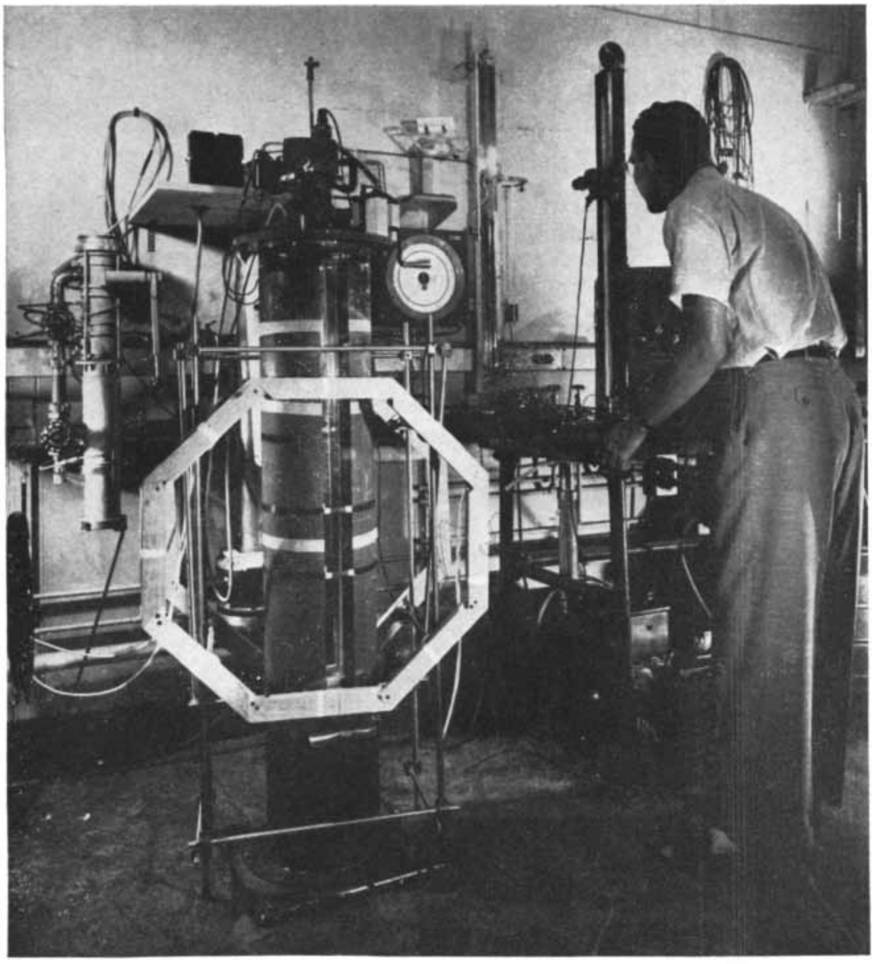
SUPERCONDUCTIVITY

When certain metals are cooled to a few degrees above absolute zero, they lose all electrical resistance. Although the phenomenon has not been explained, it has now been found to adhere to some simple rules

by B. T. Matthias

It was almost 50 years ago that Heike Kamerlingh Onnes, a Dutch investigator of the behavior of matter at very low temperatures, passed an electric current through some frozen mercury and made a startling discovery. He found that, at a few degrees from absolute zero, all resistance to the flow of the current disappeared. Physicists today are still hunting for an explanation of this bizarre phenomenon of superconductivity, which seems to contradict some of our basic ideas about nature. But though we do not understand it very well, we are beginning to learn enough about superconductivity to make use of it. This article is a report of some recent work which suggests that it may be possible to make superconductors which can be used in electrical equipment held at low temperatures.

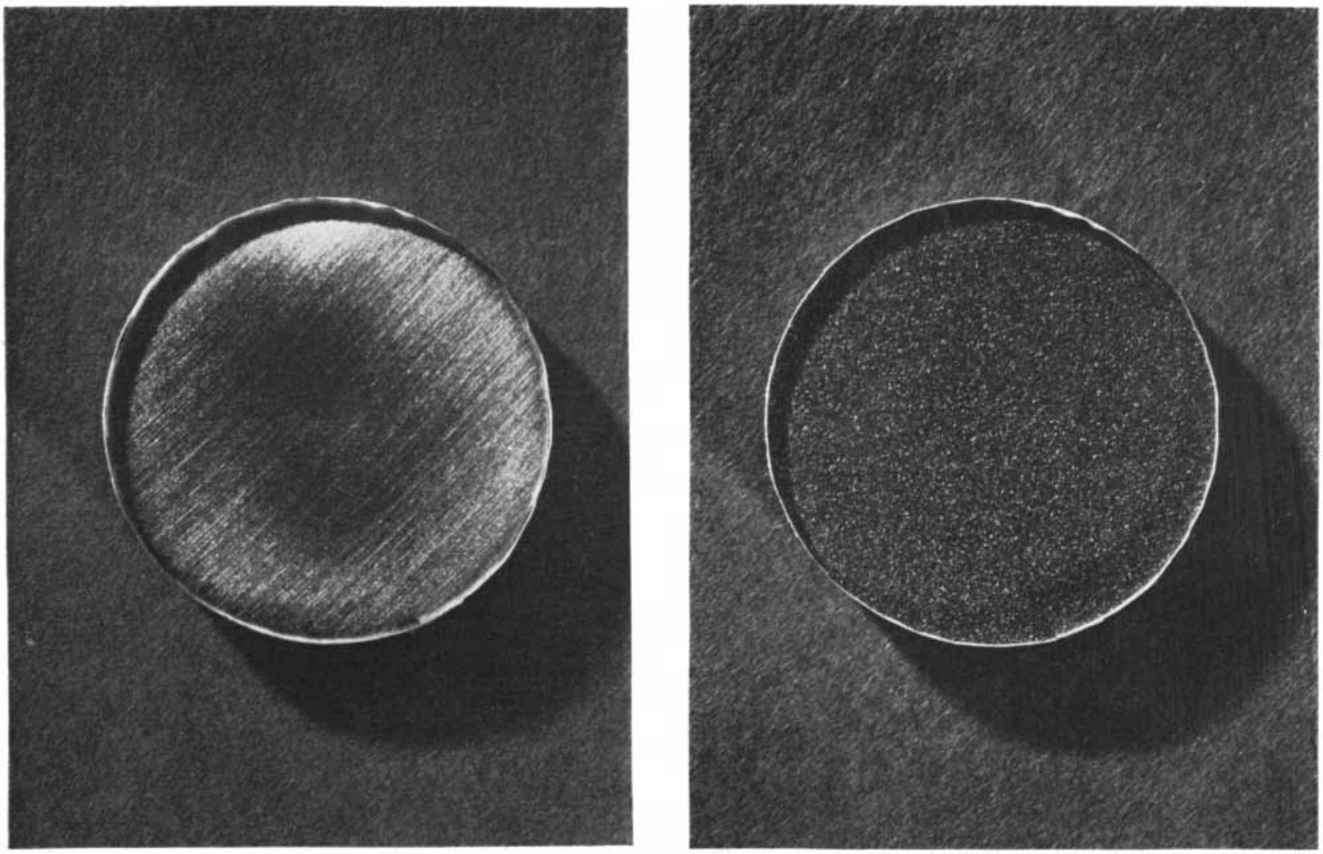


EFFECT OF A MAGNETIC FIELD on superconducting metals is studied with this apparatus in the laboratory of A. L. Schawlow at Bell Telephone Laboratories. A sample of superconducting metal is placed in liquid helium at the bottom of the cylinder at left.

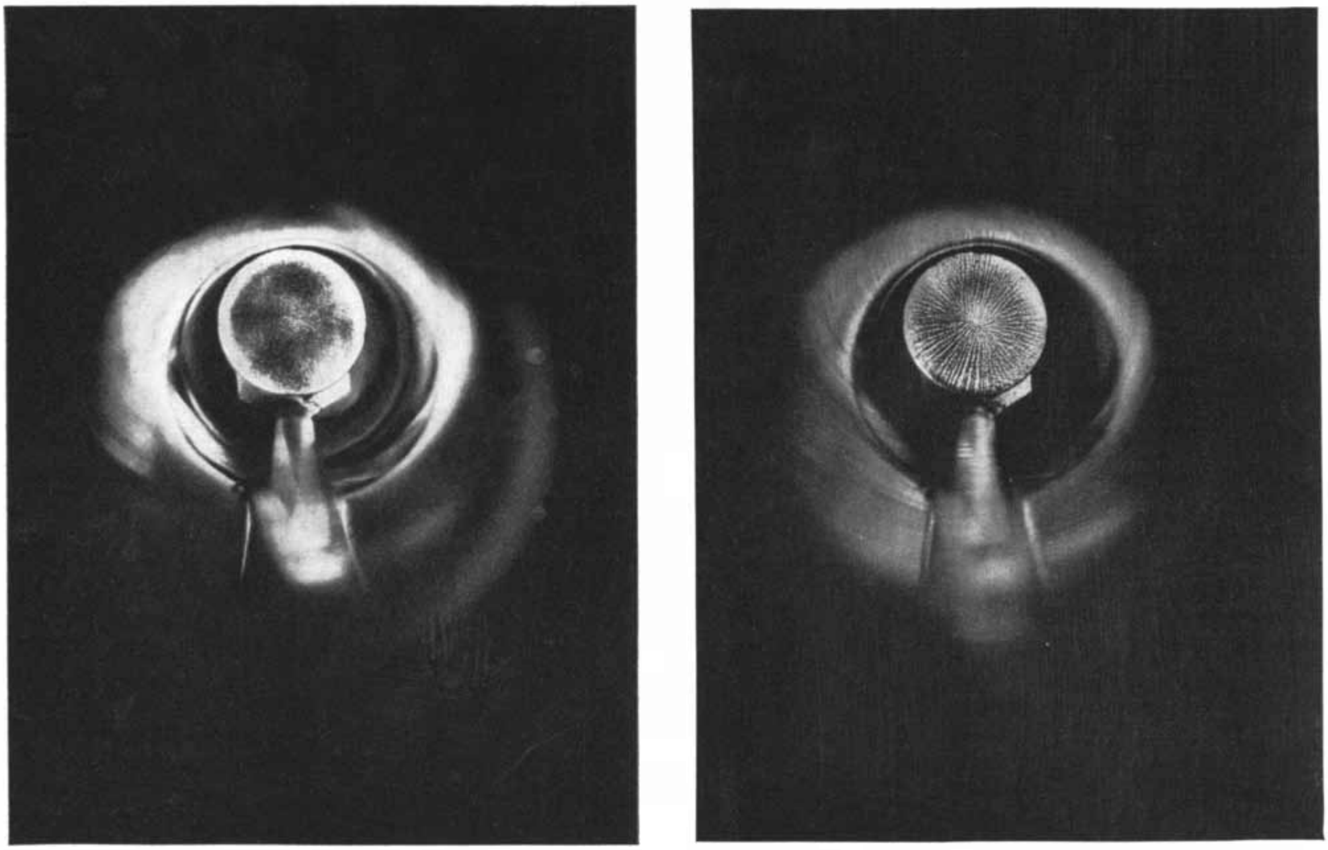
Let us begin by considering the normal conduction of an electric current by a metal. We know that the current is transmitted by the motion of electrons, driven through the metal's crystal lattices by the applied electric voltage. The electrons collide with the atoms in the lattice; this impedance of their motion constitutes the conductor's electrical resistance. The resistance increases as the temperature increases, because the vibrating atoms in the lattice then oscillate over wider distances from their lattice positions and interfere with the electrons' motion more strongly.

Now it is reasonable to suppose that if the atoms' vibrations were completely stilled by reducing the temperature to absolute zero, resistance to the flow of electrons might drop to an undetectable level. But Kamerlingh Onnes found that resistance vanished abruptly at several degrees above zero. Mercury became superconducting at 4.2 degrees Kelvin; certain other metals did so at different temperatures in the low range down to around one degree—the lowest Kamerlingh Onnes could reach. Later the German physicist W. Meissner discovered another peculiar property of metals in the superconducting state. They were impervious to a magnetic field: placed between the poles of a magnet, they completely expelled the field, so that the lines of magnetic force went around the material [*see diagram on page 94*].

About 20 years ago Fritz London, a German-born physicist then working in England, suggested a theory



SAMPLE IS PREPARED for an experiment with the apparatus on the opposite page. At left is a disk of very pure tin surrounded by a low retaining wall made of paper. At right the surface of the disk has been covered with a powder of the element niobium.



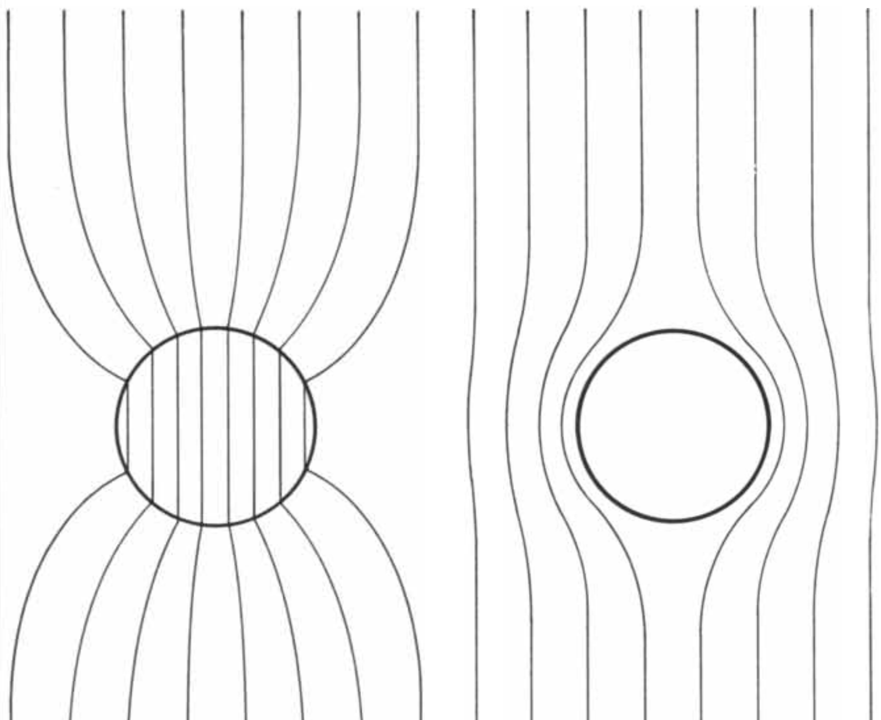
SAMPLE IS LOWERED into apparatus (*left*). Around it is the silvered wall of an insulating Dewar flask. After an electromagnet around the flask has been switched on, the particles of niobium move into superconducting and non-superconducting areas (*right*).

about the behavior of matter in the superconducting state. Since the free movement of electrons through a superconducting metal is analogous to the unimpeded motion of electrons in their orbits around the nucleus of an atom, London reasoned that an external magnetic field fails to penetrate a superconducting material because it shifts the large "orbits" of the electrons in the material so that they set up a counteracting magnetic field of their own.

London's concept gave an understandable picture, but of course it did not explain why a mass of material should behave like a single giant atom—that is to say, why reduction of the material to a very low temperature should create unobstructed orbits for the flow of electrons. In 1950 H. Fröhlich at Purdue University and John Bardeen of the Bell Telephone Laboratories attempted a more specific explanation. Their theory said that at low temperatures the vibrating atoms in a crystal lattice no longer obstruct the flow of electrons but on the contrary begin abruptly to conduct this flow in a wave-like way; in other words, the lattice vibration itself becomes the agent that makes the metal superconducting.

According to the Heisenberg uncertainty principle in the quantum theory, the vibrations of atoms can never die away entirely. Even at absolute zero the atoms in a lattice would retain an irreducible motion, called "zero-point vibration." The Fröhlich-Bardeen theory of superconductivity holds that at very low temperatures these vibrations of atoms and the motions of electrons are synchronized, so to speak. As a result of the interaction between the atoms and the electrons, the electrons reduce their energy and ride along with the lattice vibration as on a wave. Thus resistance to the flow of electrons disappears.

The theory was suggested by the fact that metals which are comparatively poor conductors at normal temperatures are most apt to be superconductors at low temperatures. Fröhlich and Bardeen reasoned that since these metals have a strong scattering effect on electrons at elevated temperatures, they



EFFECT OF SUPERCONDUCTIVITY on a magnetic field is depicted in these schematic drawings. A sphere of ferromagnetic material (*circle at left*) concentrates the lines of force in a magnetic field. A sphere of superconducting material (*circle at right*) expels the field.

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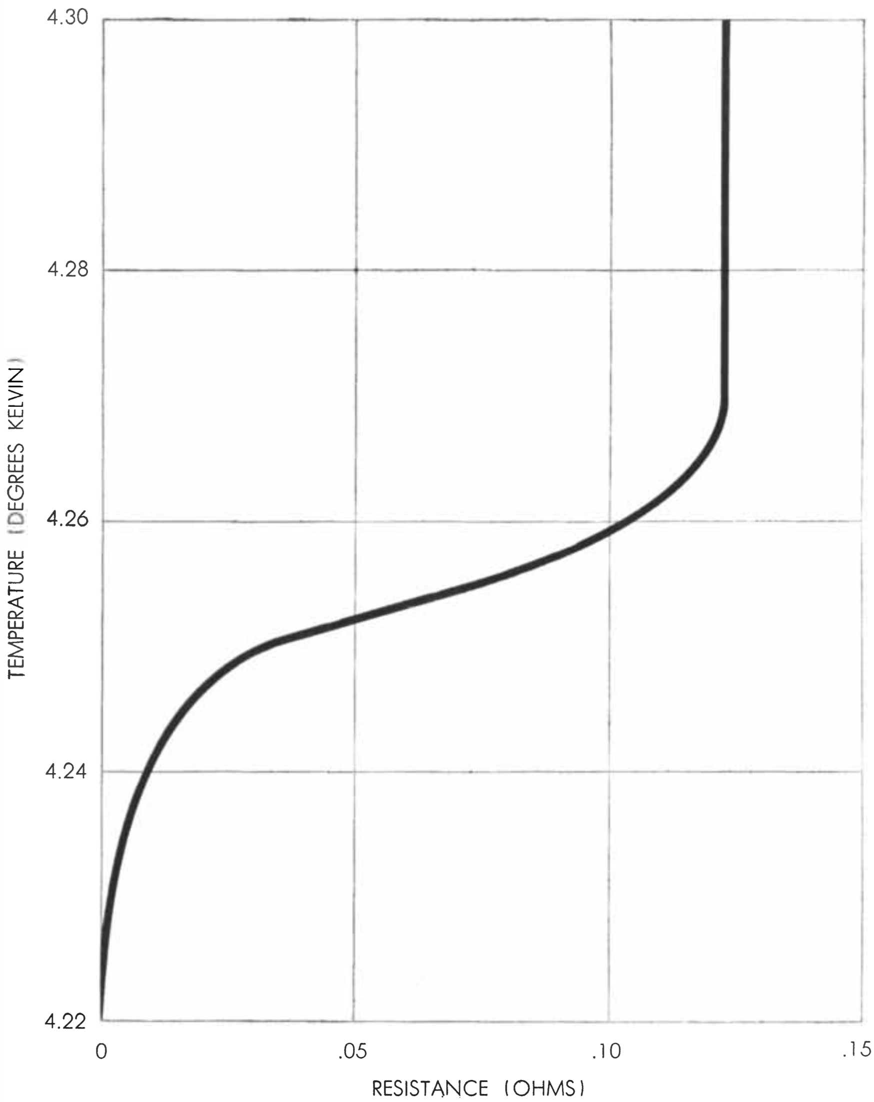
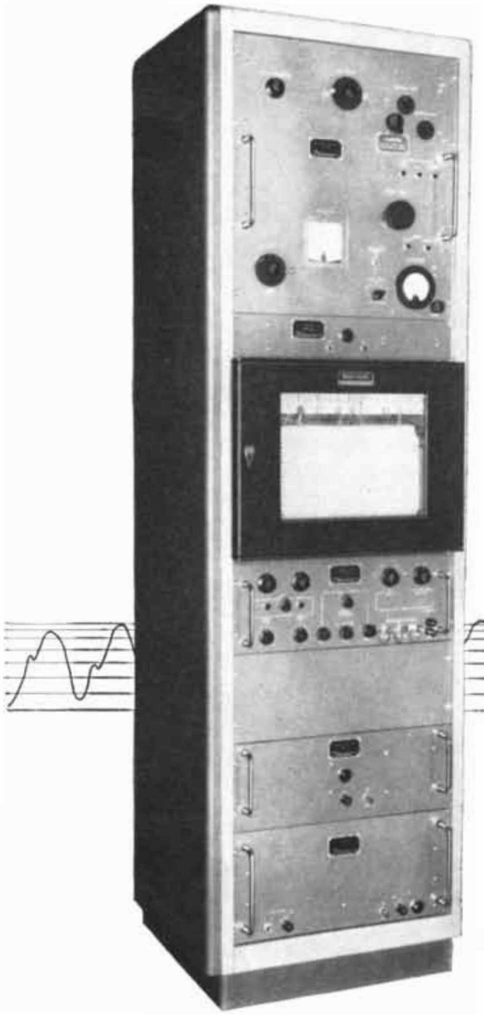
should have a strong ordering effect on electrons when the vibrations of their atoms and the motions of electrons become coordinated at low temperatures. On this reasoning, materials whose vibrating atoms interact strongly with electrons should become superconductors more readily (*i.e.*, at higher temperatures above absolute zero) than those whose atoms interact weakly with electrons. As a corollary, the heavier the element, the less likely it is to become a superconductor, because its low-temperature vibrations will be comparatively slow. Fröhlich predicted that light isotopes of an element would become superconducting sooner (at higher temperatures) than the heavier ones, and this proved to be true.

Recently Bardeen, Leon N. Cooper and J. Robert Schrieffer at the University of Illinois worked out a more complete new theory. It yields a correct description of properties of a superconductor, but there is still some question about the mathematical rigor of its treatment of the magnetic effect.

In 1950 John K. Hulm and I decided to try an entirely different approach. Since the theories offered no dependable means of predicting just what substances might be superconductors, or at what temperatures they would reach this state, we set out to find superconducting materials strictly by experiment. Our hope was that after we had tested a large number of substances, we might begin to see a pattern which would identify some of the physical and chem-



ELECTRICAL RESISTANCE OF MERCURY is plotted against temperature. The resistance disappears entirely at about 4.2 degrees Kelvin (4.2 degrees centigrade above absolute zero).



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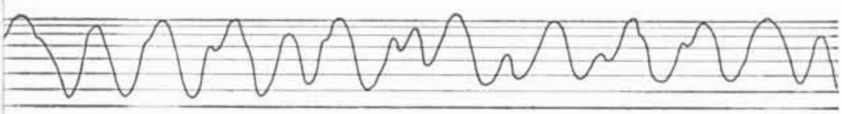

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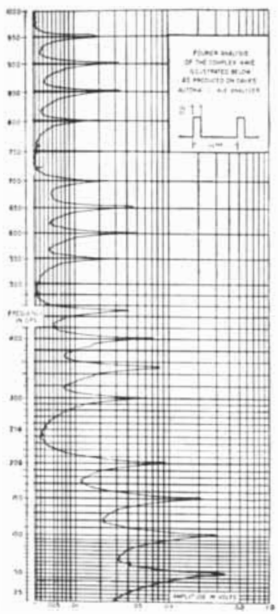

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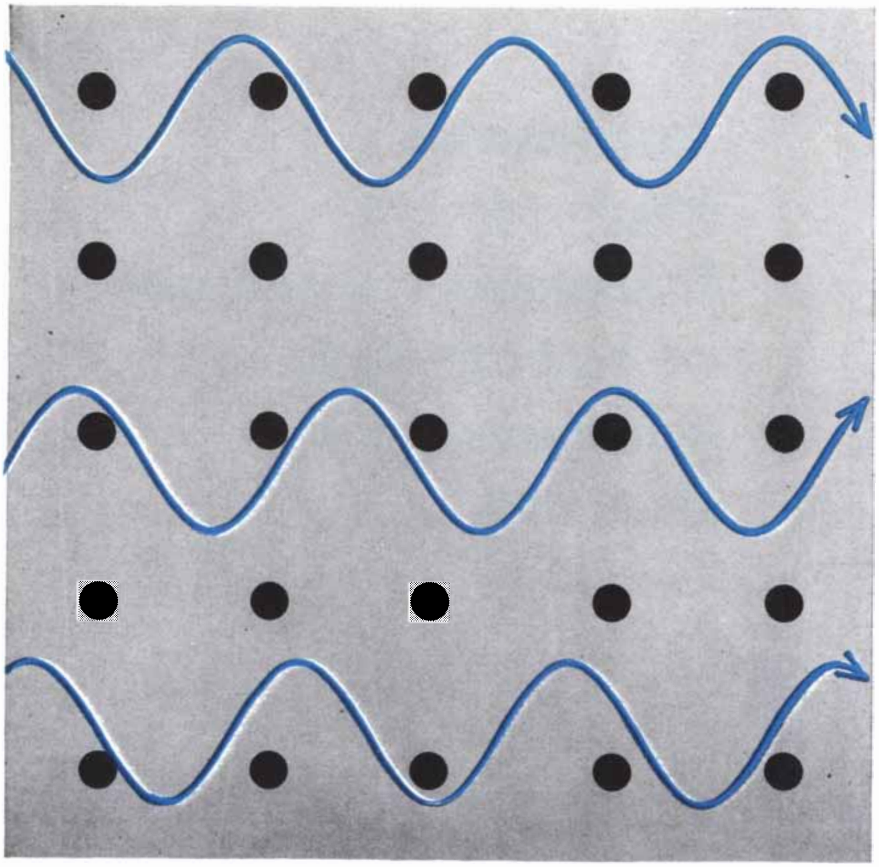
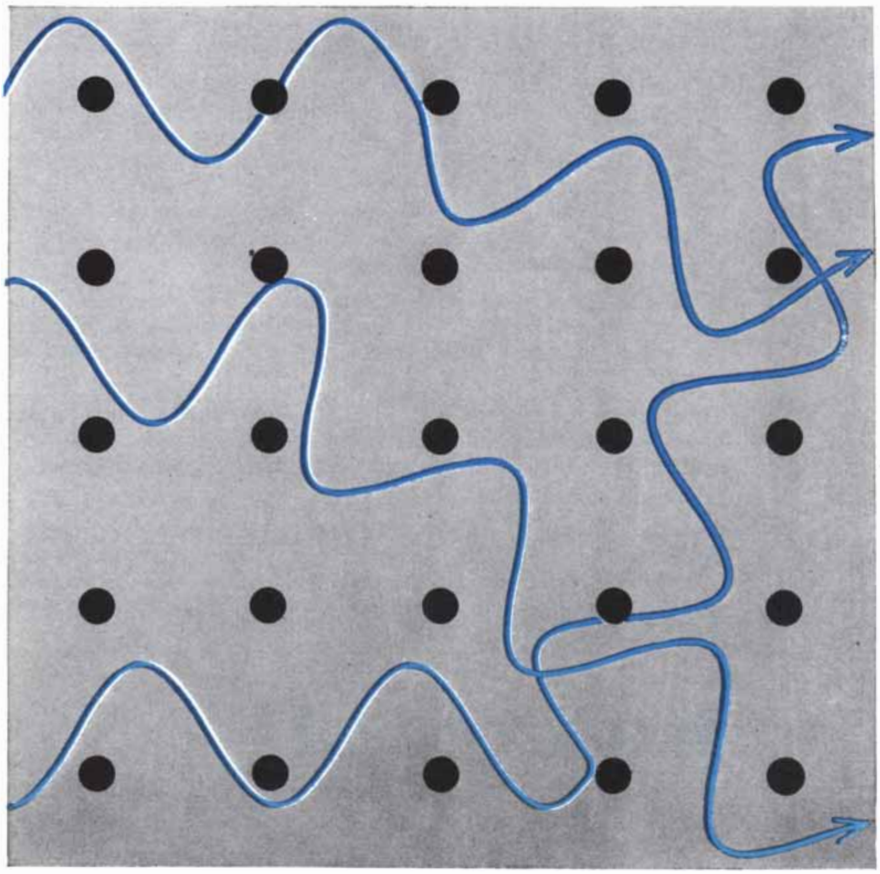




SUPERCONDUCTING ELECTRONS (*wavy lines at top*) **interact in an orderly way with atoms** (*dots*) **in a crystal. Ordinary conducting electrons** (*bottom*) **are deflected by atoms.**

ical properties associated with superconductivity.

Having almost no clues as to where to look, we tried one compound after another. At first we seemed to be getting nowhere. But after three years of testing a great number of compounds a crucial fact began to emerge. It appeared that the decisive factor determining how readily a substance would become superconductive was the number of valence electrons possessed by its atoms—valence electrons being those in an outer unfilled shell. We found that the only substances which became superconducting were elements or compounds with an average of between two and eight valence electrons per atom. And within this range the materials with an odd number of valence electrons per atom—three, five or seven—become superconducting most easily (farthest above absolute zero).

Here is the kind of rule we have been looking for. We now have a specific guide to finding or synthesizing superconductors. We should seek substances with an average of three, five or seven valence electrons per atom. To this rule we can add a few other helpful clues: it is known, for instance, that superconductivity is favored by certain kinds of crystal structure and by the amount of empty space in the crystal (*i.e.*, space not occupied by atoms).

With these empirical rules to steer us, we have been able to produce many superconducting materials. I shall illustrate with a few particularly striking examples.

The rare element technetium, found only as a product of uranium fission in atomic reactors, has seven valence electrons and a crystal structure favorable for superconductivity. John G. Daunt and James W. Cobble at Ohio State University had found that technetium does, in fact, become a superconductor at a relatively high temperature—11 degrees Kelvin. Now the elements before and after technetium in the periodic table, are, respectively, molybdenum and ruthenium. Ruthenium, with eight valence electrons, has to be cooled to within half a degree above zero to become superconducting. Molybdenum, with six valence electrons, cannot be made superconducting at all at the lowest attainable temperature (around one tenth of one degree above absolute zero). But if we make an alloy composed of equal parts of molybdenum and ruthenium, so that the average number of valence electrons per atom

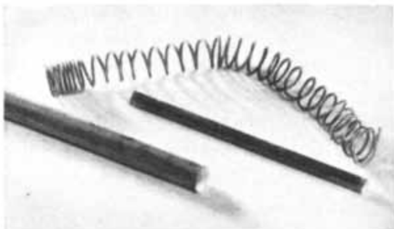
RARE EARTH RESEARCH

Recent interesting rare earth research developments

a report by LINDSAY

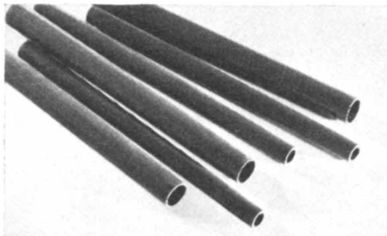
We are frequently fascinated by the imagination of researchers who are working with the rare earths. It appears that technical people, observing the many essential uses of rare earth salts in chemical and industrial processes, are looking at these fifteen unique elements as a fertile field for exploration.

During recent years, rare earths have been accepted as basic chemical tools in a wide cross section of American industry. This suggests that fruitful results may be expected from the rare earth research projects currently being carried on in industrial laboratories and pilot plant operations from coast to coast. Here, for instance, are half a dozen which may interest you.



MILES OF MISCH. This isn't a new application, but we're wondering if you know that misch metal (an alloy of the mixed rare earths) is available in wire form as well as in ingot and rod form? Cerium alloys can also be had in powder form; they are used as getters in vacuum tubes. We don't make the metal, but we can put you in touch with those who do.

FLAME SPRAYING. A new process for flame spraying various refractory oxides on metallic surfaces has been brought to near completion. Titania, zirconia and alumina can be flame sprayed, but the thing that interests us is that flame sprayed cerium oxide has some unusual properties. Rare earth oxide is a good heat radiation material, and it seems that metallic surfaces coated with rare earth oxide radiate heat much faster than do untreated surfaces.



RARE EARTHS IN PLASTICS. We frankly don't know what sort of things rare earth-impregnated plastics could be used for, but a couple of people have taken enough interest in this problem to make up experimental samples. We've been doing some playing with them ourselves and have some ideas about using them. Polyethylene, for example, can be fabricated to hold up to 5 to 10 times its weight of rare earth oxide, and we've even seen some precision-bore epoxy tubing made with a rare earth oxide filler.

SEPARATION AND SAMARIUM. We are like a slaughter house in that we would like to use everything that a rare earth separation process turns out, including the squeal. With the interest that has been generated in using gadolinium as a neutron absorber (thermal cross section about 46,000 barns), we have accumulated quite a pile of samarium oxide in rather decent purity. In the process of separating gadolinium and some of the other rare earths, samarium is produced as a by-product. If you can think of a use for samarium, we have the samarium compounds.

RARE EARTH GARNETS. These are structurally somewhat similar to the garnet variety grossularite (formula $Ca_3Al_2(SiO_4)_3$). The most interesting ones are the rare earth-iron garnets such as $Y_3Fe_2(FeO_4)_3$. This mouthful of formula has been abbreviated by researchers to "YIG" for obvious reasons. Other names stem from other rare-earth symbols. These garnets, particularly those of yttrium, gadolinium, erbium, and some others have interesting ferromagnetic properties, making them useful as ferrite materials in electronic equipment. We don't make the garnets, but we do make the rare earth oxides needed to prepare them.

SINTERED SHAPES. One of our friends once wanted to know if rare earth oxides could be pressed and sintered into shaped pieces. Apparently they can, and our friend made up some experimental hot-pressed rare earth oxide and cerium oxide pieces for us.

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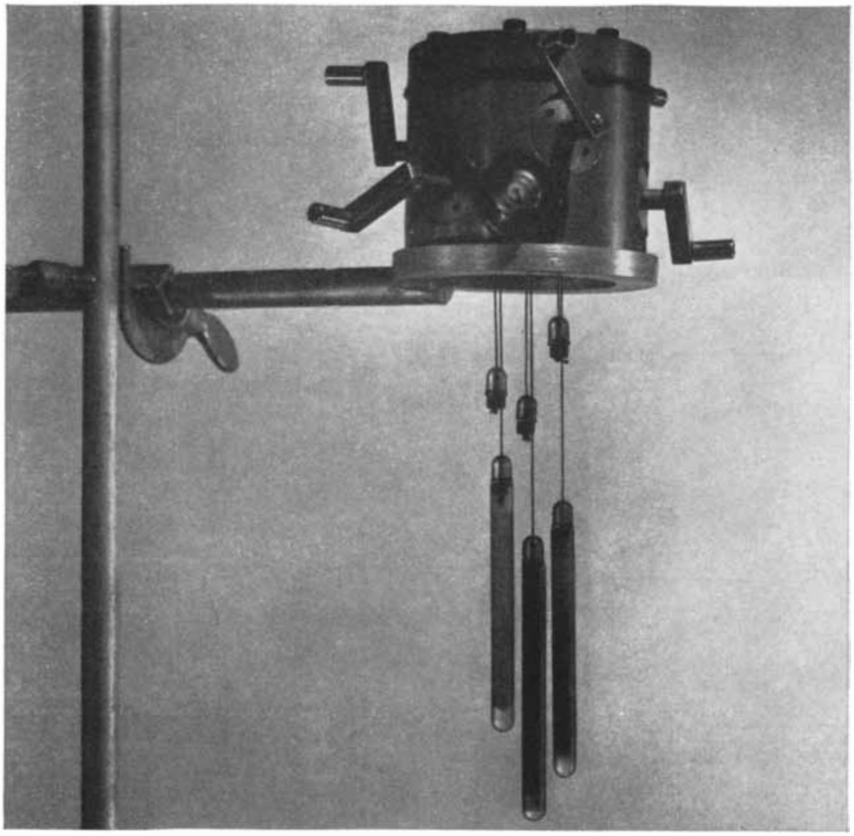
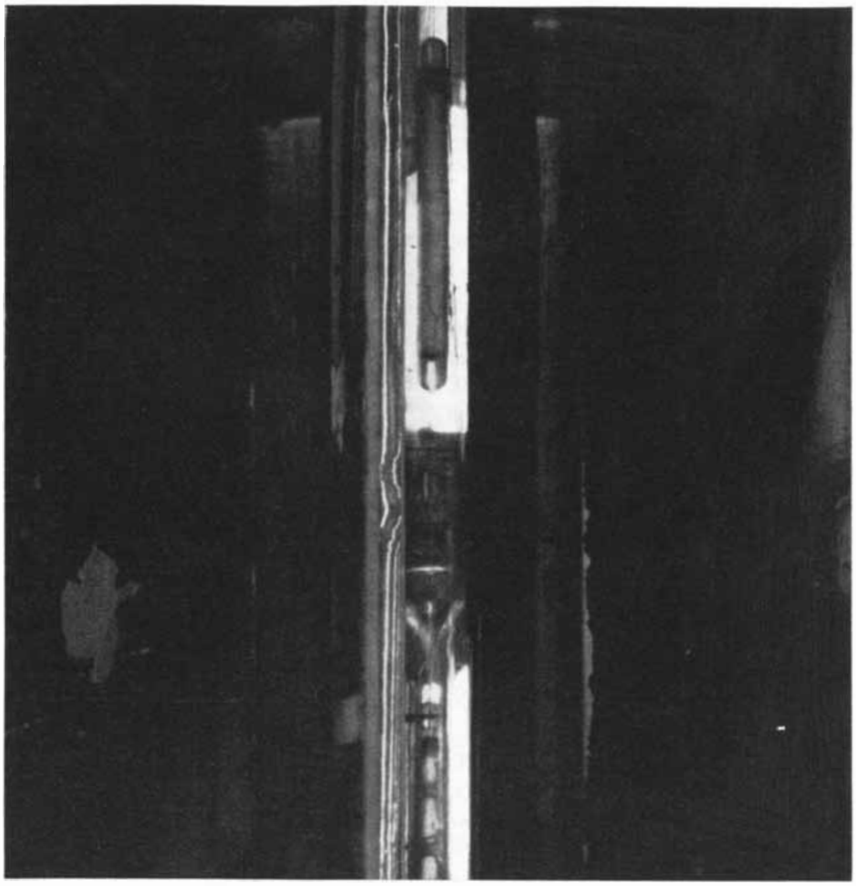




SAMPLES IN CAPSULES at top are tested by Matthias for superconductivity by lowering the capsule into a coil cooled with liquid helium. In this photograph at the bottom a capsule may be seen through a window in the apparatus just before it is lowered into the coil.

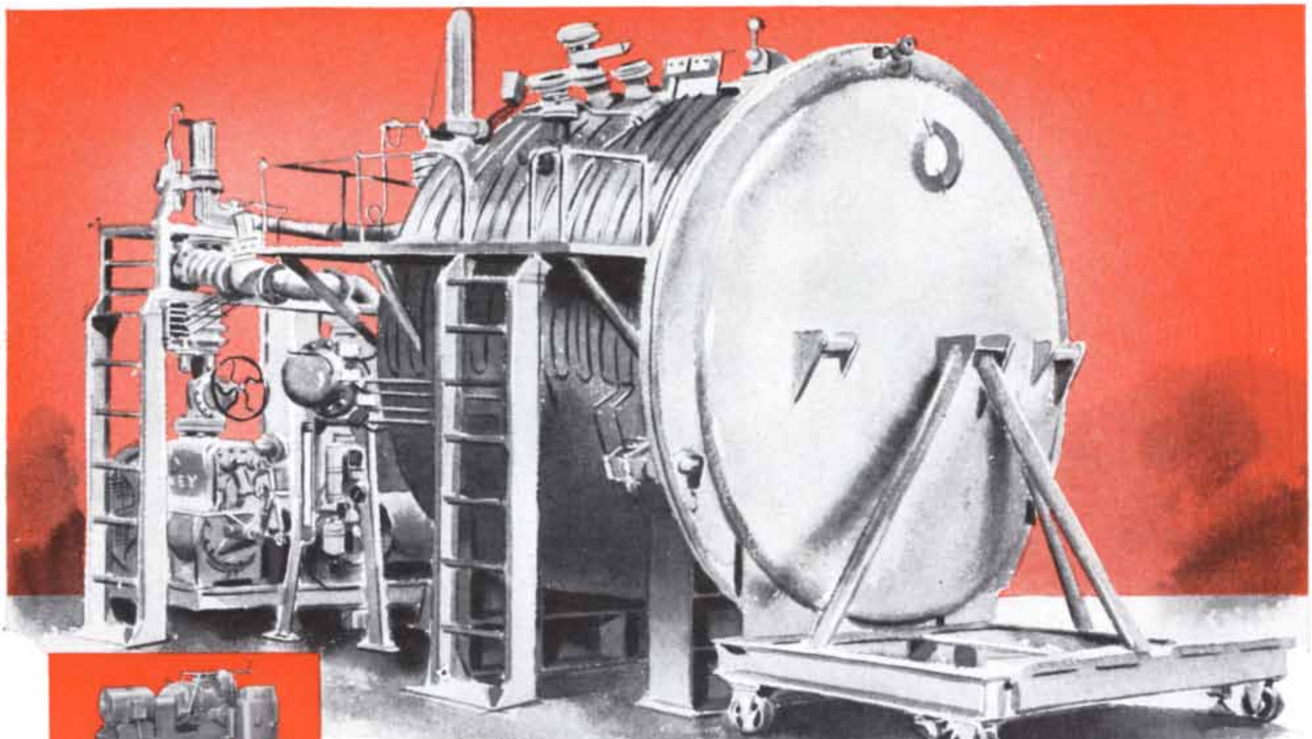
is seven and the crystal structure is identical with that of technetium, the combination becomes superconducting at 10.6 degrees—almost exactly the same as technetium's transition temperature!

Molybdenum can be made a superconductor by dissolving in it a little rhodium, which has nine valence electrons and therefore raises the average number in the mixture to slightly more than molybdenum's six. The same is true of tungsten, which like molybdenum has six valence electrons and will not become superconducting alone. We have produced many different superconductors by alloying molybdenum or tungsten with other elements, such as columbium (niobium), phosphorus, antimony or boron.

It is even possible to make a superconductor by combining two elements which by themselves are totally unfitted for this property. A good example is the combination of silicon and cobalt. Silicon, of course, is not a metal or a conductor of electricity. Cobalt has two qualities which completely disqualify it for superconductivity: it has nine valence electrons and is strongly magnetic. Yet when silicon and cobalt are combined in a cubic crystal structure, they become a superconductor, because the silicon neutralizes cobalt's magnetism and reduces the average number of valence electrons per atom to the appropriate range.

Again, we can employ another type of manipulation based on the fact that crystal bulkiness promotes superconductivity. There is a compound of nickel and arsenic which has a favorable crystal structure and a favorable valence-electron number, yet it fails to become superconductive as we would expect. What we did in this case was to replace half the nickel with the bulkier atoms of palladium, and this mixture then became a superconductor.

We found that the most favorable crystal structure for superconductivity was the one called the beta-tungsten structure—a cubic arrangement of eight atoms which makes the crystal bulky, with considerable space between some of the atoms. Compounds with this structure and a valence-electron average between 4.5 and 4.75 per atom proved to be particularly disposed to become superconducting. On that basis we deduced that a compound of tin and columbium should reach the superconducting state at a comparatively high temperature. It turned out that this compound could be made and did in fact become a superconductor at slightly



Above—Typical High Vacuum Furnace built by KINNEY.
Left—Famous KINNEY Mechanical Booster Vacuum Pump.

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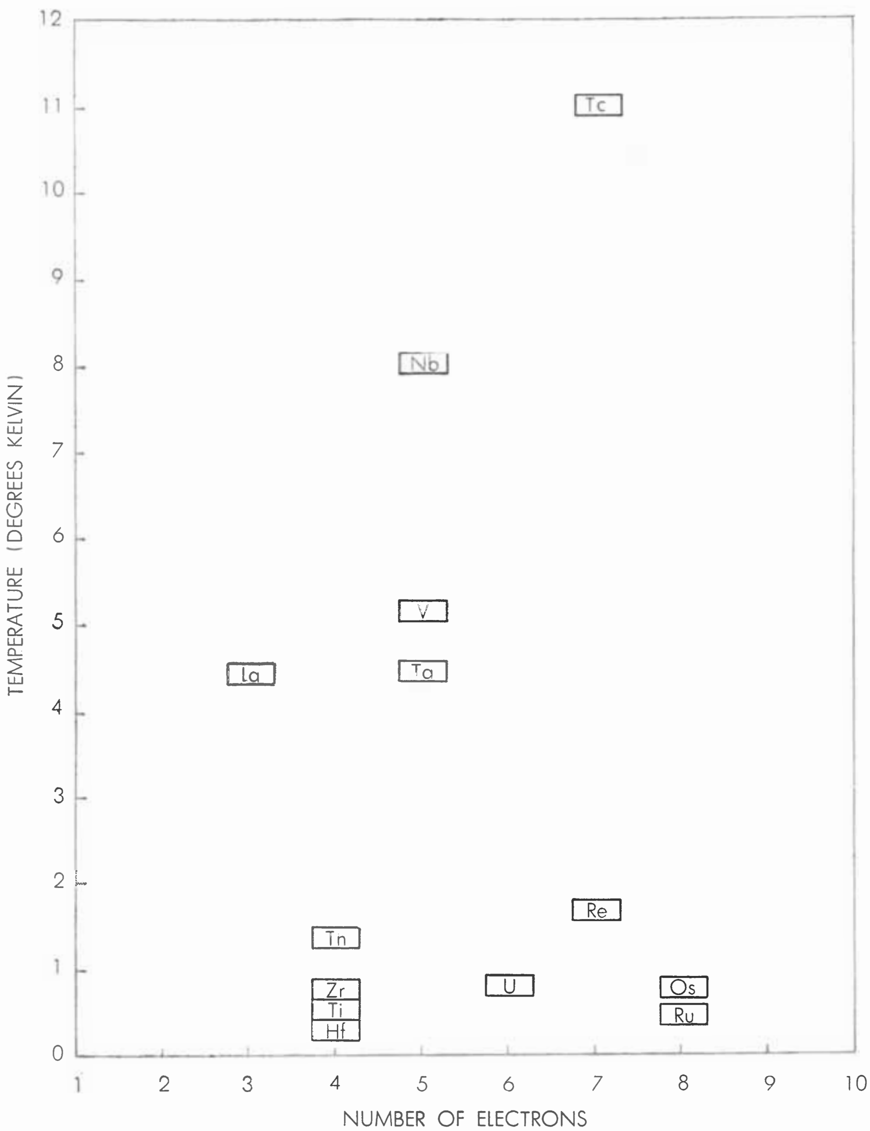
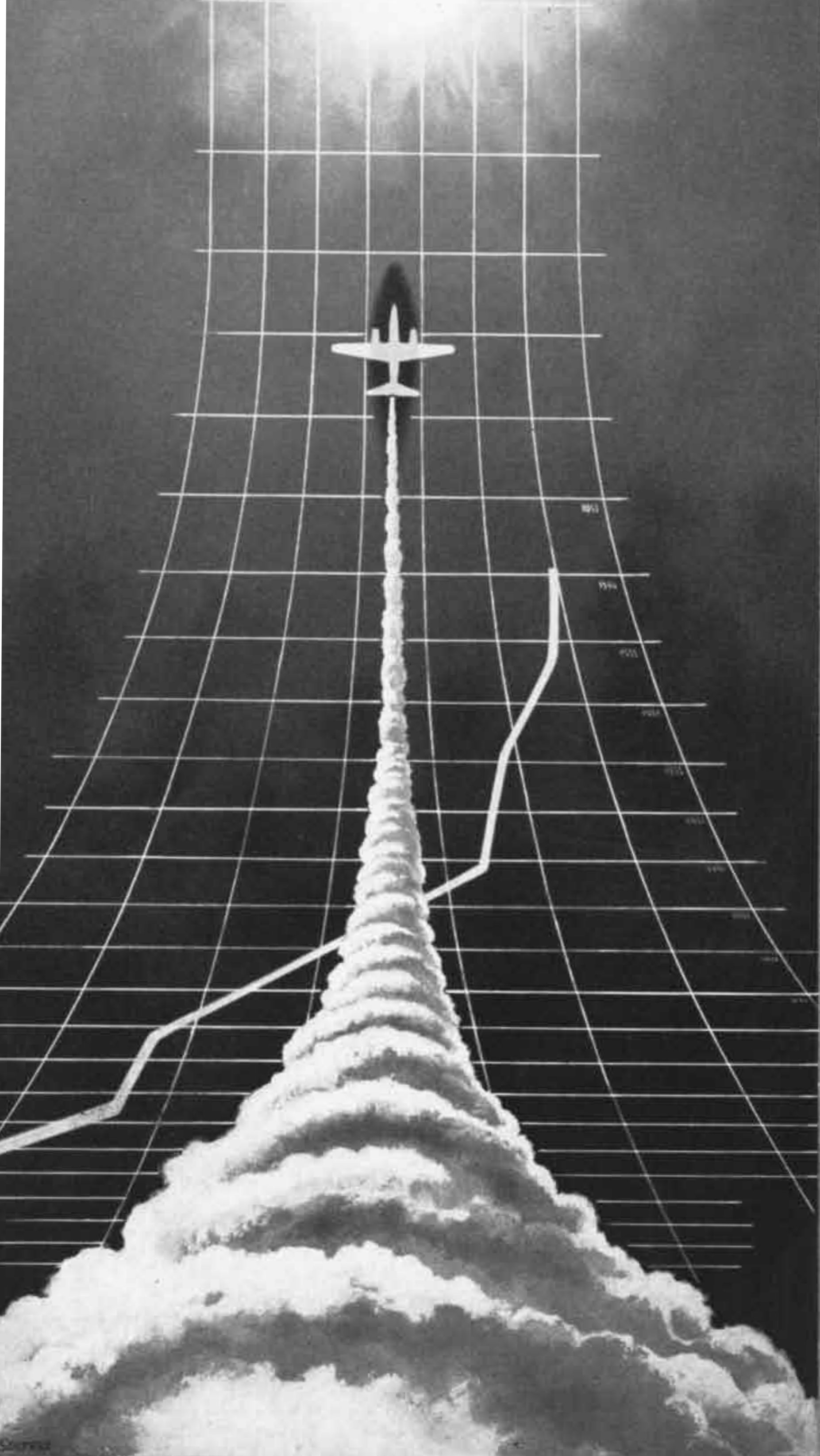
above 18 degrees Kelvin—the highest transition temperature yet found.

We can conceive of substances that may have transition temperatures as high as 30 degrees, but so far we have not succeeded in making stable compounds with the necessary specifications. At all events, transition temperatures such as 18 degrees already bring us into a range where we can begin to envision putting superconductors to work in a practicable way. Cooling apparatus for maintaining materials at these temperatures by the use of cold helium gas or liquid hydrogen is commercially available. We can now consider employing superconductors for sensitive electrical measuring instruments, switches, computer memory devices, resonating chambers in radio equipment and perhaps even transmission lines, say from the antenna to the amplifier of a radio telescope. In all these devices a superconductor would make it possible to handle extremely tiny currents or signals without any loss of their energy.



TRANSITION TEMPERATURE, or temperature at which a substance becomes superconducting, is related to the number of its valence electrons. The transition temperature of lanthanum (La) is 4.37 degrees Kelvin; of thorium (Th), 1.39 degrees; of zirconium (Zr), .7 degrees; of titanium (Ti), .53 degrees; of hafnium (Hf), .35 degrees; of niobium (Nb), 8 degrees; of vanadium (V), 5.1 degrees; of tantalum (Ta), 4.4 degrees; of uranium (U), .8 degrees; of technetium (Tc), 11 degrees; rhenium (Re), 1.7 degrees; osmium (Os), .71 degrees; ruthenium (Ru), .47 degrees. Only one group of 13 superconducting elements is shown. There is a second group of 10 elements, and a large number of compounds and alloys.



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BATS

A few remarkable and little-known facts about these flying mammals: some of them have a wingspread of nearly five feet, some catch fish on the wing, some mate in the fall but do not conceive until spring

by William A. Wimsatt

"Vespertilio the Bat is a paltry animal," says a 12th-century book of beasts. "It takes its name from the evening (*vesper*) when it goes out upon the air. It has wings, but at the same time it uses teeth—a thing not usually found in other birds. The bat parturiates like a quadruped, bringing forth not eggs but living young. Moreover, it does not fly with wings, but is supported by a membrane, poised on which, just as if on a flight of feathers, it moves and weaves about."

Today, of course, everyone knows that the bat is not a bird but a "quadruped" (*i.e.*, a mammal), that it is the only flying mammal, that it likes to live in caves, that it uses radar-like echolocation as a means of navigation. But beyond that the bat still remains for most people a creature of menace and mystery. Although zoologists have learned a great deal about bats, to the general public they are one of the least known orders of the animal kingdom.

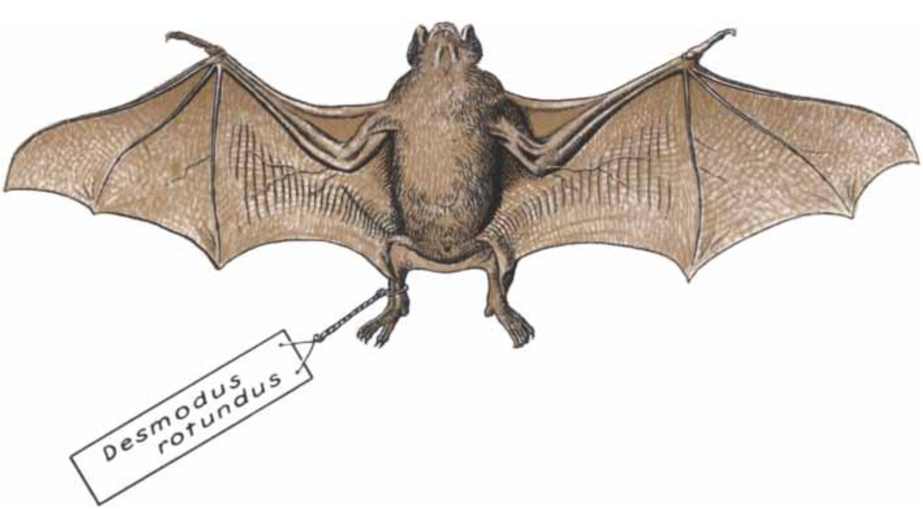
Few people realize, for example, that bats are among the most numerous of land vertebrates. They populate every major land mass in the world except the polar regions. Without doubt bats owe

HIBERNATING BATS hang by their feet in a huge clot on the roof of a section of Marvel Cave in Missouri. This one cluster consists of an estimated 14,500 free-tailed bats (*Tadarida brasiliensis*). The bat population of some large caves is numbered in the millions.

their evolutionary success in large part to their power of flight. Their wings take them out of reach of land-bound predators, and their nocturnal habit separates them from all winged predators except the owl, which is too cumbersome a flyer to catch them easily. In addition, bats seem to be endowed with a high degree of biological adaptability. In their diverse environments they have developed many unique specializations in behavior, physiology and anatomy. Bats, in consequence, are not only fascinating animals to know but offer ideal subjects for the investigation of certain fundamental problems in zoology.

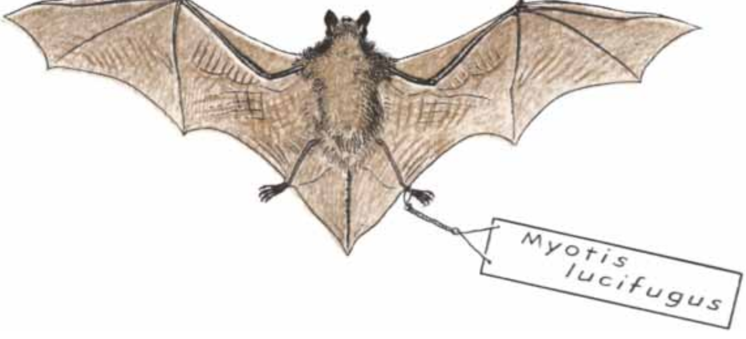
Not all bats are paltry; some are impressively large. The order of bats (*Chiroptera*) is divided into two great suborders—the *Megachiroptera* ("big bats") and *Microchiroptera* ("little bats"). The largest of the big bats, the "flying foxes" of Java, have a wingspread of nearly five feet. The *Megachiroptera* are distinguished from the *Microchiroptera*, however, not primarily by size but by anatomy and habits. The *Megachiroptera* are comparatively primitive and unspecialized. The entire suborder consists of a single family, the *Pteropidae*. They are found only in the Old World tropics. Most of them are fruit-eaters, which presumably is the reason their importation into the U. S. has long been prohibited.

The *Microchiroptera* are a more numerous and heterogeneous clan, found all over the world and subdivided into 16 families. *Vampyrum spectrum*, a Central American bat, is the giant of the group, with a wingspread of about 30 inches; the smallest species have wingspreads of 8 to 10 inches. No more than four or five families are found outside the tropics. Of these, the most widespread is the ubiquitous family *Vespertilionidae*. Its range stakes out the boundaries of the bat world [*see map on page 111*]. The pattern of distribution of bats supports the idea that the creature originated in the Old World tropics. It spread out to the New World long enough ago, however, to permit the evo-

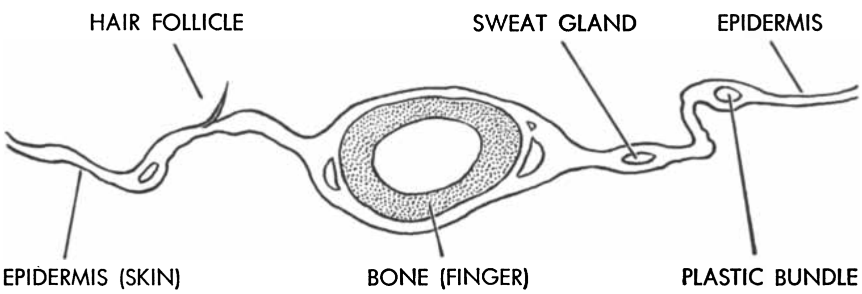


THREE SAMPLE BATS are depicted on the basis of museum specimens. *Pteropus giganteus* is a giant fruit-eating bat of India; it sometimes attains a wingspread of nearly five feet. *Desmodus rotundus* is the most abundant vampire bat. *Myotis lucifugus* is the common "little brown bat." All three are drawn to scale, about two fifths life-size.


Pteropus giganteus


Myotis lucifugus

BAT'S WING is a modified forelimb. The "fingers" are greatly elongated; the "thumb" projects outward. At top is the wing of *Natalus mexicanus*, which has a low aspect ratio (ratio of breadth to length). At bottom is the wing of *Molossus bondae*, which has a high aspect ratio. The low aspect ratio favors maneuverability; the high aspect ratio, long flights.



MEMBRANE OF BAT'S WING is shown in cross section. Between its two layers of epidermis is a thin layer of connective tissue which contains blood vessels, nerves, small hair follicles, specialized sweat glands and bands of elastic fibers and muscle (*plastic bundle*).

lution of a half-dozen specialized families which are found only in the Western Hemisphere.

Bats are sensitive to climate, especially temperature. They are not normally found in regions with fewer than 60 to 90 frost-free nights per year. Even the hardy members of the *Vespertilionidae* occupy the northern limits of their range only in summer and migrate like birds to warmer areas as winter approaches. Contrary to the common impression, not all bats hibernate. But many in the *Vespertilionidae* family and a few in other Temperate Zone families do. Significantly there is no correlation whatever between hibernation and the anatomical ranking of species: the known hibernators include primitive as well as more specialized forms. The sole correlation is with climate; the hibernating habit is found only among those bats that live in areas of annually recurring frost.

Early in their evolution, it is thought, all bats were insect-eaters, and the majority still are. They usually take their prey in flight, though many bats seem able to seek out resting insects and nonflying species in the foliage of trees, on the walls of caves and elsewhere. Even among closely related species, however, diets vary. This is illustrated by a family of "spear-nosed" bats in the American tropics. Most of the members of this family are fruit-eaters, but a few eat insects, at least two species eat both insects and fruit and several other species live almost entirely on the nectar and pollen of flowers; they have elongated muzzles and very long tongues, sometimes brush-tipped, adapted to their style of feeding. In the fruit-eating and flower-eating bats the sense of smell is apparently well-developed, whereas it is doubtful that this sense plays any significant part in the life of the insectivores.

At least two species of the same family are carnivorous: they eat smaller bats, birds and other animals as well as fruit. One of these two species is *Vampyrum spectrum* of Central America, the other lives in India. A species of the "hare-lipped" family, found in Central America and the West Indies, lives on fish. As high-speed photographs show, this bat glides low over the surface of quiet water and gaffs small fish with the claws of its greatly enlarged and specialized hind feet [*see photograph on page 112*]. It seems to drag the water at random, catching fish that happen to be swarming near the surface. A closely related hare-lipped species, though

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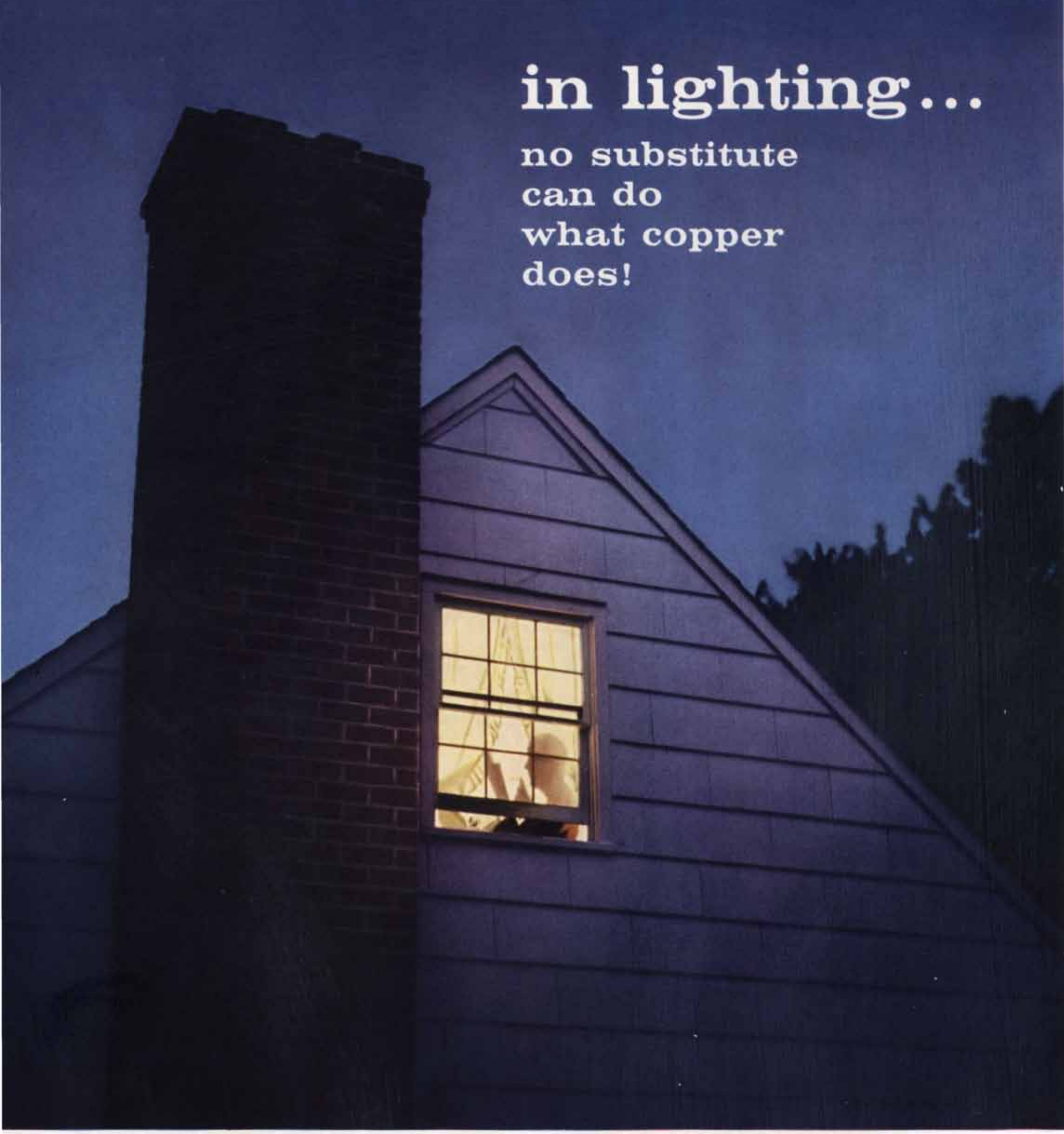

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equipped with similarly modified hind feet, appears to be exclusively insectivorous; it has never been observed to catch fish in nature and does not learn to do so under laboratory conditions even with fish-catching bats acting as demonstrators.

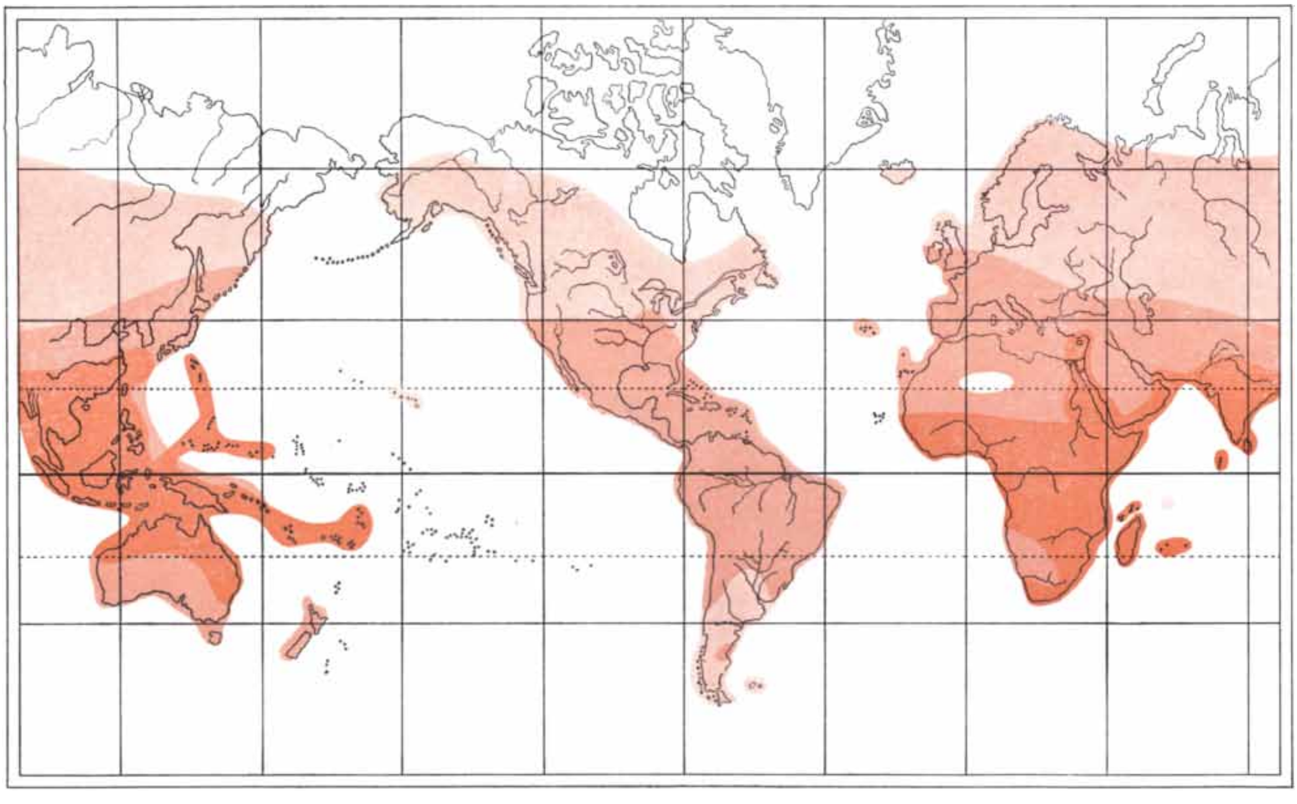
By all odds the most dramatic adaptation in feeding habits is that of the vampire bats of tropical America. These bats, related to the spear-nosed clan, actually behave as legend pictures the bat-winged specter of the Dark Ages: they subsist wholly on blood drained from living animals—including man if opportunity permits. They are not large, as bats go. The adult of the most abundant species, *Desmodus rotundus,* is slightly heavier than a mouse. Unlike most bats, the vampires, exceedingly wary and strong flyers, are also remarkably agile on the ground. They generally attack sleeping or resting animals, alighting gently on or near the prey and tiptoeing on their hind limbs and thumbs to the point selected for the bite. The sharp, narrow blades of the vampire's specially modified upper incisor teeth excavate a small segment of skin and underlying tissue, usually without awakening or paining the host. The vampire then draws up, with piston-like pumping movements of its tongue, the blood that wells into the excavation. Some investigators have claimed that the vampire bat's saliva contains an anticoagulant. Its digestive tract is modified in a number of interesting ways; among other things, the stomach is reduced to a folded tube. We are investigating the functional significance of these peculiarities in our laboratory at Cornell University.

The vampire's bite can be very dangerous, because the bat is a vector of rabies and of some diseases of livestock. Recently, as the press has reported, public health authorities made the alarming discovery that certain insect-eating bats of the U. S. also are now carriers of rabies.

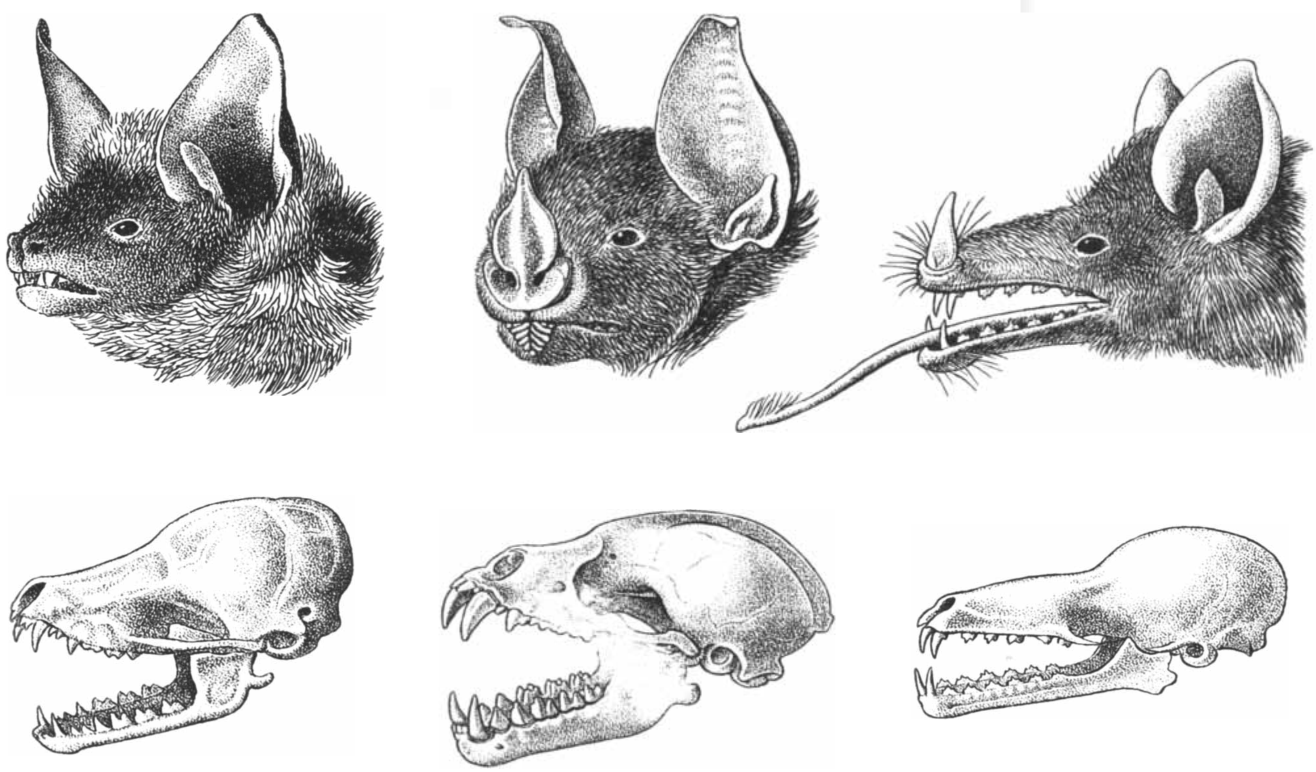
Like all small mammals, the bat must support a high rate of metabolism [see "Shrews," by Oliver P. Pearson; SCIENTIFIC AMERICAN, August, 1954]. Usually the life-span of such creatures is shortened accordingly, but bats are remarkably long-lived. Big bats kept in zoos have lived in captivity for 15 to 20 years. The "little brown bat," a common American species, has been recovered as long as 20 years after being banded in the wild. In Europe a specimen of the "greater horseshoe bat" was recovered after 16 years and 10 months—a record for that family.

Here is a first-rate physiological mystery. How can these small, fast-living animals survive so long? It is tempting to speculate that their longevity is connected with the tendency to hibernate and with the daily torpor into which they fall during their resting daylight hours. In such states the rate of metabolism is greatly reduced. But tropical bats do not hibernate, not even the close relatives of Temperate Zone hibernators. To pursue the question we need to investigate the metabolic rates of tropical bats under varying conditions of activity and ambient temperature.

The long life of bats is related to another peculiarity that sets them apart from other small mammals. Every known species of bat has a comparatively low rate of reproduction. Multiple births are exceptional, the gestation period is long, and most species are fecund only once each year. (The rule in other small mammals is the reverse: short gestation periods and frequent large litters.) Some bats breed in the autumn, some in the spring. A few, such as the vampires, breed at any time; others, twice within a certain period of the year. These various reproductive patterns suggest interesting questions about



DISTRIBUTION OF BATS is outlined. Bats of suborder *Megachiroptera* (big bats) are confined to darkest colored areas. Bats of suborder *Microchiroptera* (little bats) are found in all colored areas. Only family *Vespertilionidae* occurs in lightest colored areas.



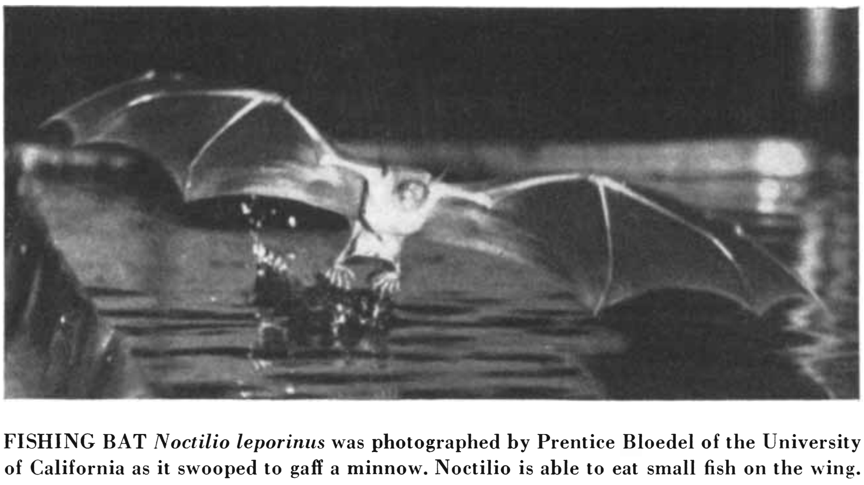
FACES AND SKULLS of four species of bats reflect their various feeding habits. At left is the little brown bat *Myotis lucifugus*, which feeds on insects. Second from left is *Phyllostomus hastatus*, which eats fruit and small animals. Third is *Choeronycteris mexicana*,

the external factors that may influence them, but systematic investigation remains to be done.

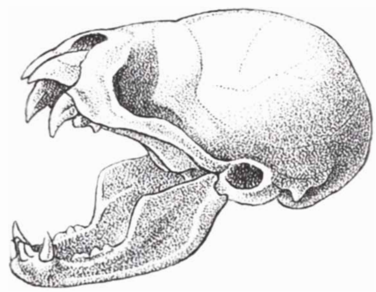
A newborn bat, of any species, is huge in relation to the adult size. The female "little brown bat" of the eastern U. S., a member of the *Vespertilionidae* family, weighs only six or seven grams, yet she gives birth to a two-gram youngster. This is equivalent to delivery of a human infant weighing 40 to 50 pounds. Furthermore, in this species as in many others, the young are born breech first, the head being the last portion to come free. With eyes still closed, the infant bat climbs up the mother's abdomen to the nipples. There it remains attached by its tiny teeth for some time, and the mother may fly about with it hunting food.

The large size of the newborn bat is probably related to the long gestation. This ranges from seven to eight months in the big bats down to 60 days in the little brown bat. The period may even vary among individuals in a species, in response to fluctuations in temperature from place to place and year to year. It can be prolonged experimentally by placing the pregnant animal in a refrigerator. This variability clearly reflects the drastic decline in the body temperature and metabolic rate of the parent bat when at rest.

The two common Temperate Zone families, *Vespertilionidae* and *Rhinolophidae*, display a most intriguing departure from the usual reproductive pattern of mammals. Ordinarily a mammal's egg can be fertilized only within a few hours after it arrives in the uterus, and spermatozoa cannot survive in the female genital tract longer than two or three days. And in most mammals (excepting only the primates) the female is responsive to the male only during a short period of heat around the time of ovulation. Not so these two families of bats. After a mating in the autumn, the sperm live over the long period of hibernation in the female, while her egg remains in the ovarian follicle, not to be shed until the spring, when it is promptly fertilized by the still-viable sperm. Such prolonged survival of spermatozoa in the female genital tract is unique, but W. H. Gates, G. E. Folk and I have been able to prove by experiment that bat sperm can live over the winter and fertilize the egg in the spring. We have learned another remarkable fact. Bats sometimes awaken briefly from their winter hibernation and copulate. Yet the



FISHING BAT *Noctilio leporinus* was photographed by Prentice Bloedel of the University of California as it swooped to gaff a minnow. Noctilio is able to eat small fish on the wing.

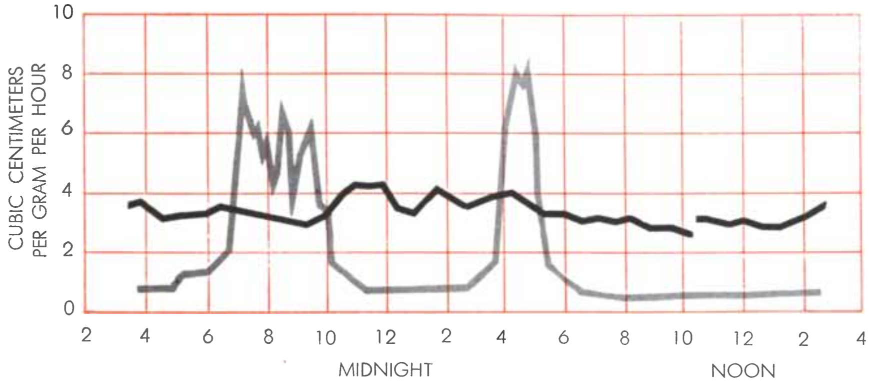


which feeds on nectar and pollen. Fourth is *Desmodus rotundus*, the vampire bat.

testes of the male bat are active for only a brief period in the autumn before hibernation. Where do the live sperm come from? Mammals store and ripen sperm in a tubular appendage of the testes called the epididymis, but it is doubtful that the spermatozoa ordinarily can survive there longer than seven or eight weeks. In the hibernating bat they live on in the male genital tract longer than that. Apparently they are kept viable by hormones which the animal continues to generate during hibernation.

In storing spermatozoa for such long periods, the common bats of northern U. S. and Canada have been doing for eons what man is only now learning to do for artificial insemination of livestock and treatment of his own fertility problems. The endocrinological details of how bats preserve sperm, and the connection between the internal process and external environmental factors, constitute a provocative subject of research which has implications far broader than the immediate concern with bats as such.

Similar challenges are posed by the fluctuations in metabolic rate which accompany hibernation and resting and which so profoundly affect other aspects of the bat's existence. Mammals, including those that hibernate, normally

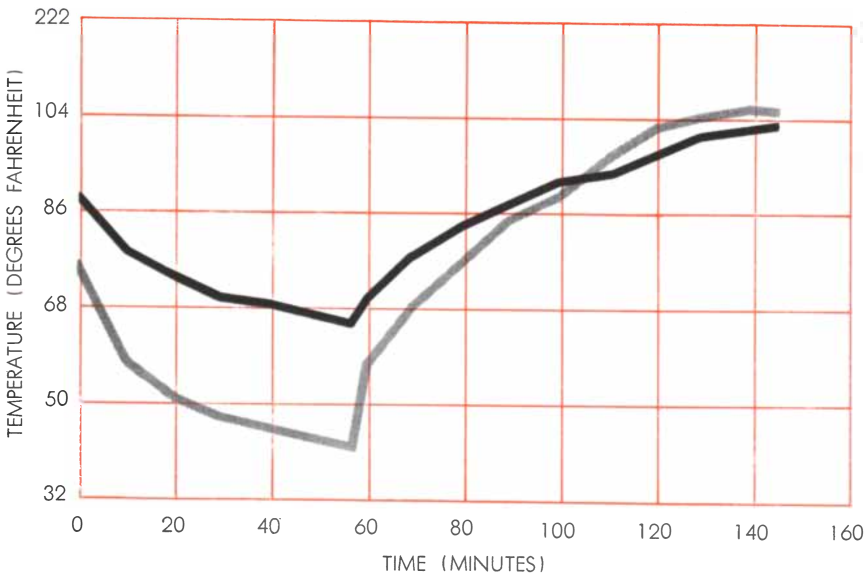


METABOLISM of *Myotis lucifugus* fluctuates over a 24-hour period (*gray curve*). The metabolism of a red-backed mouse is shown for comparison (*black curve*). The metabolism is measured in cubic centimeters of oxygen consumed per gram of body weight per hour.

adjust their rate of metabolism to the environmental temperature, to keep their body temperature constant. During hibernation this rule is reversed. Then the rate of metabolism and the body temperature vary passively with the surrounding temperature; only when the temperature falls close to freezing does the animal step up its metabolism and production of heat. What distinguishes the bats from other hibernators is that they fall into a similar torpor throughout the year whenever they rest. During their daytime resting periods their body temperature and metabolism vary passively with the temperature of the environment. Bats seem to be unique in this capacity to switch their temperature-regulating system on and off at any time of the year.

Most bats hibernate in caves, mine tunnels and similar shelters, where the temperature is fairly stable and usually stays above freezing. If it drops too low, they awake and move deeper into a warmer part of the shelter. But bats differ considerably in their tolerances, or powers of adjustment. The little brown bat is comparatively vulnerable to low temperatures and will die of desiccation if the humidity is too low. On the other hand, the big brown bat of the eastern U. S. can tolerate a much wider fluctuation of temperature and moisture; it often hibernates not far from the entrance of a cave.

Spelunkers should remember, when they intrude on the winter sleep of bats, that if the animals are repeatedly disturbed, they will soon exhaust their reserve of fat and will not be able to survive the winter. Although bats may not be the most attractive of nature's creatures, they are invaluable to science, for they have much to teach us about basic facts of physiology.



BODY TEMPERATURE of the bat *Macrotus californicus* (*black curve*) varies in response to temperature of its environment (*gray*). This response is characteristic of many bat species.

THIS IS GLASS

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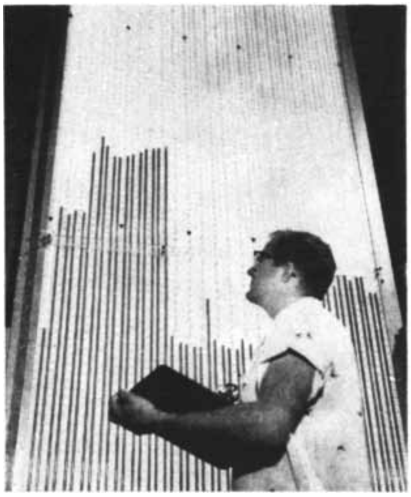
Pressures of the jet age



To take pressure readings from a jet engine sealed in a test cell, this man is using what may be the Gargantua of all manometers.

A number of these mammoth manometers (each stands better than *2 times as tall* as the average male) are used by Aro, Inc., operating contractor for the U. S. Air Force, Arnold Engineering Development Center, a collection of men and machines devoted to probing matters related to *supersonic* propulsion.

Trimount Instrument Company of Chicago makes these king-sized instruments, the main component of which is glass tubing.

This tubing is made from a PYREX brand glass. And like all items carrying the PYREX trademark, the tubing comes from Corning.

Here's why, according to the people at Trimount, they "take from" Corning for their tubing needs:

"We have found through years of experience that PYREX brand tubing is the finest for our requirements. Corning draws it to our specifications. For uniformity and extremely close tolerances required in our instruments, as well as strength and rigidity under high pressures, we specify closely held I.D. and O.D. tolerances. Also, the lengths required are important as we prefer not to use welded glass tubing . . ."

Such praise seems ample evidence that turning to Corning for glass components is sound practice from both an engineering and profit standpoint.

Thusly, an invitation to consider and investigate at your convenience. Outline your needs and we'll put our people versed in your field to work.

Or, peruse at leisure a recently issued book called "This Is Glass." It's filled with facts and pictures about glass at work in products and processes. Free.

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Pipe dreams being of an illusory and mostly impractical nature, we offer instead some *dream pipe.*

Having need for more precise terms, those in our office who write orders call this dream stuff PYREX brand glass pipe.

Admittedly, this mundane phrasing tells little about the many talents of such pipe.

For example, it is eminently practical for *unusual* plumbing tasks, being equally at home handling waste acids of a corrosive nature or carrying milk from cow to bottle in modern dairy processing setups.

Immune to corrosive attack from most materials, PYREX brand glass pipe is easily installed, carries waste acids safely and economically.

Longevity is one of many trump cards you'll hold with a handful (figurative) of PYREX pipe. Like? An actuarial-minded chap once estimated that a section of pipe *will last some 203 years on a steady diet of hydrochloric acid.*

Equally valuable is the fact that you can keep constant visual surveillance over what's being piped. If plug-ups occur, you can see where they are and get at them easily.

Also yours with any item made from PYREX brand glass No. 7740 is *ruggedness* from the standpoint of thermal shock. With a coefficient of expansion of 32.5 x 10^{-7}, you can safely use this glass for high heat environments and/or where abrupt temperature changes are common.

Physical strength is also built in. Example: In a southern paper mill there's a 400 ft. installation of 3" (O.D.) PYREX pipe handling a *mercury amalgam.* Obviously, knowing men would never trust such an assignment to any material suspect of being *frangible.*

There's a lot more about PYREX glass pipe in Bulletin EA-1. There's a lot more about the PYREX brand and other glasses in Bulletin B-83. Glad to send you either or both.

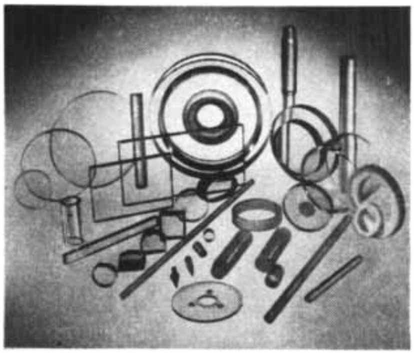
Close finish

During World War II considerable effort and experimentation were devoted to precision finishing for glass.

Since then, little has been said but quite a lot done in this field. For example, Corning makes for one customer the impeller, housings, and bushings for *an almost-all-glass pump.*

Made from PYREX brand glass No. 7740, these glass pump parts are precision ground and finished to terrifically tight tolerances.

Some of the other shapes and forms readily available with precision finishes are shown in this picture.



And this table will give you some idea of the operations and tolerances on tap at Corning.

Operation	Tolerances (inches)
Flat grinding and polishing	±.0005
O.D. grinding	±.0002
Internal grind, Step grooves, Angles and Tapers	±.0005
Circular Holes	±.005
Rectangles, Squares, etc.	±.001

Tubing, cylinders, rod, ground and polished discs and rectangles . . . these and many, many other glass forms await your investigation.

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Organic Chemical Reactions

Chemists are re-examining familiar reactions of simpler organic molecules, even tracing the courses of individual atoms. These studies help in understanding the behavior of complex compounds

by John D. Roberts

A century and a quarter ago Friedrich Wöhler of Germany, the leading pioneer of organic chemistry, wrote to his Swedish friend and co-pioneer Jöns J. Berzelius: "Organic chemistry is now enough to drive one mad. It appears like a primeval forest of the tropics, full of the most remarkable things, a monstrous and boundless thicket, with no escape, into which one may dread to venture."

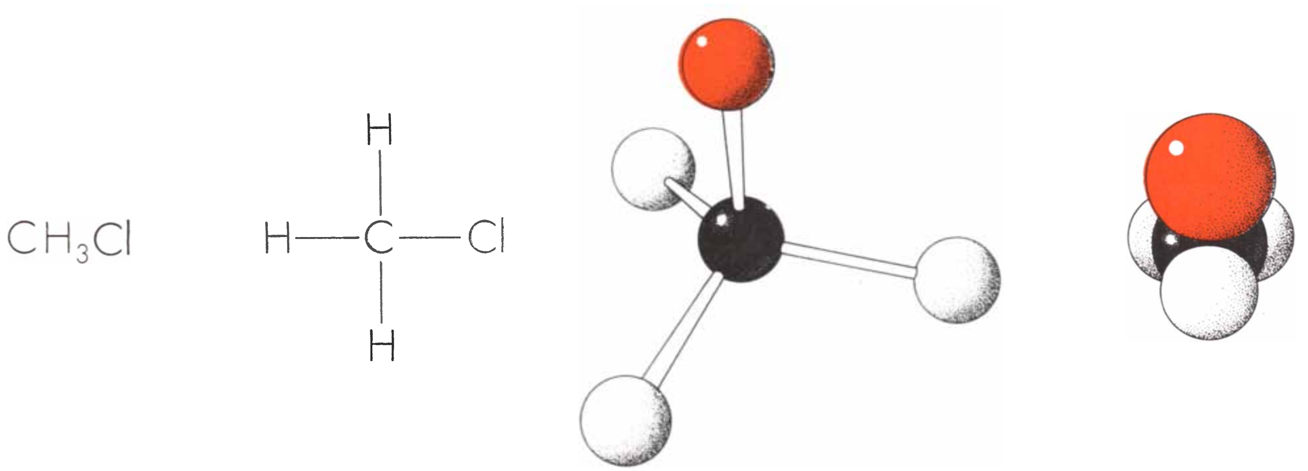
It cannot be said that chemists today have come to know every tree of that forest, or even penetrated all of its thickets. But the wilderness now looks somewhat less formidable. We know what organic substances are made of, what kinds of structure they have and how to make some of them. And we are beginning to find paths leading toward an understanding of why organic compounds behave as they do and what mechanisms govern their reactions. These reaction mechanisms are the topic of my article.

The names of organic compounds are a fearsome thicket for nonchemists, but fortunately most compounds can be portrayed simply with ball-and-stick models like a child's take-apart toy [*see drawing below*]. The sticks represent the electronic bonds linking the atoms together. In the model of the carbon atom they are set at an angle of 109.5 degrees to one another, because this is the normal angle between the atoms attached to carbon, but in some organic compounds the connections between the atoms are bent, and the bonds in such molecules act like bent steel springs rather than rigid sticks.

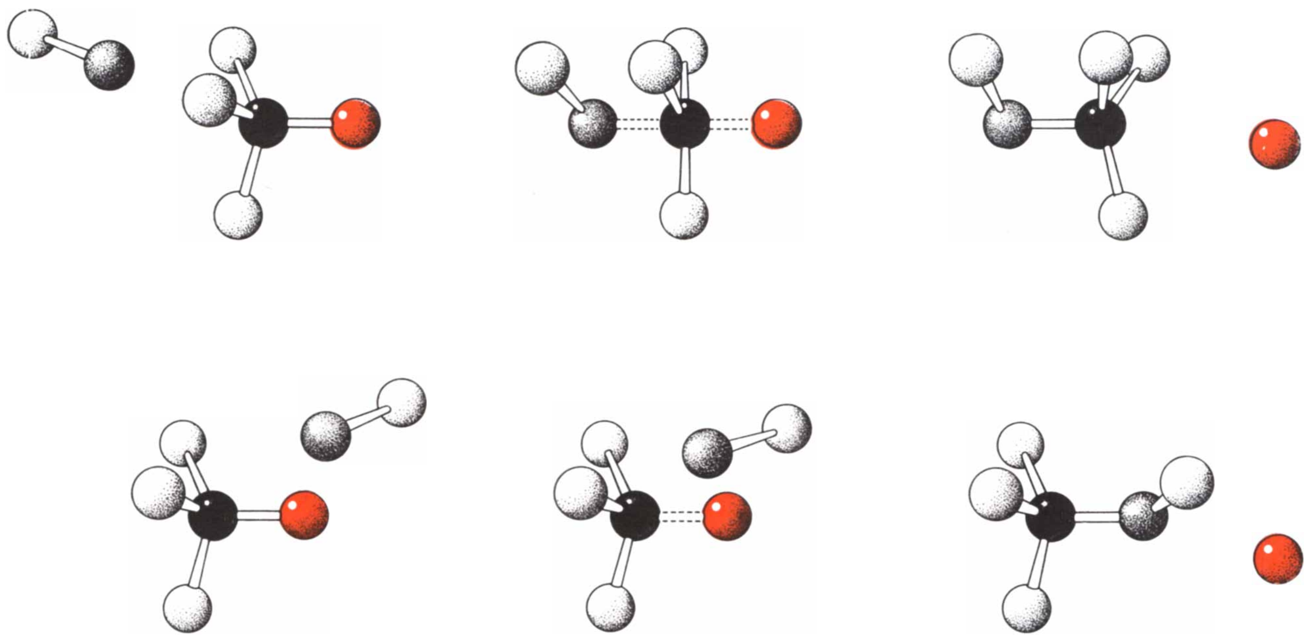
Let us try to picture a common type of reaction, well illustrated by the one between methyl chloride (CH_3Cl) and sodium hydroxide (NaOH). When the two compounds are mixed in a hot solution, the hydroxyl group (OH) from sodium hydroxide replaces the chlorine of the methyl chloride and we get methyl alcohol (CH_3OH). This is known as a substitution reaction. Our question is: How does the substitution take place?

In solution sodium hydroxide dissociates into sodium ions and hydroxide ions. We can disregard the sodium ions; in fact, the reaction goes equally well if we use lithium hydroxide or potassium hydroxide instead of sodium hydroxide. The rate of the reaction, as measured by the formation of the products, is directly proportional to the concentration of hydroxide ions and of methyl chloride molecules. Now the rate of collisions between hydroxide ions and methyl chloride molecules in the mixture also depends directly on these concentrations. Therefore we can take it as highly likely that a hydroxide ion displaces the chlorine atom by colliding with the methyl chloride molecule.

Not every collision is effective: in fact, the chlorine atom yields its place to hydroxide in only about one of every 10 million collisions. This suggests that the hydroxide ion has to approach the methyl chloride molecule in a particular



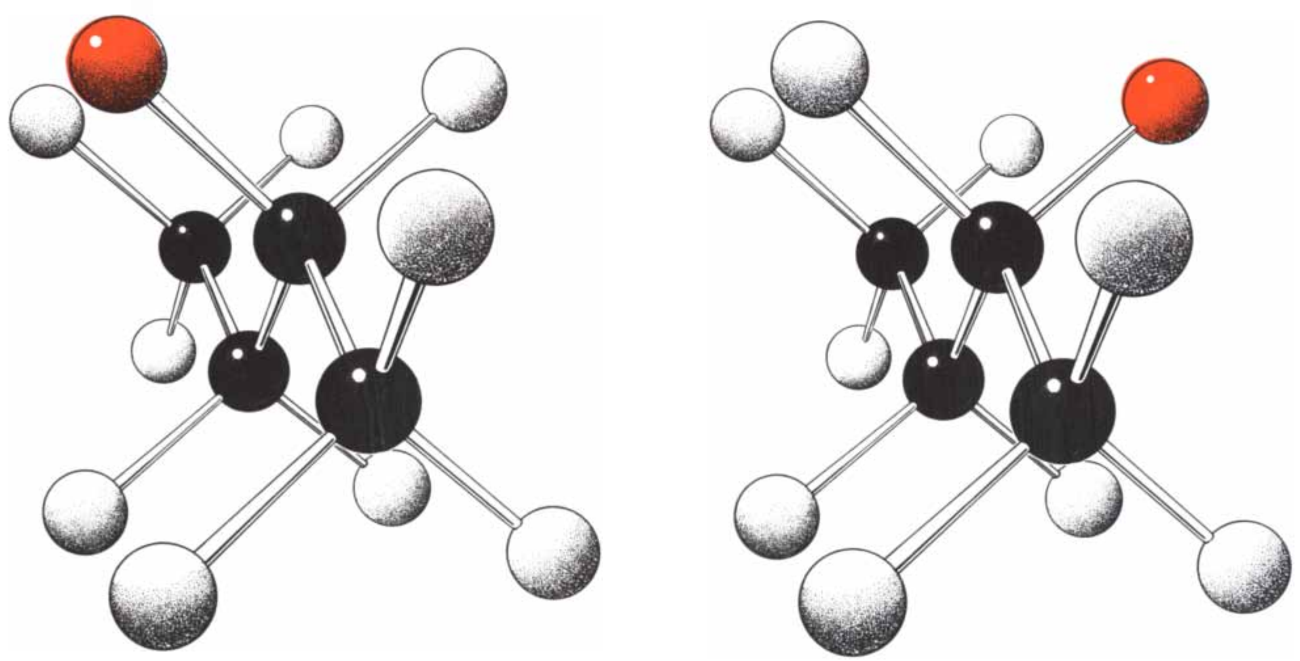
METHYL CHLORIDE molecule may be visualized in several ways. At left is condensed formula; next, the structural formula; next, ball and stick model; at right, a model showing relative sizes of atoms. Carbon atoms are black; hydrogen, white; chlorine, color.



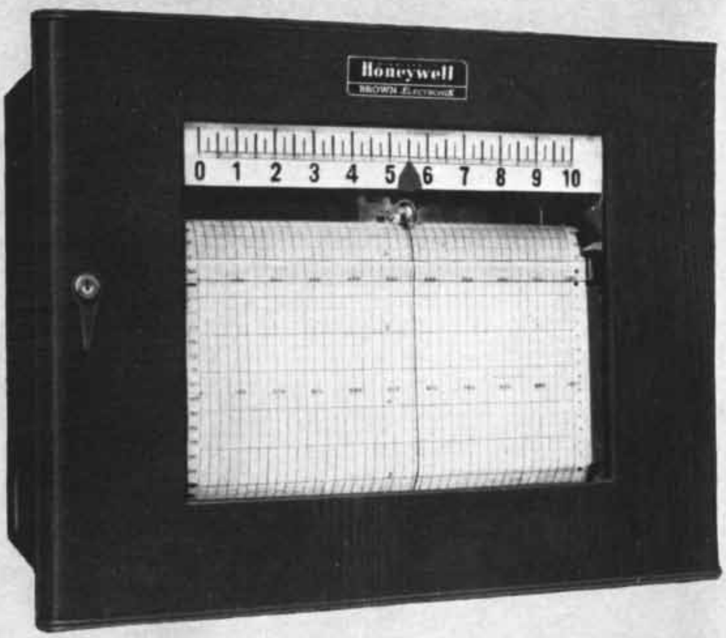
SUBSTITUTION REACTION, in which an OH group (*dumbbell*) displaces chlorine atom (*colored ball*) on a methyl chloride molecule, is diagrammed as a "back-side" reaction at top and a "front-side" reaction at bottom. The gray ball represents the oxygen atom. Bonds shown in broken lines represent the halfway point at which the OH group is attaching itself and pushing off the chlorine.

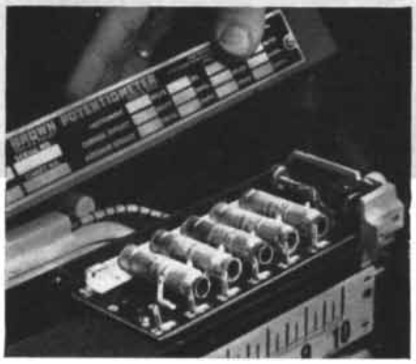
way to effect the substitution. We can think at once of two possibilities. The hydroxide ion might attack the molecule on the side where the chlorine atom is attached (the "front side") or on the opposite side (the "back side"). In the first case it would dislodge the chlorine atom directly and seize its position; in the second, it would attack the back side of the carbon atom and in so doing cause the molecule to expel the chlorine atom [*see diagrams above*].

We have no way of testing which of these attacks actually works on the methyl chloride molecule itself, because, as the diagrams show, either process would result in exactly the same structure for the transformed molecule (methyl alcohol). But we can test the issue on a somewhat more complicated chloride also containing methyl groups—the compound called s-butyl chloride. This compound can exist in two forms, each the mirror image of the other [*see diagrams below*]. We can consider one "right-handed," the other "left-handed." Now if a hydroxide ion displaces the chlorine atom in the right-handed version from the front side, it will produce a right-handed alcohol



OPTICAL ISOMERS are molecules which are identical except for their opposite "handedness." These are models of s-butyl chloride isomers. The structure at the left is a mirror image of the one at the right, just as a left hand is a mirror image of a right.





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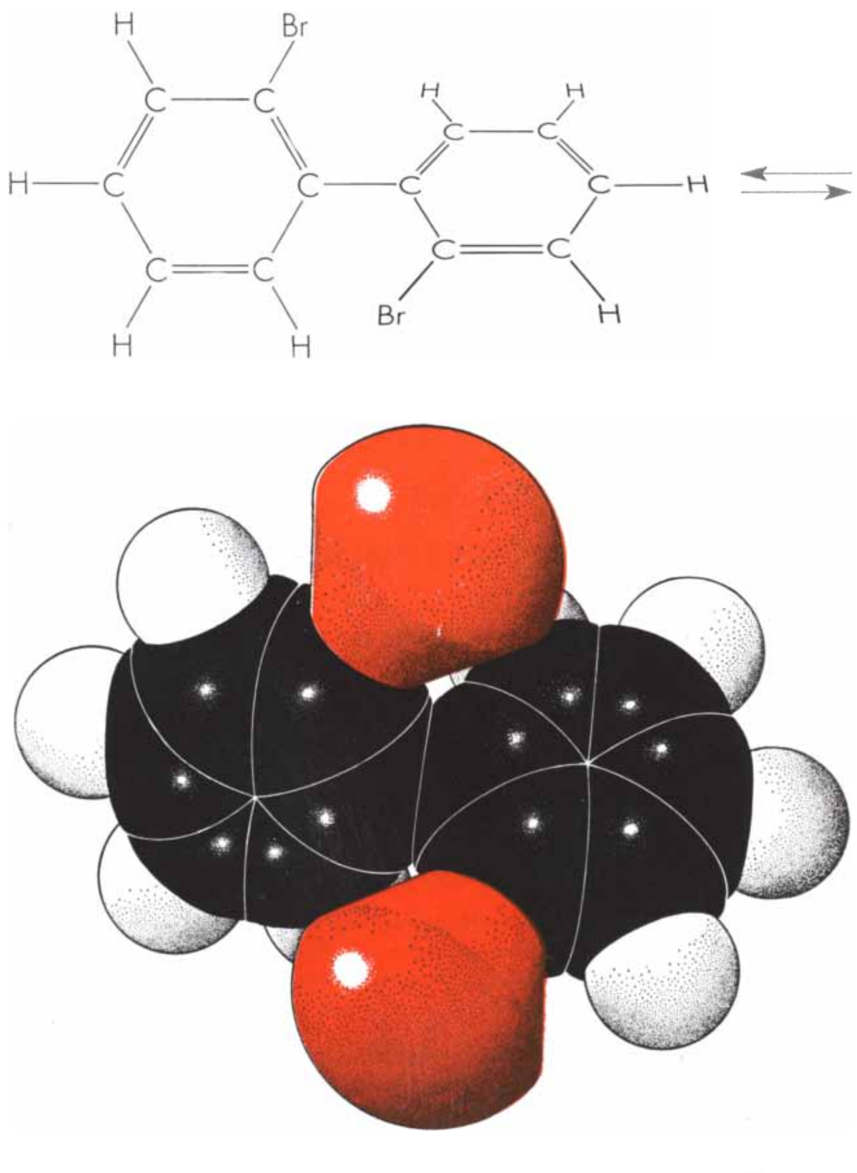
First in Controls

molecule; if it attacks from the back side, the product will be a left-handed molecule. Experiments leave no doubt about what actually occurs. The direct reaction between right-handed s-butyl chloride and hydroxide ions always produces left-handed s-butyl alcohol, which means that the ion must attack the back side.

This type of mechanism has been found to cover a whole class of organic reactions. It is called the S_N2 mechanism: S for substitution, N for "nucleophilic" (meaning that the substituting ion is attracted to the nuclear carbon atom itself, via the back side) and 2 for "bimolecular" (meaning that the reaction is effected by a collision between two molecules).

Let us look further into the mechanism. We can assume that hydroxide ions attack methyl chloride, as they do s-butyl chloride, from the back side. Now if we substitute methyl groups for the hydrogen atoms attached to the carbon atom of methyl chloride, the rate of the S_N2 reaction falls drastically. Why? The most reasonable answer is that the methyl groups, being much bulkier than hydrogen atoms, obstruct the access of hydroxide ions to the back side of the carbon atom. Strong support for this inference has been furnished by the finding that the measured reaction rates agree with theoretical calculations of the difficulty of access. To reach the carbon atom the incoming ion must push aside the methyl groups. This means it must compress them and bend their bonds. The stiffness of chemical bonds can be measured by means of spectroscopy, and the compressibility of molecules or atoms can be estimated from the extent to which they scatter a very fast beam of atoms.

Frank H. Westheimer of Harvard University worked out a problem of this sort in meticulous detail. He studied a reaction which converts a biphenyl compound from the right-handed to the left-handed form by twisting the bond that links the two phenyl rings [*see diagrams at the left*]. This involves considerable bond-stretching and distortion of the molecule, because as one ring turns around the other, their projecting atoms must push past one another. Westheimer computed how much bond-stretching, bending and compression of atoms would be required, and found that the over-all resistance corresponded closely to the rate of the reaction.

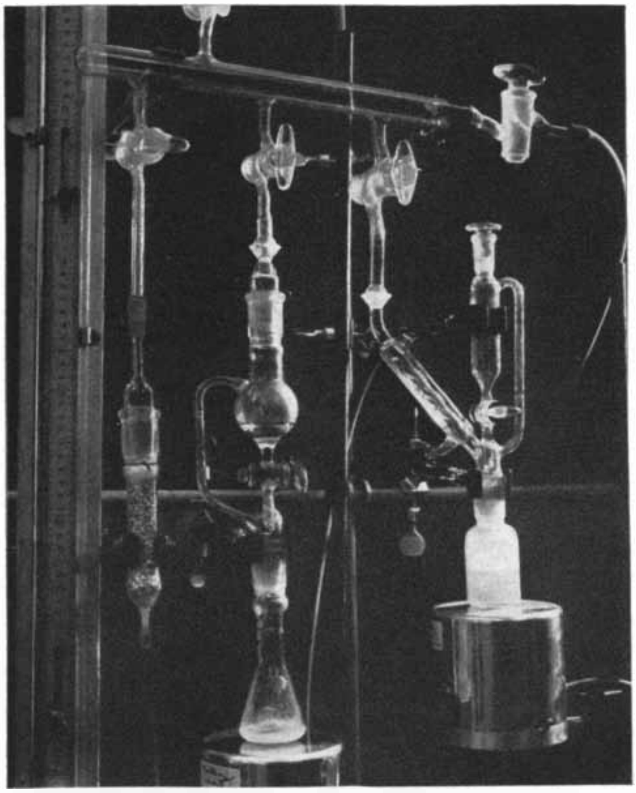


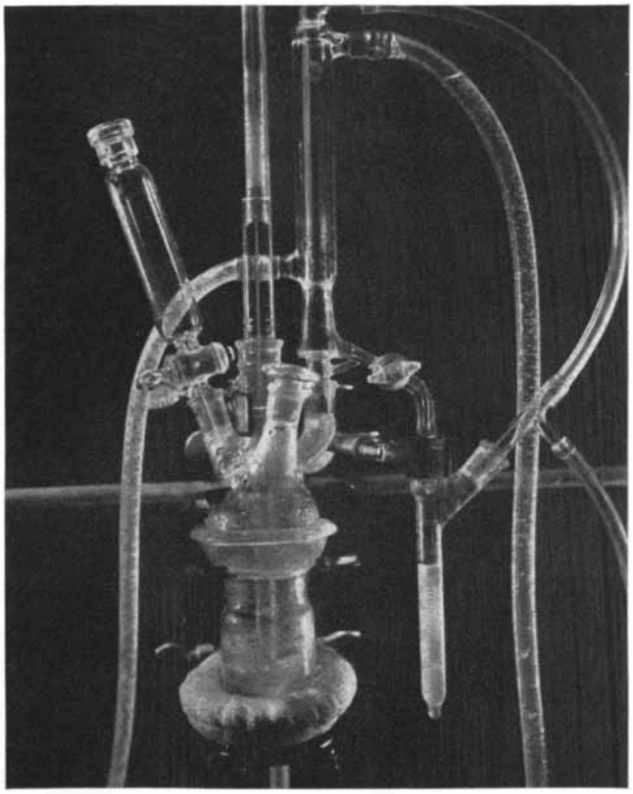
BULK EFFECT of atoms in interfering with a reaction is illustrated in these drawings. If it were not for the large bromine atoms (*in color*), the two parts of this double-ring compound (2,2′-dibromobiphenyl) would rotate freely with respect to one another, changing from right-handed form shown here to left-handed form in which bromine atoms are behind planes of rings rather than in front. Actually the bromines cannot slide past the opposite hydrogen atoms into this position unless some energy is added to distort the molecule.

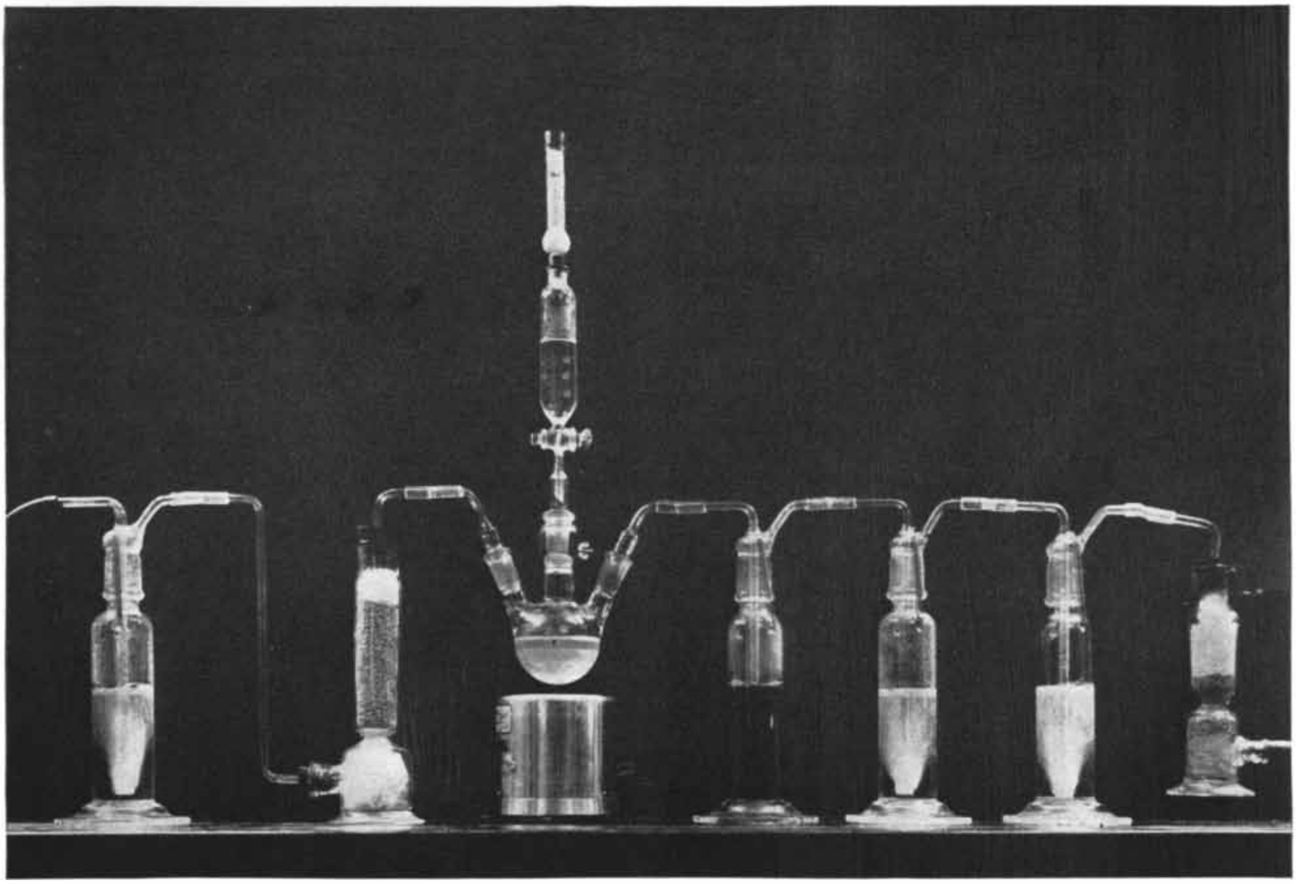
Besides the bulk effect, an electrical effect—that is, the effect of electric charges in a molecule—must play a large role in substitution reactions. Indeed, in some cases the electrical influence is stronger than the bulk effect.

What is the electrical effect? We can best approach it by considering an organic acid, such as acetic acid (CH_3COOH). This molecule contains a methyl group and a carboxyl group (COOH), the latter making it an acid. In solution the hydrogen atom splits off as a positive ion, leaving the negatively charged acetate ion. The proportion of the molecules that shed hydrogen atoms is a measure of the strength of the acid: if a high proportion drop the carboxyl hydrogen atom, the acid is strong; if a small proportion, it is weak.

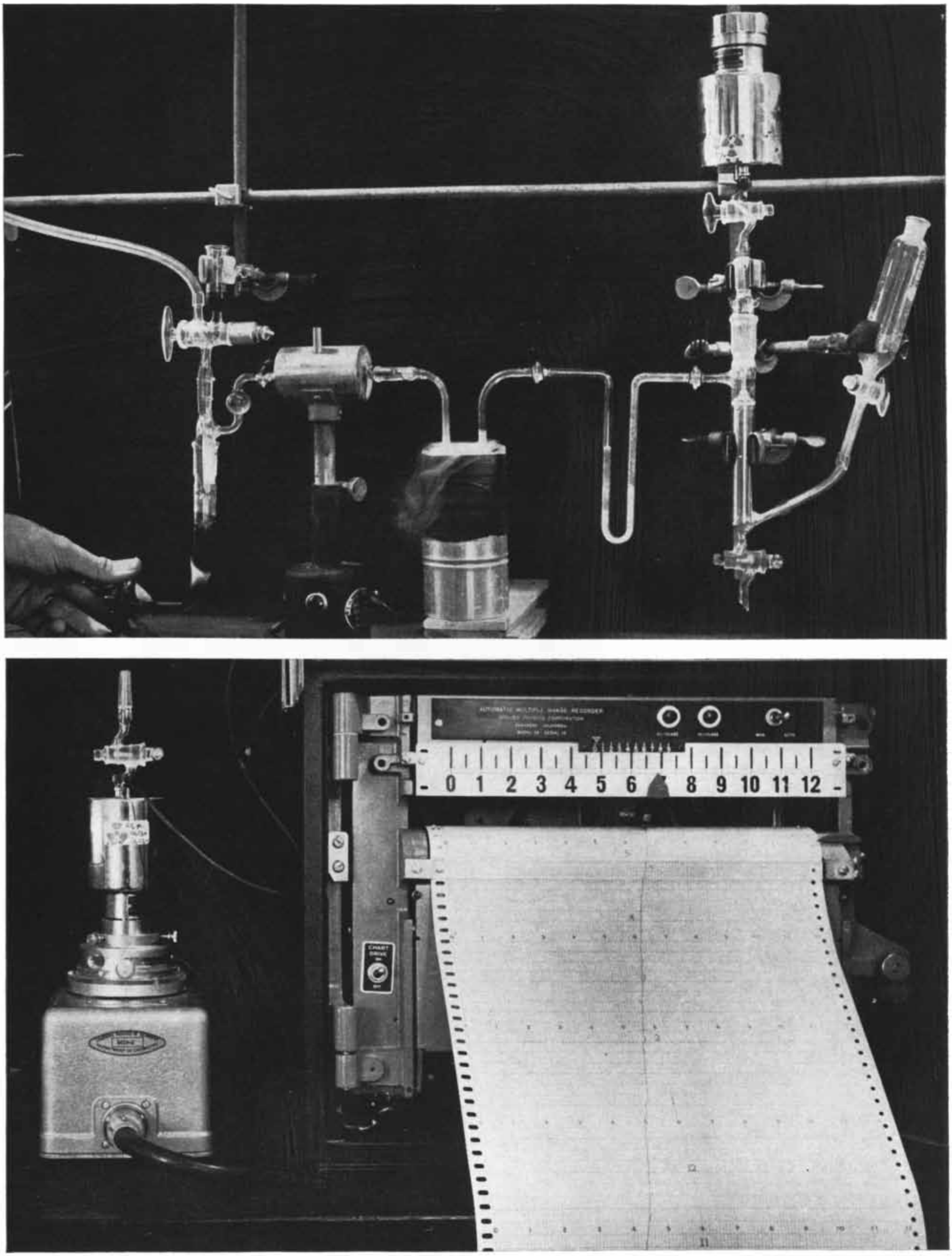
Acetic acid is a comparatively weak acid. But if we replace one of the hydrogen atoms of the methyl group with a fluorine atom, the acid becomes much stronger—200 times as strong. That is to say, the carboxyl hydrogen splits off much more readily [*see upper diagrams on page 123*]. Why so? Experiments with different compounds show that this result cannot be a bulk effect. We are forced to the conclusion that it is an electrical effect. The fluorine atom strongly attracts electrons. As a result electrons are pulled away from the hy-







RADIOACTIVE-TRACER TECHNIQUE is illustrated in the photographs on this and the following page. The experiment shown is the one described by the formulas on page 124. A three-carbon ring is tagged with a carbon-14 tail by allowing it to react with radioactive carbon dioxide in the apparatus at top left. It is then converted to a four-carbon ring in the flask at top right. Two carbons are split off and converted to carbon dioxide in the central flask of the array at bottom. The gas is collected in some of flasks to right.

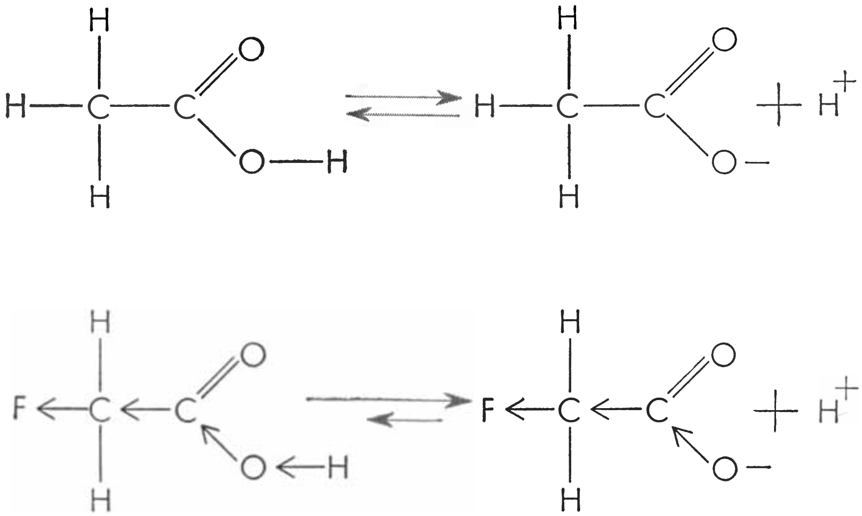


COMPLETE CONVERSION TO CARBON DIOXIDE of the four-carbon ring compound is carried out in the heated tube at the left of the top photograph. The gas is then assayed for radioactive carbon in the ion chamber at bottom. The chamber contains a central electrode insulated from the walls. When a radioactive carbon atom disintegrates it ionizes the gas in the chamber and a small pulse of current passes between electrode and walls. The total current, which depends on the amount of carbon 14 present, is recorded on chart.

droxyl group on the other side of the carbon atom to which it is attached. The hydroxyl group therefore becomes more positive; it then holds its hydrogen atom less firmly, and so the atom departs more readily as a positive ion.

Such experiments on acids show two things: (1) that fluorine and other strong attractors of electrons probably exert their influence on S_N2 reactions by the electrical effect, and (2) that methyl groups exert mainly a bulk effect, for they have little electrical effect.

How does the electrical effect work in S_N2 reactions? In a general sense, by much the same process as in acetic acid, but in the opposite direction. If a fluorine atom is substituted for a hydrogen atom on the carbon atom of methyl chloride, it pulls electrons away from the carbon atom, so that the carbon atom becomes more positive. The carbon therefore holds the negative chloride ion more firmly, and as a result replacement of the chlorine by hydroxide ions is slowed down.



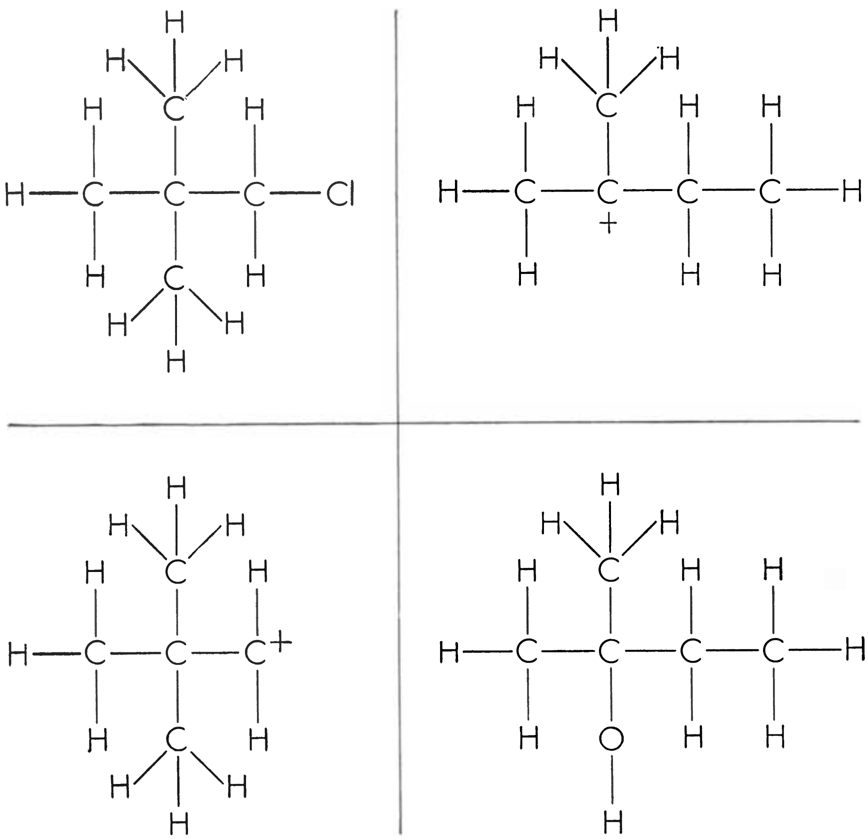
ELECTRICAL EFFECT of fluorine is shown diagrammatically. Acetic acid (*top left*) ionizes weakly. When fluorine is substituted for hydrogen at left end (*bottom*) it attracts electrons from other atoms, as suggested by arrows, so that H ion can break away more easily.

Let us turn to another type of substitution reaction, which plainly proceeds differently from S_N2 because its rate is totally independent of the concentration of the hydroxide ion. It is called S_N1, the 1 representing the fact that its rate depends only on the concentration of the molecule that is to be converted. This mechanism, like S_N2, converts organic chlorides to alcohols, but in a different way: water now supplies the hydroxide ion.

In the simplest form it is a two-step process. First the molecule ionizes slowly in water, releasing the chlorine as a negative ion. The molecule then reacts rapidly with water (HOH), taking on the OH and leaving the H as a positive ion, which promptly joins up with free OH to re-form water.

An important feature of the S_N1 process is that it often rearranges the structure of the reacting molecule. An example is the action of water on a five-carbon compound called neopentyl chloride. After the molecule has shed the chlorine atom, one of its methyl groups swings around from the side to the end of the molecule, and the hydroxide ion takes its place [*see lower diagrams on this page*]. Thus the reaction of neopentyl chloride with water yields not neopentyl alcohol but an alcohol with a different structure, called t-amyl alcohol.

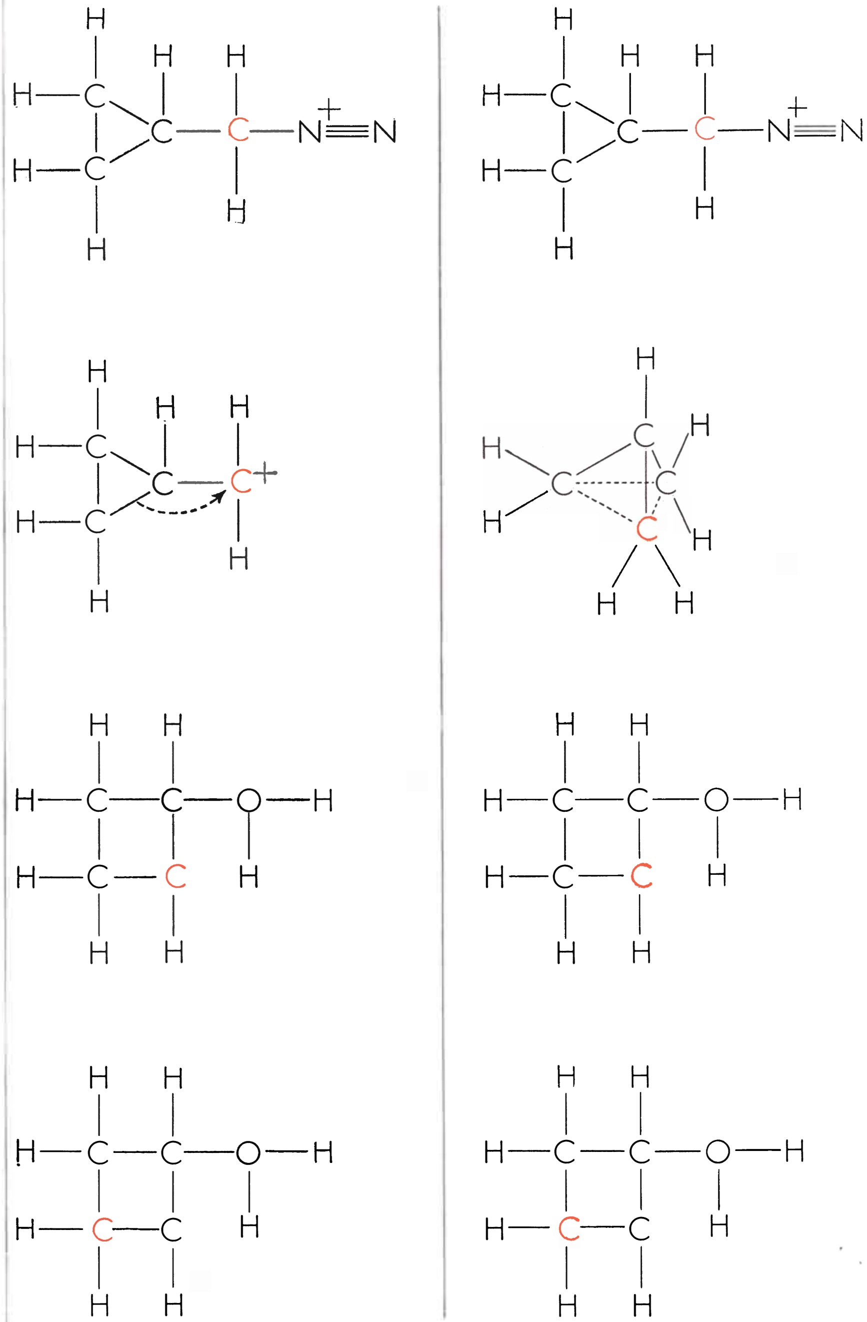
The structure-changing type of reaction is important in the petroleum industry. It is used to convert "straight-



REARRANGEMENT OF CARBON SKELETON is demonstrated when neopentyl chloride (*top left*) is converted to alcohol. When Cl breaks off, producing an ion (*bottom left*), a neighboring carbon moves to the ionized site (*top right*), leaving a charge on the central carbon. This atom now picks up the OH group to form the alcohol shown at bottom right.

chain" gasolines with poor antiknock properties into "branched-chain," high-octane gasolines.

Sometimes the carbon atoms of a molecule are thoroughly scrambled in an S_N1 reaction. Although the final product may not suggest this, investigations with radiocarbon 14 as a marker bring the reorganization to light. It becomes an intriguing challenge to try to reconstruct the sequence of events. An example is illustrated by the accompanying diagrams [*see below*]. Here a three-carbon ring with a tail is converted into a four-carbon ring. It would appear that the ring had simply opened and



COMPLEX CARBON SHUFFLING is illustrated in these diagrams. Left-hand column shows possible steps in which a three-carbon ring (*top*) is converted to a four-carbon ring (*third from top*), apparently by a simple rearrangement of a bond (*second from top*). If this were the mechanism, then carbon-14 atom (*red*) should always be next to the carbon which lost the ring bond and gained an OH group. Actually one third of the product has the labeled atom diagonally across from this carbon, as in the bottom diagram. This is now explained by the sequence in the right-hand column, in which the original ring forms an intermediate pyramid-like ion (*second from top*) from which it falls into the final configurations.

The Glacier breaking ice in McMurdo Sound. Mt. Erebus in background. (Official U.S. Navy Photo)

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To the Glacier, our Navy's largest and most powerful icebreaker, driving a path through ice up to 22 feet thick is all in the day's work. Here it is shown breaking a channel through 17 feet of solid ice at approximately 18 knots in Antarctica's McMurdo Sound as part of Operation Deep Freeze I and II. In view of the importance of communications at the bottom of the world, the Glacier is virtually a floating electronic laboratory. It contains nine AN/SRR-13A and seven AN/SRR-11 radio receivers, as well as two AN/SPA-YA Range Azimuth Indicators, one on the bridge and the other in the CIC. All of this RCA equipment has given continuous and dependable service, unaffected by the tremendous shocks to ship and gear, as 21,000-horsepower engines send the ship crashing forward under conditions never before faced by any icebreaker.

USS Glacier driving through pack ice in Ross Sea. (Official U.S. Navy Photo)

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DEFENSE ELECTRONIC PRODUCTS

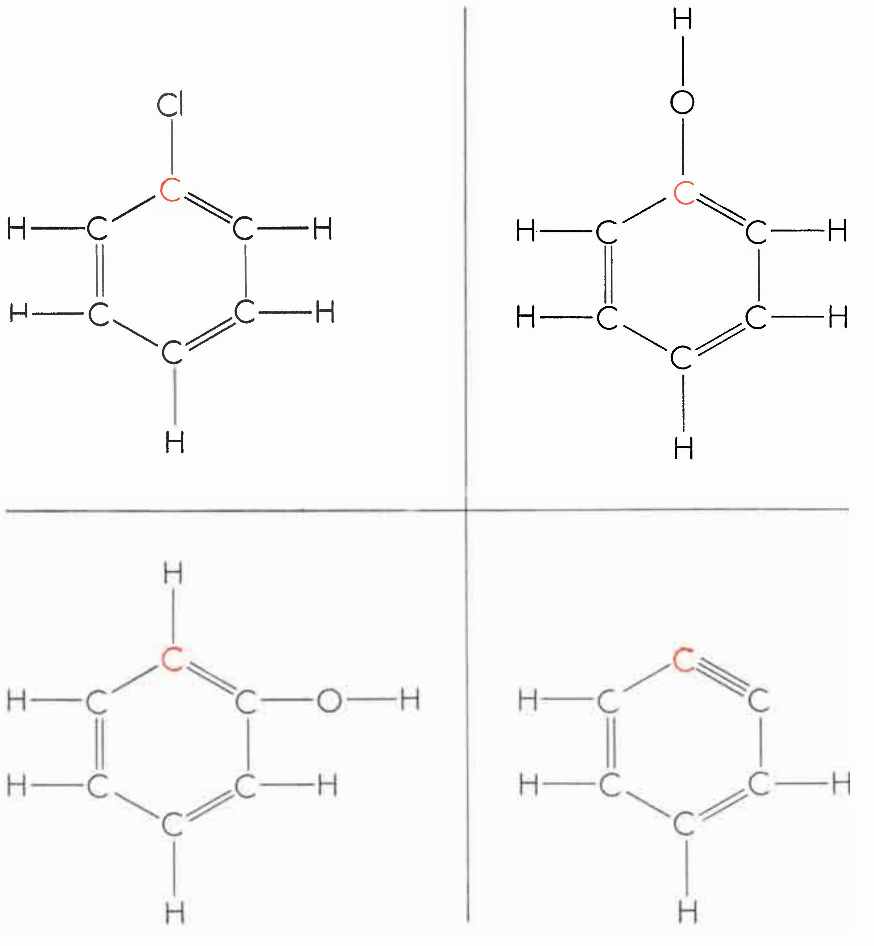
RADIO CORPORATION of AMERICA

CAMDEN, N. J.

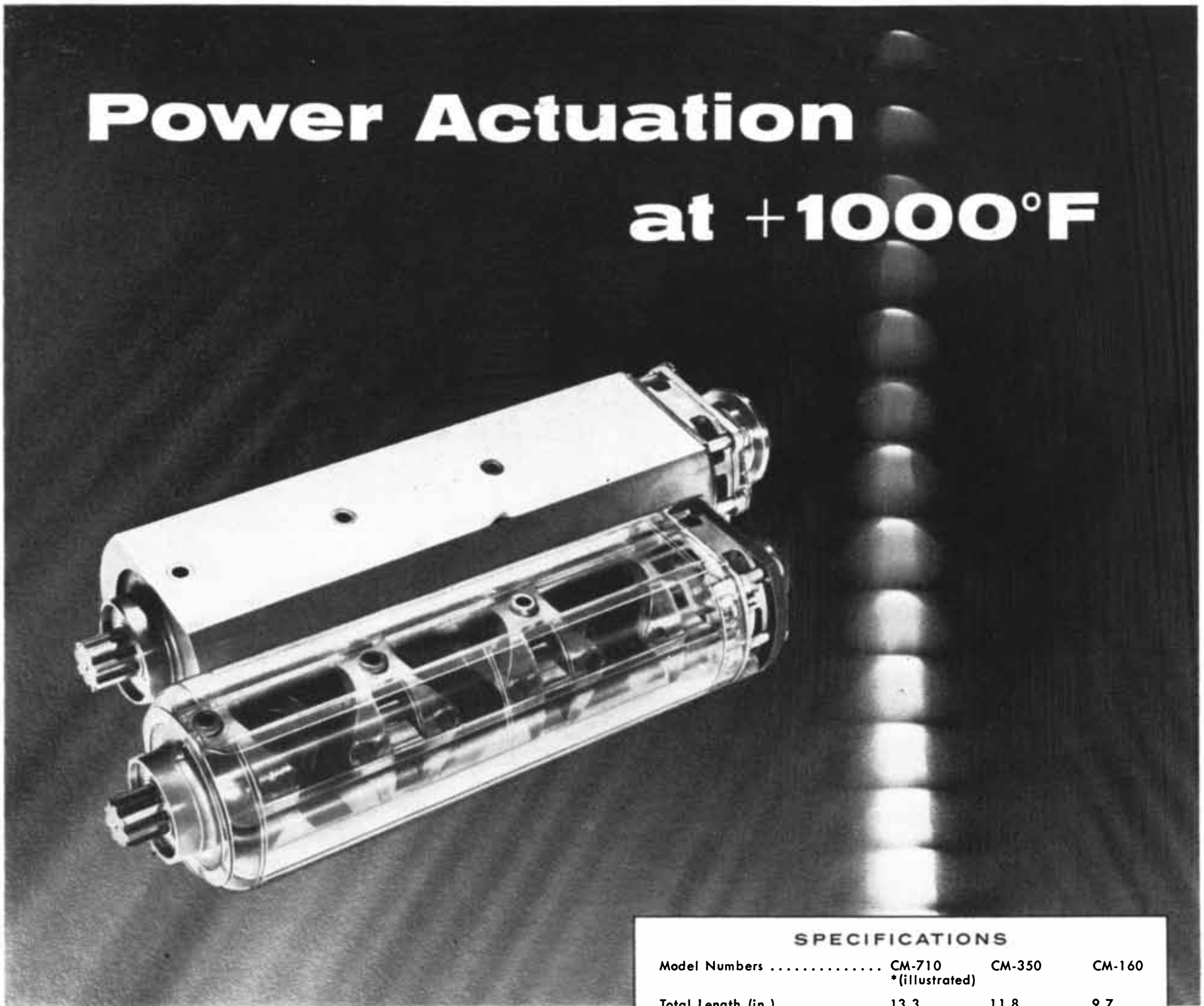
picked up the tail. But we discover that in about one third of the product the tagged carbon atom turns up in an unexpected place. Attempting to picture what has happened, we deduce that the molecule first twisted itself into a pyramid. Any of the three bonds running to the peak of the pyramid may break to take on the hydroxide group; since all three events are equally likely, two thirds of the product molecules should have the tagged carbon next to the OH and one third opposite it. This is almost exactly the proportion we find experimentally.

As a final example of an intricate reaction, consider the conversion of chlorobenzene to phenol [*see diagrams below*]. In this reaction there appears to be no structural rearrangement, and the reaction rate is proportional to the concentrations of both the chloride molecule and the hydroxyl ion. It would seem to be an ordinary S_N2 reaction. Yet experiments on molecules labeled with carbon 14 show that the OH group often turns up not on the carbon atom vacated by the chlorine but on the one next to it. We now know that when the chlorine atom breaks off, the adjacent carbon simultaneously loses a hydrogen atom, and a triple bond is fleetingly established. To begin and end on a pair of common atoms these bonds must be distorted from the normal 109.5-degree bond angle. The ring shape of the molecule distorts them much further. Chemically, this means that the bonds break easily. When they do, the opened bonds take up H and OH from the water. Since the triple bond between the two carbon atoms may open in either direction by chance, the OH is equally likely to appear on the carbon atom vacated by the chlorine or on the one adjacent.

The "boundless forest" of organic chemistry has grown extraordinary foliage of which Wöhler never even dreamed. Much of the forest has been well mapped, but we still have far to go before we shall be able to understand the reaction mechanisms by which living cells make organic compounds.



REARRANGEMENT REACTION, in which phenyl chloride (*top left*) is converted to phenol by reaction with sodium hydroxide, is diagrammed. The OH group would be expected to take position of the chlorine (*top right*). Sometimes, however, it appears one atom away (*bottom left*). Explanation is formation of an intermediate compound with triple bond (*bottom right*).



SPECIFICATIONS			
Model Numbers	CM-710 *(illustrated)	CM-350	CM-160
Total Length (in.)	13.3	11.8	9.7
Min. Height (in.)	3.1	2.9	2.5
Max. Dia. Envelope (in.)	4.0	3.2	2.5
Weight (lb.)	22	15.5	7.5
Output at 200 psig supply pressure and 1200 rpm (hp)	18.5	9.1	4.2
Starting Torque at 200 psig supply pressure (inch-pounds)	1800	890	400

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Subjective Probability

In the course of their daily lives men must constantly measure the probability of events. How these personal judgments conform to the actual laws of probability is investigated by experiment

by John Cohen

Only on things uncertain I rely
I have no doubt except in certainty
And from blind chance for knowledge I inquire

So wrote François Villon, the 20th-century French poet who happened to live in the 15th. He spoke for all of us, for whenever we choose, judge or decide, whether we interpret the past or foretell what is to come, we do so with incomplete or unsure knowledge. Uncertainty dogs our every step. Since we must act on incomplete information, risk attends our daily decisions and undertakings—in driving a car and crossing a road, on the field of sport and in the marriage bed, in picking a winner on the stock exchange or in a political election.

How do we measure the probabilities of success or failure? An inquiry into this subject of course falls in the domain of psychology. Our actions are based upon our private assessment of our chances, which in turn depends upon our experiences and maturity in reasoning. We develop subjective concepts of probability which permeate and guide our thoughts and actions. In the department of psychology of the University of Manchester we have been exploring the elusive processes of subjective probability for some time by experiments. One of our aims has been to determine whether subjective probability has anything in common with mathematical probability, and to what extent subjective probability obeys distinctive psychological rules of its own. We have endeavored to trace the development of ideas about probability, especially in youngsters of school age.

To start with, take a simple experiment testing the notion of statistical distribution. We show children aged 10 to 16 a bowl containing blue and yellow beads and inform them that there are equal numbers of blue and yellow beads in the bowl. The experimenter then draws beads from it at random, four at a time, and puts four beads in each of 16 cups. The children are asked to tell how many of the cups will contain respectively: (1) four blue beads, (2) three blue and one yellow, (3) two blue and two yellow, (4) one blue and three yellow, (5) four yellow.

On the basis of such experiments we have found that children apparently progress through four stages. The younger children (around 10) merely guess vaguely that the five possible combinations are not equally likely. Those a little more mature realize that the most frequent (or most probable) content of the cups will be two blue and two yellow beads. At the third stage youngsters advance to the conclusions that one blue and three yellow beads will occur as often as one yellow and three blue, and that four blue and four yellow also have equal probabilities. Finally the older children conclude that the combination of one and three is more likely than all four of the same color. These experiments thus show how, with increasing age and experience, uncertain situations are structured in closer and closer accord with the objectivity of mathematical expectation.

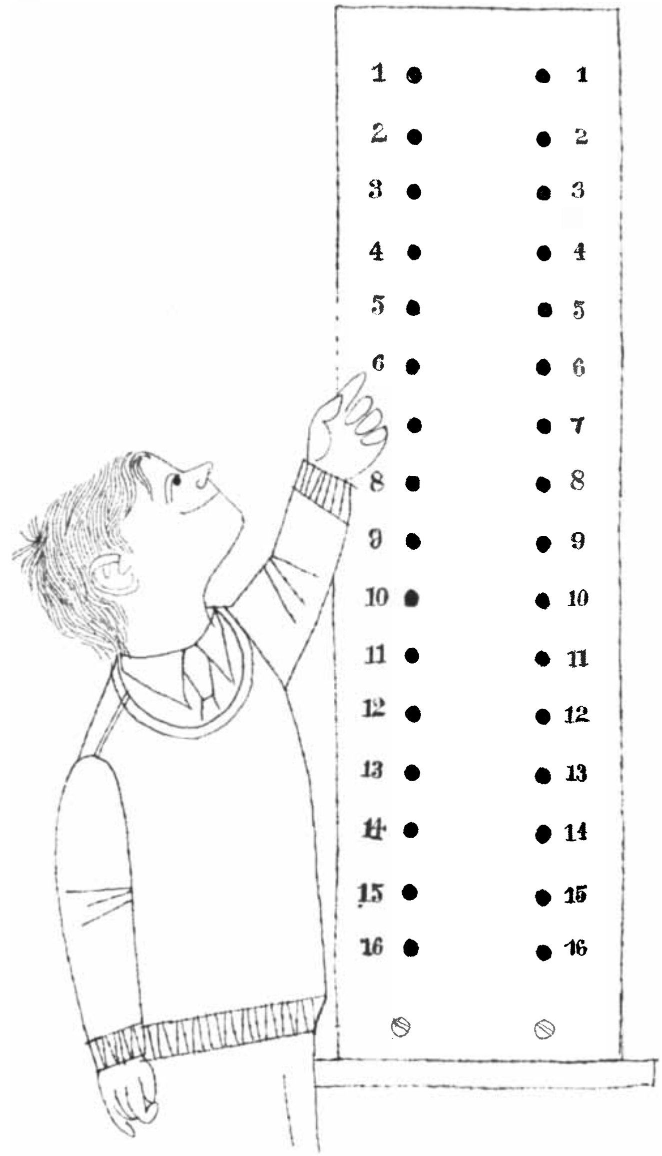
The idea of sampling is an essential element for making sensible decisions; indeed, it may be the basis of thought itself. We send out mental antennas to feel or taste the universe, and from these samples, which give us only partial information, we learn to form sound judgments about the total "populations" they are supposed to represent. Sometimes the populations vary continuously; in such cases the fluctuations in successive samples themselves may lead to discovery of a law of nature.

Let us now consider whether estimates of the probability of success in a given task obey rules similar to those of mathematical probability or are subject to different, psychological rules. One rule of mathematical probability convenient for such a test is the additive theorem: namely, that small, independent probabilities of a particular event add up to a larger probability. Thus if you are drawing for a lucky ticket in a pool, your chances of success will increase in proportion to the number of tickets you take. In one of our experiments we confronted our subjects with a choice between taking a single large probability or a set of smaller probabilities: *e.g.*, they were allowed to draw either one ticket from a box of 10 or 10 tickets from 100, in the latter case putting back the ticket drawn each time before making the next draw. Mathematically, of course, the chance of drawing the prize ticket was exactly the same in both cases. But most of the subjects proved to be guided mainly by psychological rather than mathematical considerations.

If the 10 draws had to be made from 100 tickets in one box, about four fifths of the subjects preferred to make a single draw from a box of 10. Indeed, this preference held even when they were allowed to make 50 draws from the box of 100. Apparently the subjects feared that they might repeatedly draw the same ticket that they had put back. On the other hand, when they were allowed to draw the 10 tickets (or even fewer) from 10 separate boxes of 100 each, then a majority of the subjects swung to a preference for the plural chance over the single draw from a box of 10. That is to

A bus is driven between two posts in an experiment by the author and his colleagues at the University of Manchester say, they swung from underestimating the plural chance to overestimating it. There is a type of mentality, in fact, which regards two draws as better than one under any circumstances. Some of the subjects preferred drawing two tickets from a box of 100 to drawing one from a box of 10.

Everyday life presents many situations of this kind, where we must choose between a large chance and a combination of smaller ones. For example, a jury (or a scientist) sometimes has to weigh one large item of evidence against the sum of several small items. Now there is also another type of situation which resembles the foregoing but in which the chances are not actually additive. For instance, a general may have to decide whether to stake success on a single big battle or a succession of smaller ones. Assume that he must win each of the smaller battles in order to undertake the next in the series. Then the chances are not additive but multiplicative: that is, if the chance of success in each battle is 1/2 (50 per cent), the over-all chance for the series is $1/2 \times 1/2 \times 1/2$. . . . The more battles he has to win on this basis, the smaller is his chance of final success. We have tested the responses of subjects to such a situation, offering them a choice between a single chance (ranging from certainty of success down to one chance in 1,000) and a set of chances amounting to, say, $1/3 \times 1/3 \times 1/3$. Even highly intelligent adults often choose the multiple chance although it is mathematically smaller than the single chance. They tend to inter-



Children were asked to guess in which of two columns a light would flash

Utica technician viewing a meltdown of Udimet 500—a new vacuum melted alloy in the high temperature field.

pret the successive chances as additive, and the more stages there are, the bigger is their overestimation of the probability of success.

We have studied people's estimates of the chance of success, or the risk of failure, both in tasks that involve no danger (*e.g.*, throwing a ball at a target) and in others that do involve danger (*e.g.*, driving a bus between two posts). In the latter experiment the posts were set at various distances, ranging from gaps which the bus could clear very easily to openings narrower than the bus. We compared the risk-taking of a group of beginners just starting training as bus drivers with that of trained drivers and of an experienced instructor.

We found that the experienced drivers not only performed more successfully than the inexperienced but also took less risk. That is, while the beginners attempted the task even when they were far from sure that they would succeed, and sometimes tried to drive the bus through an impossibly narrow gap, the trained drivers seldom did; the instructor never. He was able to judge accurately whether he could or could not drive his bus through a given gap. His maximum risk-taking level (the smallest gap through which he would attempt to take the bus) was one at which he thought he would always succeed and did in fact always succeed.

Plainly this kind of investigation could be useful in improving safety, not only in automobile driving but also in many other activities involving a human operator. We are at present studying how risk-taking by drivers is affected by imbibing various quantities of alcohol.

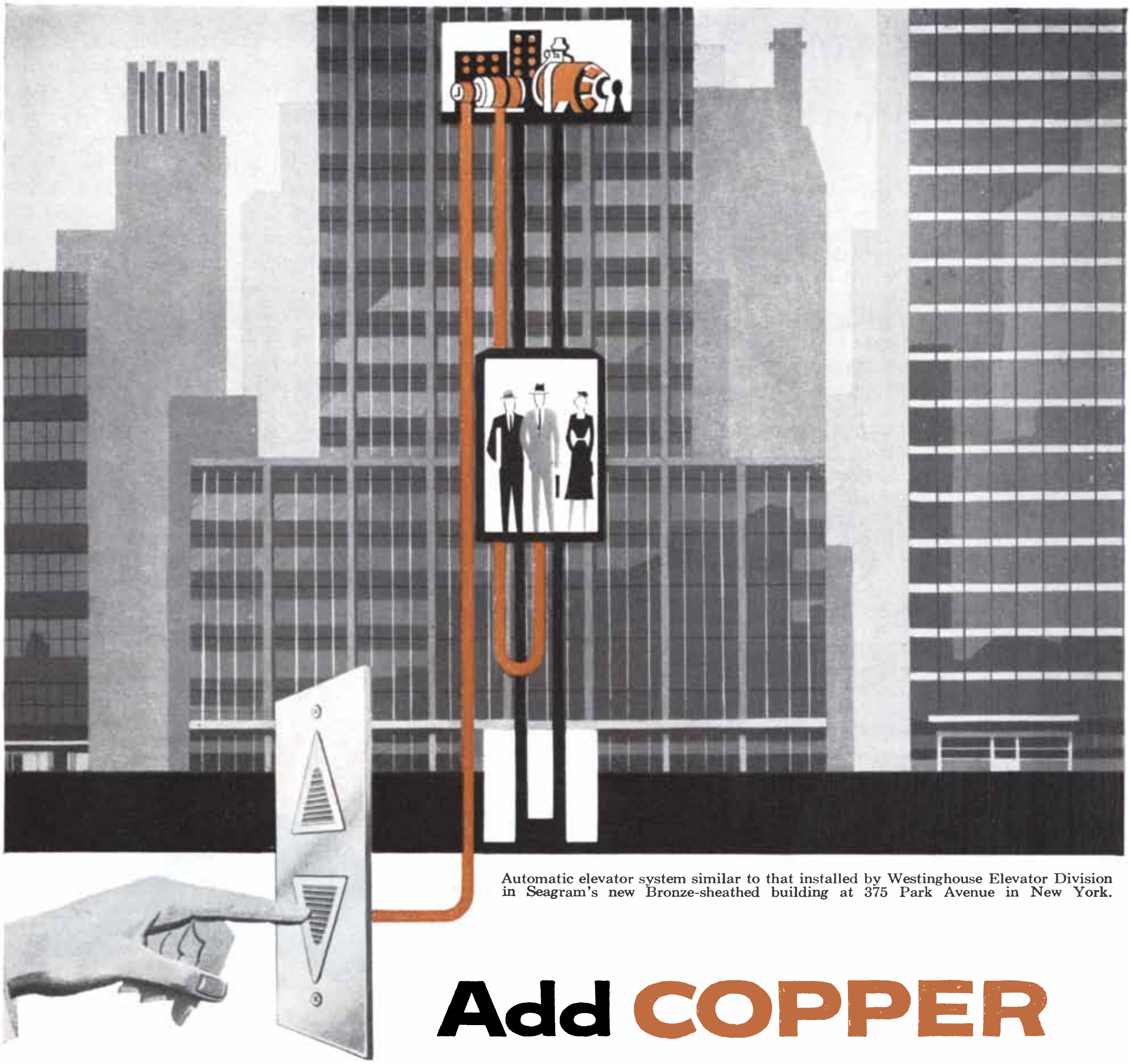
Uncertainty pervades our lives so thoroughly that it dominates our language. Our everyday speech is made up in large part of words like "probably," "many," "soon," "great," "little." What do these words mean? "Atomic war," declared a recent editorial in the London *Times*, "is likely to ruin forever the nation that even victoriously wages it." How exactly are we to understand the word "likely"? Lacking any standard for estimating the odds, we are left with the private probability of the editorial writer.

Such verbal imprecision is not necessarily to be condemned. Indeed, it has a value just because it allows us to express judgments when a precise quantitative statement is out of the question. All the same, we should not and need not hide behind a screen of complete indefiniteness. Often it is possible to indicate the bounds or limits of the quantitative value we have in mind.

One big battle, or several small ones?

The language of uncertainty has three main categories: (1) words such as "probably," "possibly," "surely," which denote a subjective probability and are potentially quantifiable; (2) words like "many," "often," "soon," which are also quantifiable but denote not so much a condition of uncertainty as a quantity imprecisely known; (3) words like "fat," "rich," "drunk," which are not reducible to any accepted number because they are given various values by different people.

We have been trying to pin down, by experimental studies, what people mean by these expressions in specific contexts, and how the meanings change with age. For instance, a subject is told "There are many trees in the park" and is asked to say what number the word "many" means to him. Or a child is invited to take "some" sweets from a bowl and we then count how many he has taken. We compare the number he takes when alone with the number when one or



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more other children are present and are to take some sweets after him, or with the number he takes when instructed to give "some" sweets to another child.

First, we find that the number depends, of course, on the items involved. To most people "some friends" means about five, while "some trees" means about 20. However, unrelated areas sometimes show parallel values. For instance, the language of probability seems to mean about the same thing in predictions about the weather and about politics: the expression "is certain to [rain, or be elected]" signifies to the average person about a 70 per cent chance; "is likely to," about a 60 per cent chance; "probably will," about 55 per cent.

Secondly, the size of the population of items influences the value assigned to an expression. Thus, if we tell a subject to take "a few" or "a lot of" beads from a tray, he will take more if the tray contains a large number of beads than if it has a small number. But not proportionately more: if we increase the number of beads eightfold, the subject takes only half as large a percentage of the total.

Thirdly, there is a marked change with age. Among children between six and 14 years old, the older the child, the fewer beads he will take. But the difference between "a lot" and "a few" widens with age. This age effect is so consistent that it might be used as a test of intelligence. In place of a long test we could merely ask the subject to give numerical values to expressions such as "nearly always" and "very rarely" in a given context, and then measure his intelligence by the ratio of the number for "nearly always" to the one for "very rarely." We have found that this ratio increases systematically from about 2 to 1 for a child of seven to about 20 to 1 for a person 25 years old.

Nowhere are the processes of subjective probability more beautifully exhibited than in gambling. This is, of

For elections and rain the prediction "is certain to" means about a 70 per cent chance

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Jayne Marie Mansfield, with the help of her famous mother, christens Temco's jet trainer "Pinto"

The TEMCO-built TT-1 proudly joins the Navy's air arm as the "Pinto" — first primary jet trainer to be accepted by the U. S. Military. It is an aircraft as reliable and rugged as the famous Pinto ponies of the Texas plains.

The Pinto was born in Texas . . . designed, built and tested at Temco's own expense to meet the need for all-jet training. It won competitive evaluation tests at the Navy's Patuxent River Air Test Center. Subsequent exhaustive tests have proved its capabilities for true jet performance with highest safety factors.

The Pinto is an outstanding example of Temco initiative and engineering skills. Similar achievements are being made in the fields of guidance systems, electronics, and missile weapons systems. The experienced engineer seeking the challenge of a growing organization, plus the prestige of a soundly established company — will find *his* opportunity at Temco!

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MISS MANSFIELD APPEARS SOON IN THE JERRY WALD FILM PRODUCTION "KISS THEM FOR ME".

course, an ancient and universal practice of mankind. It seems to be linked, like ideas of destiny, primitive justice and divination, with the human awe of unpredictable events. The gods of folklore, in Indian, Greek and Nordic mythology, shaped human destiny by lots or dice. Primitive justice was, therefore, like a game of chance, a way of discovering the decision of the gods. The lawsuit was probably at first a contest which took the form of judgment by ordeal: victory was taken as supernatural proof of the justice of one's cause. No single feature of our lives is more charged with anxiety or passionate beliefs than a gamble such as the toss of a coin to decide an issue. No wonder that gamblers get worked up into violent frenzies (sometimes eating the cards or smashing the dice) and are ready to stake anything: wives, families, fingers, teeth, eyebrows, even personal freedom. Perhaps, as Sigmund Freud suggested, there is a sexual element in gambling; indeed, it often produces the same sequence of pleasure, guilt and remorse as the practice of masturbation.

In our studies of the manifestations of subjective probability in gambling we have given particular attention to the Monte Carlo fallacy: the well-nigh unanimous belief that after a run of successes a failure is inevitable, and *vice versa*. We tested young children with a display board containing two vertical columns of lights [*see drawing on page 130*]. The lights were lit in succession, on one side or the other, up to a certain point, and the child then had to guess whether the next light would be in the right-hand or left-hand column.

Children from the age of six to 11 underwent this test. The youngest tended to alternate their guesses from one column to the other: that is, they might guess that the light would appear on the left side; if that guess failed, they would switch to the right side the next time, and so on. Older children followed the pattern of what had happened on the board: if more lights were lit on the left side, they would predict that the next light would appear on the right, regardless of their preceding guess.

Not until about the age of 12 do children begin to sense that each event may be independent of those that have gone before. At this age, as we found in coin-tossing experiments, youngsters start to predict that any given toss may be either heads or tails. As a 12-year-old girl expressed it: "When you toss a penny, nobody, *nobody* can tell you, even the cleverest of people, which it is going to be, because it might be either." Nevertheless, even with this appreciation, youngsters do not fully grasp the idea of a statistically independent outcome. Very few, it appears, realize that the guesses must be made in a purely random manner. From the youngster of six to the very bright adolescent of 16, predictions follow a complex system of pattern-seeking, associated with preferences for esthetic symmetry, fairness or magic.

How many are "some" sweets?

These experiments give us a glimpse into the mind of the gambler. He seems unable to detach his prediction of an event from outcomes of similar events in the past, although in a sense he may "know" that the new event is entirely independent of those previous outcomes. Like many children, he is apt to treat luck and ill luck as stores which can be used up, and to think that success in guessing is due to the possession of some uncanny shrewdness or occult power which acts like a divining rod.

The further study of subjective probability promises to be of considerable theoretical interest as well as practical importance. It offers a novel method of investigating the growth of our mental powers from infancy onward, providing a single conceptual scheme for the study of how we perceive, think, learn, decide and act. It suggests new possibilities for comparative researches into abnormalities of thought and behavior, such as in schizophrenia, obsessional disorders and brain injuries.

There may also be a moral for teach-

Surface Reports on steel processing

from powder to pills of steel

Low grade ores have long been an inviting possible dietary supplement for this country's amazing appetite for steel. Taconite, however, has resisted efforts to refine it until a fairly recent breakthrough in processing techniques. It is possible to powder, concentrate, and pellitize the lean ores, but how to make the pellets sturdy enough to stand the rather rough subsequent handling was a challenge that literally took years to make commercially practical. Heat treatment of the pellets was a big part of the answer.

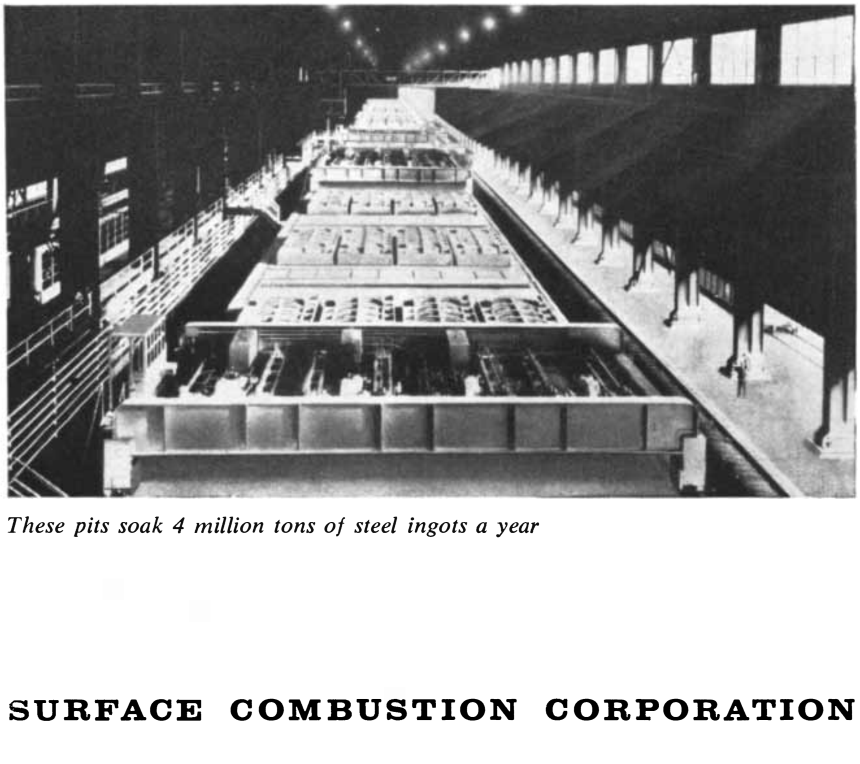
From the very beginning Surface participated actively in research aimed at commercial utilization of taconite, and recently acquired exclusive rights to license the process and equipment for pelletizing iron ore by the Erie Mining Company shaft furnace method.

Twenty-four furnace units are being built by Surface for the Erie taconite plant at Hoyt Lakes, Minnesota. The entire plant and associated facilities involve some 300 million dollars and will be the largest installation of its kind.

the pit that worked

Here's a news story that's thirty years young. Back in 1927, Surface Combustion Corporation developed the one-way fired soaking pit for steel ingots—a radical departure from the then conventional methods of heating the pits with several burners. Logic would have said this technique would sacrifice uniform heating for economy.

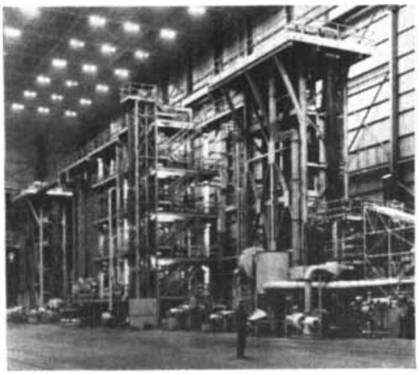
But the pits did work far better than original expectations. Today the Surface one-way firing method is the standard of the industry, and that Surface is still pioneering after thirty years is attested by a most recent installation of 48 Surface pits for one of America's greatest steel producers. This is the largest pit installation ever built and will be part of a facility with a rated capacity of four million tons annually.



These pits soak 4 million tons of steel ingots a year

high speed annealing

The bright annealing of strip for tin plate is—to put it mildly—a difficult problem, partly because of the need for enormous speed and capacity, but chiefly because of the heat radiating characteristic of the bright metal. Metallurgical and dimensional specifications are tight. High heat inputs are needed, with very close control of temperatures through the entire operating cycle.



6-story tower annealer for tin strip

Meeting such demands sometimes leads to rather dramatic installations. One of Surface's strip annealers is six stories high and the strip itself travels at 1000 feet a minute.

Many large annealing installations bear the Surface nameplate, because steel production people and investors generally like to know ahead of time that a new line is going to pay off.

For further information on any phase of steel processing from ingot to finished product—or for any other Surface services, write Surface Combustion Corporation, 2391 Dorr St., Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

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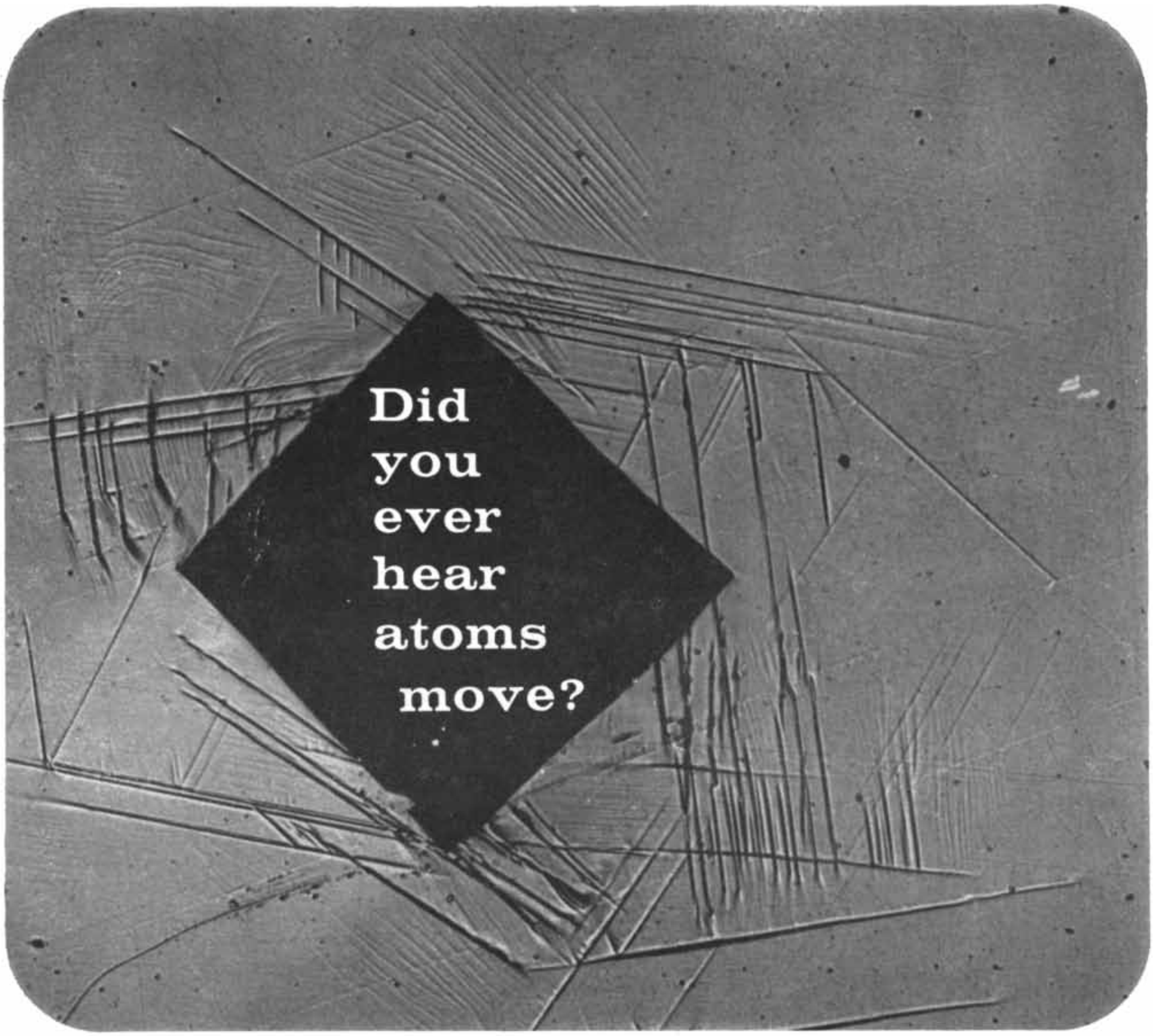
Surface® Heat Treat, Steel Mill, Glass Divisions • Kathabar® Air Conditioning & Drying Division • Janitrol® Aircraft Division • Janitrol® Heating & Air Conditioning Division • Webster Engineering Company: Boiler Burner Division ers. Our system of education tends to give children the impression that every question has a single, definite answer. This is unfortunate, because the problems they will encounter in later life will generally have an indefinite character. It seems important that during their years of schooling children should be trained to recognize degrees of uncertainty, to compare their private guesses and extrapolations with what actually takes place—in short, to interpret and become masters of their own uncertainties.

Subjective probability also has its place in the study of crime. Certain classes of criminals may differ from their law-abiding neighbors only in being more sure that they will escape detection. Or they may differ only in their level of maximum risk-taking, that is, in being ready to act at a level of uncertainty of success where their neighbors would hold back. Further, we have started some studies which may form a bridge between psychology and economics. For example, we are studying people's behavior at auctions in an attempt to relate subjective expectations of gain or loss to the actual risks of an economic enterprise. Finally, the study of subjective probability makes possible an experimental attack on all sorts of problems involving uncertain situations. In particular, it offers a new perspective for the study of accidents—in transport, in industry and, not least, in the home.

Sigmund Freud reflects on gambling



ONLY the whisper of a physicist's breathing breaks the stillness of the laboratory as he positions a single crystal of age-hardened steel under a sharp diamond penetrator. He squints at a dial . . . touches a foot pedal. And the pyramidal point of the diamond slowly presses into the polished surface of the steel crystal.

The instant that diamond touches steel, things begin to happen inside the crystal. Atoms that were locked in position begin to slip and slide—layers at a time—as they are pushed out of place. Some layers abruptly wrinkle and corrugate, to form crystallographic "twins," when sections of the crystal distort under the load.

If you listen hard when this happens, you can hear a faint, sharp "click." This is the sound of twinning—the sound of atoms violently shifting, moving, within the crystal.

You can see it twinning, too—or, rather, the results of it. Examine the surface of the deformed crystal through a high-powered microscope, and you can see a characteristic pattern of ridges and ripples that forms on the surface when the atomic layers distort. The photomicrograph above is typical. (The black diamond is the depression made by the penetrator.)

By studying many slip and twinning patterns and correlating them with other experimental data, scientists at U. S. Steel are trying to learn exactly what happens, atomically, when a steel is bent, flexed, or broken. The new knowledge they are gaining will enable them to control the microstructure of steel with still greater precision. It will enable them to continue the steady improvement in performance and quality of existing USS steels and to develop new, more versatile, and more useful USS steels.

That is why *fundamental* physical and chemical research is an important and continuing activity at U. S. Steel's Research Center. It benefits U. S. Steel, its customers, and everyone who uses products of steel. It also aids the forward march of science, because it helps other scientists who are striving to better understand the nature and behavior of matter. United States Steel, Pittsburgh 30, Pennsylvania.

UNITED STATES STEEL

MATHEMATICAL GAMES

Nine titillating puzzles, the answers to which will be given next month

by Martin Gardner

Last February this department presented nine "brain teasers" which, judging by the number of letters which followed, inflamed the passions of readers who like to solve puzzles. Here are nine more of these problems. Some are old, some new; none calls for advanced mathematical skills except possibly the problem of the amorous bugs and the seemingly unsolvable problem of the ivory sphere. All have elegant or unexpected elements in their solution. The answers will appear in this department next month.

1.

Four golf balls can be placed so that each ball touches the other three. Five half-dollars can be arranged so that each coin touches the other four [*see illustrations at bottom of page*].

Is it possible to place six cigarettes so that each touches the other five? The cigarettes must not be bent or broken.

2.

Two ferryboats start at the same instant from opposite sides of a river, traveling across the water on routes at right angles to the shores. Each travels at a constant speed, but one is faster than the other. They pass at a point 720 yards from one shore. Both boats remain in their slips for 10 minutes before starting back. On the return trips they meet 400 yards from the other shore.

How wide is the river?

3.

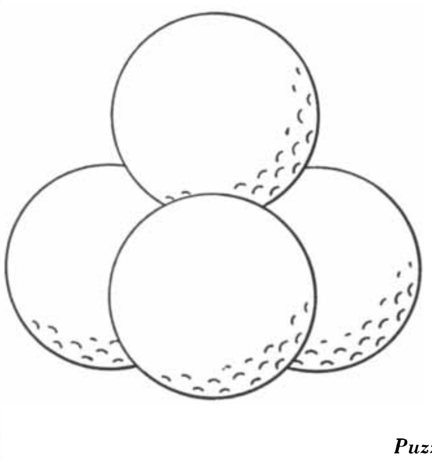
A rectangle is inscribed in the quadrant of a circle as shown [*top of page 142*]. Given the unit distances indicated, can you accurately determine the length of the diagonal AC?

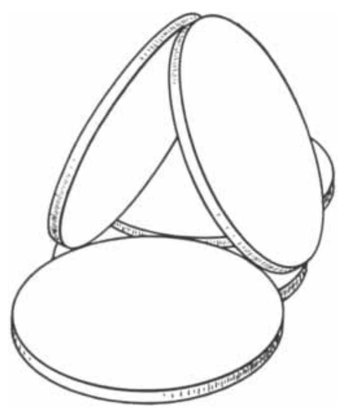
Time limit: one minute!

4.

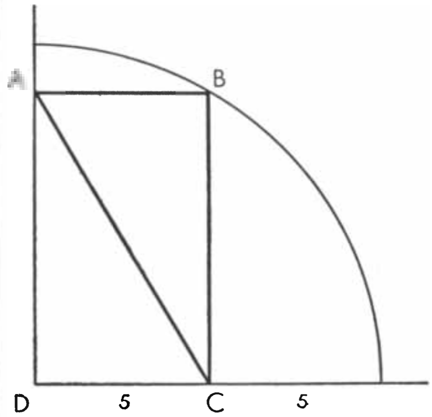
An electrician is faced with this annoying dilemma. In the basement of a three-story house he finds bunched together in a hole in the wall the exposed ends of 11 wires, all alike. In a hole in the wall on the top floor he finds the other ends of the same 11 wires, but he has no way of knowing which end above belongs to which end below. His problem: to match the ends.

To accomplish his task he can do two things: (1) short-circuit the wires at either spot by twisting ends together in any manner he wishes; (2) test for a





Puzzle 1



Puzzle 3

closed circuit by means of a "continuity tester" consisting of a battery and a bell. The bell rings when the instrument is applied to two ends of a continuous, unbroken circuit.

Not wishing to exhaust himself by needless stair-climbing, and having a passionate interest in operations research, the electrician sat down with pencil and paper and soon devised the most efficient possible method of labeling the wires.

What was his method?

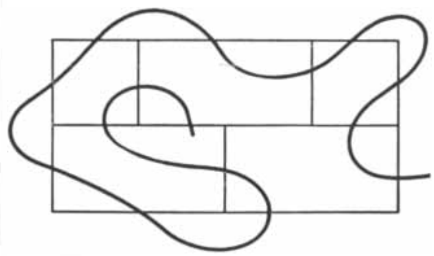
5.

One of the oldest of topological puzzles, familiar to many a schoolboy, consists of drawing a continuous line across the closed network shown at the bottom of this page so that the line crosses each of the 16 segments of the network only once. The curved line shown here does not solve the puzzle because it leaves one segment uncrossed.

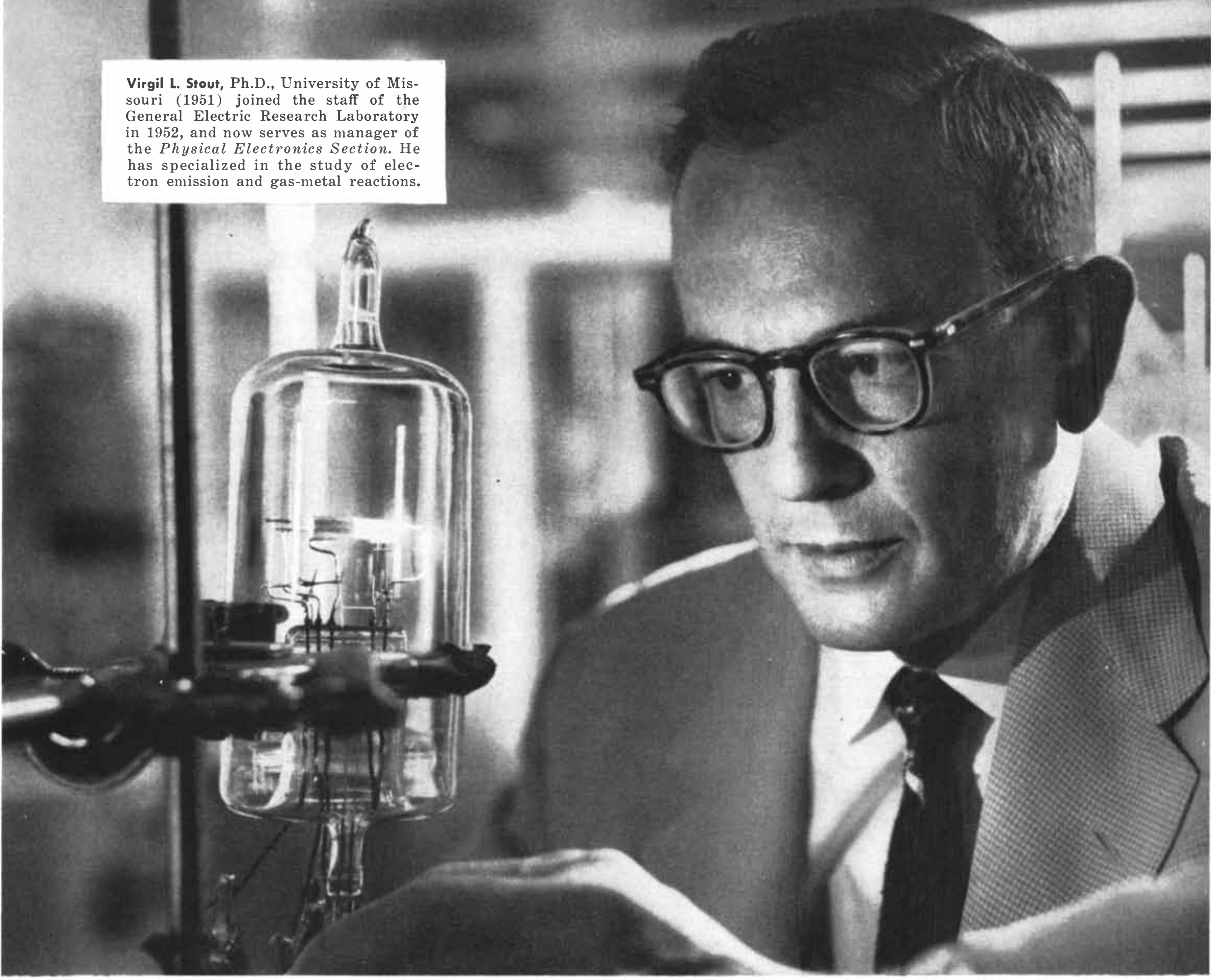
It is not difficult to prove that the puzzle cannot be solved on a plane surface. Two questions: Can it be solved on the surface of a sphere? On the surface of a torus (doughnut)?

6.

Assuming that a match is a unit of length, it is possible to place 12 matches



Puzzle 5



Virgil L. Stout, Ph.D., University of Missouri (1951) joined the staff of the General Electric Research Laboratory in 1952, and now serves as manager of the *Physical Electronics Section.* He has specialized in the study of electron emission and gas-metal reactions.

Reactions in vacuum

General Electric's Dr. Virgil L. Stout helps improve vacuum tubes by learning basic facts about cathodes and anodes

A key to basically better vacuum tubes is improved cathodes — surfaces that will emit more electrons with greater reliability. Several years ago at the General Electric Research Laboratory, experiments showed that cathodes using titanium as the base material had a very short life. In finding the fundamental reasons for the disadvantages of titanium in cathodes, Dr. Virgil L. Stout and his associates uncovered new knowledge explaining the metal's advantages as an electron collector.

Titanium, when used as an anode, was found to provide an unexpected bonus. In its reaction with barium oxide molecules, which evaporate from the cathode, titanium not only absorbs the unwanted oxygen but also lets the barium return to where it started, thus maintaining the cathode's efficiency.

Dr. Stout's basic scientific contributions have helped his associates develop many electronic devices — among them a family of extremely small and efficient titanium-ceramic vacuum tubes that can operate at red heat and radar frequencies.

At General Electric, such research is motivated by a belief that providing scientists with the tools, the incentives, and the freedom to seek out new knowledge is the first step toward progress for everyone.

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on a plane in various ways to form polygons with integral areas. On this page are two such polygons: a square with an area of nine square units, and a cross with an area of five.

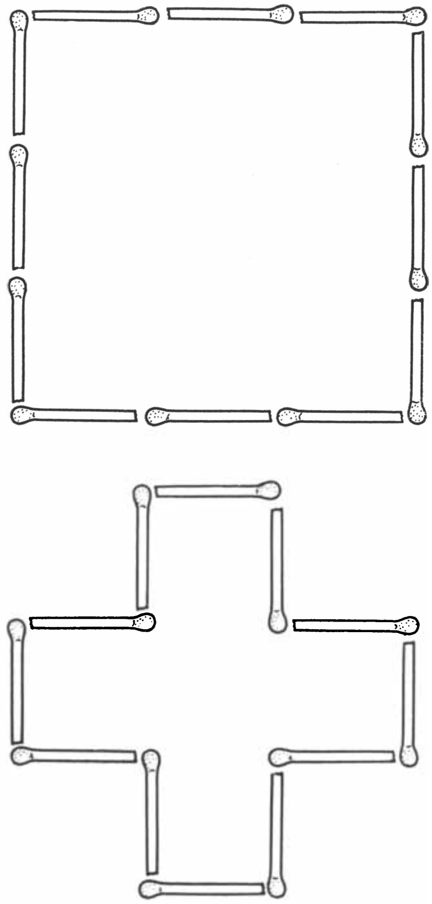
The problem is this: Use all 12 matches (the entire length of each match must be used) to form in similar fashion the perimeter of a polygon with an area of exactly four square units.

7.

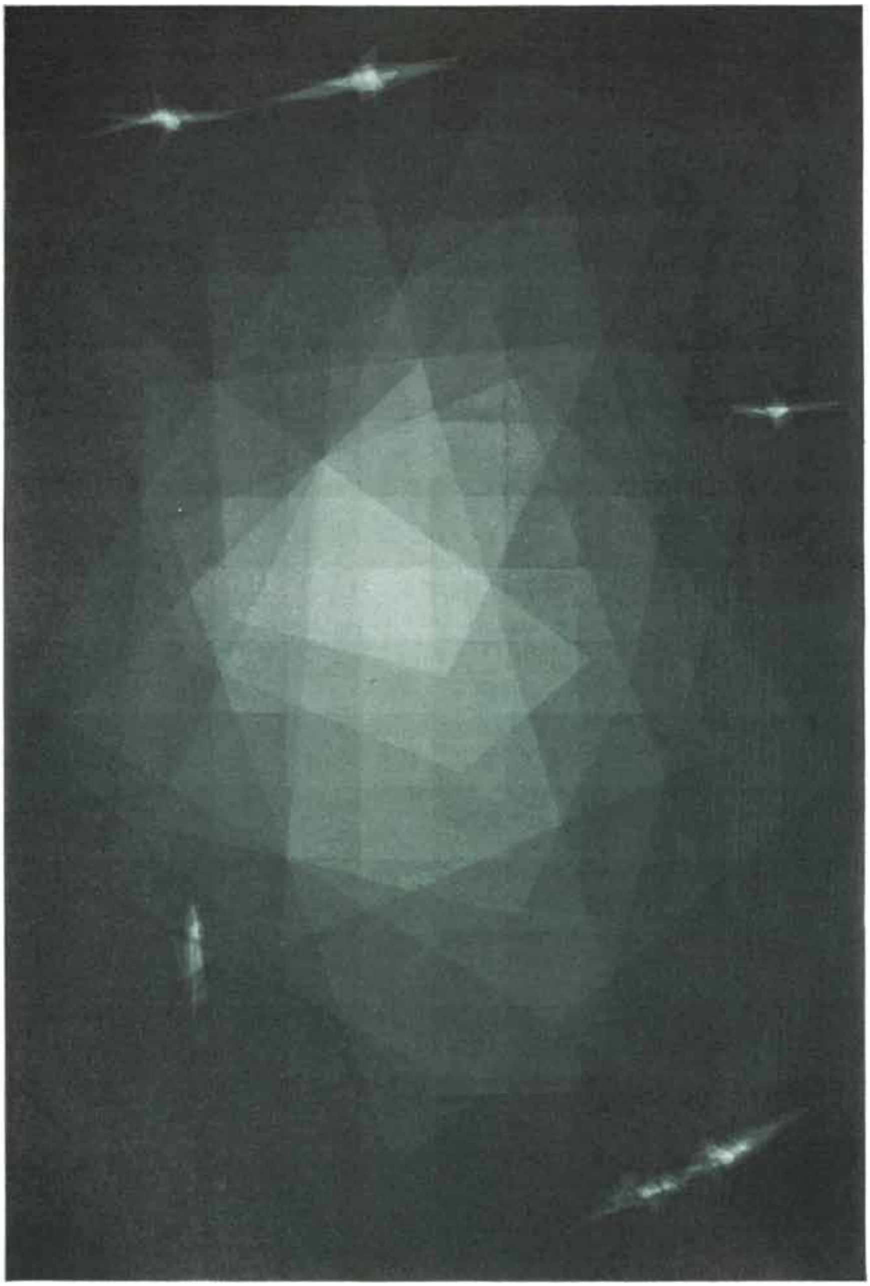
This incredible problem—incredible because it seems to lack sufficient data for a solution—appeared in a recent issue of *The Graham Dial*, a publication of Graham Transmissions Inc. A cylindrical hole six inches long has been drilled straight through the center of a solid ivory sphere. What is the volume of ivory remaining in the sphere?

8.

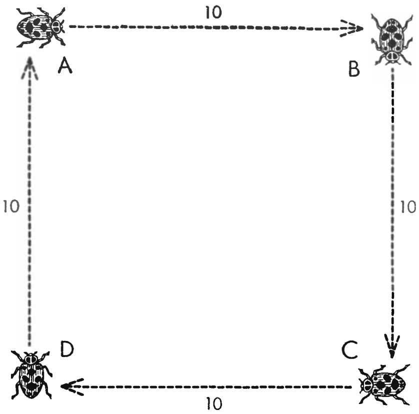
Four bugs—A, B, C and D—occupy the corners of a square 10 inches on a side. A and C are male, B and D are female. Simultaneously A crawls directly toward B, B toward C, C toward D



Puzzle 6



"FORCES OF NATURE," another in a collection of paintings by Simpson-Middleman, two talented artists who find in the natural sciences the subject matter for their contemporary expressions. Courtesy John Heller Gallery, Inc.



Puzzle 8

and D toward A. If all four bugs crawl at the same constant rate, they will describe four congruent logarithmic spirals which meet at the center of the square.

How far does each bug travel before they meet? The problem can be solved without calculus.

9.

"I hear some youngsters playing in the back yard," said Jones, a graduate student in mathematics. "Are they all yours?"

"Heavens no," exclaimed Professor Smith, the eminent number theorist. "My children are playing with friends from three other families in the neighborhood, although our family happens to be largest. The Browns have a smaller number of children, the Greens have a still smaller number, and the Blacks the smallest of all."

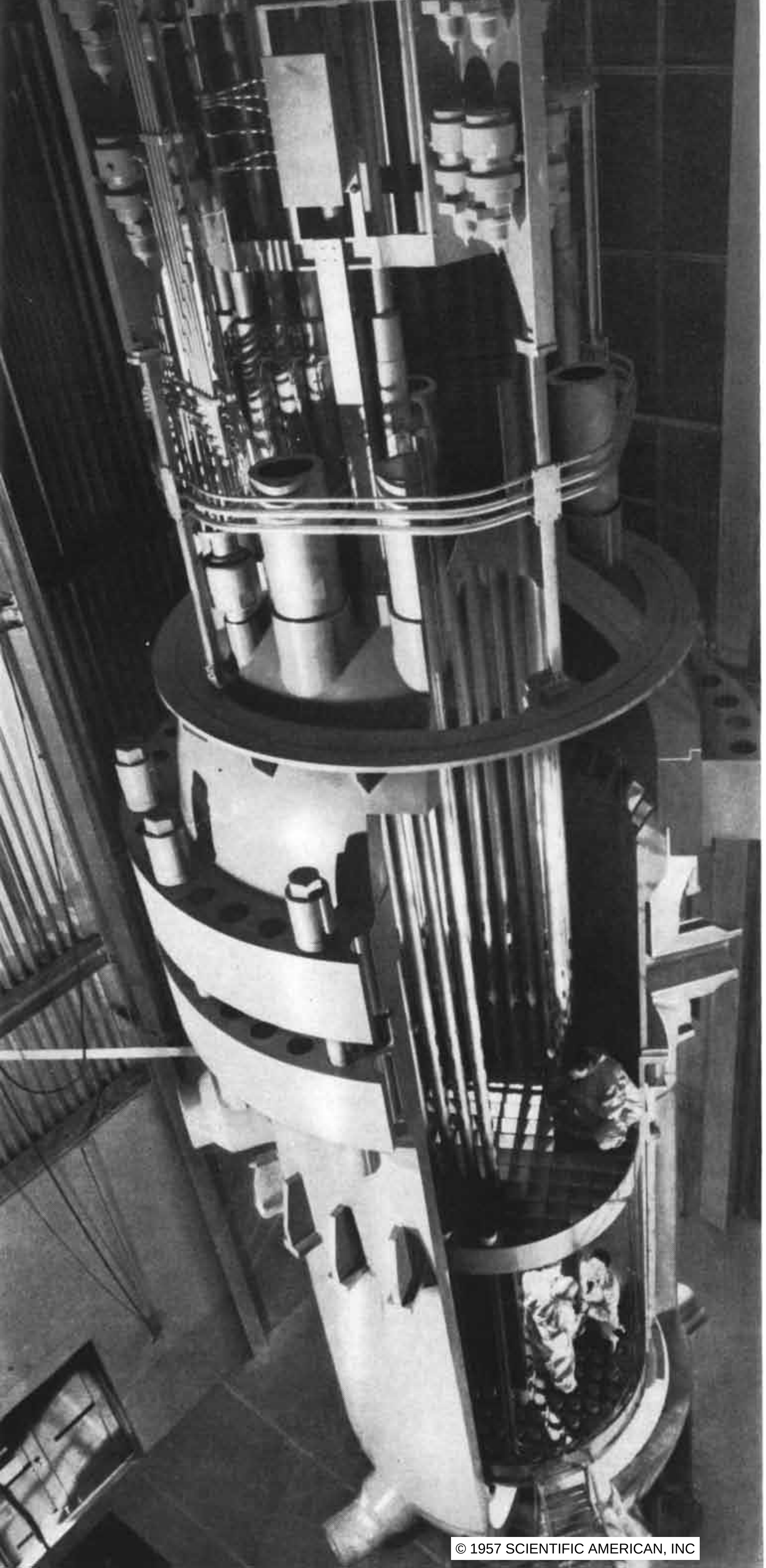
"How many children are there altogether?" asked Jones.

"Let me put it this way," said Smith. "There are fewer than 18 children, and the product of the numbers in the four families happens to be my house number which you saw when you arrived."

Jones took a notebook and pencil from his pocket and started scribbling. A moment later he looked up and said, "I need more information. Is there more than one child in the Black family?"

As soon as Smith replied, Jones smiled rather smugly and correctly stated the number of children in each family.

Knowing the house number and whether the Blacks had more than one child, Jones found the problem trivial. It is a remarkable fact, however, that the number of children in each family can be determined solely on the basis of the information given above! The problem was originated by Lester R. Ford, former head of the mathematics department at the Illinois Institute of Technology.



Designing reactor for nation's first full-scale nuclear power station

This mockup of the pressurized water reactor for the nation's first full-scale civilian nuclear power station, being built at Shippingport, Pa., rises four stories tall at Bettis Atomic Power Division. The full-size model is shown when it was under construction. The Shippingport Atomic Power Station is being built as a joint venture of the United States Atomic Energy Commission and the Duquesne Light Company. Westinghouse is developing the nuclear components under a contract with the AEC. Duquesne Light Company will operate the station.

Design of the Shippingport reactor is just one of the challenging nuclear projects at Bettis, one of the leaders in the growing atomic power industry. We welcome inquiries from physicists, mathematicians, and engineers interested in a rewarding career in this new industry. Please address your résumé to:

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THE AMATEUR SCIENTIST

How to make extremely energetic sparks for high-speed photography and other purposes

by C. L. Stong

Few encounters with nature leave the observer more profoundly impressed than a close brush with lightning. Those who escape from the experience with a whole skin never forget the blinding flash, fearful concussion and accompanying odor of "brimstone." The power of nature's big spark to rip trees and other objects apart has long intrigued experimenters. Yet relatively few have undertaken even a small-scale study of the instantaneous discharge of electricity through gas at atmospheric and higher pressures. This is difficult to explain in view of the success which followed the study of comparable discharges through gases at low pressure. Among other accomplishments, this latter work opened the field of electronics. A host of volumes record this work. In contrast, the word spark appears in the index of only about one physics text in four, and these usually dismiss the subject with a few paragraphs on the venerable Rhumkorff coil. Thus far only two noteworthy applications have been found for the spark. Pioneers of the wireless telegraph used it as an automatic switch in the so-called spark transmitter, and modern engineers find it a handy means for igniting gasoline in engines and cigar lighters.

We may soon hear more about sparks, if the work of two engineers at the University of Michigan lives up to its promise. H. C. Early, research engineer, and E. A. Martin, professor of electrical engineering, have been looking into the nature and applications of high-energy sparks under the sponsorship of the U. S. Army Office of Ordnance Research. They have succeeded in concentrating about half the peak current of a major lightning stroke into a hair-thin path a half-inch long that offers appreciable electrical resistance to the discharge. The results should fascinate amateurs who like sound and fury in their experiments. The sparks made by Early and Martin punch holes through metal plates, emit light which pales the sun and, in one proposed application, emboss paper with printed characters at speeds impressively higher than those of any process now in use. Numerous other applications are implied. Apart from its potential uses, the high-energy spark turns out to be a simple and relatively inexpensive device for investigating the behavior of matter under extremes of temperature and pressure that should open a whole new field of interest to amateurs.

Little energy is represented in ordinary sparks such as those developed across the electrodes of induction coils or capacitors charged to high voltage: the resistance of air normally drops so low during the discharge that the spark gap acts as little more than a short-circuit. The electrical power which appears in any load, according to Ohm's law, is equal to the square of the current multiplied by the resistance of the load. Hence the problem of developing a high-energy spark cannot be solved effectively by the brute-force method of merely substituting sources of higher voltage and current. Attempts to deliver more power to a load which takes the form of a short-circuit simply end in more power being dissipated by the associated apparatus and wiring. The solution of the problem of creating energetic sparks lies in increasing the resistance of the gap.

Early and Martin have devised two ingenious ways of doing this. In their first arrangement the gap is immersed in water, the spark being initiated through a fine wire which literally explodes when power is applied. The power source is designed for a rate of rise in current of tens of thousands of amperes per microsecond. Accordingly, an instant after the switch is closed the spark gap is transformed into a column of plasma expanding against water, the inertia of which causes a build-up in pressure on the order of 10,000 atmospheres. In the second method recessed electrodes are sandwiched between two sheets of insulating material. This forces the spark into the form of a wide, restrained ribbon under high pressure. In each arrangement the electrical resistance of the path increases with pressure. The source of power is a capacitor charged to high voltage by a transformer-and-rectifier combination identical in principle with those found in radio receiving sets.

Most of the underwater experiments have been made with the capacitor charged to 25,000 volts. Measurements show that at this initial potential the spark absorbs some 400 million watts from the capacitor. The current reaches a peak value of 85,000 amperes. For a few microseconds the radiated energy, much of it within the visible portion of the spectrum, equals that of a black body heated to a temperature of 54,000 degrees Fahrenheit, some six times hotter than the surface of the sun. The resulting shock wave propagated through the water is capable of exerting pressures up to 70 tons per square inch.

Amateurs should not find the construction of the apparatus difficult. The circuit for underwater discharges assembled by Early and Martin employs five General Electric Pyranol capacitors connected in parallel for a total capacity of 5.8 microfarads. These units are relatively costly if purchased new, but some are available on the surplus market. It is also possible to build a capacitor by stacking sheets of aluminum foil between sheets of insulating material such as Mylar film, alternate sheets of foil being connected to common leads. The unit is then potted in a wooden tank filled with transformer oil.

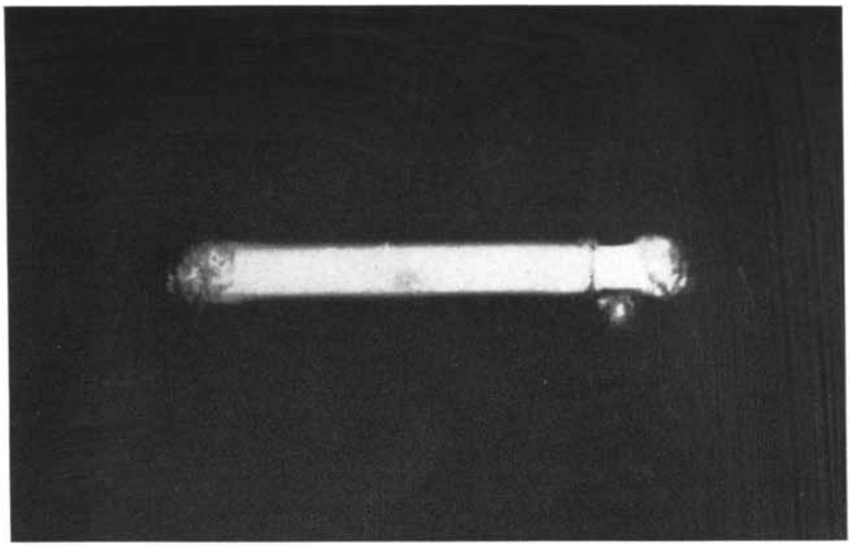
A number of 25,000-volt transformers from the early days of amateur radio are still around; one of these will provide the necessary voltage. If one cannot be located, pay a visit to the local power company. Pole transformers used on 13,000-volt transmission lines are occasionally discarded. Some are of the three-phase type, and can easily be converted to step 110 volts up to 26,000 volts. Ignition transformers used in home oil-burners, or a neon-light transformer with the magnetic shunt removed, may also be employed. When they are connected in a voltage-doubling circuit, these make an inexpensive voltage source.

Either of two types of rectifiers may be used. Vacuum-tube rectifiers designed for high-voltage applications are manufactured by the Westinghouse Electric Corporation. They are known as Kenotron diodes and are capable of handling high power. Another suitable rectifier is the Radio Corporation of America 5825 tube, which has an inverse peak-voltage rating of 60,000 volts and is relatively small and inexpensive. The RCA 1B3-GT8016, with an inverse peak rating of 30,000 volts, is also small and inexpensive.

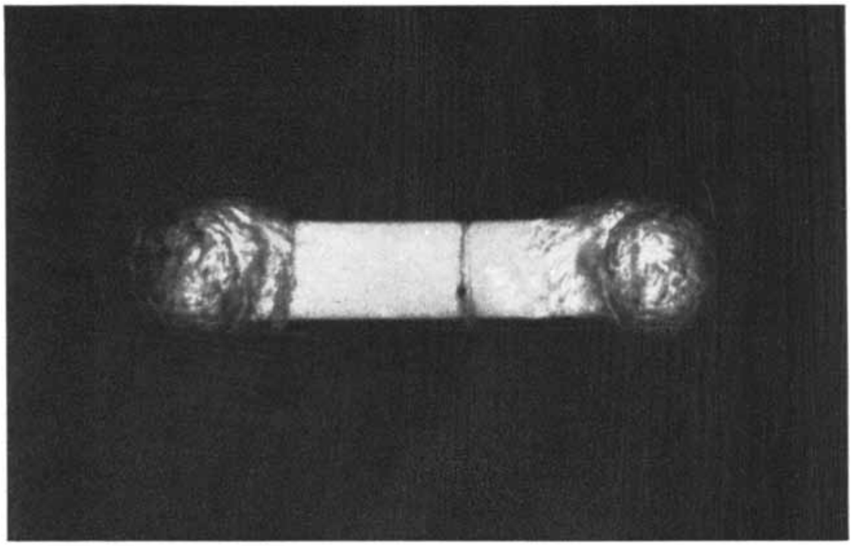
The high current-handling ability of Kenotron tubes permits the capacitors to be charged quickly, a convenience but not a necessity. The tubes are costly, and require relatively large, expensive transformers. The current available from voltage-doubling circuits employing the RCA types is small. When they are used, precautions must be taken to avoid corona leakage encouraged by sharp edges and corners on the high-voltage conductors, or the charge will leak off through the air as fast as it is delivered by the power supply.

The entire power supply, including the rectifier, must be housed in a well-shielded cabinet, not only to prevent stray radiation, which is capable of creating radio interference, but also as a safety measure. The voltages are lethal. All doors to the cabinet should be fitted with interlock switches for breaking the line voltage automatically and short-circuiting the capacitors with a copper bar when the doors are opened. A manually operated switch for closing the circuit between the capacitor and spark gap should be mounted inside the cabinet. A type of switch suitable for the purpose uses two metal spheres about an inch in diameter, one of which is movable. The arrangement may be thought of as a knife-switch with spheres substituting for the conventional switch blades. The spheres reduce corona discharge. The device is operated by means of a long pull-cord of Fiberglas. When the movable sphere is moved close to the stationary one, a spark jumps and initiates the discharge.

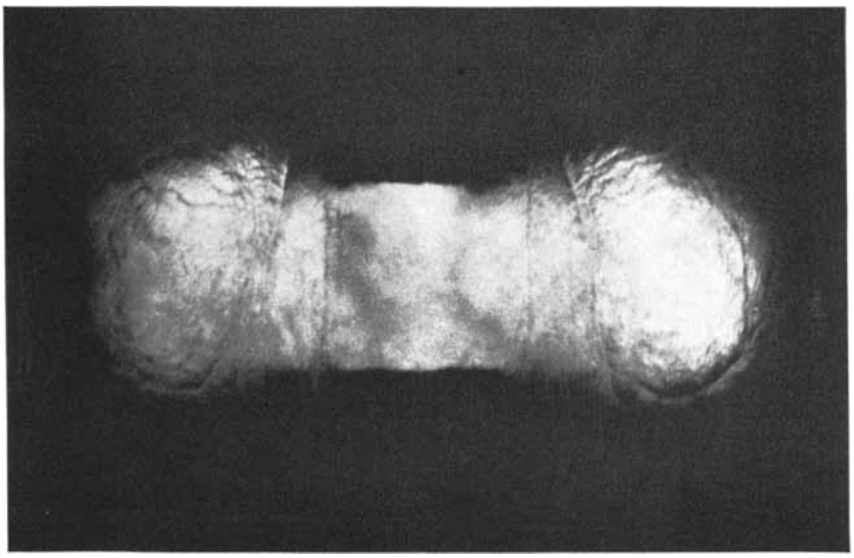
Because of the intense pressure wave



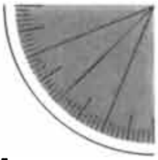
Kerr-cell photograph of an underwater spark one microsecond after initiation of discharge

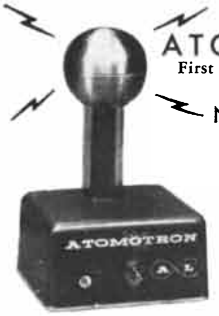


The same spark four microseconds after initiation of discharge



The spark 12 microseconds after initiation of discharge



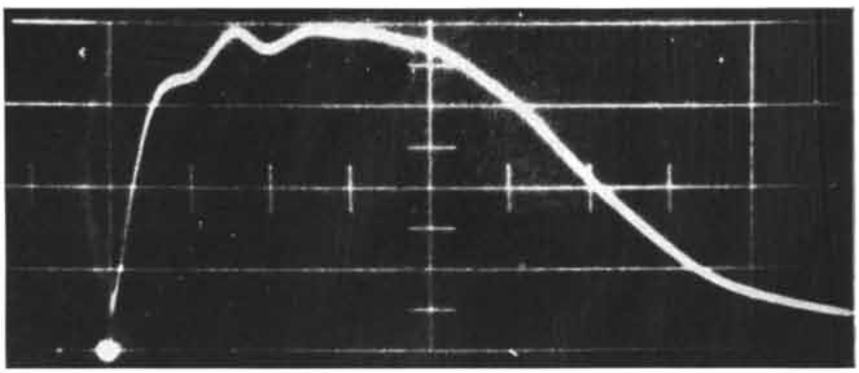


generated by the underwater spark, the gap assembly is housed in a two-gallon welded steel tank with 3/32-inch walls. The tank is fitted with a splash-proof cover, as shown in Roger Hayward's drawing on page 156. Leads for the underwater portion of the circuit may be made of RG-8-U coaxial cable, which is stocked by most dealers in amateur radio supplies. The outer conductor of braided wire is stripped off. The spark is observed through a Plexiglas window of convenient size set in rubber gaskets in the front wall of the tank.

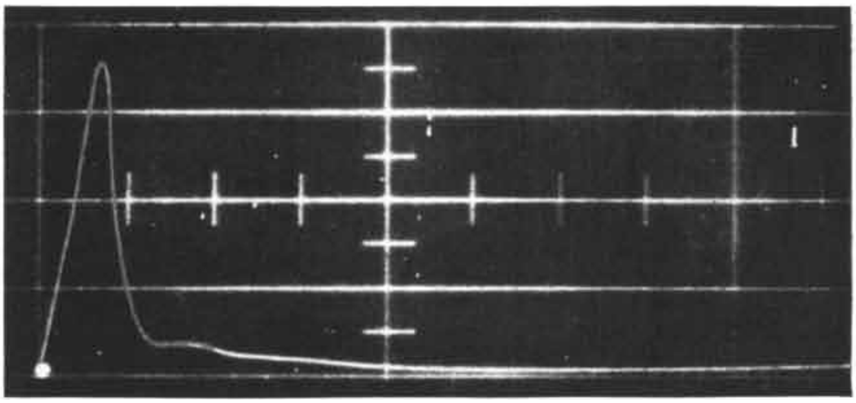
A serviceable gap may be formed by cutting back the insulation of the coaxial cable to expose an eighth of an inch or so of the central conductor, and bending the ends of the cables toward one another. The cables are stiff enough to retain their position prior to the discharge, so the gap need not be supported on an insulating column. Early and Martin found it desirable, however, to control the position and shape of the spark by connecting a wire of .001 inch diameter between the electrodes. This "initiating" wire prevents the spark from taking an erratic path and hence permits experimental results to be reproduced closely. The tank may be filled with tap water.

Short leads of strap copper about an inch wide should be used between the capacitor and the underwater portion of the circuit. They may be cut from copper flashing or other thin sheet. By minimizing self-inductance, leads of this shape permit the current to discharge at maximum rate.

The high-energy spark is an excellent light source for high-speed photography. Radiation from the underwater discharge persists for about 30 microseconds. Even if the window of the tank is masked to pinhole size, the minute though brilliant flash will blacken a sheet of Super XX film at a distance of 50 feet! The exposure interval may be shortened to a microsecond or less by means of a "shatter shutter" devised by Early and Martin. This essentially consists of a thin sheet of glass painted black and supported within a few thousandths of an inch of the initiating wire. The opposite side of the wire is backed by a block of porcelain, as shown in the drawing on page 152. Light is transmitted through a slit or pinhole scraped in the paint. When the assembly is placed in the tank, care must be taken to assure that no bubbles remain between the glass and block. Within about a twentieth of a microsecond following the explosion of the initiating wire, the shock wave starts shattering the glass into very



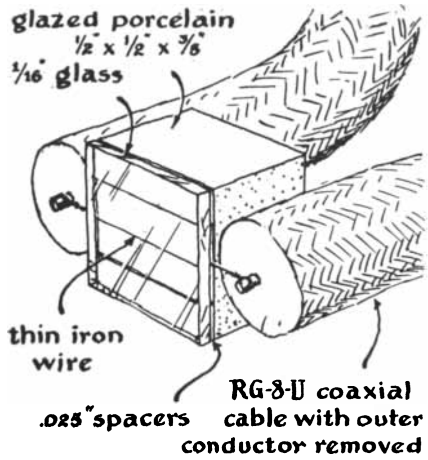
Oscillogram of light from underwater spark (four microseconds per horizontal division)



Oscillogram of light from underwater spark limited by "shatter shutter"

fine particles. The glass is transformed into a translucent body which scatters the light within the block until repeated reflections with the block walls absorb it. The shatter shutter is attractive for applications where high intrinsic brilliance and ultra-short exposures are desired, as is often the case in schlieren and shadowgraph systems. Oscillograms of light pulses emitted by the spark, both with and without the shatter shutter, are reproduced on page 150. The sweep speed (horizontal scale) in both oscillograms is four microseconds per division. The oscillograms were made by feeding the output of a photoelectric cell into a cathode-ray oscilloscope, the sweep along the time axis being triggered by a pulse from the high-voltage circuit. Some idea of the intensity of the light source can be gained from the shadowgraph of the compass tips on page 158. The exposure, limited to two microseconds by a shatter shutter, was made on Super XX film. In this experiment the size of the source was limited to a pinhole aperture measuring 1/16 inch in diameter, yet more light was transmitted than required for proper exposure. The spark was located 29 feet from the film and the compass was supported at a distance of 18 inches in front of the film. Although no lens was used, the knurling on the heads of the clamping screws was recorded clearly.

Another accessory which not only enhances the spark's versatility as a light source but enables the experimenter to investigate some of the microsecond events associated with the growth and decay of the discharge is the Kerr cell. This device, invented in the last century by the Scottish physicist John Kerr, is based on the property of some transparent substances, such as nitrobenzene, to alter the polarization of transmitted light when subjected to a strong electrical field. The cell essentially consists of a pair of electrodes, resembling the plates of an air capacitor, spaced a few millimeters apart and immersed in nitrobenzene contained in a liquid-tight cell fitted with windows on opposite sides. A filter of high-extinction Polaroid film is mounted in front of each window, one filter fixed rigidly and the other arranged so that it can be rotated about the optical axis of the cell. A beam of light is polarized by the first filter and proceeds to the second, where it is absorbed if the plane of the second filter's polarization is crossed with respect to the first. If a pulse of voltage is now impressed on the electrodes, the optical property of the nitrobenzene is altered so that the plane



Details of shatter shutter

of the beam's polarization is rotated to correspond with that of the second filter. Accordingly the device, normally opaque, becomes transparent whenever a voltage pulse of proper magnitude is applied to its electrodes. Thus the Kerr cell is a high-speed shutter, one capable of opening and closing in a small fraction of a microsecond. Combined with the underwater spark and a schlieren optical system, the Kerr cell makes it possible to shoot knife-sharp pictures of high-velocity events such as the passage of a rifle bullet. Clear pictures of the spark channel at any stage of development can also be made with the Kerr cell. The size of the channel, its rate of growth, the relative intensity of the radiation and other characteristics of the spark may thus be investigated in considerable detail. A series of pictures made by Early and Martin of typical spark-channel growth appears on page 149.

In constructing the Kerr cell it is desirable to restrict the light so that the full beam passes between the electrodes. This can be accomplished by mounting a pair of apertures just beyond each filter. It is well to remember that nitrobenzene, although the best liquid for most Kerr-cell experiments, is highly volatile, poisonous, inflammable and a wonderful solvent for the cements one would most like to use in putting the glass parts of the cell together. The cell is triggered by a 7,000-volt direct-current pulse which may be derived from any of the conventional pulse-generator circuits. A number are described in *Electronics: Experimental Techniques* by William C. Elmore and Matthew Sands.

In addition to the energy radiated by the spark in the form of light, heat and ultraviolet rays, much is dissipated by the shock wave which develops during the early stages of the discharge. After

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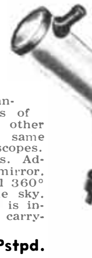

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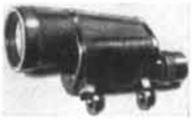

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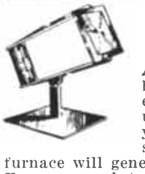

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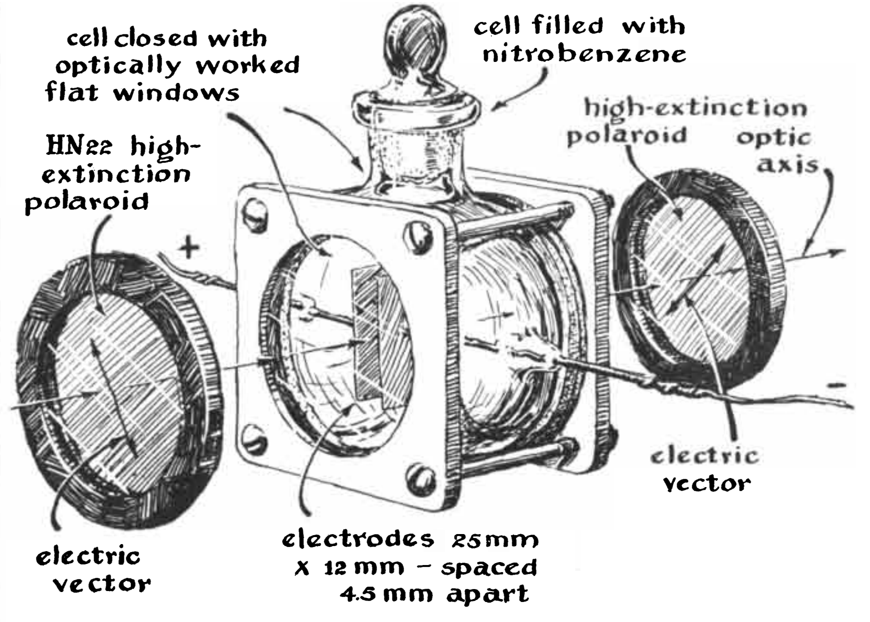


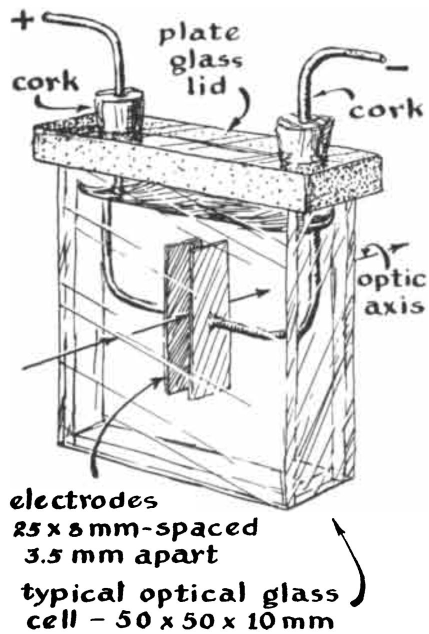
Details of Kerr cell

about five microseconds both the pressure and the electrical resistance of the channel drop appreciably, halting the absorption of energy from the capacitor. Even so the shock wave packs enough wallop in the form of mechanical energy to suggest a number of interesting experiments. In one Early and Martin filled a small, thick-walled pressure vessel with polluted swamp water containing a variety of microorganisms. The water was subjected to a single discharge to learn whether the steep-front pressure wave could sterilize the water. Subsequent microscopic examination failed to show a trace of living organisms. Later, however, it was determined by means of culture techniques that some spores survived and were capable of growth.

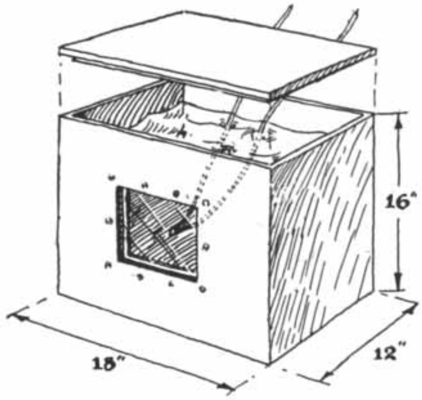
The underwater spark's capacity for doing mechanical work can be demonstrated by exploding an underwater spark about 3/8 inch from the bottom of a sheet-metal tank. If a perforated steel die is placed against the underside of the tank, a clean hole will be punched in the bottom of the tank. In one such experiment the metal slug was ejected with such force that it ricocheted off a block of metal and buried itself in a plank of wood.

Similar, though less intense, forces can be developed by sparks in air. The essential increase in the resistance of the spark channel is achieved by recessing a pair of wire electrodes in the face of a ceramic block and covering them with a second block. This confines the discharge to the thin space between the blocks, as shown in the drawing on page 160. If the surfaces are relatively flat, so that the film of air between them is on the order of a thousandth of an inch thick, the spark will be accompanied by a shock wave capable of blowing the top block 10 feet into the air. Impressive effects can be observed even when the spark is powered by a relatively small source. A .02-microfarad capacitor charged to 10,000 volts, for example, is sufficient to produce a shock wave in air with a peak pressure of 100 atmospheres.

One of many possible applications suggested for an "air gun" of this type



Details of optical-glass Kerr cell



Splashproof tank used for spark experiments

is that of high-speed printing. The paper to be printed is placed on top of the block containing the recessed electrodes and covered with a die or stencil of the character to be printed. The shock wave punches a clean replica of the stencil out of the paper. Raised characters can similarly be embossed in paper if an engraving is substituted for the stencil die. The embossed paper may be passed under an inked roller which coats the tops of the raised characters and thus improves their legibility. Sufficient energy for embossing 100-pound, highly calendered paper can be derived from a .01-microfarad capacitor charged to 8,000 volts, corresponding to about .3 watt-seconds.

Early and Martin devised a simple experiment for investigating the upper speed-limit of the embossing process. A paper disk is clamped in a sanding flange and chucked into a variable-speed drill-press. The rim of the paper runs between the face of the recessed block containing the electrodes and that of the die. The gap is fired after the disk has reached a predetermined speed. At a rim speed of 150 feet per second, Early and Martin found that the printed character, whether embossed by a die or punched from a stencil, was sharp and clean. At 260 feet per second perceptible blurring occurred, but the printing was still legible. Assuming characters of the size commonly used in typewriters, this corresponds to a printing rate of 374,400 words per minute! A practical machine based on the principle would necessarily reproduce text at a much lower rate, of course, because time would be consumed in moving the various dies into position. This could be accomplished by engraving the alphabet and other characters on the rim of a thick disk, somewhat as in the conventional stock ticker. The desired character would be printed by firing the gap at the appropriate instant.

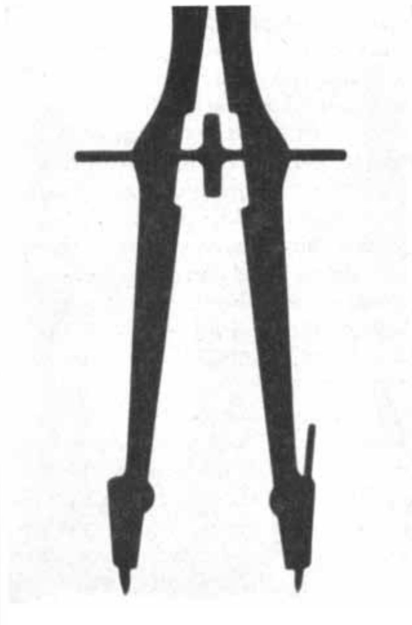
Aside from its interest as a printing mechanism, an apparatus for embossing paper by this method also affords a means for investigating certain properties of the shock wave. The gas pressure generated by the spark can be determined roughly by an analysis of the shape of the embossed character and the time required to make the impression. From the known speed of the Martin-Early spinning disk, for example, the rim velocity was calculated to be .007 centimeters per microsecond. The travel of the paper during the embossing operation (as determined from the blurring) was approximately .0025 centimeter. The embossing time was therefore on the order of three microseconds. The punched part of the paper was displaced .02 centimeter in three microseconds. The mass of the paper, determined by weighing a sample, was .006 grams per square centimeter.

The acceleration of the paper is equal to twice the distance traveled, $2 \times .02$ centimeters, divided by the square of the time, $(3 \times 10^{-6})^2$ seconds, or about 4.5×10^9 centimeters per second per second. Force is defined as mass times acceleration. The force generated by the spark is therefore equal to the mass of the paper, 6×10^{-3} grams, multiplied by the acceleration, 4.5×10^9 centimeters per second per second, or 2.7×10^7 dynes per square centimeter. This is equivalent to about 27 atmospheres or 375 pounds per square inch.

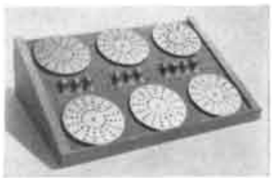
It has been proposed that the underwater spark could be used for measuring such properties as the elasticity of materials under high stress. If a small piece of wire screening is placed behind the underwater spark, for example, Kerr-cell photographs show a discontinuity in the screen's image caused by optical refraction at the cylindrical shock front. A prism of the material to be studied could be placed in the tank so that the difference in sonic velocity through the prism and through the water would show up in the photograph as an optical displacement of the image of the screening caused by refraction. The difference in displacement between the refracted and unrefracted shock front would give the angle of refraction. From this information the velocity of the shock wave through the material can be calculated. The square of the velocity, when multiplied by the density, gives the elasticity, the quantity desired, and suggests how the amateur may investigate numerous other physical properties of materials by means of shock-wave effects generated by sparks both in air and water.

Richard J. Blume of the Watson Scientific Computing Laboratory at Columbia University writes: Quartz-crystal clocks are a professional interest of mine, and I should therefore like to offer a comment on the article by W. W. Withrow, Jr., which appeared in "The Amateur Scientist" for September. Withrow has demonstrated that the construction of a quartz clock is within the means and capability of the amateur. The task can be made considerably easier, however, than the text leads one to suppose. Specifically, the article contains several terrifying references to the trickiness of multivibrator circuits, especially the one which is required to divide the 120-kilocycle signal by precisely 20 to produce the 6-kilocycle signal. Contrary to the impression created by the article, a multivibrator is a tame and dependable object—if it is not required to divide by too large a number. Twenty is too large. If the division by 20 were carried out in three successive steps of 2, 2 and 5 (by the substitution of three successive multivibrators for Withrow's one) the amateur would experience much less difficulty during the initial adjustment of the circuits and the long-term stability of the multivibrator chain would be vastly increased."

In commenting on the same article Robert Kruse, of the Robert Kruse Laboratory in Madison, Conn., writes: "It



Shadowgraph made by spark at 29 feet



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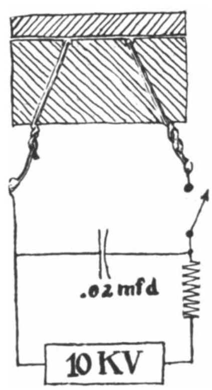
is only fair to warn those intending to duplicate Withrow's 60-cycle quartz clock that these devices do not attain their final stability for several months, during which time frequent adjustments may be necessary. The change in operating characteristics with age occurs partly in the tubes, partly in other components, and sometimes in the crystal itself. In one extreme case observed about 12 years ago a crystal bar drifted almost linearly for over a year. A happier choice of tubes might also have been recommended. Since replacement of a multivibrator tube may require readjustment of the resistors, it is desirable to use the 6SN7 tube rather than the 6SL7, the emission of which is somewhat limited for this service.

"Incidentally, multivibrators are rich in harmonics up to the 50th or higher. Accordingly a crystal clock may also be used as a source of stable frequencies, both radio and audio. These may be tapped from the multivibrator through a vacuum-tube amplifier, if the amplifier is not too tightly coupled to the source. A suitable amplifier for this service can be built around the 6J5 tube, being similar in circuitry to Withrow's preamplifiers. Such a system has been made commercially in highly refined form for about 20 years; with the aid of a thermostatically controlled enclosure for the crystal the daily variation of the frequency is about 1 part in 200 million. An even older application of the idea in a unit now in service at the University of Minnesota was used for some years in a factory where intermittent motor loads caused very bad line-voltage fluctuation. Yet we were able to keep the daily variation to 1 part in 5 million as judged by the beat-note of the 5-megacycle harmonic against the carrier frequency of WWV."



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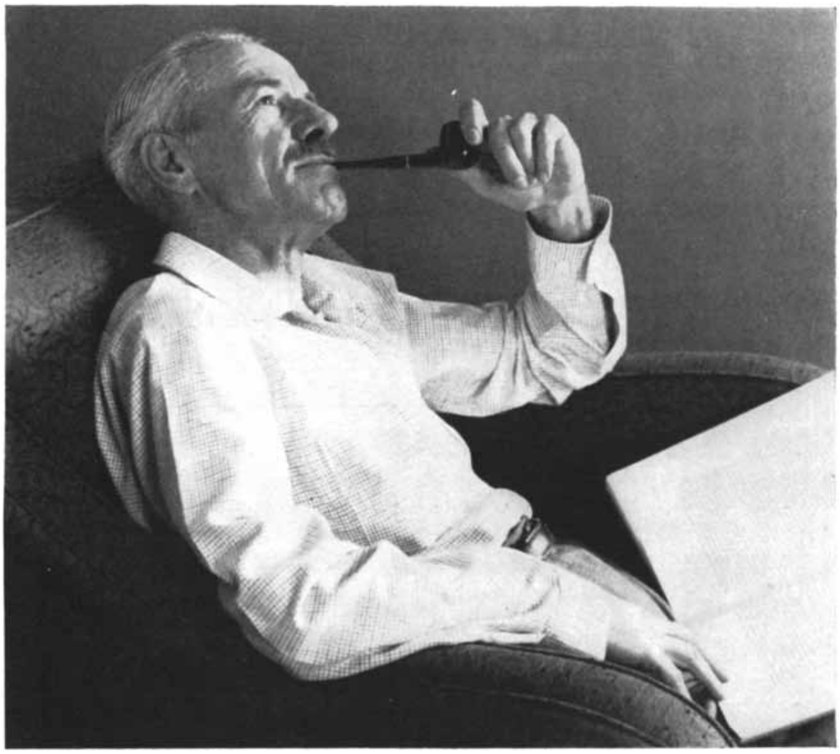

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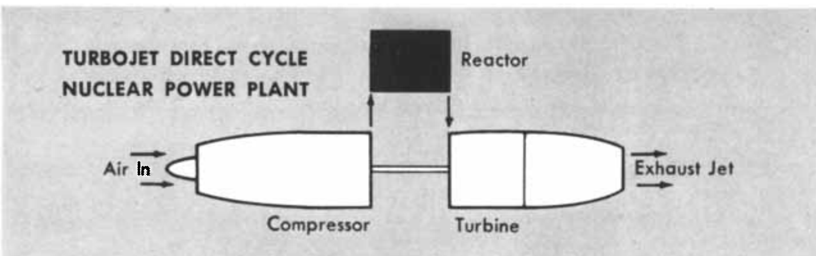

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A stimulating survey of education in the world of Greece and Rome

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A History of Education in Antiquity, by H. I. Marrou. Sheed and Ward ($7.50).

History, even more than science, must be remade periodically. Remade, not merely revised, because the past is not dead. The past is gone; in this sense it is beyond our power and need not concern us. But the past is apt to deceive us. The historical record is sparse, and it becomes even sparser as we go backward in time. Many classical writings have disappeared. Our knowledge of antiquity is grossly imperfect and intertwined with legends and fables. To know the past better, to improve the understanding of our origins, does not lie beyond our power. It is in this light that one recognizes H. I. Marrou's work, a history of education from Homer to the collapse of the Roman Empire, to be a memorable achievement. Professor Marrou, a distinguished scholar of the Sorbonne, has opened a window on the ancient world; the view it affords is refreshing and enlarging.

Everything of importance in our own civilization, says Marrou, we owe to the Greco-Latins, and this is truest of our system of education. Even the 20th century, which puffs its wares and asserts priorities, would concede that there is abundant evidence to support this claim. Many scholarly works have been written on the subject, but the new findings are so numerous and so specialized that the time has come for a filling of gaps and a synthesis. Marrou offers this fresh perspective.

The account begins with Homer, from whom the Greek cultural tradition "rises in an unbroken line." It was around the *Iliad* as a "central pivot" that the whole of Greek education was to be organized. This great book was an epic of the deeds of heroes, and for a long time it was sung or recited rather than read. Despite this special character it played a key role in the evolution of education in a "noble warrior" culture to that in a "scribe" culture. The record of the period which Marrou covers does not, as he remarks, "conform to the famous parabola shape"—ascent, high point and inevitable decline—"so dear to antiquity." It is true that from the tenth to the fourth century B.C. the curve ascended. This was the period of genius culminating in the Golden Age—the "great creative epoch" of Hellenic civilization during which lived most of the poets, playwrights, historians and philosophers whose names are synonymous with Greek culture. But classical education "did not attain its distinctive form" until after this epoch. And once this maturity had been attained, the definitive forms, curricula and methods which made up the system lasted for many centuries. It ruled the Hellenistic era, and "the infusion of new blood from Rome gave it a fresh lease of life." In short, the educational curve stayed on a high plateau, at one point splitting into two branches, one "going on indefinitely in the Byzantine East," the other existing in the Latin countries until the barbarian invasions cut it off.

The first section of Marrou's book considers the knightly culture of Homeric times and Spartan education. Sparta was not always, as the conventional notion has it, "a harsh, barbarous city petrified in an attitude of morose distrust." In archaic times it was "a great cultural center open to strangers, to the arts, to beauty, to everything it would later pretend to reject." Until the fifth century B.C. it was Athens's predecessor as the center of Hellenic civilization. But about 550 B.C., after a political and social revolution in which the aristocrats reasserted themselves, Sparta's development "came to an abrupt halt." The intellectual side of education was reduced to a minimum; absolute patriotism was exalted; the welfare of the state was the supreme consideration. The state took charge of all children. Those born sickly and deformed were thrown into the *Apothetes*, the dung-pit; a healthy child became the property of the state at age seven. At 12 it was taken away from its family. Boys were taught discipline and obedience, how to bear arms, how to endure privation and pain, how to fight, how to be cruel and how to steal. Girls were less rigidly controlled, but their main function, as under fascism, was considered to be the production of babies, and every phase of their education was subordinated to this end. They "had to learn 'to put aside all delicacy and womanish tenderness' by hardening their bodies and appearing naked at feasts and ceremonies." The later Spartan ideal, which has been so much admired, was "the ideal of a barrack-room sergeant-major"—the kind of thing which is today glorified at Parris Island.

"I must now speak of pederasty, for it affects education," wrote Xenophon. In an excellent chapter Marrou discusses this important subject, which historians have usually distorted or treated with "excessive circumspection." Greek homosexuality was of a military type, in essence "a comradeship of warriors." The older man desired to stand out in the eyes of his beloved as a hero; the younger, to show himself worthy. There was established a "closed masculine community," in which the older men were fatherly teachers in constant, close personal association with the younger men. Later, as a different type of education arose, as the aristocracy declined and the literary supplanted the military culture, the love relationship persisted but in a somewhat different guise: the fervent and often passionate attachment of disciple to master. Socrates attracted "the flower of Athenian youth and bound them to him with the ties of amorous passion." Plato, Xenocrates, Aristotle, Euripides and Eudoxus were among the famous lovers of antiquity. Sexual acts played a part in many of these relationships, but this was not the heart of the matter. The love of the master for the pupil involved, as Socrates said, the very opposite of sensual desire—an aspiration toward perfection, an ideal of excellence. For the adolescent member of the part-

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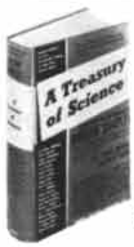

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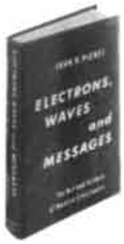

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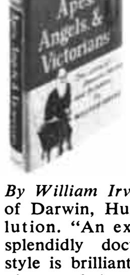

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nership to be loved by a leader of thought was presumably an inspiration to learning.

Marrou passes from this topic to the early Athenian education, with its de-emphasis of military elements and its gradual democratization of the aristocratic tradition; to the birth of the school as an institution; to the founding of the first schools of medicine and of philosophy; to the pedagogical revolution effected by the Sophists; to the origins and early economics of the teaching profession. (Protagoras charged 10,000 drachmas for tutoring a pupil for three or four years, but prices soon fell and within a short time Isocrates was lamenting the fact that "blacklegs" were ready to carry on the business at a bargain rate of 300 or 400 drachmas.) The final chapters of this section on the pre-Hellenistic period consider the two master educators of the classical tradition: Plato and Isocrates. Plato held out the philosophers' pursuit of inner perfection as the aim of education; Isocrates advocated the more practical preparation of young people for life, particularly political life. Plato sought the attainment of quiet, solitary wisdom. The philosopher, he said, must renounce practical ambition and "turn to the city he bears within himself." Isocrates sought to foster in his disciples the "ability to make decisions, an intuitive grasp of the complexity of human affairs, and a perception of all the imponderable factors which help to direct one's 'opinion' and make it a just one." These were the rival streams which flowed together and produced the classical tradition in education. In some respects the two schools of thought were in opposition and conflict; in many respects they strengthened each other and enriched the system which followed.

And now Marrou reaches what he calls the very heart of his subject. In a dozen brilliant chapters he paints a picture of education in the Hellenistic age. We may think of this period as beginning in the generation following Aristotle and Alexander the Great—say about 300 B.C. The conquests of Alexander had immensely enlarged the area dominated by Hellenism. The eastern frontier of this area was extended 2,000 miles from the Aegean to the Syr Darya and the Indus rivers. Egypt and Persia lay open. The Greeks settled in the villages of Fayum, in Babylon, in far-off Susiana. Wherever they settled they set up their primary schools and gymnasiums. There was not only an abrupt change of scale, from a handful of cities and islands to vast empires, but also an abrupt cultural transformation within the Greek federation itself. The "traditional framework of the ancient city broke up, or at least retreated into the background." The monarchical state, it is true, was too divided, too riven by wars and dynastic ambition to take the city's place as the "supreme norm of thought and culture." It had "none of the moral authority required for imposing any fundamental discipline of the kind that gives a meaning to life and the world in which man lives." This complex of circumstances opened the way for a re-evaluation of the individual. No longer bound by "the corporate conditioning and totalitarian pressure of city life," and held only loosely by the state, Hellenistic man began to think himself a citizen of the world. The ideal he envisaged is perfectly described by the word humanism, understood in its pristine, uncorrupted sense. For each man the basic task was, in the old phrase, the modeling of his own statue. He saw himself as the center and measure of all things. He regarded the cultivation of his capacities, the fulfillment of his needs, the assertion of his rights, the fullest development of his personality, as the sole aim of human existence. This was the philosophy which animated education in the Hellenistic era. Education was conceived as something more than a technique for fitting a child to be a man; it was a lifelong dedication to the supreme values of culture and to self-realization.

Formal education in the Hellenistic age began when the pupil was seven and went on until he was about 20. Seven years or so were devoted to primary school; adolescence was passed in the gymnasium (*i.e.*, high school); the last year or two consisted of a course of civic and military training known as the ephebia. Generally speaking, education, especially at the higher levels, was subject to official control—that of the city or municipality, not the kingdom. In Hellenistic Egypt, whose policy was exceptional, all schools were privately run by associations—"perhaps," says Marrou, "of 'old boys.' " No municipal post was more exalted than that of "master of the gymnasium," or "gymnasiarch." He was chosen from the most influential and, above all, the most affluent of the citizens. His adjutant was a "hypo-gymnasiarch." The gymnasiarch, as the supreme authority, did not actually teach. This was left to an expert—the "pedotribe," or "cosmete," who had various assistants. There was also a committee of "controllers of wisdom," and, later, "sophronists," who were jointly responsible with the gymnasiarch for the administration of the ephebia.

Despite this elaborate official hierarchy, it was not usual for a city to take on the actual direction or upkeep of its educational establishments. Appeals were made to the generosity of private individuals to furnish the necessary financial backing. The reward for such support was to become known as a "benefactor," a title of great renown. A typical benefactor was a certain Polythrous, who, toward the end of the third century, gave his own city of Teos 34,000 drachmas, which was invested at about 11½ per cent and provided income to pay teachers' salaries. Often the gymnasiarch himself was expected to dig into his pocket to keep his school going. The first qualification for the job was, therefore, to be rich. Thus a woman, or even a baby, if it was the heir to a great fortune, could be a gymnasiarch. But the great majority of schools were neither philanthropically supported nor state endowed. They were run on a strictly commercial basis. Pupils paid fees and teachers collected what they could. Except for a few celebrated instructors this was not apt to be much.

What about the curriculum? To begin with, physical training, while no longer of primary concern, "remained an essential part of the process of initiation into civilized life." The pursuit of athletics was a characteristic that set the Greeks apart from other people. For example, if you had found yourself among the Jews in Jerusalem around 175 B.C., "you would have discovered that adopting 'the customs of the *goyim*' meant, chiefly, doing exercises in the nude on a sports-ground." From Marseille to Babylon to Egypt to the Crimea, in great cities and in tiny colonial villages, gymnasiums and stadiums appeared. In the Greek way of life the development of the body was connected not only with hygiene, but also with esthetics and ethics.

There was a good deal of professional sport, but there was no lack of amateur activity, and school sport was vigorously pushed. Athletics included various types of ball games, running, broad-jumping (in which a stone or bronze dumbbell was held in each hand), throwing the discus and the javelin, wrestling and boxing. Boxers wore hard leather gloves and aimed chiefly at the head. The best thing was not to get hit. A champion in the reign of the Roman Emperor Titus is remembered for being able to keep his guard up for two days and tire out his opponent without letting him land a single blow. There was also a violent event —pancratium—which combined boxing and wrestling and in which everything from kicks in the stomach to biting was allowed. (For some reason it was deemed improper to put your fingers in your opponent's eyes or nose or mouth.) It is a curious fact that the Greeks, though a seafaring people, did not go in for swimming sports. They knew how to swim—"'He can neither read nor swim' was a common way of describing a nitwit"—but they did not treat it as a sport. All sports were performed in the nude, but sometimes under the burning sun it was permitted to wear a little cap, which was made from dog-skin and tied by a lace under the chin.

The school itself was sometimes called a palestra, sometimes a gymnasium. Marrou describes as representative the lower gymnasium in Priene, which dates from the second century B.C. and has been completely excavated. It stood on a terrace surrounded by a high wall. The plant included a sports-ground and several two-story buildings. These housed a splendid marble-faced lecture hall, a common room, baths, a "coryceum" (the punching-bag room), an "elaeothesium" (where oil was stored), a "conisterium" (where sand and dust used for care of the skin were kept) and a massage room. There was a stadium, a spectators' enclosure and a covered track for practice in bad weather. And in the common room used by the ephebes one can still see hundreds of their scratchings on the wall: "This is so-and-so's place, son of so-and-so."

Slowly athletics lost the prestige and importance it had had in Greek education. Several factors, among them professionalism and specialization, contributed to this decline. But the main reason was the development of other "subjects," especially literature. By the time of the Christian era, physical education was dead. Few would complain that in our time—school sports notwithstanding—it has not been revived.

Drawing and music were a part of Greek education. The child learned to use charcoal and to paint on a board made of boxwood. Music was at first as important as gymnastics. The instruments essential to ancient music were the lyre and the oboe, but Aristotle excluded the latter from his educational theory; by the second century school instruction was to be had only on the lyre. Nothing was written down in the teaching of music; the pupil sat opposite the master and imitated him as best he could. Choral singing and dancing were also taught, but they were like our school theatricals and lay outside the official curriculum.

Marrou brilliantly analyzes the decline of music. He points out that music was a heritage from archaic times; it appeared therefore as a recessive and not a dominant characteristic in Hellenistic culture. Technical progress meant specialization; this in turn meant "a kind of divorce from the general culture and education." In Homer's days, and even a little later, music was a spontaneous folk expression. The instruments were simple; almost any child could be taught to play and enjoy them. Then great composers—Melanippides, Cinesias, Phrynis, Timotheus—introduced complicated rhythms and harmony. Now one had to practice and to master an elaborate technique. In his *Politics* Aristotle discusses at length the dilemma which music teachers faced. He concluded that, just as it was not the purpose of physical education "to breed champions," so musical education should not attempt to turn out professionals but only promote the child's "harmonious development" so that he would have taste and could enjoy music. This sound theory was unfortunately never translated into practice. Marrou makes the point that the tradition handed down by Plato and Aristotle "also helped to perpetuate ingenuous ideas about the efficacy of music as a moral agent, a personal and social discipline." Music, it was believed, cools erotic ardor; music soothes bad temper. While they were away fighting, the heroes of the Trojan War kept their wives faithful by choosing the right musicians; a tune in the Phrygian mode on the oboe is a sure cure for sciatica if played above the affected part—these legends were accepted as fact. A sensible music pedagogy could not thrive side by side with such beliefs. The gap between school music and the living art widened. Listening to music was more popular than ever, but fewer and fewer amateurs played it.

When a little Greek boy of a reasonably well-off family trotted off to school, he was accompanied by his "pedagogue." This was a slave who carried his young master's belongings, and, when needed, a lantern. He remained at the side of the schoolroom, and at the end of the day or at lunch he escorted the child home and even carried him if he was tired. But the "pedagogue" had a heavier responsibility. He was the child's moral tutor. He trained him in manners, helped mold his character and morals. A constant supervisor, the pedagogue often came to be resented in adolescence as an "unbearable tyrant." His importance, says Marrou, is reflected in his name:

in Hellenistic Greece the word "pedagogue" lost its original meaning of "slave companion" and began to take on the modern meaning.

After the little boy got to school and settled himself in his classroom on a backless wooden stool, the master, enthroned on an armchair with slanting legs, took over. Schoolteaching was a badly paid, despised occupation. It was often followed by a man of good family who had come down in the world. ("He's either dead or else he's teaching somewhere," a certain wag in antiquity remarks about someone who is missing.) To be a teacher one had to know how to read and write and to wield a hard leather strap made of a bullock's tail. It was not expected of the teacher that he edify his pupils or enrich their outlook; the high role of inculcating a whole way of life did not fall to the primary-school teacher until the Middle Ages.

The actual method of Hellenic instruction in the three R's was a trifle grotesque. No effort was made to ease the child's task; the more painful, the better. First he learned the alphabet, then syllables, then words, then sentences. There was no "reading by wholes"; no one would have dreamed of arousing the child's interest by "The cat sat on the mat." He had to memorize the names of the letters without even knowing what they looked like. Herod Atticus had a dim-witted son who found this feat beyond him. Twenty-four slaves were therefore brought up with him, each being named after one of the 24 letters. This was for millionaires; less privileged boys had to tread a harder path. The crowning phase of this regimen was to read selected passages from Euripides, say, or Homer. This presented, as is easily imagined, extraordinary difficulties for young children. Often they had not the faintest notion of what they were reading. Moreover, the Greeks used a *scriptio continua* in which there was no punctuation and even the words themselves were not separated from one another. It should be noted that all reading was aloud; throughout antiquity silent reading was exceptional: "People read aloud to themselves, or, if they could, got a servant to read to them."

Writing was taught in the same way as reading. There was a cursive script and also a system of writing by capitals. The child used a stylus to scratch his letters and syllables on the waxed surface of a wooden board, but sometimes ink was used on a board of different design. The pen was made from a reed; the ink came as a solid and was powdered and watered down by the pedagogue; a small sponge was used as an eraser. Exercise books of sheets of papyrus served the wealthier pupils; fragments of pottery, the less privileged. When a child got to the point where he could write sentences, a wide variety of aphorisms were displayed for copying, *e.g.*, "The learning of letters is the beginning of wisdom," or more pointed phrases such as "Work hard, my lad, if you do not want a whipping."

The mathematical syllabus was not inspiring. The child was taught to say and read numbers, cardinals and ordinals. How to count on the fingers was also taught. In Hellenic times this was a real art by means of which the two hands could be used to denote any whole number from 1 to 1,000,000. (A million was indicated by the two hands locked together.) Besides whole numbers, fractions and certain simple relations had to be learned. But observe that in antiquity addition, subtraction, multiplication and division were "far beyond the horizon of any primary school." The fact that calculating tables and counting machines were in widespread use showed, says Marrou, that not many people could add. This holds for much later times, "even in educated circles."

The higher Hellenistic culture, writes Marrou, "remained faithful to the archaic tradition and based itself on poetry, not science." This is reflected in secondary and higher education whose principal aim was not so much "to develop the reasoning faculty as to hand on its literary heritage of great masterpieces." The culture of Hellenistic times was not "revolutionary or innovating"; the great creative drives were spent. Instead this civilization basked in its glory and lived off its capital.

Homer's popularity was at its height. Alexander the Great took his precious copy of the *Iliad* with him on all his campaigns. "Homer was not a man but a god" was one of the first sentences that children copied in their handwriting lessons. Philosophers regarded the *Odyssey* as the more important of the books; men of letters and the schools preferred the *Iliad*. Other poets, among them Hesiod, Apollonius of Rhodes, Sappho and Pindar, were not neglected. Euripides had a high place in the school syllabus, as did Aristophanes. Aeschylus, Sophocles, Menander were studied, and of course Demosthenes.

In the secondary schools the teacher was known as a "grammarian"; in the higher schools, as the "rhetor." The method of teaching at both levels was not much more enlightened than in the primary schools, where the "grammatist" was in charge. Texts were studied in merciless detail. They had to be learned by heart and recited "with expression." They were broken down into separate words and even syllables, which in turn were subjected to an almost insane lexicographic and etymological analysis. Every character, place, event, river named in the literature was the object of "historical" research. Students seriously traced the mythical descent of heroes and gods, a branch of learning which was called "genealogy." Enormous effort was expended on the science of grammar—on the parts of speech, on gender, on mood, tense, the conjugation of verbs and similar delights. Composition was taught: elementary exercises by the grammarian, higher flights by the rhetor. Every step was dogmatic and meticulously codified, every suspicion of originality and imagination was extirpated from the student's efforts. An Egyptian writing board of the Hellenistic period shows us a schoolboy dutifully declining a fable based on Pythagoras. First, in the singular nominative: "The philosopher Pythagoras, having gone ashore and started giving language lessons, advised his disciples to abstain from flesh meat." Then the genitive: "We are told that the opinion of the philosopher Pythagoras was . . .", and so on. Then the dative: "It seemed good to the philosopher Pythagoras. . . ." Then the vocative: "O philosopher Pythagoras. . . ." Then the plural: "The Pythagorases, philosophers, having gone ashore. . . ."

Amid these pedantic japes very little attention was devoted to the ideas and feelings of the poetry and prose. When the grammarian was not drilling and beating his pupils, he lectured them on the moral aspects of literature. His ultimate object was to hold up as models the heroic examples of "human perfection" in the annals of the past. From Homer he tried to extract a complete moral code. This was not always easy, but the teachers and writers managed it. If, for example, Homer showed the "lewd adulterer" Paris "forgetting all about the fighting and going to bed with Helen in the middle of the day, this is obviously so that he can pour scorn on such goings on." But it must be recognized, as Marrou points out, that these crude endeavors were something quite apart from the essence of Hellenistic education. Classical culture was "proud of its pedantry," but the aim of education, however inept the methods, was to make students the very opposite of pedants—rounded, aware, elevated in outlook, appreciative of cultural values in all forms.

Though literature had pride of place in the secondary-school syllabus, mathematics, following the advice of both Plato and Isocrates, was given serious attention. Geometry was taught directly from Euclid's *Elements.* The same text served for a time in the teaching of arithmetic, but the most important book was the *Introduction to Arithmetic* by Nicomachus of Gerasa. The influence of this work was so great, Marrou tells us, that arithmetic took the place of geometry as the key part of mathematics. Both subjects, it should be noted, were taught as speculative and abstract disciplines. Geometry was a matter of reasoning about purely intellectual figures unrelated to the shapes of sense experience; arithmetic was the theoretical science of numbers, incorporating investigations into their esthetic, mystical and moral properties. The calculation of surfaces and volumes did not belong to geometry but to such subjects as geodesy or metrics. These were taught to surveyors, masons and other lowly practitioners and did not form part of a liberal education. And so with arithmetic, which, again on Plato's advice, and following Pythagoras's noble example, was divorced from squalid problems of profit and loss, buying and selling. Two other mathematical studies were the numerical laws governing music and mathematical astronomy. The latter was the most popular of the four branches of mathematics, less for its theoretical value than for its connection with astrology, which had a high standing in Greco-Roman society. But formal instruction was in astronomy proper, and there is no evidence that astrology got into the schools.

As the Greco-Roman period advanced, literature began to elbow out the sciences. Marrou states that in the end mathematics was practically eliminated from the secondary-school syllabus. The subject continued of course to be studied by specialists and philosophers, but it had to be kept alive in higher education because it received no nourishment from below. Even in the teaching of astronomy, science was invaded by the "literary grammarian." The most popular text in the field was not any one of the several straightforward astronomical handbooks which were available, but a poem of 1,154 hexameters by Aratus of Soli written about 275 B.C. and entitled *Phaenomena.* Aratus was not an astronomer but a minor philosopher and man of letters. His poem has no mathematics, no numbers and very little of astronomical theory. It is mainly descriptive, and its explanations of planetary motions and kindred phenomena are anthropomorphic. It also contains numerous errors of observation. Yet this hodgepodge of a work was primarily responsible not only for astronomy retaining its prominent place in secondary-school education, but for the essentially literary, nonscientific emphasis given to the teaching of the subject.

The whittling down of the sciences in the schools of the Hellenistic age had far-reaching consequences. For nothing, as Marrou writes, "is more characteristic of classical tradition—as we can see from the influence it has had and still has on our education—than the predominance of literature and the dislike of mathematics as a basis for general education." Mathematics lost its place in the common culture. This place it never regained. Mathematics continued to be respected and admired, but one did not have to learn it to be considered an educated man.

Higher education forms the subject of another of Marrou's admirable discussions. Philosophy and rhetoric received the main emphasis. Poets, artists, philosophers, rhetors, physicians were among those who lectured to the ephebes. The schools had their libraries in which works of every kind were to be found. A remarkable institution was the Museum in Alexandria, where men of science as well as scholars lived in community as pensioners and pursued their researches with the help of an incomparable collection of books and the botanical and zoological gardens. The pensioners had their disciples in philosophy, in philology, in rhetoric, in medicine. For the truly cultivated man rhetoric was the queen of subjects. The rhetorical form of culture—Isocrates's ideal—had won out over Plato's philosophical form. To the art of oratory later Greek education attached the highest value. Philosophy, to be sure, was not despised; one might even study medicine and be accepted as a man of culture. But in this case the physician, to escape being regarded as a mere technician, had to be an all-round man, to have studied, as Galen did, philosophy, logic, mathematics, grammar.

Paideia, that famous, ambiguous word which meant both education and culture, must be understood as describing the ideal of what was primarily "a lecturer's culture," in which the "word . . . acquired the value of an absolute and became in a way an end in itself." We are contemptuous of rhetoric; we live among public blimps and political windbags. In the Hellenistic age rhetoric had already forgotten its original aim, which was to teach men how to compose and deliver speeches for serious occasions and had turned into an insincere, pompous formalism. Yet we must not overlook that rhetoric, apart from providing a system of values for literature, had social values. Open to all educated people, "and peacefully installed at the heart of a tradition that was passed down for centuries," the system of rhetoric "meant a common standard, a common denominator between all types of intelligence, uniting writers and public, the classics and the 'moderns,' in mutual understanding and harmony."

The teaching of philosophy concludes this central portion of Marrou's survey; it is followed by a prospect of Roman education, which was on the whole "merely an extension of Hellenistic education to the Latin or Latin-speaking regions in the West." Professor Marrou has written a rich, imaginative book. He commands an admirable style. He has an immense erudition which serves him perfectly and never gets out of hand. He is far from indifferent to social problems, and he has broad knowledge of the science of education. He has a nice sense of humor and a suitable disrespect for things which deserve disrespect. His study gives insight into grave problems of modern education. Our civilization has come to depend on specialists and on technology. This is our strength, but it also fragments society. Is the Greek ideal of the rounded man lost beyond recall? Is the unity among men which may be their last hope possible of attainment in a time when education increasingly emphasizes the need for specialization? Marrou's book makes clear our magnificent inheritance from the ancients and enables us soberly to judge what we have done with it.

Short Reviews

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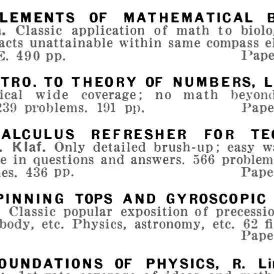

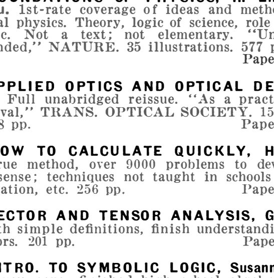

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volume he makes plain where he stands. He was a pupil of Morris Cohen, John Dewey and Frederick Woodbridge; he acknowledges a substantial debt to the writings of Charles Peirce, Bertrand Russell and George Santayana; his ideas also were shaped by Rudolf Carnap and Philipp Frank. Nagel came to intellectual maturity in the period between the two world wars and, like so many students of philosophy of that period, found himself unable to accept "any of the grand philosophical systems of the past as tenable interpretations of nature and human society." Trained as a mathematician, and inclined by temperament both to the common-sense and hard-headed empiricism of the physical sciences, he found himself increasingly drawn to a naturalistic outlook. This faith holds that "spatio-temporally organized bodies are the only agents of causal change"; that there is "an irreducible plurality" of things, qualities and processes in the world; that the universal scheme is neither directively organized nor "rationally integrated"; that "the human scene is but a passing incident in the history of the cosmos"; that moral standards are good if they fit the needs of human beings and liberate their energies, but not otherwise. Moreover, for understanding, such as it may be, of the events of the world, and for control of the environment, neither authority nor intuition nor bare reasoning can be relied upon. To get the hang of things one must observe them. They are what they are in our experience; they are not illusions masking a "metaphysically superior reality." Logic and mathematics furnish the only "necessary truths"; they alone are inescapable, valid in all possible worlds. All other statements are contingent. If true in Brooklyn on July 8 this year, they may not be true in the Bronx at the same time, or in Tierra del Fuego, or when Socrates drank the hemlock. Mathematics and logic are considered valuable intellectual tools for ordering our ideas but they say nothing about the substantial world. As to scientific theories, Nagel takes a middle position between the notions that they are pure conventions or fictions and that (as Bertrand Russell suggests) there is a "structural similarity," a kind of point-to-point correspondence between presumptively true statements and their subject matter. In this department, as in others, Nagel does not claim to give definitive answers; he is pragmatic and content to examine particular theories in given formulations and usage. Everywhere in his writing he is unambiguous, and careful not to claim more for what he means than what he says. The school with which Nagel identifies himself is, as several of these essays show, deeply concerned with the scope of the logic of the natural sciences and with its bearing on problems of moral and social inquiry. It is often said that naturalism is stonily indifferent to such questions. This is a canard of anti-intellectualism. Nagel and others like him care as much about human welfare as any responsible member of society. They recognize that the methods of natural science have often been abused in the study of human affairs; that grandiose theories and inappropriate techniques have characterized social studies; that the yield has not infrequently been barren and trivial. Yet Nagel is steadfast in his belief that these methods, properly applied, offer the only sensible key to enlightenment in human behavior, the sole basis for a rational science of society. This admirable volume explains the high reputation its author has made as a philosopher of science, and the respect and affection he has gained from his many students.

ARCHAEOLOGICAL STUDIES IN SZECHWAN, by T.-K. Cheng. Cambridge University Press ($13.50). Many prehistoric remains have been unearthed in the Chinese province of Szechwan. These remains, collected at some 90 sites, are for the most part housed in museums and have not been described. Dr. Cheng has examined the museum collections in order to formulate an archaeological chronology; this monograph gives a systematic report on the principal items. They range from chipped stone implements of the Mesolithic Period of some 7,000 years ago through pottery, monuments, tombs, coffins, statues and figurines, mirrors, coins, metal tools, household utensils and other artifacts, some dating from as recently as A.D. 1600. More than 100 plates, many of exceptional beauty, adorn this volume, which is a fine contribution to the study of prehistory and the cultural development of western China.

THE NEXT HUNDRED YEARS, by Harrison Brown, James Bonner and John Weir. The Viking Press ($3.95). A geochemist, a biologist and a psychologist have prepared this assessment of man's natural and technological resources—what he has today, what he can expect to develop and draw upon over the next century. The book is based both upon the authors' studies and a series of conferences held with a group of industrial officials representing 30 large American corporations. Among the topics briefly

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reviewed are the demands for raw materials in an industrial society, the different rates of industrialization throughout the world, problems of population growth, food production, present energy resources and future potentialities, the availability and rising need for technical and scientific skills, the role of science in conserving and augmenting food and materials. Clearly written and unpretentious, this report contains valuable data and sensible opinions. It is addressed to the plain reader.

THE PAPERS OF THOMAS JEFFERSON, VOL. XIII, edited by Julian P. Boyd. Princeton University Press ($10). The new volume of the *Papers* covers the period from March to October, 1788, and finds Jefferson in Paris, well established as Franklin's successor, discharging the thousand and one duties of minister plenipotentiary of the United States of America. As the representative of a country both insolvent and still in the throes of hammering out its constitution, his job demands of him everything from persuading a pinchpenny Congress to give him a decent allowance to writing letters of introduction for travelers, attending to trade interests, struggling to keep alive his country's credit, defending its prestige and succoring its sailors from Mediterranean pirates and potentates. Jefferson, it is scarcely necessary to say, is never petty or dull even when attending to dull and petty details, but the main appeal of this, as of many other volumes of the great Princeton edition, lies not in the record of official labors but in the picture of the man's personal interests, ideas and activities. He expresses his views on musical instruments, on plants, on agriculture, on architecture, on French and German wines; he compiles a diverting travel guide and reports his own journey through France, Germany and Italy; he instructs Thomas Paine on the theory of gravitation and receives the latter's delightful critique of the notion of "attraction of cohesion" by which particles of matter are held together; he discusses local customs; he tries to straighten out the involved affairs of John Paul Jones; he studies mechanical arts and manufactures; he devises a new plow; he designs a hygrometer which he hopes will be an improvement on existing models; he buys books on the use of the microscope, on the "Oran-outang," on Shakespeare, on Indian vocabulary, on parliamentary subjects, on Aeschylus, on nautical observations, on chemistry, on astronomy; and he is notified that a year earlier the governors of Harvard University conferred upon him an honorary degree on "account of his literary and political character and personal worth."

INTRODUCTION TO FINITE MATHEMATICS, by John G. Kemeny, J. Laurie Snell and Gerald L. Thompson. Prentice-Hall, Inc. ($6.65). This text by three members of the Dartmouth faculty is part of a new freshman mathematics program at that college. Students may elect to take this course along with traditional instruction in analytical geometry and other subjects leading to the calculus. The authors state that their aim "was to choose topics which are initially close to the students' experience, which are important in modern-day mathematics, and which have interesting and important applications." The range of material is broad and varied. It includes compound statements, set theory, partitions and counting, probability theory, vectors and matrices, linear programming and the theory of games, applications of mathematics to social science problems. The beginning of each chapter is simple, presupposing no previous acquaintance with the subject, but the climb soon gets pretty steep and obviously requires a guide and ropes. A determined effort was made to concoct lively examples: they deal with such things as poker and chess, the rainfall in the land of Oz, political elections, student examinations, dates with blondes, defective peanut-vending machines and television programs. One may be permitted to doubt that the students will find these problems as delicious as the authors intended. The problems by themselves work no pedagogic magic and no unusual breakdown of hard ideas is achieved. What distinguishes this text from others is novelty of content rather than exceptional clarity in explanation.

THE GALATHEA DEEP SEA EXPEDITION 1950-1952, described by members of the expedition. The Macmillan Company ($8). Beginning in the 19th century a number of the leading maritime nations sent out warships on combined "surveying, exploring, and politico-commercial cruises," and often they would take along one or more naturalists. A famous example was the South American voyage of the *Beagle* (1831-1836), which had Charles Darwin aboard. The results of this survey were of the first importance to the future of natural science. Forty years later the *Challenger* laid the foundations of oceanography, one of the fruits of its epochal voyage being proof that living things exist as far down as 20,000 feet. Denmark ventured into the field in 1845 with a rather large expedition on the corvette *Galathea*, which circumnavigated the globe and carried out valuable scientific studies. In 1950 Danish scientists launched another expedition, commemorating the earlier voyage, on a 1,600-ton former British naval sloop, H.M.S. *Leith*, renamed the *Galathea*. The main object was the exploration of the greatest ocean deeps, the trenches and canyons, some of which—to the east of the Philippines—plunge to 35,000 feet below the surface. Members of the expedition have written this uncommonly interesting account of their adventures and discoveries. They describe the many different types of measurements, the technique of trawling, the echo-sounding and hydrographic studies, the geomagnetic investigations, the visits to the Seychelles, the Nicobars and Campbell Island, home of elephant seals and albatrosses. Surveys were made of sea snakes, of coastal fish, of oceanic bird life, of the volume of food produced in different regions of the sea. Anton F. Bruun, the *Galathea* leader, examines the problem of how deep-sea fauna get their food [*see article beginning on page 50*]. Down to a certain level there is a "rain" of dead plankton organisms from the surface layers. But this supply of plants and small animals thins out steadily on the way down, and after a few hundred meters most of it has been eaten, which is why the population of higher animal life gets very sparse. At the bottom, however, there is a new accumulation of dead organic matter, mostly vegetation from the land—branches, leaves, palms, mangrove fruits and so on. The local residents cannot digest this material but they are served by hordes of bacteria which break up the cellulose and much else besides. The bacteria themselves are gobbled up by the mud eaters (worms, sea cucumbers and bivalves), which are eaten by crustaceans, which are in turn eaten by fish. So the chain of life is maintained. Among the specimens brought back was the remarkable *Galatheathauma axeli*, a fish with a luminous organ suspended from the roof of its mouth. This most readable scientific report is made doubly attractive by many excellent illustrations.

Notes

LIGHT SCATTERING BY SMALL PARTICLES, by H. C. van de Hulst. John Wiley & Sons, Inc. ($12). A treatise on the scattering of light and the problems of physics, astrophysics, chemistry and meteorology connected with this phenomenon.

GALACTIC NEBULAE AND INTERSTELLAR MATTER, by Jean Dufay. Philosophical Library ($15). A leading French astronomer presents a technical account of interstellar matter.

EXPERIMENTAL DESIGNS, by William G. Cochran and Gertrude M. Cox. John Wiley & Sons, Inc. ($10.25). A second, revised edition of a manual for research workers in many different fields engaged in the planning of experiments.

A POPULATION STUDY OF PENGUINS, by L. E. Richdale. Oxford University Press ($6.75). This valuable ornithological monograph is part of a report on the yellow-eyed penguin, based on a painstaking 18-year field study in New Zealand.

A TREATISE ON PHOTOELASTICITY, by E. G. Coker and L. N. G. Filon; revised by H. T. Jessop. Cambridge University Press ($12.50). This excellent work on the basic theory of stress-optical effects, published in 1931, is here reprinted minus the color plates, with a few corrections and with an introduction giving an outline of the developments since original publication.

ELECTRICITY AND MAGNETISM, by B. I. Bleaney and B. Bleaney. Oxford University Press ($10.10). An able, comprehensive text covering both the theory and practice of electricity and magnetism, designed either for an undergraduate or first-year graduate course.

THE WONDER OF SNOW, by Corydon Bell. Hill and Wang ($5). An agreeable, anecdotal natural history of snow: what it is, how and why it falls, where it lies, the story of great blizzards, the machinery of avalanches, snow surveying, the nature of snow crystals, the study of weather cycles. Photographs.

HANDBOOK OF SNAKES OF THE UNITED STATES AND CANADA, by Albert Hazen Wright and Anna Allen Wright. Cornell University Press ($14.75). Some 350 species of snakes of the U. S. and Canada are embraced in this work, whose topics include range, size, longevity, distinctive characteristics, habitat, period of activity, breeding, food, venom and bite, enemies. Field notes by innumerable observers, lists of authorities, photographs and maps augment the usefulness of the compendium.

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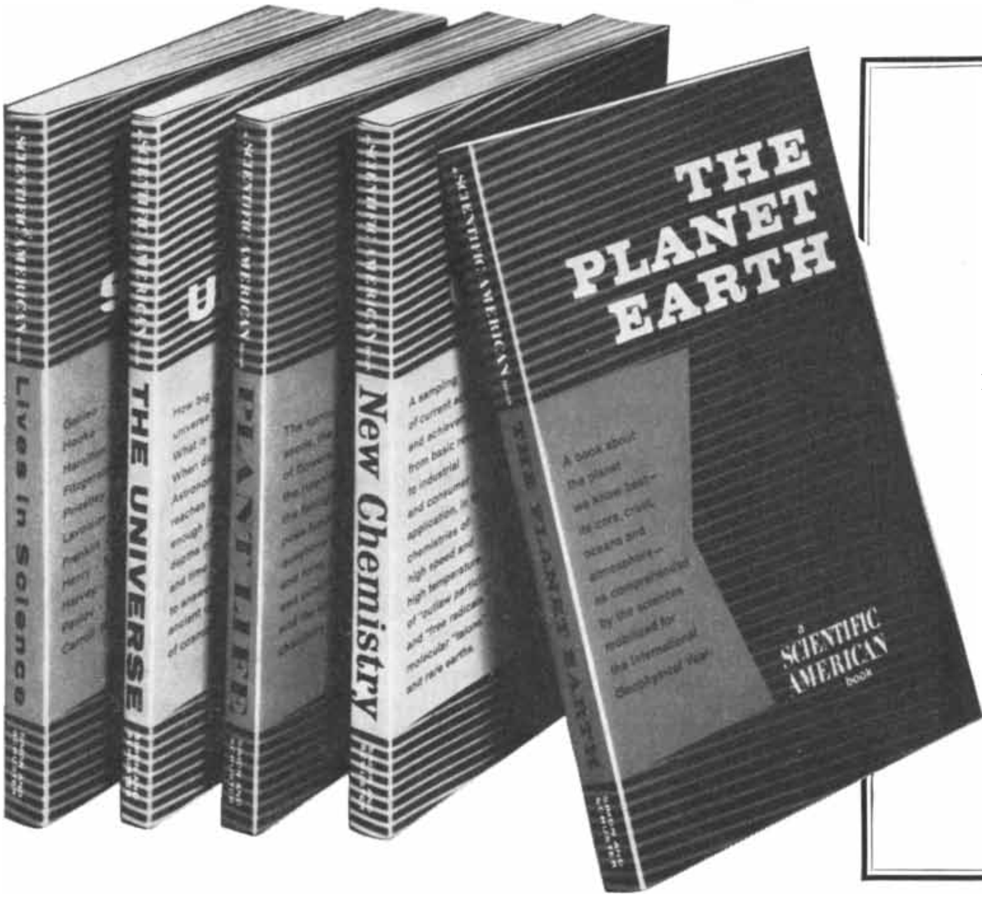

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BIBLIOGRAPHY

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

A NATIONAL SCIENCE POLICY

Basic Research: A National Resource. U. S. Government Printing Office, 1957.

ANIMALS OF THE ABYSS

Aspects of Deep Sea Biology. N. B. Marshall. Hutchinson's Scientific and Technical Publications, 1954.

Deep-Sea Research. Vols. 1-4. Pergamon Press, Inc., 1953-57.

The Depths of the Ocean: A General Account of the Modern Science of Oceanography Based Largely on the Scientific Research of the Norwegian Steamer Michael Sars in the North Atlantic. Sir John Murray and Johan Hjort. Macmillan and Company, Limited, 1912.

The Galathea Deep Sea Expedition 1950-1952. Edited by Anton F. Bruun, Sv. Greve, Hakon Mielche and Ragnar Spärck. The Macmillan Company, 1957.

Marine Geology. Ph. H. Kuenen. John Wiley & Sons, Inc., 1950.

The Oceans: Their Physics, Chemistry and General Biology. H. U. Sverdrup, Martin W. Johnson and Richard H. Fleming. Prentice-Hall, Inc., 1942.

Papers in Marine Biology and Oceanography. *Deep-Sea Research,* Supplement to Vol. 3. Pergamon Press, 1955.

SHANIDAR CAVE

A Paleolithic Site in the Zagros Mountains of Northern Iraq. Report on a Sounding at Shanidar Cave (Part I). R. S. Solecki in *Sumer,* Vol. 8, No. 2, pages 127-192; 1952.

A Paleolithic Site in the Zagros Mountains of Northern Iraq. Report on a Sounding at Shanidar Cave (Part II). R. S. Solecki in *Sumer,* Vol. 9, No. 1, pages 60-105; 1953.

The Seven Caves: Archaeological Explorations in the Middle East. Carleton S. Coon. Alfred A. Knopf, 1957.

Shanidar Cave, A Paleolithic Site in Northern Iraq. Ralph S. Solecki in *Annual Report of the Board of Regents of the Smithsonian Institution,* pages 389-425; 1954.

The Shanidar Cave Sounding, 1953 Season, with Notes Concerning the Discovery of the First Paleolithic Skeleton in Iraq. R. S. Solecki in *Sumer,* Vol. 9, No. 2, pages 229-232; 1953.

"THE ORGANIZER"

Analysis of Development. Edited by Benjamin H. Willier, Paul A. Weiss and Viktor Hamburger. W. B. Saunders Company, 1955.

Aspects of Synthesis and Order in Growth. Edited by Dorothea Rudnick. Princeton University Press, 1954.

Dynamics of Growth Processes. Edited by Edgar J. Boell. Princeton University Press, 1954.

Embryonic Transplantation and the Development of the Nervous System. Ross G. Harrison in *The Harvey Lectures,* pages 199-222; 1907-08.

Embryonic Development and Induction. Hans Spemann. Yale University Press, 1938.

SUPERCONDUCTIVITY

A Search for New Superconducting Compounds. B. T. Matthias and J. K. Hulm in *The Physical Review,* Vol. 87, No. 5, pages 799-806; September 1, 1952.

Superconductivity. D. Shoenberg. Second edition. Cambridge University Press, 1952.

The Superconductivity of Some Transition Metal Compounds. George F. Hardy and John K. Hulm in *The Physical Review,* Vol. 93, No. 5, pages 1,004-1,016; March 1, 1954.

Superfluids. Vol. I: Macroscopic Theory of Superconductivity. Fritz London. John Wiley & Sons, Inc., 1950.

BATS

Aspects of a Population Study of Cavern-Dwelling Bats. John W. Twente, Jr., in *Journal of Mammalogy,* Vol. 36, No. 3, pages 379-390; August, 1955.

Bats. Glover Morrill Allen. Harvard University Press, 1939.

The Feeding Efficiency of Insectivorous Bats. Edwin Gould in *Journal of Mammalogy,* Vol. 36, No. 3, pages 399-407; August, 1955.

Hunting Methods of Fish-Eating Bats, Particularly Noctilio lepo-

RINUS. Prentice Bloedel in *Journal of Mammalogy,* Vol. 36, No. 3, pages 390-399; August, 1955.

OBSERVATIONS ON THE CALIFORNIA MASTIFF BAT. Philip H. Krutzsch in *Journal of Mammalogy,* Vol. 36, No. 3, pages 407-414; August, 1955.

THE RATE OF METABOLISM OF SOME SMALL MAMMALS. Oliver P. Pearson in *Ecology,* Vol. 28, No. 2, pages 127-145; April, 1947.

ORGANIC CHEMICAL REACTIONS

MECHANISMS FOR LIQUID PHASE HYDROLYSES OF CHLOROBENZENE AND HALOTOLUENES. Albert T. Bottini and John D. Roberts in *Journal of the American Chemical Society,* Vol. 79, No. 6, pages 1,458-1,462; March 20, 1957.

THE STUDY OF ORGANIC REACTION MECHANISMS. Paul D. Bartlett in *Organic Chemistry: An Advanced Treatise,* Vol. 3, pages 1-121; 1953.

USES OF ISOTOPES IN ORGANIC CHEMISTRY. Dorothy A. Semenow and John D. Roberts in *Journal of Chemical Education,* Vol. 33, No. 1, pages 2-14; January, 1956.

SUBJECTIVE PROBABILITY

DECISION PROCESSES. Edited by R. M. Thrall, C. H. Coombs and R. L. Davis. John Wiley & Sons, Inc., 1954.

LA GENÈSE DE L'IDÉE DE HASARD CHEZ L'ENFANT. Jean Piaget. Presses Universitaires de France, 1951.

RISK AND GAMBLING: THE STUDY OF SUBJECTIVE PROBABILITY. John Cohen and C. E. M. Hansel. Philosophical Library Inc., 1956.

MATHEMATICAL GAMES

FUN WITH FIGURES. J. A. H. Hunter, Oxford University Press, 1956.

MATHEMATICAL PUZZLES. Geoffrey Mott-Smith. Dover Publications, Inc., 1954.

THE AMATEUR SCIENTIST

ELECTRICAL BREAKDOWN OF GASES. J. M. Meek and J. D. Craggs. Clarendon Press, 1953.

SUPERSONIC FLOW AND SHOCK WAVES. R. Courant and K. O. Friedrichs. Interscience Publishers, Inc., 1948.

TEMPERATURE OF THE UNDER-WATER SPARK AS COMPUTED FROM DISTRIBUTION OF INTENSITY IN OH ABSORPTION BANDS. Earl D. Wilson in *Journal of the Optical Society of America,* Vol. 17, pages 37-46; July, 1928.

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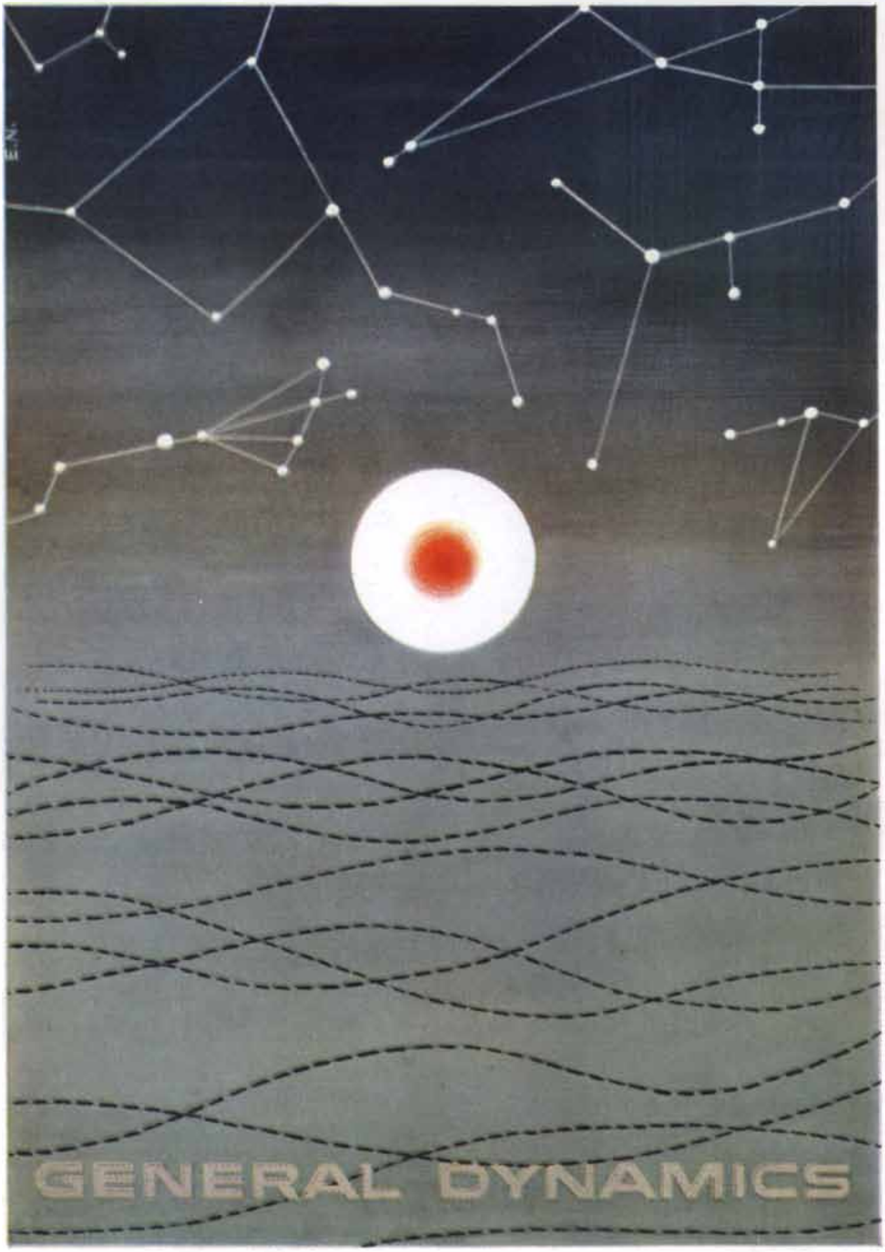

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