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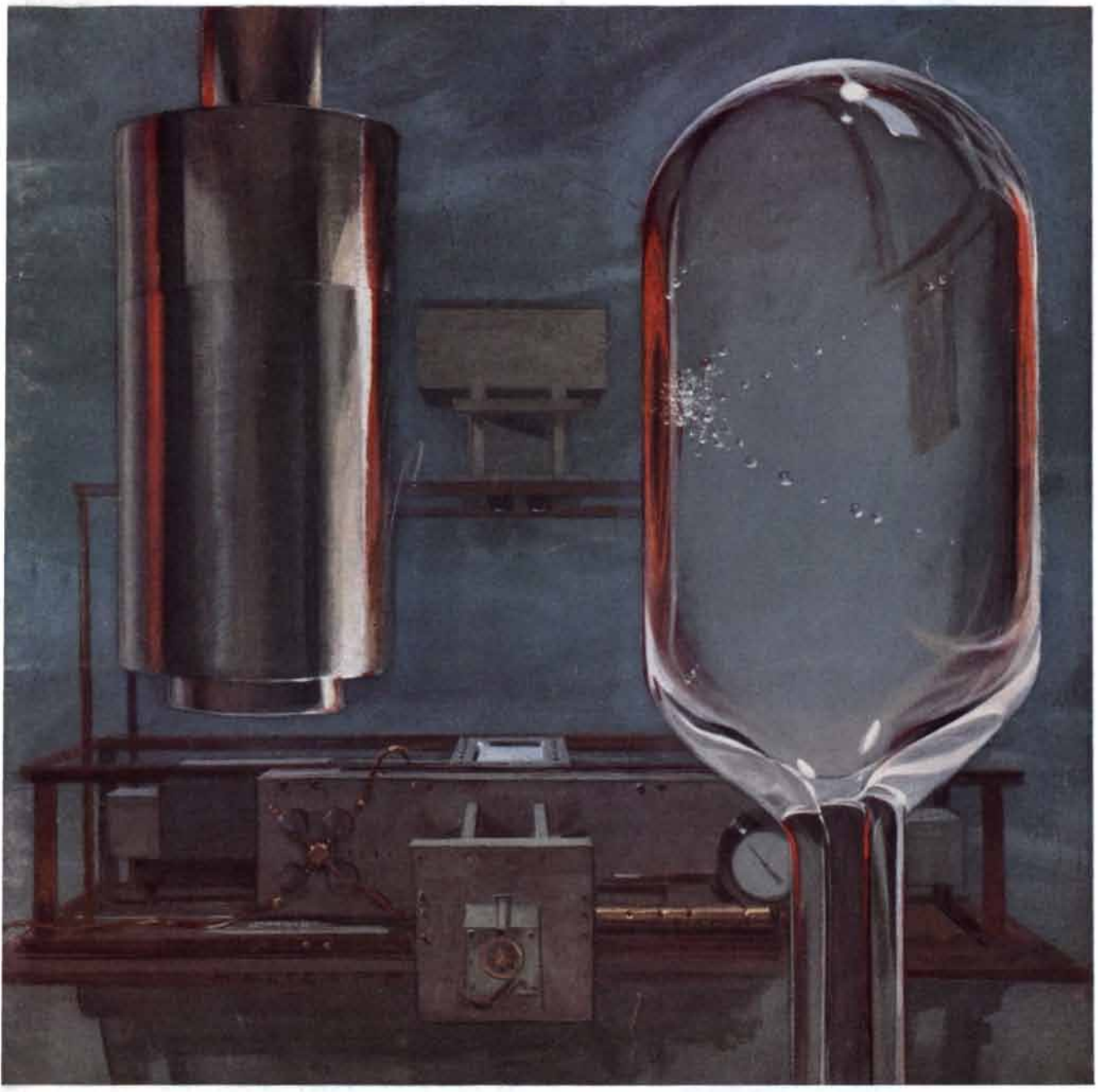

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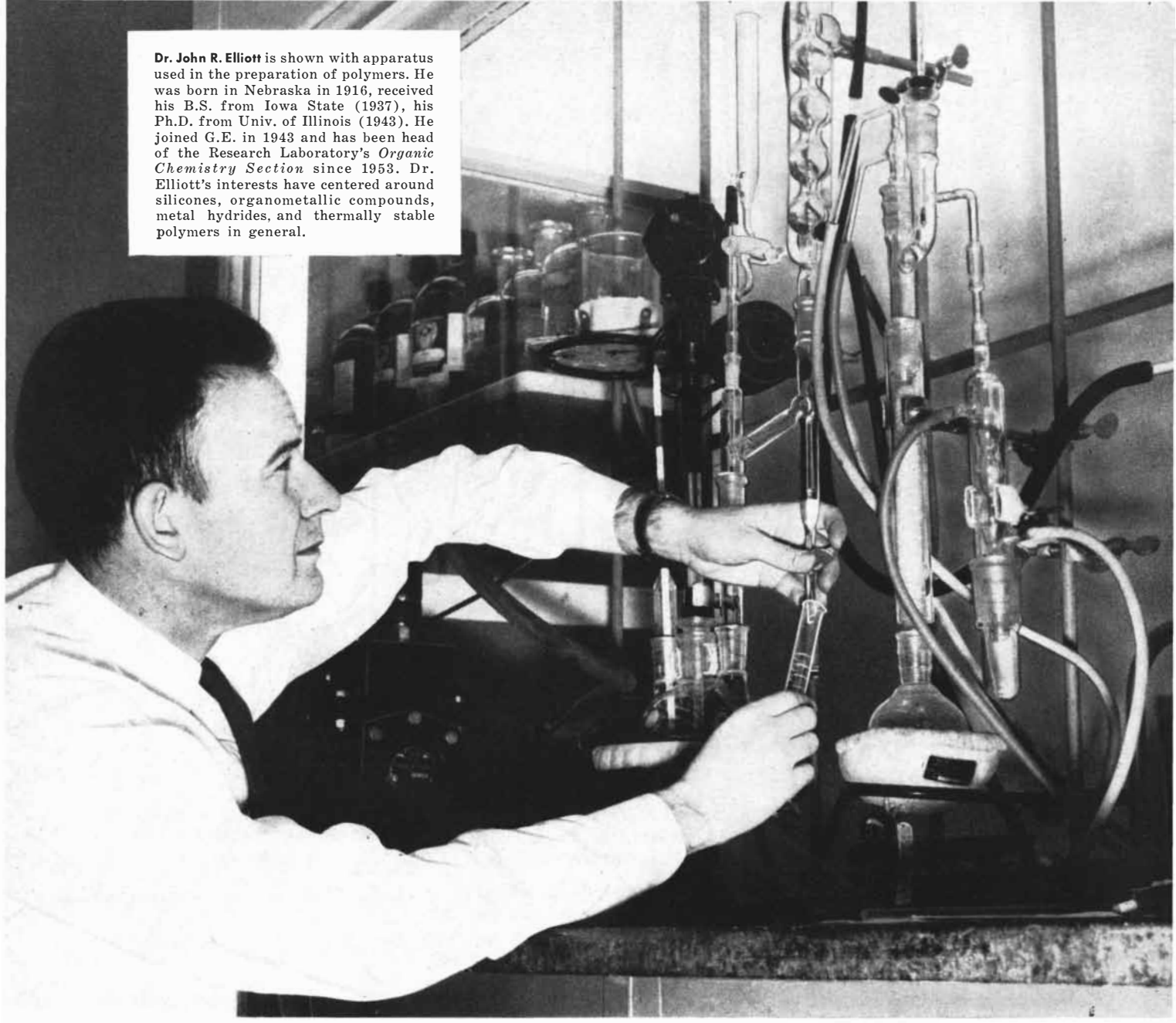

Dr. John R. Elliott is shown with apparatus used in the preparation of polymers. He was born in Nebraska in 1916, received his B.S. from Iowa State (1937), his Ph.D. from Univ. of Illinois (1943). He joined G.E. in 1943 and has been head of the Research Laboratory's *Organic Chemistry Section* since 1953. Dr. Elliott's interests have centered around silicones, organometallic compounds, metal hydrides, and thermally stable polymers in general.

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G.E.'s Dr. John R. Elliott develops thermostable polymers

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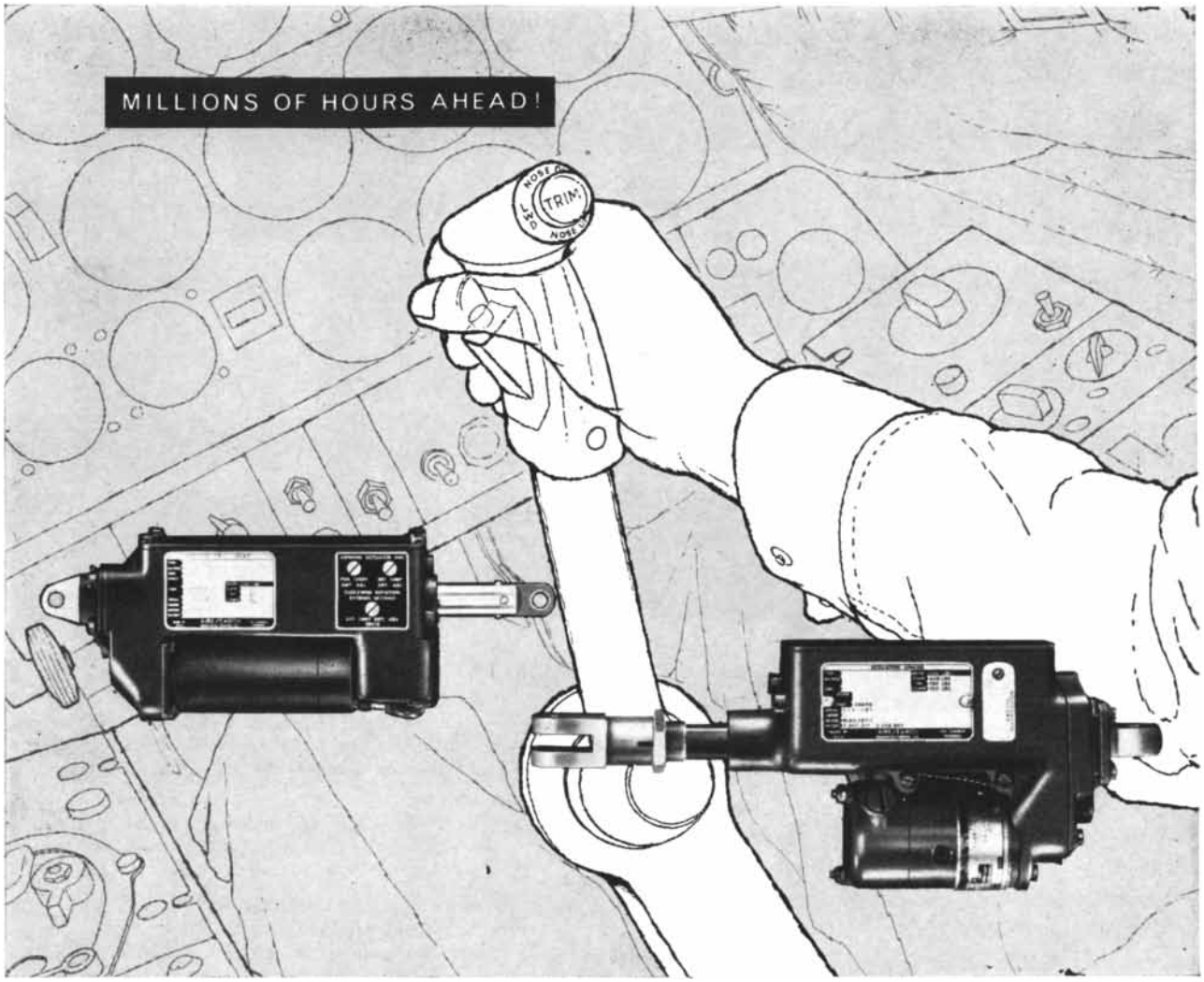

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W. W. Lindsay, Jr., Electronics Committee Chairman (left), Sherwood C. Frey, Navy Studies Department Manager (seated), and R. P. Buschmann, Company Studies Department Manager (right), examine relationships between plane and radar performance.

Operations Research and Systems Analysis

Dr. L. Alaoglu, Mathematics Committee Chairman (left), and Ed Quilter, Capt. U.S.N., Ret., Consultant (right), discuss alternate overseas transport routes between the U.S. and Europe.

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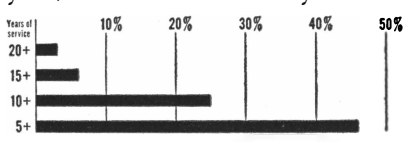

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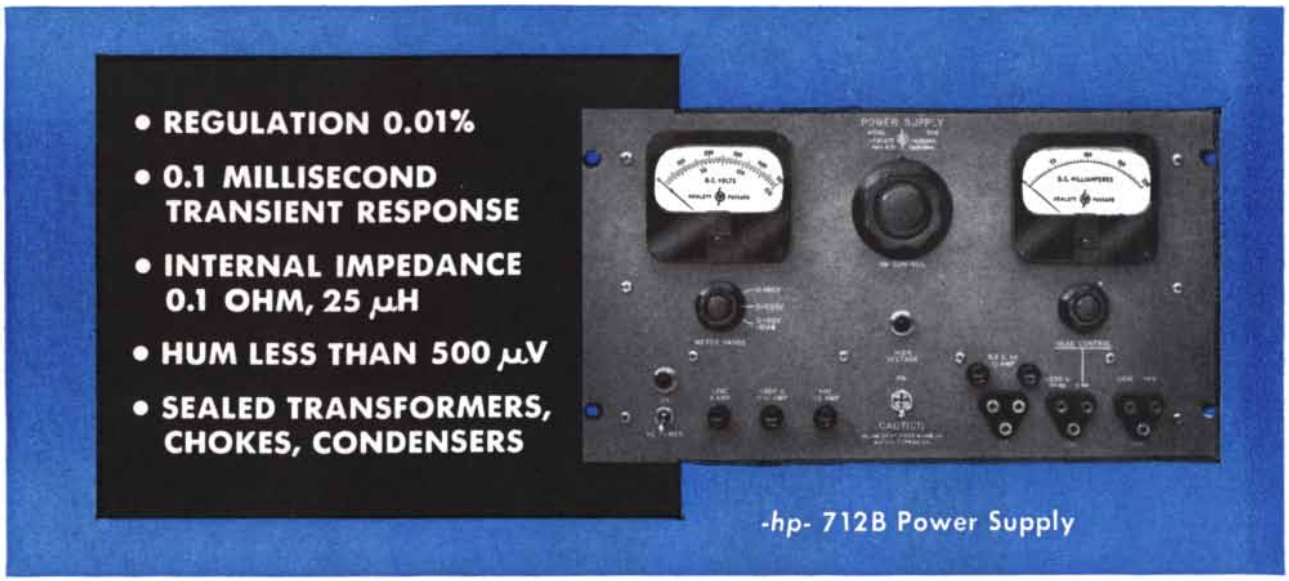

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LETTERS

Sirs:

The explorer Paul Du Chaillu, in his *Exploration and Adventures in Equatorial Africa*, mentions "an affliction which is common in Africa, and is called Gouamba,—but for which we happily have no name." He fails to give any description of the disease, but adds "Gouamba is the inordinate longing and craving of exhausted nature for meat; the vegetable diet here is not of a satisfying nature, at best." This was in 1856. It occurred to me that this might be a still earlier mention of kwashiorkor, the protein deficiency disease described by Hugh C. Trowell in your December issue.

JOHN DARDESS, M. D.

Chatham, N. Y.

Sirs:

The interesting article "Kwashiorkor" in your December issue says that the nutritional disease by that name was evidently described first in 1906. No other information appears as to how long it has afflicted the people of extensive tropical and adjacent temperate areas.

In *The Atlantic* for December, 1953, John F. Brock, M.D., pointed out that in Africa the disease (which your article reports as occurring, in its most

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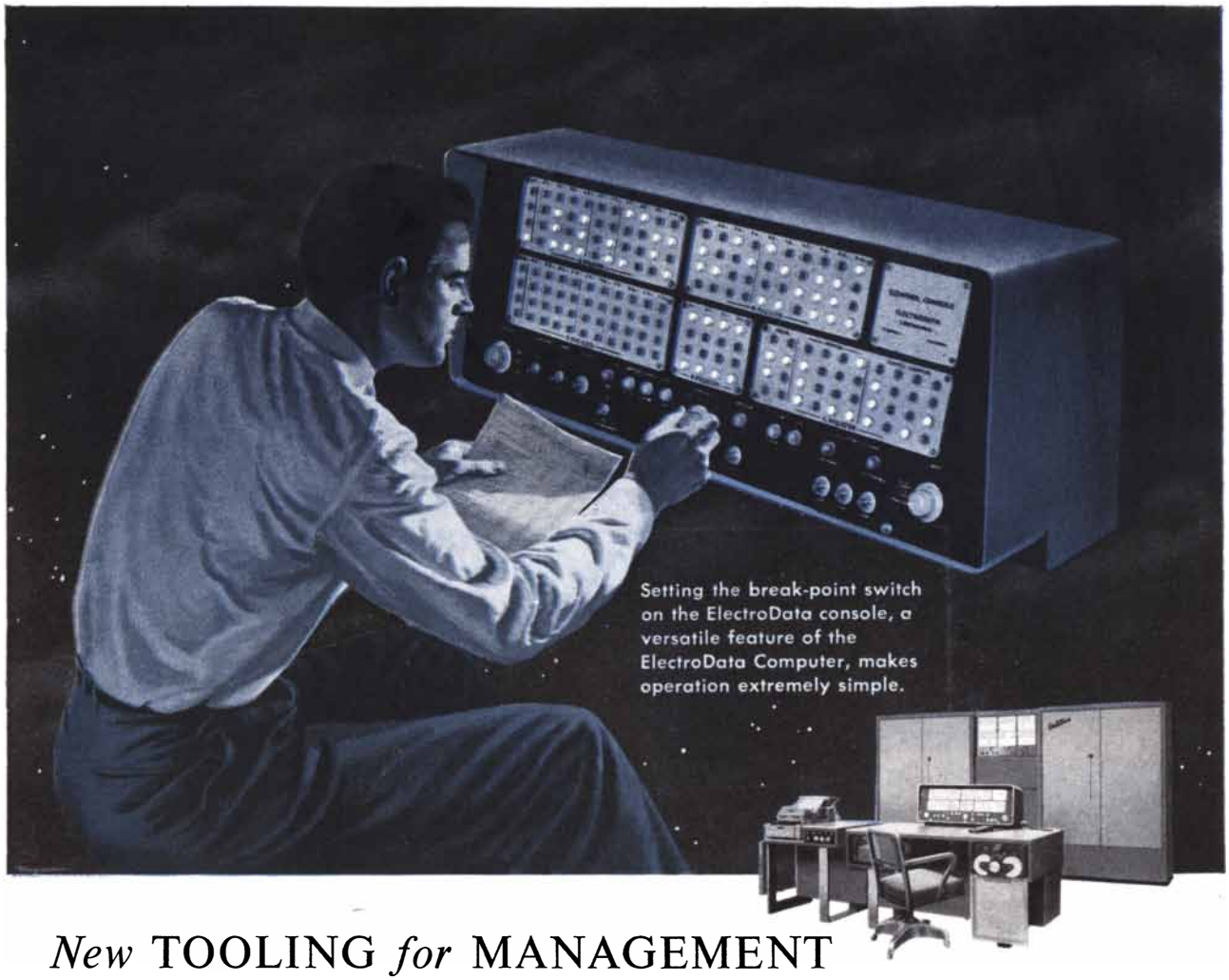

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easily recognized and most frequently fatal form, in children under three years of age) results from changes introduced by "missionaries and educators from the West"; to them it was acceptable that infants be breast-fed for six or nine months, but it just was not right that breast feeding continue to the age of 18 or 24 months. Nothing in your article seems to conflict with the assumption that changed cultural practices account in large part for the presence of the disease in young children.

Perhaps this conclusion may be drawn: In many areas kwashiorkor as a common and severe affliction of young children is largely the result of sudden interruption of practices which had served as important adaptations to environmental conditions.

ALEXANDER LINCOLN, JR.

Meredith, N. H.

Sirs:

Whenever I read *Scientific American* I am irresistibly led to make a comment.

The account of Robert Hooke by E. N. da C. Andrade [SCIENTIFIC AMERICAN, December, 1954] is elegantly done. There is, however, one little episode in Hooke's career which throws a good deal of light upon his character.

We know that Hooke and Newton were bitter antagonists. When Hooke discovered the connection between a tension and the longitudinal deformation that accompanies it (the now-famous "Hooke's law" which every schoolboy can recite), he feared that his discovery would be stolen by unscrupulous men. So what did he do? He published it in the form of an anagram which read: *ce iii nosss tt uv.*

Years later he divulged the proper order of the letters to be: *ut tensio sic vis.* This is to say, as the extension, so the force. . . .

JULIUS SUMNER MILLER

El Camino College, Calif.

Sirs:

This is a late but sincere appreciation of George Wald's excellent article *The Origin of Life* [SCIENTIFIC AMERICAN, August, 1954]. To me it is one of the most fascinating but at the same time logical discussions of the subject written in recent years.

May I suggest two small points which may be of interest. Professor Wald states

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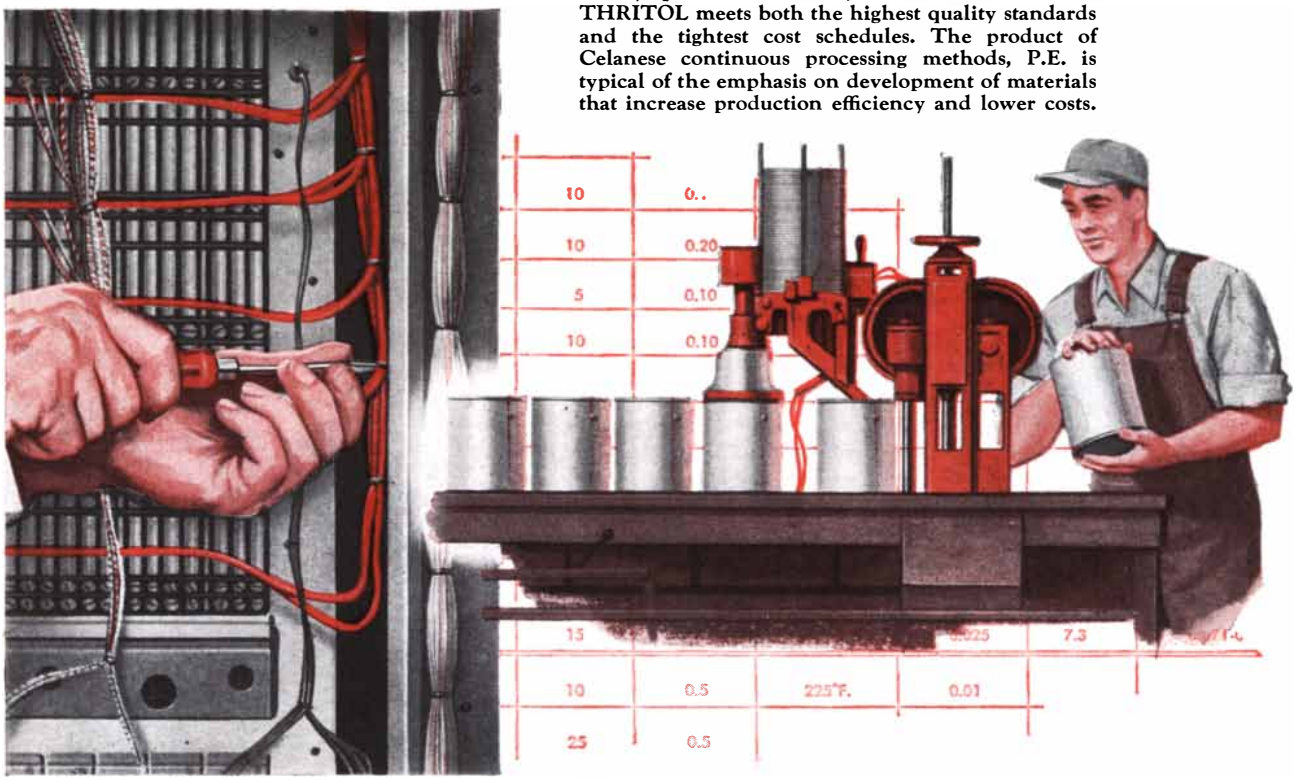

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that the early organisms depending on energy from fermentation were living on borrowed time. They had to take the evolutionary steps to fully photosynthetic organisms before their food supply, organic materials produced previously without the intervention of living matter, was exhausted. Would not a predator-prey relation have obtained somewhat similar to those of today? Presumably such food materials were still being synthesized to some extent. If the increasing "fermenter" organisms built a population beyond their food supply would they not be cut down in numbers until the population did fit the food supply? Such balancing of populations is of course operative in all predator-prey relations among modern organisms. Would not the stabilization of fermenters and food supply very materially increase the available time for the series of evolutionary steps necessary to produce photosynthetic organisms? . . .

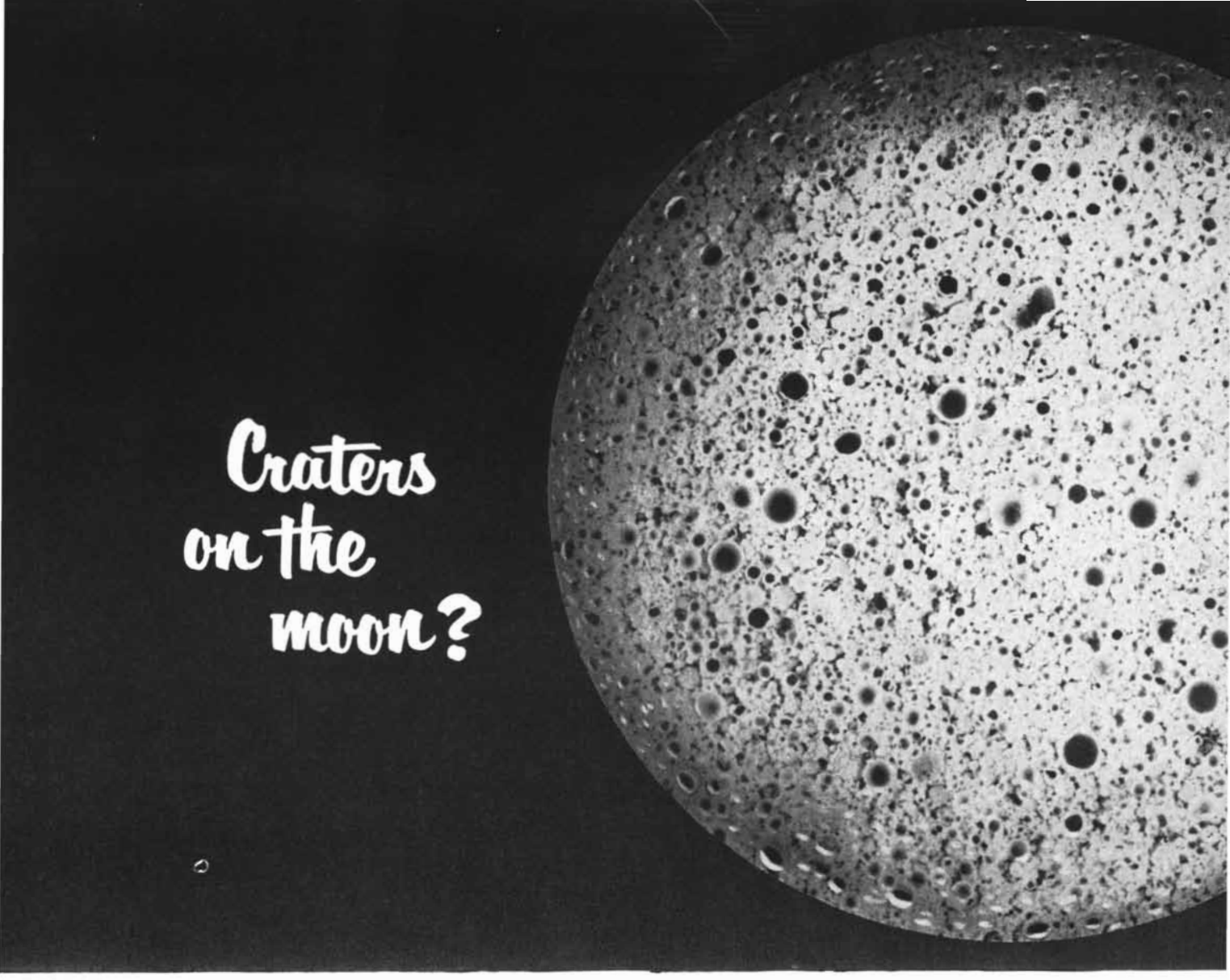
I believe I detect in Professor Wald's article belief in a "theory of inevitability." Given a planet with suitable conditions and time, life is not only probable but inevitable. Living matter of at least the cellular stage and up always exhibits some degree of awareness of its environment. It must in order to adjust itself to its environment. Thus increasing awareness must have had great survival value. Given time, space and numbers of organisms was it not inevitable that a self-aware (self-conscious) organism should eventually evolve? On Earth it turned out to be *Homo*. . . .

In respect to the letters written about Professor Wald's article, certain additional remarks seem in order. From Mr. Irwin's letter I gather that he believes there would be no laws of probability operating in the Universe if men were not around to try them out; a peculiarly human viewpoint.

Professor Probst's reference to Lecomte du Noüy's "Human Destiny" should be countered by asking for quotations from the rest of the book. It is one of those unfortunate books that is packed with errors from cover to cover. May I refer Professor Probst to footnote 3 on page 44 of George Gaylord Simpson's *The Meaning of Evolution* for a complete condemnation of the book. The only reason for reading the book is to be able to answer the questions of students who read it eagerly because of its attractive title.

F. J. TREMBLEY

Lehigh University
Bethlehem, Pa.



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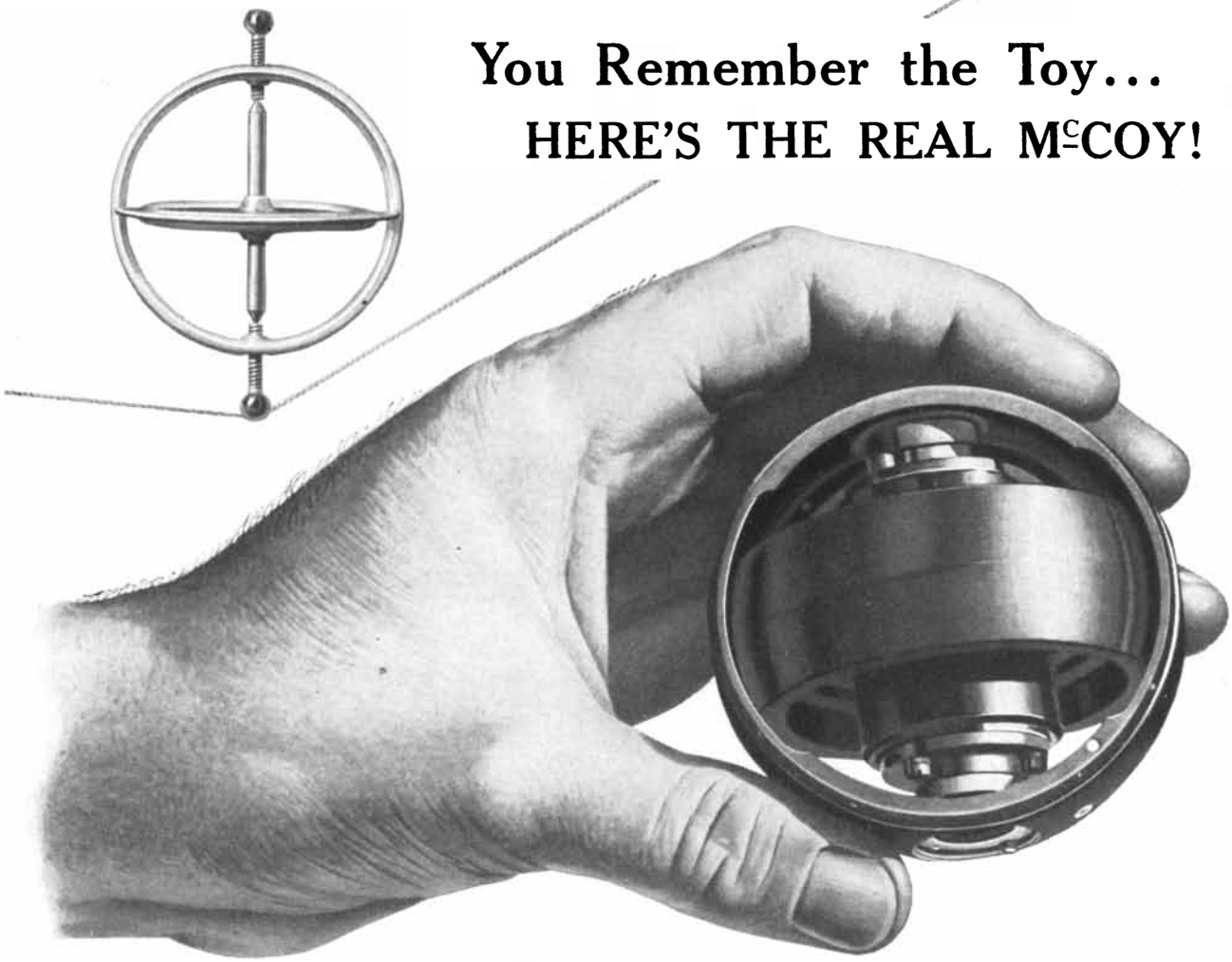
Carborundum finds that alumina bubbles can be used almost anywhere you need a top-quality refractory with the convenience of a castable. Back-up linings for nonferrous melting furnaces . . . burner blocks for core ovens . . . boiler furnaces . . . malleable annealing furnaces . . . side-wall back-ups. These bonded alumina bubbles are also offered as prefired brick and in special shapes.

If you are looking for *better* refractory performance at higher operating temperatures, look for refractories containing ALCOA Alumina. You'll find they last longer, require fewer tear-downs, are actually most economical.

ALCOA does not make refractories, but we will gladly discuss with you the properties and characteristics of the various ALCOA Aluminas. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 729-B Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA CHEMICALS

ALUMINUM COMPANY OF AMERICA



You Remember the Toy... HERE'S THE REAL McCOY!

Bendix GYROS... amazingly precise

navigate planes, guide missiles, point

ONE of the first gyroscopes on record is credited to Bohnenberger; the date, 1810. Compared to today's precision-made gyros, of course, it was in the toy class.

The evolution of the gyro from a novelty to a definite place of importance in the field of aviation and our national defense program is worth noting.

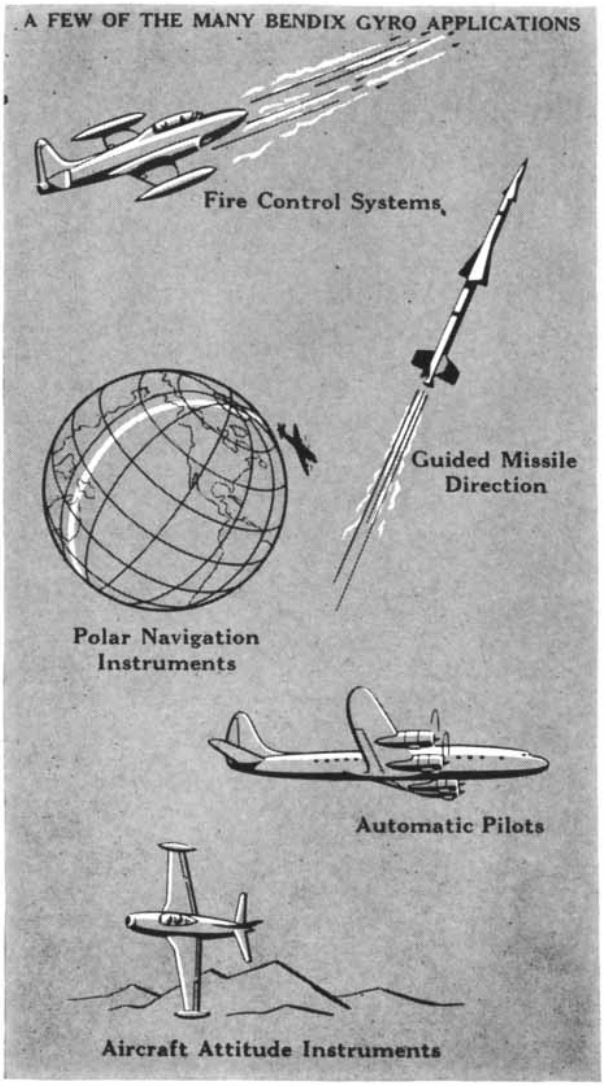
The value of a gyro is in direct ratio to its accuracy. Thus, even if early applications had been apparent, the gyros of the 19th century could not have met the requirements.

Some of the first practical applications of the gyro were in instruments for airplanes. And while most Bendix Gyros today still find their way into commercial and military airplanes, they also do many other jobs—help point guns, stabilize aerial photographic platforms, direct and stabilize radar antennas and many others.

It should be explained that a gyro does not stabilize or control anything directly—*except itself*.

But its peculiar ability to hold *itself* fixed, almost unwaveringly, in any designated position despite the movements of the object to which it is attached, provides the gyro's user with a vital requirement—a firm, stable reference point on which to base calculations or corrective actions.

Developing and manufacturing gyros and gyro-controlled instruments for blind flight, automatic pilots and the famous Bendix Polar Path† compass which has made polar navigation practical, is another facet of the Bendix Aviation Corporation's diverse operation handled by our Eclipse-Pioneer Division, Teterboro, N. J. Contacting E-P will get you quick answers to problems involving aviation instruments and components.

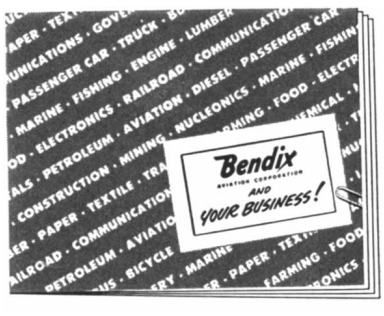


"tops" that help fly and guns, take pictures, aim radar!

For the complete picture of Bendix and ideas on how some of our thousand products can contribute to the efficiency of your business, write to the address below for the brochure "Bendix and Your Business."

ENGINEERS: Bendix diversity offers unlimited opportunity to experienced men and undergraduates. Write for the interesting brochure "Bendix and Your Future."

BENDIX AVIATION CORPORATION
Fisher Building • Detroit 2, Michigan



THE NAME Bendix AVIATION CORPORATION MILLIONS TRUST

PRINCIPAL DIVISIONS AND BASIC PRODUCTS

ECLIPSE-PIONEER, TETERBORO, N. J.
aviation instruments and components; foundry.

SCINTILLA, SIDNEY, N. Y.
aviation ignition systems; industrial engine magnetos; diesel fuel injection; electrical connectors; ignition analyzers.

RED BANK, EATONTOWN, N. J.
electron tubes; dynamotors; inverters; AC-DC generators.

BENDIX RADIO, TOWSON, MD.
radar; auto, railroad, mobile and aviation radio; television.

ECLIPSE MACHINE, ELMIRA, N. Y.
bicycle coaster brakes, Stromberg carburetors, electric fuel pumps, starter drives.*

ZENITH CARBURETOR, DETROIT, MICH.
automotive, marine and small engine carburetors.

BENDIX-SKINNER, DETROIT, MICH.
micronic filters.

PACIFIC, NORTH HOLLYWOOD, CALIF.
telemetering equipment; hydraulic and electric actuators; depth recorders; boat steerers.

BENDIX FRIEZ, TOWSON, MD.
meteorological instruments, precision instruments and recorders.

BENDIX PRODUCTS, SOUTH BEND, IND.
automotive brakes, carburetors, power steering; aviation brakes, landing gear, fuel metering.

MARSHALL-ECLIPSE, TROY, N. Y.
brake blocks, brake lining, synthetic resins.

CINCINNATI, CINCINNATI, OHIO
automatic viscosity regulators, nuclear products.

BENDIX COMPUTER, LOS ANGELES, CALIF.
digital computers.

HAMILTON, HAMILTON, OHIO
jet engine controls and aircraft pumps.

LAKESHORE, ST. JOSEPH, MICH.
power steering and automotive devices.

UTICA, UTICA, N. Y.
aviation components.

MONTROSE, SOUTH MONTROSE, PA.
aviation components.

PIONEER-CENTRAL, DAVENPORT, IOWA
aviation instruments and components; ultrasonic cleaners.

YORK, YORK, PA.
electronic devices; test equipment.

BENDIX-ECLIPSE OF CANADA, LTD.
Windsor, Ont.

BENDIX INTERNATIONAL
New York City

*REG. U.S. PAT. OFF.
†EXCLUSIVE TRADE NAME OF BENDIX AVIATION CORPORATION

50 AND 100 YEARS AGO

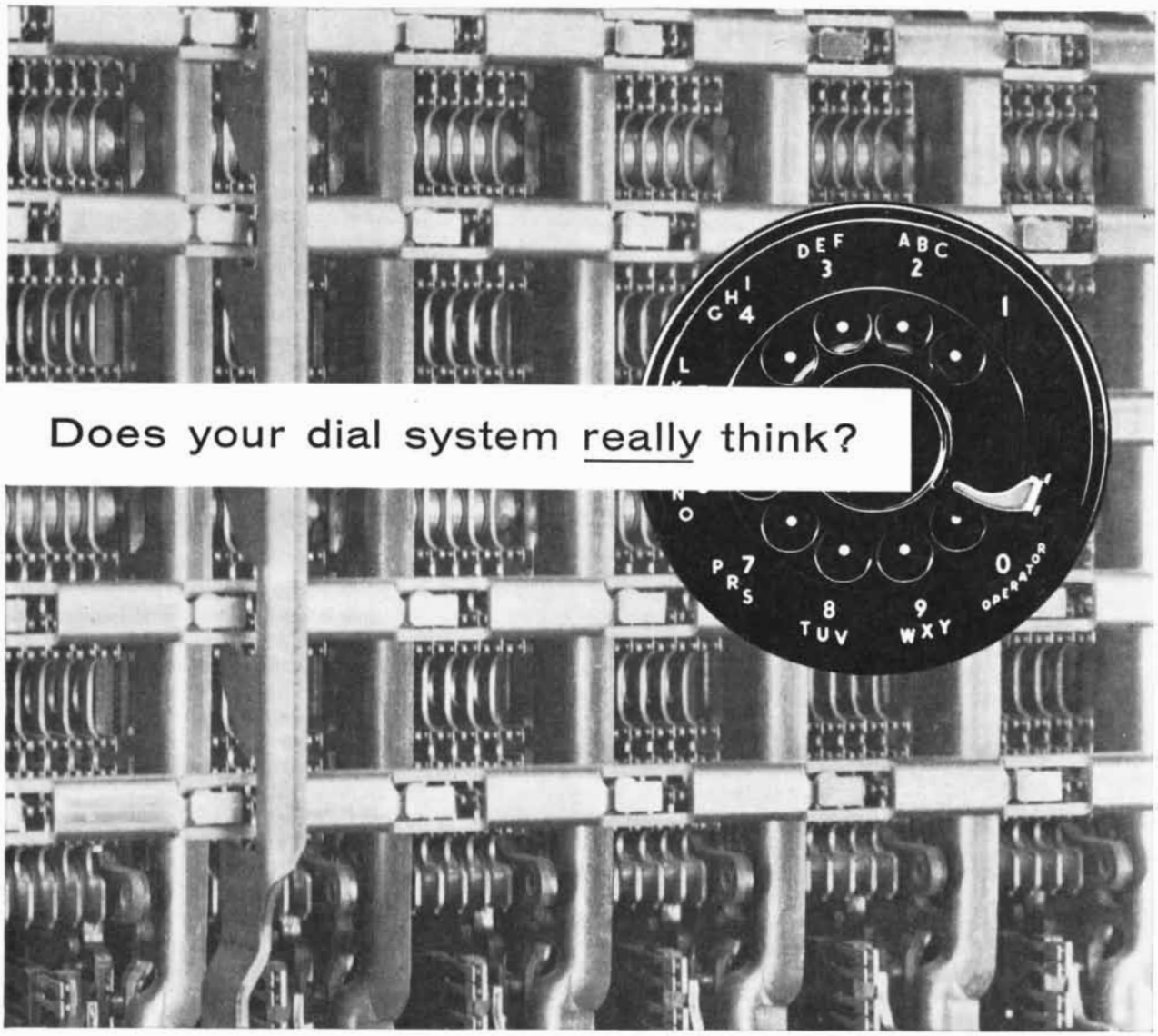
SCIENTIFIC AMERICAN

FEBRUARY, 1905: "The electric horn is undoubtedly the most novel auto horn. It was exhibited at the Paris Automobile Salon by M. Legenare of Rheims, France, and is the invention of M. Colas. It is operated by current from a battery, which, being transformed with the aid of a Ruhmkorff coil, causes a telephone receiver diaphragm in the horn to vibrate when a button is pressed in the steering wheel. The receiver is an ordinary telephone, one composed of a permanent circular magnet in the field of which is a coil that attracts the diaphragm. This receiver can be screwed on any horn in place of the usual piece containing the reed. The horn can be blown as long or loud as one pleases by simply pressing a button. Its note may be varied by adjusting the trembler. The horn is much more powerful than those usually employed. A battery of six accumulators giving 12 volts is used to operate it."

"The Aero Club of Paris has asked permission from the municipal authorities to make experiments in aviation in the Galerie des Machines in February. Under the head of aviation, among other experiments will be some in mechanical aerial direction. The building is so large that the results will be almost the same as would be obtained in the open air, with the difference that the disturbing effect of wind need not be feared."

"Among the prizes offered this year by the Paris Academy of Sciences is the Pierre Guzman prize (100,000 francs), for the discovery of a means of communicating with any celestial body other than the planet Mars; failing the award of the capital sum, the interest will be awarded every five years for a work important to the progress of astronomy."

"The prizes for the year 1904 have been awarded, we learn from *La Nature*, by the Paris Society for the Encouragement of National Industry. The grand prix of the Marquis d'Argenteuil has been awarded to Auguste and Louis



Part of the control equipment of a modern dial system—dial telephony's equivalent of a brain. It goes into action the instant you dial a call, selecting the telephone you want to reach and directing the switches that set up the connection . . . just as the brain directs the muscular actions of the body.

This question can't be answered until we learn more about the nature of thought. But dial telephone systems *do* simulate many of the processes of the human brain. For example, when a number is dialed, Bell's newest switching system—

COUNTS the dial pulses

REMEMBERS them

DECIDES ON the best route to a nearby town or across the nation

TESTS to see if the route is clear

SELECTS an alternate if the first route is busy

REPORTS difficulties in circuits, if any

Today's automatic switching reflects the creative thinking of many scientists and engineers at Bell Telephone Laboratories. Each year your dial telephone is able to do more for you. And this is but one phase of the continuing effort to keep your Bell telephone service the world's best.

BELL TELEPHONE LABORATORIES

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS

Lumière for their discoveries in photography."

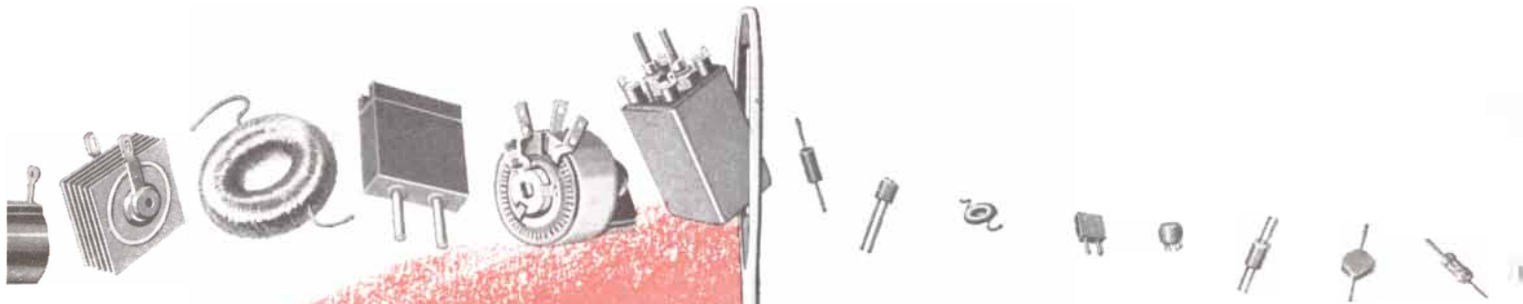
"Much concern is felt for the fate of Dr. Charcot, who is leading an Antarctic expedition which started more than a year ago. It is known to have encountered a terrible storm in April last year and has not been heard of since, nor have any traces of its movements been discovered by Uruguay, which sent out a party to its rescue. M. Charles Rabot, a member of the committee of the Society of Geography of Paris, intends to organize another search party to ascertain its fate."

SCIENTIFIC AMERICAN

FEBRUARY, 1855: "A great number of petitions have been sent in to Congress against extending the three patents for reaping machines, viz: Hussey's, McCormick's, and Moore and Hascall's."

"A question of great importance with divines and men of science at the present day, is that of the age of our planet, and the different changes which have taken place upon it, as related in Genesis. In the last number of the *Bibliotheca Sacra*, the Rev. John O. Means, of East Medway, Mass., presents his views at great length on this subject, and takes the latter view of the question, namely: that the days mentioned in the first chapter of Genesis, if interpreted to mean *indefinite periods of time*, would reconcile science and the Scriptures in every particular. He employs some strong arguments in favor of this view of the question. Sir Charles Lyell believes that it must have taken 67,000 years to form the delta of the Mississippi, and 35,000 years for the Niagara River to form its present channel from the Falls to Queenstown. Nearly all the eminent geologists believe this, and they consider the facts to prove it are so strong that they cannot be gainsaid. Mr. Means reasons strongly to prove that the meaning of the word day in the first chapter of Genesis is an indefinite period of time, and makes out a very strong case in favor of the world being perhaps a million years of age, according to the Mosaic account of creation."

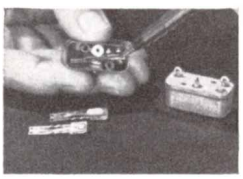
"Dr. Gideon B. Smith, of Baltimore, says the seventeen-year locusts will make their appearance this year along the eastern coast of Maryland to Carlisle, Pa.,



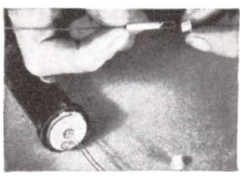
MINIATURIZATION

When there's only room for improvement

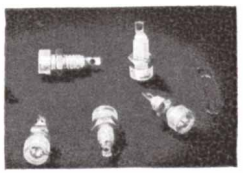
...there's a treasury of ideas in **KEL-F® PLASTIC**



Space saving insulation... machined from KEL-F Plastic rod.



Miniature Test Jacks for 500 volt RMS "HF" circuit...injection molded of KEL-F Plastic.



Contact Bar insulated with KEL-F Plastic...injection molded directly to beryllium-copper.

When you have to squeeze more and more into less and less space...when materials lack the specific properties you need for miniaturization, we suggest you look into the possibilities of KEL-F Plastic.

The development of KEL-F Plastic, a fluorocarbon polymer, was inspired by a vital problem of miniaturization in the field of electronics. What it accomplished then, it can repeat for your products.

KEL-F Polymer is a dense, tough thermoplastic with outstanding resistance to the effects of high and low temperatures. In wire insulation, tube sockets, connector blocks, printed circuit bases, transistor seals, and other applications its zero moisture absorption, non-wettability and dimensional stability can provide high level performance under severe conditions of temperature and humidity.

The compressive strength is high. Bearing loads of 8,000 psi result in only 4% to 5% permanent set. KEL-F Plastic can actually be used for structural members. Electrical properties are outstanding. They include superior resistance to arcing, surface flash-over and thermal cycling.

KEL-F Plastic is readily moldable by extrusion, compression, injection and transfer methods. Molding techniques are fully perfected, and molded components can be depended on to exhibit all the inherent characteristics of the original molding material.

KEL-F Plastic is available as a molding compound, or it can be obtained in rods, tubing, sheets and film from a number of suppliers. It is also available in dispersions, suitable for bake-coating of metals and certain non-metals. The full story of KEL-F Polymer should be in your active file. Write us.

®*Registered trademark for The M. W. Kellogg Company's Fluorocarbon polymers.*

Miniature Rectifier and mount for parts...injection molded of KEL-F Plastic.

THE M. W. KELLOGG COMPANY

***Chemical Manufacturing Division*, P. O. Box 469, Jersey City, N. J.**

SUBSIDIARY OF PULLMAN INCORPORATED

and also in Kanawha, Va., and Lexington, Ky. They can be found in all the above places, wherever trees, shrubbery, or forests grew in 1838, by digging down one or two feet."

"A new map of the Arctic Regions has been published by the British Admiralty, on which the names affixed to various localities by the American expedition sent out by Henry Grinnell, Esq., have been adopted; and in particular Grinnell's Land, discovered by said expedition, is entered conspicuously on the map, it having been on a previous map of the Admiralty called Prince Albert's Land."

"The New York *Tribune* has lately been somewhat violent in its attacks upon the Smithsonian Institution. The whole anger of the *Tribune* may be concentrated in one sentence, namely, the majority of the Board of Regents have decided that the expending of the donation of Smithson to erect and maintain a huge library in Washington would be a violation of the will of the donor. The Board is right, as any uninterested man of common sense must allow who reads that will. The Virginia *Sentinel* takes the ground that the method of *active operations* by scientific investigations and by cheap publications of new discoveries for general distribution is the only way to carry out the will. The *Sentinel* says, 'If a mammoth and indiscriminate library had been the agency to which Smithson looked to accomplish his purpose, he would have said so, because he could have said so in a word.' Prof. Agassiz, the distinguished man of science, has addressed a letter to Mr. Upham, member of Congress, in relation to the controversy now raging about the management of the Smithsonian Institution, in which he sustains the course pursued by Prof. Joseph Henry and the present Board of Regents. In the course of the letter he takes the ground that the Smithsonian Institution is not strictly an American institution, but that it was designed by its founder 'to increase and diffuse knowledge among men.' He also mentions a curious fact, bearing upon the present controversy, going to show that the testator designed that his bequest should be appropriated to the publication, rather than to the accumulation, of books. He says that the whole bequest was originally made to the Royal Society of London, but afterwards transferred to the United States because the Society refused to publish certain scientific papers submitted to them for that purpose."

CORNING GLASS BULLETIN

FOR PEOPLE WHO MAKE THINGS

Three problems . . . one "E-C" answer

How would *you* shield a complex, static-sensitive hunk of machinery from stray electric charges and still keep its innards open to inspection?

That's a problem IBM faced in designing their now-famous electronic calculator—and solved with E-C glass. Ordinary glass wouldn't do. It wouldn't keep electrons in line. Metal would have been ideal for the shielding job, but not so good for seeing through. E-C coated glass does the one and allows the other.

E-C coated glass is a PYREX brand glass. It stands up well under physical and thermal shocks. But its main claim to fame is the transparent, conductive coating (about 20-millionths inch thin) that's permanently bonded to one side of it. It's this coating that keeps static charges from gumming up IBM's complex circuits busy calculating.

But there's more to E-C coated glass than shunting off unwanted electrical charges. Run a current through it and you've got a heating element that gives forth with a *uniform*, dry, controllable, radiant heat, up to 350° C. The emphasis is on *uniform*—no furrows of heat with coolth in between; no dead spots.

This uniform heating element is already at work in medical sterilizers, drying ovens, room heaters, chicken brooders.

And here's a third kind of application. Turn an E-C panel around and you have a highly efficient heat *reflector*. A well-known steel company protects shear pulpit operators from the fiery heat of billets in process with transparent E-C panels.

Product or process—the potential of E-C coated glass hardly seems tapped. We've learned a lot about it that we'd be glad to share with you.

Multi-aptitude problem—So many folks have exhibited so much interest in the ability of our VYCOR brand 96% silica glasses to survive, unscathed, wide temperature variations (quick switches from below freezing to 1800° F. or higher) that its other attractions for a designer may fall into oblivion.

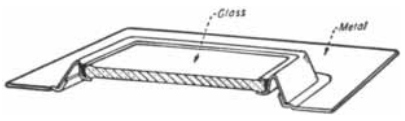
This we don't want to happen, and you might not either. Actually, there are seven VYCOR brand glasses available today—all high silica, but each compounded to develop specific aptitudes. Glass 7911, for example, we control especially for uniform, high transmittance of short-wave ultraviolet. It has notably high electrical resistivity, too, and low power loss. Glass 7910 meets germicidal lamp requirements for transmitting ultraviolet at 254 millimicrons. Glass 7950 will absorb most of the visible light from a tungsten filament (2700° K.), but let infrared radiation pass freely.

Our brand new bulletin B-91, "VYCOR brand Industrial Glassware by Corning," completes the story with all the basic data we can put in print about all seven VYCOR brand glasses—with curves and illustrations. It just might stimulate an application idea or two for you. Would you like a copy?

On becoming attached—Nothing personal—just a first step, we hope, toward informing you about ways of attaching glass to metal.

We've found a lot of our customers have more than a passing interest in this subject. We do too, as you might imagine, what with some 50,000-odd formulas for glass hankering to be put to new uses.

Below, for example, is *one* of the "recommended methods of attaching glass to metal structures"—from a bulletin of that name!



This particular one is a soldered joint between glass and metal. The glass panel has a metallized edge to accommodate soldering to the metal frame.

The brochure (actually an editorial reprint from "Product Engineering") shows some 16 other types, including threaded joints, pressure-tight joints, spun-metal joints and electrical connections. We'd be delighted to send you a copy.

* * * *

Which brings us to our basic theme—glass itself. That's a world amazing even to those of us who spend most of our waking hours exploring its apparently endless boundaries.

What progress we've made to date, mostly working with folks who have materials problems to solve, is spelled out in a little volume we've offered before and offer again in light of the sustained demand for it. A copy of "Glass and You" will show how this centuries-old material fits 20th century technology. It's a good starting point for getting acquainted. May we send you a copy?

Corning means research in Glass

CORNING GLASS WORKS, 30-2 Crystal Street, Corning, N.Y.

Please send me the information checked below:

☐ E-C glass; ☐ "VYCOR brand Industrial Glassware by Corning"; ☐ "Methods of attaching glass to metal structures"; ☐ "Glass and You"; ☐ Send a representative to call on me.

Name_____ Title_____

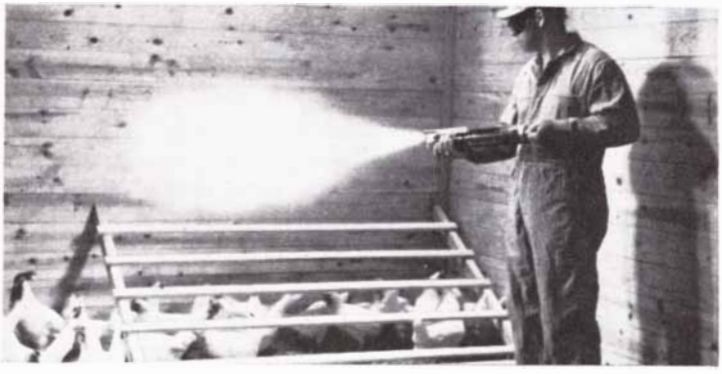
Company_____

Address_____

City_____ Zone_____ State_____

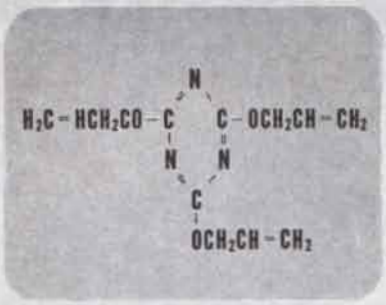
Life...

on the Chemical Newsfront



POULTRY NOW CAN BE MASS-VACCINATED against Newcastle Disease by spraying new BIOLATOR* Newcastle Vaccine Dust *Lederle* into the house. One man now can vaccinate 10,000 birds an hour. Birds gain immunity by inhaling the new dust vaccine—a preparation of the live virus type. (No. 1)

PROJECT #1000. On a third repeat order from the same client, Chemical Construction Corp., a Cyanamid subsidiary, was awarded its 1000th job in its 40th year. Among the many projects completed during 1954, Chemico placed "on stream" 1000 tons daily capacity for anhydrous ammonia. (No. 2)



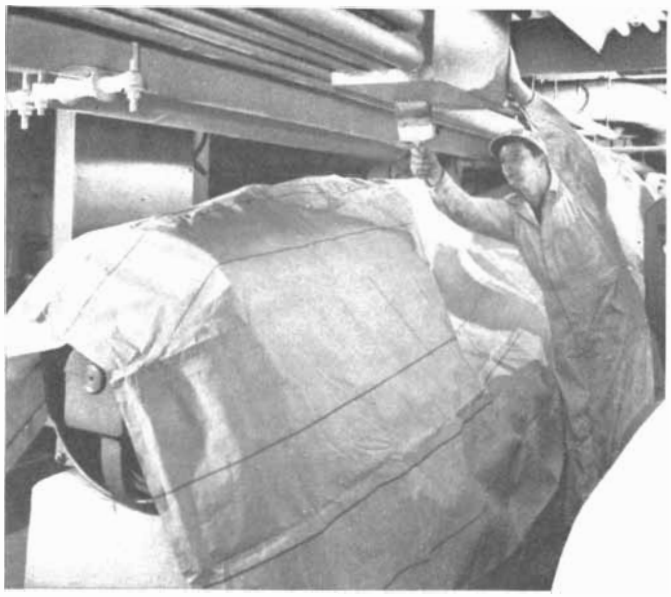
Triallyl cyanurate lends unique heat resistance to plastics for:

Heat-stable, pit-resistant casting resins for safety glasses or windows; and for...

Heat-stable wire coating compositions with excellent electrical properties; and...

Special aircraft applications where a copolymer of triallyl cyanurate and a maleic alkyd make glass cloth laminates with flexural strengths of 30,000 psi even after 24 hours exposure to 500°F.

Triallyl cyanurate, with its stable triazine ring and reactive allyloxy group on each carbon, is used in copolymers to produce such heat-resistant plastics. Recent price reduction gives this chemical added attraction for new product development. (No. 3)



PAPER DROP CLOTHS for painters, made by Fibleco Illinois Corporation, are among many new market-expanding paper products made possible by Cyanamid's MELOSTRENGTH® Resin. The MELOSTRENGTH* Paper is made by Mosinee Paper Mills with MELOSTRENGTH Resin, which binds paper fibers strongly together so paper stays strong even when soaking wet. Because the paper is stronger dry, too, drop cloths stand up through hard scuffing, abrasion and other abuse. Such properties open many new uses for paper. (No. 4)

FOUNDATION FOR THE NEW TRIM LOOK is often a foundation garment woven of rubber thread. When the rubber is compounded with Cyanamid's new ANTIOXIDANT 425*, these garments stay white, with minimum discoloration due to aging of the rubber. ANTIOXIDANT 425, now in full commercial production, gives rubber highest resistance to discoloration yet attainable. (No. 5)

"Cogitations"

AEROCAT TRIPLE A*, High Alumina Catalyst has proved its value in fluid cracking for the petroleum industry. It maintains 15-25% higher equilibrium activity than regular 13% alumina catalyst and permits greater freedom of operation, excellent selectivity, and lower stack losses. (No. 6)

Increasing speeds in papermaking processes tend to accentuate two-sidedness in the finished paper. Differences in color, structure and surface characteristics on the two sides are the most usual effects of two-sidedness. The possibility of two-sidedness always exists because paper is made from a dilute pulp poured on a wire screen followed by drainage of water through the wire. The fines in fibers, fillers and additives tend to be washed out of the bottom or wire side of the paper more than from the top or the felt side. A laboratory method has been developed to produce two-sidedness accurately in sample papers. The method has been used to develop color formulations which give minimum two-sidedness on mill-run sheet. Complete details are available in Technical Bulletin No. 827 of Cyanamid's Organic Chemicals Division. (No. 7)

Wood waste can be converted to hardboard at low temperature cure and short cure cycle with new aminoplastic resins PDL-1-1969 and PDL-1-1970, which give high strength and do not discolor. Hardboard is suitable for structural or furniture applications. (No. 8)

Architectural white enamels made with CYCOPOL® 340-18 copolymer resin stay white longer and retain high gloss even under high humidity conditions. This new CYCOPOL resin has infinite solubility in aliphatic hydrocarbons and promotes excellent flow in enamels. (No. 9)

Relieve edema with DIAMOX® acetazoleamide *Lederle*, the new oral diuretic and acid-base regulator, which inhibits the enzyme carbonic anhydrase, and reduces acidification of the urine. Oral administration of DIAMOX is easier than injection of mercurial diuretics. DIAMOX, a prescription drug, is particularly effective in congestive heart disease. (No. 10)

More information on any of the products mentioned in these pages is available on request. Write to "Chemical Newsfront," American Cyanamid Company, 30 Rockefeller Plaza, New York 20, N. Y., or use the coupon below—simply checking the items on which you wish additional information.

*Trade-mark

AMERICAN Cyanamid COMPANY
30 ROCKEFELLER PLAZA
NEW YORK 20, NEW YORK

SEND more information on the following items mentioned in the February, 1955 issue of LIFE on the Chemical Newsfront:

S. A.

No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.
Literature ☐ Prices ☐ Sample ☐ of_____

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

THE AUTHORS

BERNARD and JUDITH MAUSNER ("A Study of the Anti-Scientific Attitude") are, respectively, a social psychologist and a physician—also husband and wife. The study they report here was made during the past two years while they lived near Northampton and Bernard was assistant professor of psychology at the University of Massachusetts. He has just transferred to the Psychological Service of Pittsburgh as research psychologist. Bernard was born in New York City and has three degrees from Columbia University, including a Ph.D. Judith, also born and educated in New York, has an M.D. from New York Medical College and has worked at Beth Israel and Bellevue Hospitals. The Mausners collaborate professionally and in their hobbies, which include playing chamber music (cello and piano) and bird watching.

WALTER ORR ROBERTS ("Corpuscles from the Sun") is director of the Colorado High Altitude Observatory. He was one of the men who set up the coronagraphic station at the Observatory, arriving there in 1940 "with the coronagraph, a wife and a broken-down car." He writes: "I started out in astronomy as an amateur telescope maker, one of the many followers of the Ingalls column. As a boy I used to make the pilgrimage to Stellafane, the telescope makers' Vermont rendezvous. And under the tutelage of an enthusiastic older amateur in Brockton, Mass., I made a six-inch Pyrex reflector of Newtonian design in my high-school days." At Amherst College and later as a graduate student at Harvard University Roberts strayed into physics and physical chemistry. In 1939 he decided to be an astronomer: "I came in touch with Donald H. Menzel and astrophysics, and was so taken with it that I gave up plans to work in physical chemistry and went hard to work on the coronagraphic project which Menzel was preparing for Climax, Col." Roberts is a 10-minutes-a-day violinist.

DONALD A. GLASER ("The Bubble Chamber") is assistant professor of physics at the University of Michigan. Born in Cleveland in 1926, he went to the Case Institute of Technology with the idea of becoming a mechanical engineer. After six weeks he decided against engineering and turned to

Can you plan your company's future position?

A characteristic ingredient of every product of the Consolidated Engineering group is Progress. Here's one example . . .

Not too many years ago, crude oil yielded only a few different grades of gasoline, several lubricating oils and some greases. Today, the petroleum industry makes hundreds of profitable products, from aviation fuels to chemicals and plastics, that are changing everyday life.

One of Consolidated's major products, the commercial mass spectrometer, appeared at the time when the petroleum and natural gas industries were ripe for expansion and modernization. By changing a laboratory curiosity into a practical industrial tool, Consolidated helped in no small measure to bring about the revolution in oil and gas technology. Through faster and more accurate product analyses, the mass spectrometer provided a new method for pin-pointing a company's financial and competitive position, aided in planning new and more profitable processes. The entire oil industry *progressed* . . . to an entirely new level of growth, prosperity and technical achievement.

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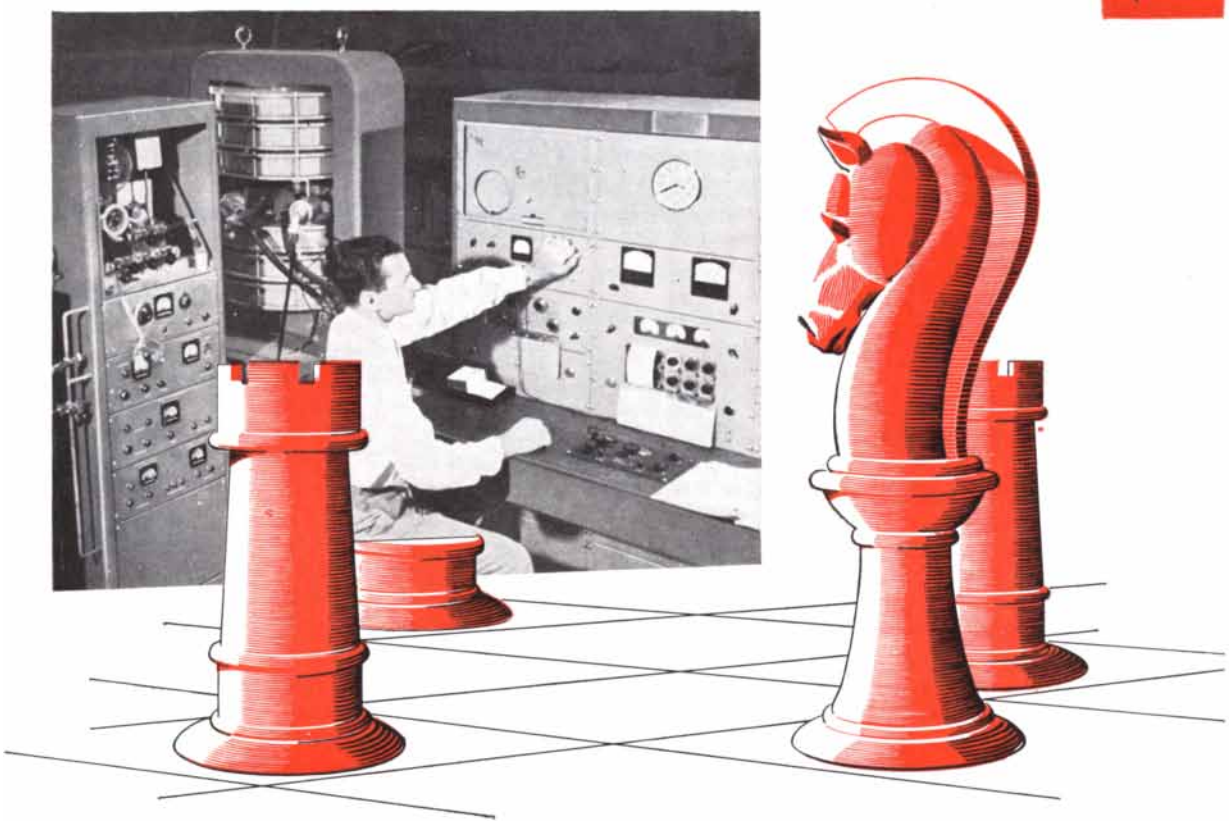

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physics. He went to do his graduate work at the California Institute of Technology under Carl D. Anderson, and for his Ph.D. thesis investigated high-energy cosmic rays. Glaser claims that the encouragement to try his bubble-chamber idea, which he had already been mulling over, came one night during a beer session with some physicist friends: "After several pitchers of beer we began to wax philosophical about physics. One of the boys, looking dreamily into the pitcher of beer before him, saw the usual streamers of bubbles and remarked, 'Nuclear physics should be easy. You can see tracks in nearly everything.' Just for fun I actually exposed some beer to gamma rays the next day in the laboratory. Nothing happened." But as he explains in his article, he went on to more serious tests which succeeded. Like several other authors in this issue, Glaser is a devotee of chamber music. While in high school he was a violist in the Cleveland Philharmonic Orchestra, and he still joins friends in quartets.

GEORGE W. GRAY ("The Yerkes Laboratories"), a member of the staff of the Rockefeller Foundation, is a frequent contributor of articles to SCIENTIFIC AMERICAN; the most recent was "Human Growth" in the issue of October, 1953.

LEONID HURWICZ ("Game Theory and Decisions") is a professor of economics and mathematics at the University of Minnesota. Born in Moscow of a Polish family, he took a degree in law at the University of Warsaw in 1938. He came to the U. S. in 1940 and has been associated with the Cowles Commission for Research in Economics, off and on, since 1941. In 1945-1946 he held a Guggenheim fellowship. In 1948 Hurwicz assisted the Economic Commission for Europe, which surveyed the postwar economic prospects of the Continent for the United Nations. He has worked on economic applications of the new theory of games, which, he believes, has already made itself useful by giving economists mathematical models for problems of resource allocation.

FRANKLIN C. McLEAN ("Bone") is emeritus professor of pathological physiology at the University of Chicago. He was born in Maroa, Ill., in 1888, went to the University of Chicago and took his M.D. at Rush Medical College in 1910. His career has been varied: he was a professor of medicine at Peiping Union Medical College in China, a lieu-

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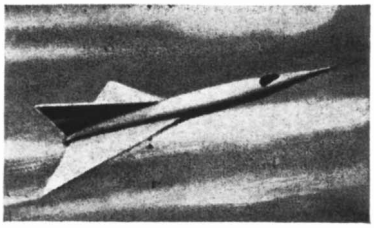

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tenant colonel in the Chemical Warfare Service and has written 148 research papers on various subjects. In the foreword to his forthcoming book, *Bone*, he notes that his interest in calcium goes back 20 years to researches with A. Baird Hastings, now at the Harvard Medical School, on calcium in the blood. "Following this, I began an exploration of the blood-bone relationship, and shortly thereafter, in collaboration with William Bloom, this led to a conscious effort to bridge some of the gaps between the chemical and morphological approaches to an understanding of bone. Our interests then broadened, until it became apparent that we were concerned with every aspect of the physiology and biochemistry of bone." McLean has given much of his spare time to helping Negroes to enter medicine, especially through the National Medical Fellowships, Inc., of which he is secretary-treasurer. In 1953 the Chicago Commission on Human Relations cited him as having "given 25 years of devoted effort to improving medical care for Negroes, breaking down barriers to their training in medical colleges and advancing them in the medical profession."

EDWARD E. DAVID, JR. ("Ears for Computers"), is a supervisor on the staff of the Bell Telephone Laboratories. Born in North Carolina, he studied electrical engineering at Georgia Institute of Technology, served on an aircraft carrier during World War II, then went to the Massachusetts Institute of Technology for graduate work on microwaves and noise theory, receiving his doctorate in 1950. At the Bell Laboratories he has been concerned mainly with underwater sound; he has also supervised research on some aspects of speech communication. He was recently selected by the Eta Kappa Nu honor society as one of the "Outstanding Young Electrical Engineers" of 1954.

VICTOR A. GREULACH ("Plant Movements") is a professor of botany at the University of North Carolina. An Ohioan, he has a Ph.D. in botany from Ohio State University. Between 1940 and 1949 he was on the faculty of the Texas Agricultural and Mechanical College; during some of these years he was also associated with the Houston Museum of Natural History. Greulach's chief field of research is plant growth, especially the effects of growth inhibitors. He wrote an article entitled "The Rise of Water in Plants" for SCIENTIFIC AMERICAN in October, 1952.

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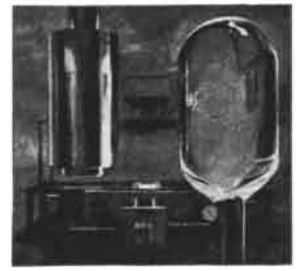

THE COVER

The painting on the cover depicts a bubble chamber, a new device of physics which makes the tracks of subatomic particles visible (*see page 46*). On the right side of the painting is a small glass bubble chamber. The large cylinder at the left is a source of penetrating radiation. Here the radiation has caused a nuclear explosion in the chamber, leaving two tracks of bubbles. In the background is a bubble chamber of advanced design.

THE ILLUSTRATIONS

Cover painting by Stanley Meltzoff

Page	Source
36-37	Sara Love
38-39	Bernarda Bryson
40	Yerkes Observatory
41	James H. Godsey, Jr.
42-43	Yerkes Observatory (*top left*), Mount Wilson and Palomar Observatories (*top right*), Colorado High Altitude Observatory (*bottom*)
44-45	Eric Mose
46	University of California
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76	Keith Hayes
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84	James Egleson
85	University of Chicago (*top*), R. A. Robinson (*bottom*)
86	University of Chicago
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100-101	John Langley Howard
102-104	William J. Koch
106	Otto Stuhlman, Jr.
109	New York Public Library
121	Joseph F. Burke
122-124	Roger Hayward

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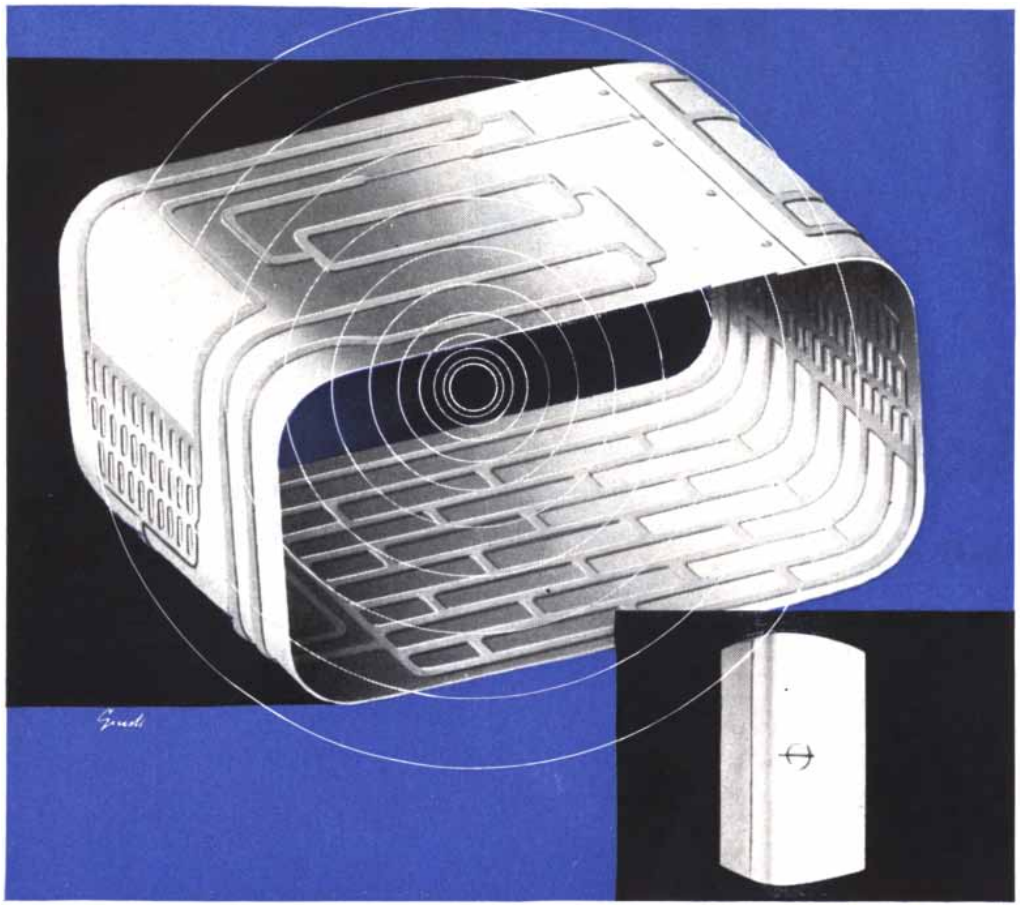
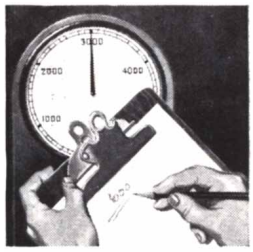


Complete Flexibility. Any pattern of tubing—any manufacturing design that can be drawn on paper — can now be produced simply and easily *inside* perfectly bonded metal sheets. Dimensions of tubing can be fixed as desired.



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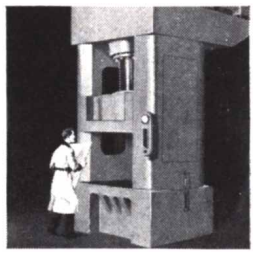

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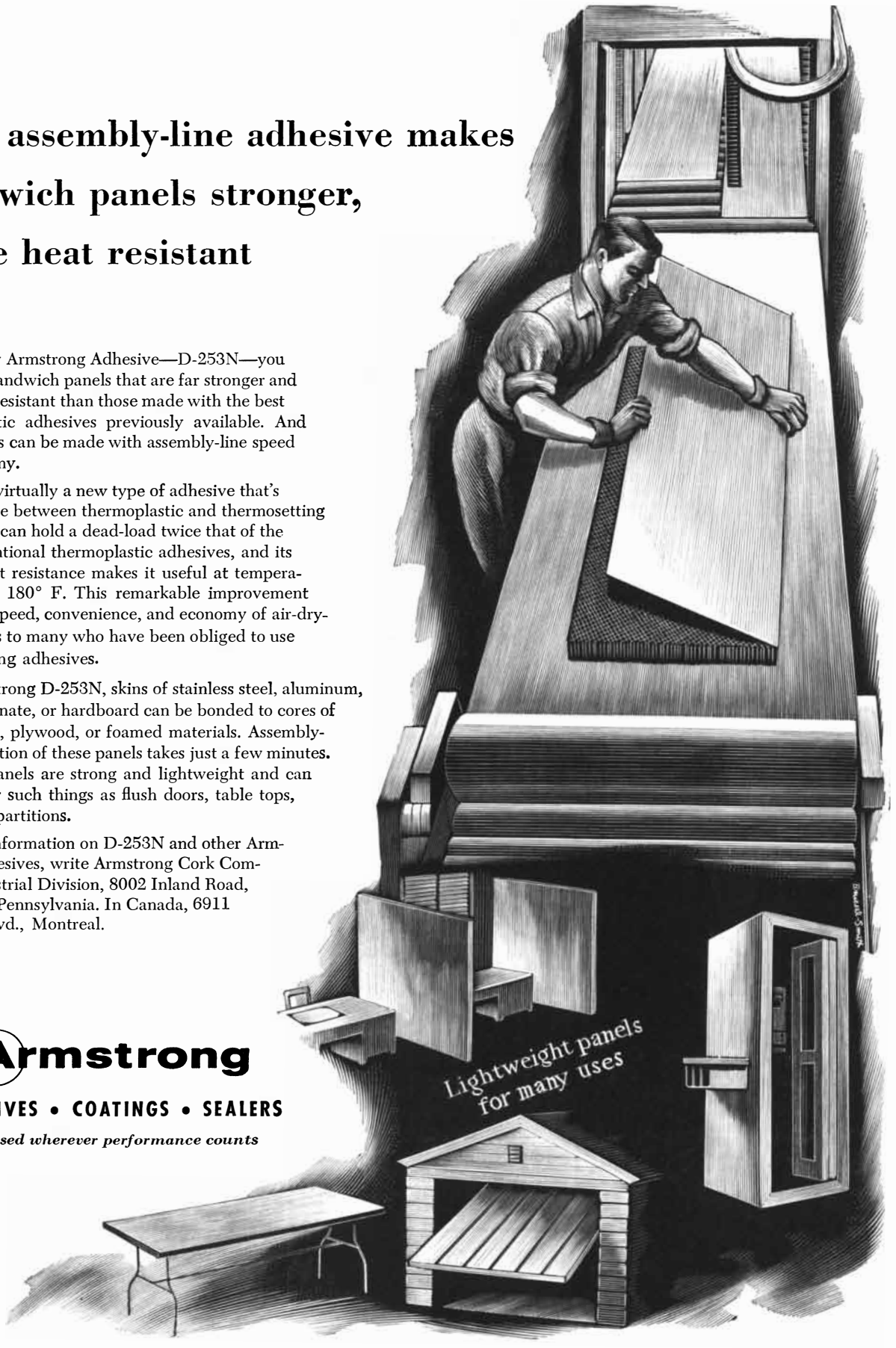

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SCIENTIFIC AMERICAN

FEBRUARY, 1955 VOL. 192, NO. 2

A Study of the Anti-Scientific Attitude

It has been clearly demonstrated that fluoridation tends to prevent tooth decay and does no harm. Then why are many people violently against it? How the question was investigated in Northampton, Mass.

by Bernard and Judith Mausner

Many people, particularly scientists, believe that we are suffering in the U. S. from a national epidemic of irrationality—what Senator J. W. Fulbright of Arkansas has called the "swinish blight of anti-intellectualism." The current outbreak has expressed itself in many manifestations, but they are reducible to two well-recognized symptoms: a deep distrust of "intellectuals" and rejection of ideas or discoveries that conflict with entrenched beliefs. Can we do anything more than name the disease and describe its symptoms? It would be helpful to have more data on the causes of the malady and possible methods of combatting it. This article will report the results of a case study which may offer some light. The place of the study was the town of Northampton, Mass., and the occasion was a dispute over fluoridation of the town's water supply.

Fluoridation is an excellent example of the careful application of scientific knowledge to a problem. As David B. Ast, director of the Bureau of Dental Health in the New York State Department of Public Health, has said, no other public health measure has ever been so thoroughly studied and tested before it was introduced. Ever since 1908 it has been observed that people living in regions where fluorides occur naturally in the water have a remarkably low incidence of tooth decay. In 1945 controlled studies of artificial fluoridation of the water supply were started in three communities: Grand Rapids, Mich., Newburgh, N. Y., and Brantford, Ontario. The nine-year results of these tests, plus many others, have convinced the scientists who have investigated the matter that artificial fluoridation can greatly reduce dental caries among children who drink the water during their teeth-building period and that the procedure is perfectly safe. Fluoridation has been recommended by an impressive list of scientific organizations, including the American Medical Association, the American Dental Association, the National Research Council and the U. S. Public Health Service. And more than 1,000 communities in the U. S., with a total population of more than 17 million, have adopted it so far.

However, from the beginning there has been opposition. The opponents, mostly laymen but also including a few scientists, have formed two national organizations—the National Pure Water Association and the National Committee against Fluoridation—and many local committees to fight adoption of the idea. The issue has twice been argued before committees of Congress. In 57 out of 104 communities where the question has been voted on by the electorate, the opponents have defeated fluoridation.

A content analysis of the anti-fluoridation argument shows that it has three main themes: (1) fluoridation is an experiment which has not proved its value and may hold unknown dangers; (2) fluorides are poisons; (3) treatment by public agencies of the water that everyone must drink is a step in the direction of socialized medicine and an invasion of individual rights.

As for the first of these objections, public health and dental authorities believe that the effectiveness of fluoridation has been so well proved that it need no longer be considered an experiment; objections that the case has not been proved, they feel, betray a lack of understanding of epidemiological research. Many people find it difficult to accept conclusions based on statistical analysis rather than on laboratory or clinical "proofs." The most careful evaluation to date of the supposed dangers of fluoridation, carried out by a committee of the St. Louis Medical Society, found no good evidence that it is dangerous. Populations who have been drinking fluoride-containing water for some time show no unusual death rate or incidence of degenerative disease, cancer or children's bone fractures—all dangers mentioned by the opponents.

The poison theme is based on a failure to appreciate that a substance may be safe or even beneficial in small doses

QUESTIONNAIRE ITEMS	AGREE		NO OPINION		DISAGREE	
	PRO	ANTI	PRO	ANTI	PRO	ANTI
SCIENTIFIC BODIES LIKE THE AMERICAN DENTAL ASSOCIATION AND THE U. S. PUBLIC HEALTH SERVICE ARE THE BEST SOURCES FOR FACTS ABOUT FLUORIDATION.	92	50	6	15	2	35
A GOOD REASON FOR OPPOSING FLUORIDATION IS THAT IT INFRINGES ON INDIVIDUAL RIGHTS.	25	79	12	7	63	14
FLUORIDATION IS *NOT* A STEP TOWARD SOCIALIZED MEDICINE.	65	39	7	19	28	42
DENTISTS WILL PROFIT FROM FLUORIDATION BECAUSE IT MOTTLES (DISCOLORS) THE TEETH.	9	23	18	43	73	34
SINCE FLUORINE IS ONLY BENEFICIAL TO CHILDREN, EVERYBODY SHOULD NOT BE FORCED TO DRINK IT.	25	85	12	6	63	9
FLUORIDATION HAS BEEN A SUCCESS WHEREVER IT HAS BEEN TRIED.	45	6	49	37	6	57
CHEMICAL INDUSTRY IS FOR FLUORIDATION EVEN THOUGH IT MAY BE DANGEROUS BECAUSE THEY WILL BE ABLE TO PROFIT FROM SELLING THEIR FLUORIDE WASTES.	10	52	24	25	66	23
VOTING ON FLUORIDATION IS AS SENSIBLE AS VOTING ON THE USE OF PENICILLIN IN TREATING DISEASE.	61	39	16	16	23	45
PEOPLE SHOULD NOT BE FORCED TO DRINK SOMETHING WITHOUT THEIR CONSENT.	65	93	10	3	25	4
THE BENEFITS OF FLUORINE COULD *NOT* BE OBTAINED BY HAVING DENTISTS GIVE IT DIRECTLY TO CHILDREN IN THE SCHOOLS.	36	21	32	34	32	45
THE WATER COMMISSIONERS WERE TAKING ADVANTAGE OF THEIR POSITION IN STARTING FLUORIDATION WITHOUT CONSULTING THE PUBLIC.	31	81	9	6	60	13

INTERVIEWS of the Northampton study were based on these 11 statements. The 397 people interviewed a week before the fluoridation vote were asked (1) to give their opinion of each statement and (2) to indicate whether they intended to vote for or against fluoridation. The responses of the pro- and anti-fluoridation groups are separated at the right in per cent.

though it is toxic in large amounts. Opponents of fluoridation have pointed out that sodium fluoride is a rat poison and fluorine is a component of deadly "nerve gases." This theme has inspired some bizarre, irrational fears. It has been suggested that in the event of war saboteurs could poison our water by dumping large quantities of fluoride into the reservoirs from the fluoridation apparatus. Actually it would be hard to imagine a more cumbersome method for sabotaging water supplies. Enormous amounts of fluoride, more than is ever normally stored at a water-treatment station, would be required to produce a concentration high enough even to mottle the teeth. Despite these sober facts, the lurid picture of a saboteur poisoning the entire population by pulling a switch has apparently been easy to evoke. One anti-fluoridation pamphlet has suggested that fluoridation is a part of a subtle conspiracy on the part of our enemies to "paralyze, demoralize and destroy our great republic from within" by undermining us with a nerve poison in the water.

The third argument, that fluoridation is an invasion of individual rights, raises a complex issue. In innumerable public statements the opponents of fluoridation have called it compulsory mass medication. However, so are compulsory smallpox vaccination and many other modern public health measures. The proponents of fluoridation consider that the invasion of individual rights involved in compelling everyone in a community to drink fluoridated water is minor when weighed against the incalculable benefits to our next generation from the reduction of dental disease.

There has been a host of other objections to fluoridation: its cost (about 10 cents per person per year), the allegation that it makes water taste foul (in the small amounts used the fluorides are actually tasteless), the complaint that it kills goldfish and makes dogs and cats ill (actually there is no evidence of harm to animals). The power of suggestion has been vividly demonstrated on several occasions. For instance, in New York's Westchester County and two or three other localities the announcement that the water would be fluoridated was followed by a flood of complaints of bad-tasting water, sudden aches and pains, and dead goldfish and dogs—even before any fluoride was put into the water! A witness before a Congressional committee declared that he had fainted from drinking two cups of coffee made from fluoridated water.

In short, the objections to fluoridation, however unrealistic or unfounded, have deep psychological roots. To what extent does the general public share the fears and attitudes of those who have campaigned against fluoridation? It was this aspect that we set out to investigate in Northampton, where the issue came to a referendum. Before the election we (Allan Leavitt, Sidney Robbins and Bernard Mausner) surveyed the attitudes of leaders of the community and a representative sample of the city's population.

The fluoridation controversy in Northampton had followed a typical course. A local committee of the Dental Society had recommended fluoridation after an investigation of its merits made at the mayor's request, and the City Council had then held hearings, voted approval of the step and appropriated money to carry it out.

Opponents of fluoridation continued to argue against the practice, and the foremost objector, a professional chemist, actually installed a still in his home to prepare fluoride-free water. He was elected mayor some months later, and on taking office attempted to halt appro-

priations for fluoridation. An *ad hoc* anti-fluoridation committee obtained the signatures of more than 10 per cent of the town's voters on a petition demanding that fluoridation be stopped. A local judge issued an injunction against it. The injunction was loosely worded; it banned the addition of all chemicals to the water. The water commissioners therefore halted chlorination as well as fluoridation, and one melodramatic evening issued a radio appeal to the public to boil drinking water. This literal interpretation of the injunction was greatly resented by the public. The injunction was eventually voided, but by that time opponents of fluoridation had succeeded in having a referendum on the subject placed on the ballot for the following November.

The pro-fluoridation leaders, mainly dentists, felt that the weight of scientific evidence and authority was so strong that they did not need to campaign intensively; moreover, they were justifiably unwilling to make enemies in the town. The anti-fluoridation forces, on the other hand, continued vigorous activity. They kept up an active telephone and letter-writing campaign. The night before the election the local newspaper carried two advertisements. One, signed by a majority of the dentists and physicians in town, soberly explained the virtues of fluoridation and urged its adoption. The other, sponsored by "The Northampton Non-Political Anti-Fluoridation Committee," was couched in these terms:

"DO YOU KNOW THAT—

". . . Fluoridation is mass medication regardless of the needs or wishes of the people. . . .

"Fluoride is a poisonous waste from aluminum manufacture. It is dangerous and costly to dispose of. . . .

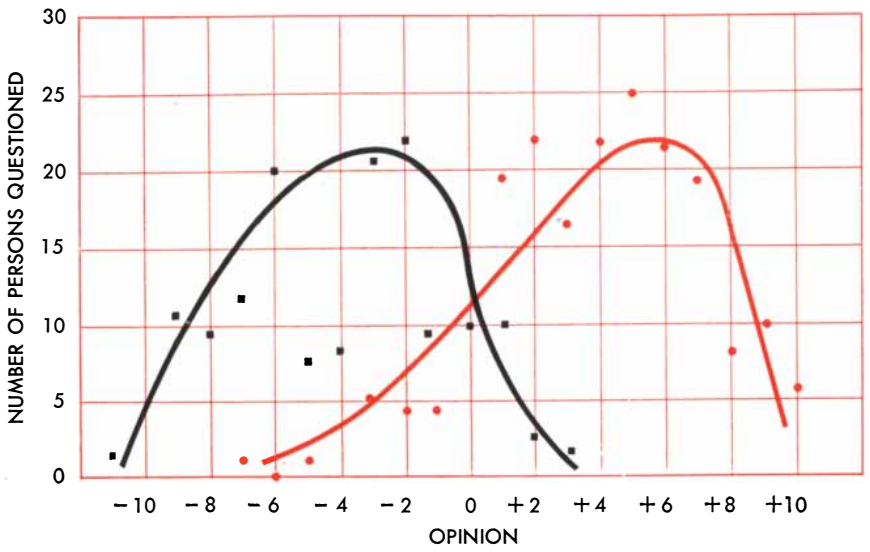
"Fluorine is a powerful poison that gradually deprives the body of calcium whether children or adults, with ill effects on organs as well as bones. . . .

"Fluoridation could play into the hands of our enemies. America is too big to be conquered by invasion, but with fluoridation machines at the reservoirs, the population in important centers could easily be wiped out or made non-resistant. . . .

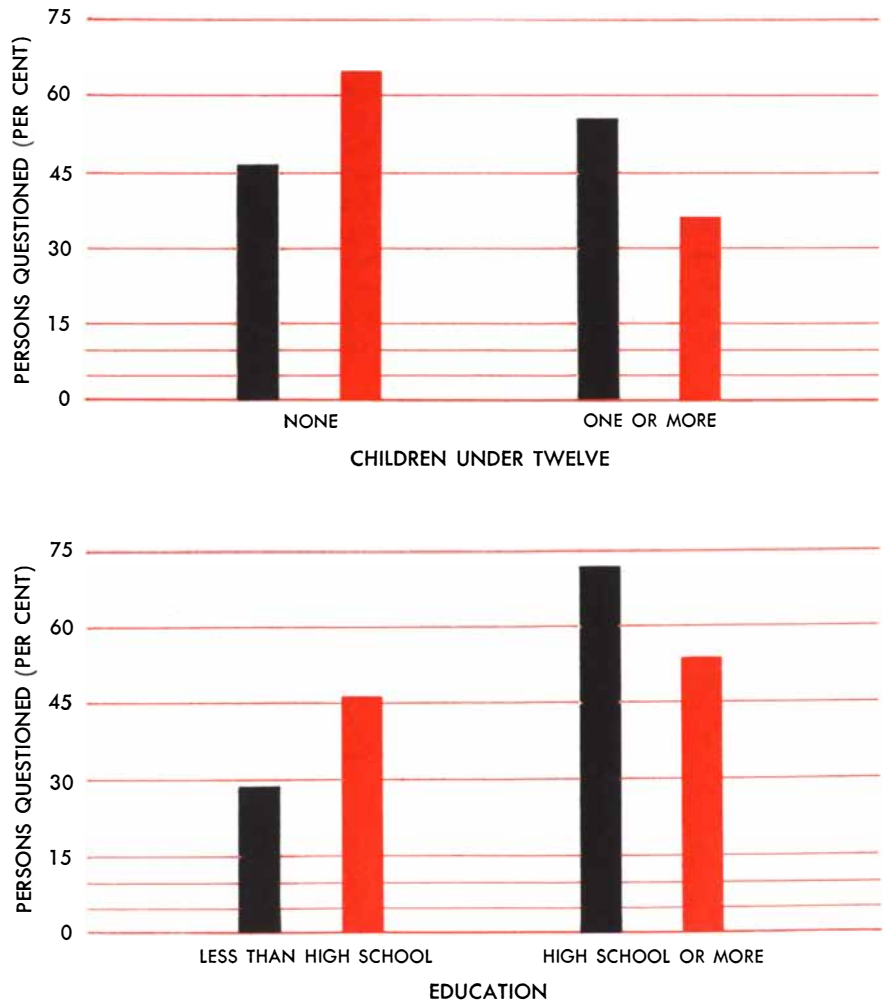
"J. Edgar Hoover, head of the FBI, has warned the public to be on guard against any attempts at poisoning of public water supplies. (AP Dispatch, Feb. 27, 1951.)

"THINK THIS OVER.

"LET US KEEP NORTHAMPTON'S WATER PURE AND NORTHAMPTON SAFE! VOTE 'NO'



ATTITUDE toward fluoridation was derived from opinions expressed during the interview. Scores in the minus direction indicate pro-fluoridation opinions; those in the plus direction, anti-fluoridation opinions. The scores of those who expressed their intention of voting for fluoridation are in black; the scores of those who expressed their intention of voting against it, in color. This demonstrates that opinions were consonant with voting intentions.



OTHER ELEMENTS were also correlated with voting intention. In both of these bar charts the percentage of people who expressed their intention of voting for fluoridation is in black; the percentage of people who expressed their intention of voting against it, in color.

ON THE FLUORIDATION REFERENDUM ON NOVEMBER 3, 1953."

Fluoridation was defeated by a vote of two to one.

In our opinion survey, made during the week before the election, we interviewed a sample of 397 potential voters, selected on a quota basis to give accurate representation of the sexes and age and occupational groups in the town. That our sample was indeed representative was proved by later tests.

The persons interviewed were asked their opinions on pro- and anti-fluoridation statements representing the major themes in the controversy; on each item the respondent was asked to express his opinion on a five-point scale: agree strongly, agree, no opinion, disagree, disagree strongly. He was also requested, at the end of the interview, to indicate how he expected to vote.

The questionnaire was designed to answer two questions: first, how pro- and anti-fluoridation attitudes were distributed in the population; second, what role each theme played in determining how people would vote.

Who were against fluoridation? They were predominantly people of the older age groups, people without children under 12, people of the lower income brackets and middle- or lower-class occupations. Support for fluoridation came mainly from the younger groups and those in professional, managerial and other white-collar occupations. One of the most striking differences was in education. A large proportion of the anti-fluoridation voters had failed to finish high school. Among high-school and college graduates, the majority favored fluoridation. Yet there was a large number of graduates, even some with post-graduate education, who accepted the anti-fluoridation arguments.

Thus the demographic factors show two independent trends: (1) the younger people are more likely to be for fluoridation than older ones, probably in part because they are more likely to have children under 12, and (2) the people of higher education, occupations and incomes are more likely to be for it than those of lower social status.

The pro and anti groups were significantly different in their responses to specific arguments or statements about fluoridation. The disagreement between them was especially clear-cut on the question whether fluoridation had been a success wherever tried. The anti voters overwhelmingly refused to accept reports of its success or to accept scientific organizations as the best authorities on fluoridation. Many of them felt that public health officials, dentists and the chemical industry were in a conspiracy to impose the measure on the public; they agreed with the statements that "dentists will profit from fluoridation because it mottles the teeth" and that the "chemical industry is for fluoridation, even though it may be dangerous, because they will profit from it."

The questionnaire is discussed

The question concerning acceptance or rejection of scientific authority is what especially interests us here. Almost 95 per cent of those approving fluoridation accepted scientific organizations as reliable sources of information on the subject. Among the anti voters those with little education tended to reject scientific authority. However, in the anti group two thirds of those with better than high-school education professed to accept the authority of the scientific organizations. Their opposition to fluoridation suggests either a failure of communication from the scientists, which is unlikely in this well-educated group, or an unconscious rejection of these sources. The deciding factor may be not the specific content of education but rather the set of attitudes toward scientists developed during schooling.

The anti-fluoridation voters on the whole seemed to be more impressed by the few deviant scientists and professional people who opposed fluoridation than by the organized medical and scientific groups that favored it. Some, indeed, as we learned in a later survey, voted against it under the impression that "dentists and chemists say it . . . is bad for children's teeth." In any case, a layman, not being trained to evaluate authorities, generally must commit an act of faith in choosing among conflicting points of view. This suggests that a major function of education should be the establishment of criteria, if these can be defined, for weighing authorities.

We were struck by the pervasive attitude of suspicion among those who opposed fluoridation. They were suspicious not only of scientific organizations but of the scientists themselves. To them, as to all those who fear the "egghead," it seems perfectly reasonable to suppose both that scientists would lend themselves to a conspiracy with enemies of our country, and that, at the same time, they would permit themselves to be used by a giant monopoly. During the campaign in Northampton (as elsewhere) it was rumored that the American Dental Association and the U. S. Public Health Service had been subverted by the Aluminum Company of America; the Dental Association was said to have received large research grants from ALCOA as the price for favoring fluoridation. Thus even those opponents of fluoridation who did not see a saboteur lurking in every corner were able to invest it with an odor of conspiracy by claiming that fluoridation was being promoted for profit.

The fear of conspiracy, which has

Feelings ran high

been such an important component of the anti-fluoridation cause, is often strengthened by the manner in which fluoridation is introduced. Usually it is arranged primarily in conferences between local dentists or public health authorities and town officials and technicians; public hearings are often held, but they rarely achieve wide publicity. The anti-fluoridation forces often move into the battle with full vigor only after fluoridation has been started. It is hardly surprising that they are able to convince a large portion of the population that fluoridation has been "put over" on them. In Northampton, for instance, 82 per cent of the antis, and even 32 per cent of the pros, agreed with the statement that the water commissioners had taken advantage of their position to start fluoridation without consulting the public. This despite the fact that there had been public hearings and an appropriation by the town council before treatment of the water began. The same sequence of events apparently occurred in Williamstown, Mass., in Seattle and in Cincinnati. The Cincinnati case is especially interesting because one person, a radio announcer, succeeded in creating violent anti-fluoridation sentiment in a city in which fluoridation had been accepted without much debate.

The case of Mt. Clemens, Mich., offers a contrast. There the director of water purification, on deciding that fluoridation was a desirable procedure, brought into play the active cooperation of such groups as the Parent-Teachers Association, the District Health Service, the school health services and local U. S. Public Health Service officials. The climate of public opinion was carefully prepared. Speeches presenting the facts were made at a large number of public meetings. There were demonstrations of the virtues of fluoridation by the P.-T.A. in a local home exposition. When fluoridation was introduced, there was no opposition, and so far as we have been able to determine there has been no opposition since.

Undoubtedly for many of the 1,000 communities in which fluoridation is now a routine matter, such careful preparation was not necessary. This suggests an interesting research project: to compare communities which have erupted into a volcano of protest over fluoridation with those in which it was adopted with relatively little controversy.

Can scientists draw any lessons from the anti-fluoridation outbreaks? The strength of the opposition to fluoridation can be attributed to three important factors. Firstly, the anti-fluoridation arguments are understandable, easy to follow. Their weaknesses are often difficult for a layman to grasp. Secondly, these arguments are grounded in some of the most widely held ideas and emotions of our culture. In their appeal to respect for individual rights, to fear of poison, to a watchful conservation of public funds, they ring a bell for most people. Thirdly, they are clearly related to the *Zeitgeist*, the current suspicion of scientists, the fear of conspiracy, the tendency to perceive the world as menacing.

In contrast, the proponents of fluoridation have all too often ignored public psychology in presenting their case. They have relied too heavily on the fiat of organized science and have tended to dismiss opponents as "crackpots" and to deride their arguments. The greatest flaw has been the failure to prepare the public adequately. As a result there develops a polarization of attitudes which makes it very difficult to change opinion.

While it would be foolhardy to attempt generalizations about anti-intellectualism on the basis of this one phenomenon, our analysis of anti-fluoridation sentiment does suggest a pattern for the study of other manifestations. In examining any anti-intellectual movement we can ask what kinds of people participate in it, what fundamental motives and thought processes support it. If the fluoridation case is any indication, we shall find the motives understandable, if irrational. In our attempts to overcome anti-intellectual feelings we can try to avoid the errors of relying on prestige, of name-calling and of failing to reach people before issues become polarized. Unfortunately the pressure of events often makes this last step impossible. However, an attempt, at least, to understand anti-intellectualism and to meet it on its own ground should make it easier to defeat.

Corpuscles from the Sun

The connection between these solar particles and terrestrial effects such as magnetic storms and the aurora has long been known. But what is the mechanism that accounts for these effects in detail?

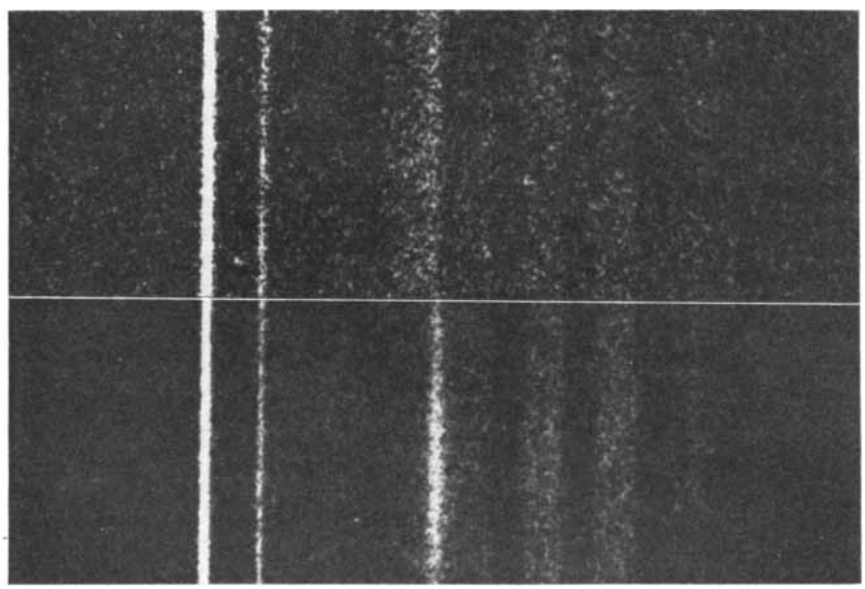
by Walter Orr Roberts

Between us and the sun, 93 million miles away, there is a daily traffic of radiation as familiar and predictable as yesterday's sun tan or tomorrow's sunrise. Less familiar, and much harder to explain, is the fact that across that vast distance the sun bombards us not only with light and heat but also with streams of particles of its own substance. Although we cannot see or feel them, they have astonishing effects upon the atmosphere of the earth. Bursts of corpuscles from the sun account for the spectacular aurora borealis—a phenomenon that has always entranced and mystified mankind. And they are responsible for the great magnetic storms in the atmosphere whose violence and dramatic effects were brought to light by the age of radio.

A magnetic storm is as impalpable as magnetism itself, yet it can be a vivid experience. The one that occurred on Easter Sunday, 1940, the most violent on record, is deeply impressed on my memory. As a graduate student at the Harvard College Observatory, I was stationed that evening at the Observatory's small telescopes in Cambridge. As twilight came on, I noticed that the sky was not darkening normally. Soon a brilliant aurora lit up the northern sky, extraordinarily bright even against the glow of the lights of Boston. Great plumes of light stretched like searchlights from the far north to the zenith; ribbons of light, some with a reddish hue, moved swiftly across the sky.

Meanwhile a magnetic storm swept over the world. Short-wave radio communication between Europe and the U. S. was cut off for many hours. Teletype machines all over the eastern U. S. began typing gibberish. Wirephoto networks broke down. The magnetic disturbance induced extra currents as high as 60 amperes in high-voltage power lines, blowing some major circuit fuses and plunging large areas into darkness. Twenty-two power companies reported serious interruptions of their transmission lines. At the dozens of geomagnetic measuring stations around the world, the needles measuring the earth's magnetic field behaved wildly.

The particle streams from the sun may have important effects on our weather. In 1953 a great corpuscular bombardment toward the end of August was followed by days of intensely hot weather in the eastern U. S. Geomagnetic records show that the dust-bowl period of the 1930s was also a period of magnetic storms very similar to those of 1953. Thus there is every reason to investigate these solar beams and to try to forecast their occurrence and their consequences.



SPECTRA made by Aden B. Meinel of the Yerkes Observatory demonstrate that neutral hydrogen atoms bombard the upper atmosphere during an aurora. The red line that is emitted by hydrogen atoms runs down the middle of both spectra. The spectrum at the bottom was made in the direction of the magnetic horizon; the spectrum at the top, in the direction of the magnetic zenith. The middle line at the bottom is due to hydrogen in the atmosphere. The corresponding line at the top is spread out toward the left, or violet, end of the spectrum. This indicates that the hydrogen atoms responsible for the top line are moving through the upper atmosphere toward the spectrograph at high speed.

The possibility that beams of electrified particles might be reaching the earth from the sun was first suspected a century ago. At 11 a.m. on September 1, 1859, Richard C. Carrington, an astronomer at the British Royal Observatory, noticed a brilliant eruption on the face of the sun—a phenomenon now known as a "flare." At the instant of the flare there was a sudden fluctuation in

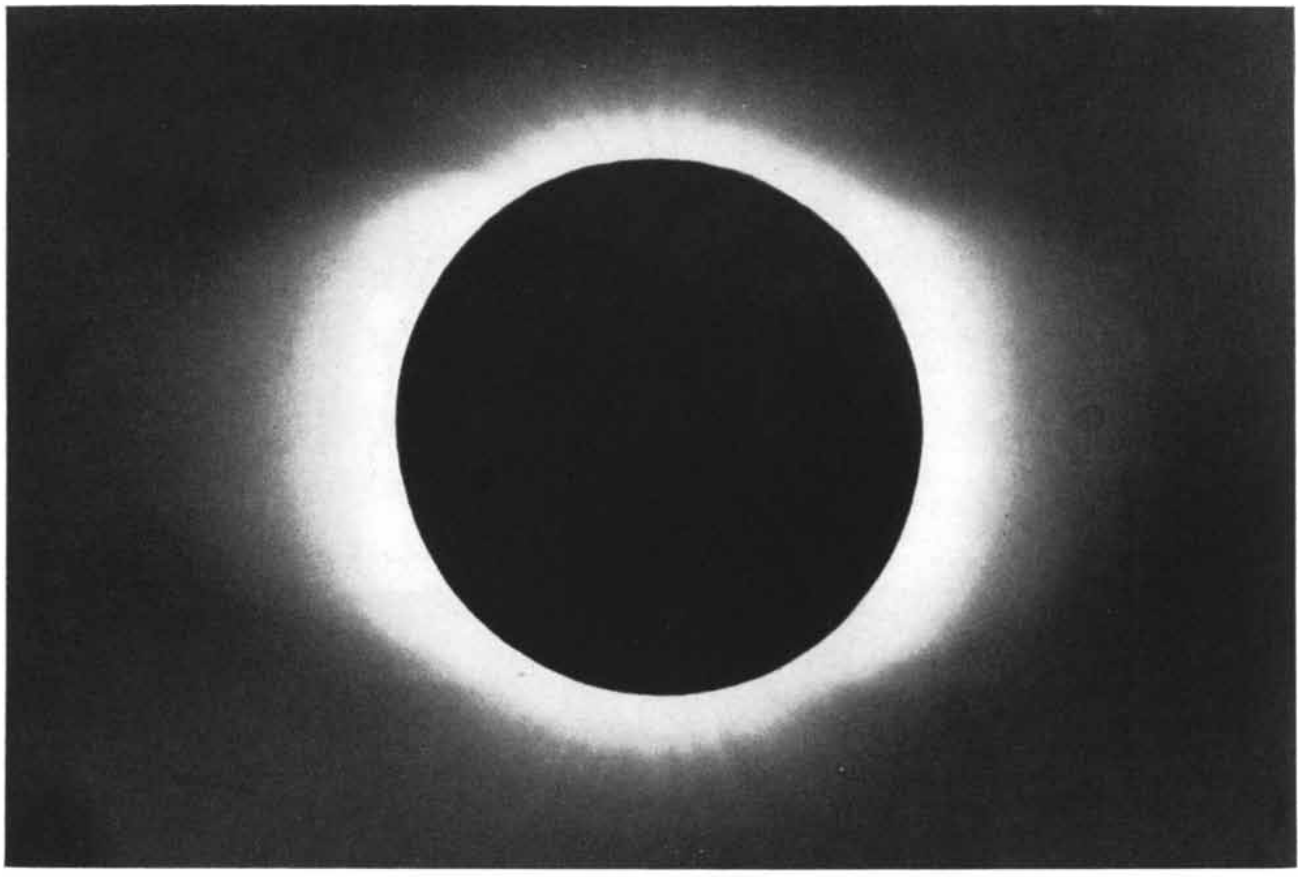
the strength of the earth's magnetic field. Then on the following two days a violent magnetic storm was recorded by instruments at the Kew Observatory. Balfour Stewart, its director, suggested that the magnetic disturbance on the earth was related to the sun's eruption, but the idea was so unbelievable that everyone except Stewart and Carrington dismissed the sequence of events as a coincidence.

In time, as more and more such coincidences were observed, geophysicists realized that the magnetic disturbances in the earth's atmosphere must indeed stem from the sun. The deflection of magnetic needles at the moment of the solar flare must be caused by intense ultraviolet radiation, and the later magnetic storm must be due to electrified particles which take a day or two to travel from the sun to the earth. Around the turn of the century various investigators recognized that the same streams of particles also must be responsible for the aurora.

Such particles of course would be funneled toward the poles by the earth's magnetic field, thus accounting for the "northern" and "southern" lights. But it still remained to be proved that clouds of electrified particles could actually stream from the sun to the earth. The first to offer a sound theory of how it might occur were Sydney Chapman and V. C. A. Ferraro of England. They suggested that during a flare the sun ejects a powerful stream of protons (hydrogen nuclei) and electrons. The ejected clouds of ions are, as a whole, neutral in charge, because they consist of roughly equal numbers of protons and electrons. They travel intact through space, and they plunge into the earth's upper atmosphere as great aggregates of particles. Their impact excites atoms in the atmosphere to luminescence and gives rise to the spectacle of the aurora. It also generates in the atmosphere powerful electric currents which produce the magnetic storms.

How the corpuscles travel through space is still in dispute. The Alfvén school of "magneto-hydrodynamicists," for instance, maintains that the Chapman-Ferraro theory is basically incorrect, and that the solar corpuscles, as well as cosmic rays, are accelerated by magnetic and electrical fields in space [see "Electricity in Space," by Hannes Alfvén; SCIENTIFIC AMERICAN, May, 1952]. In any case, the existence of the corpuscular visitors from the sun has now been verified by direct evidence: namely, by identification of neutral

AURORAS were photographed at Goose Bay in Labrador by Master Sergeant James H. Godsey, Jr., of the U. S. Air Force. All three photographs were made on the same street.

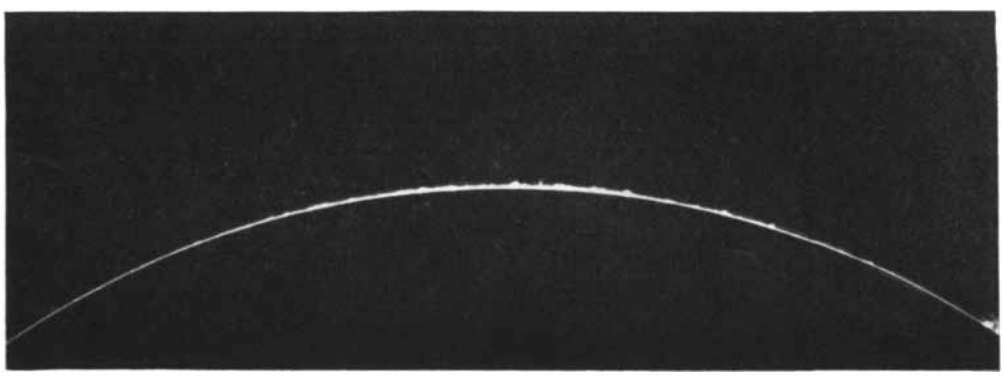


CORONA of the sun was photographed during the eclipse of June 30, 1954. The photograph was made at Mellen, Wis., by Kenneth L. Hallam and John Bahng of the Washburn Observatory. At top and bottom are "polar streamers"; at left and right, "equatorial plumes."

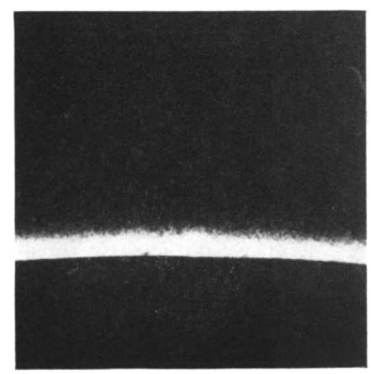
atoms of hydrogen in the spectrum of an aurora. The spectral lines of the hydrogen corpuscles are shifted greatly toward the violet, and this Doppler effect testifies to the high speed at which the corpuscles are traveling when they arrive in the earth's atmosphere.

What produces the beams of corpuscles from the sun in the first place? This has been the primary problem ever since they were discovered. Carrington observed that the great eruption he saw occurred near a large sunspot region. Sunspots, signaling some tremendous activity on the face of the sun, are an obvious place to look for the source of the corpuscular streams. The most violent magnetic storms and most brilliant auroras have generally come a day or so after a large sunspot crossed the center of the sun's disk. Astrophysicists were interested and dismayed to discover, however, that streams of corpuscles and the attendant magnetic storms frequently come when the face of the sun is innocent of spots and seemingly placid!

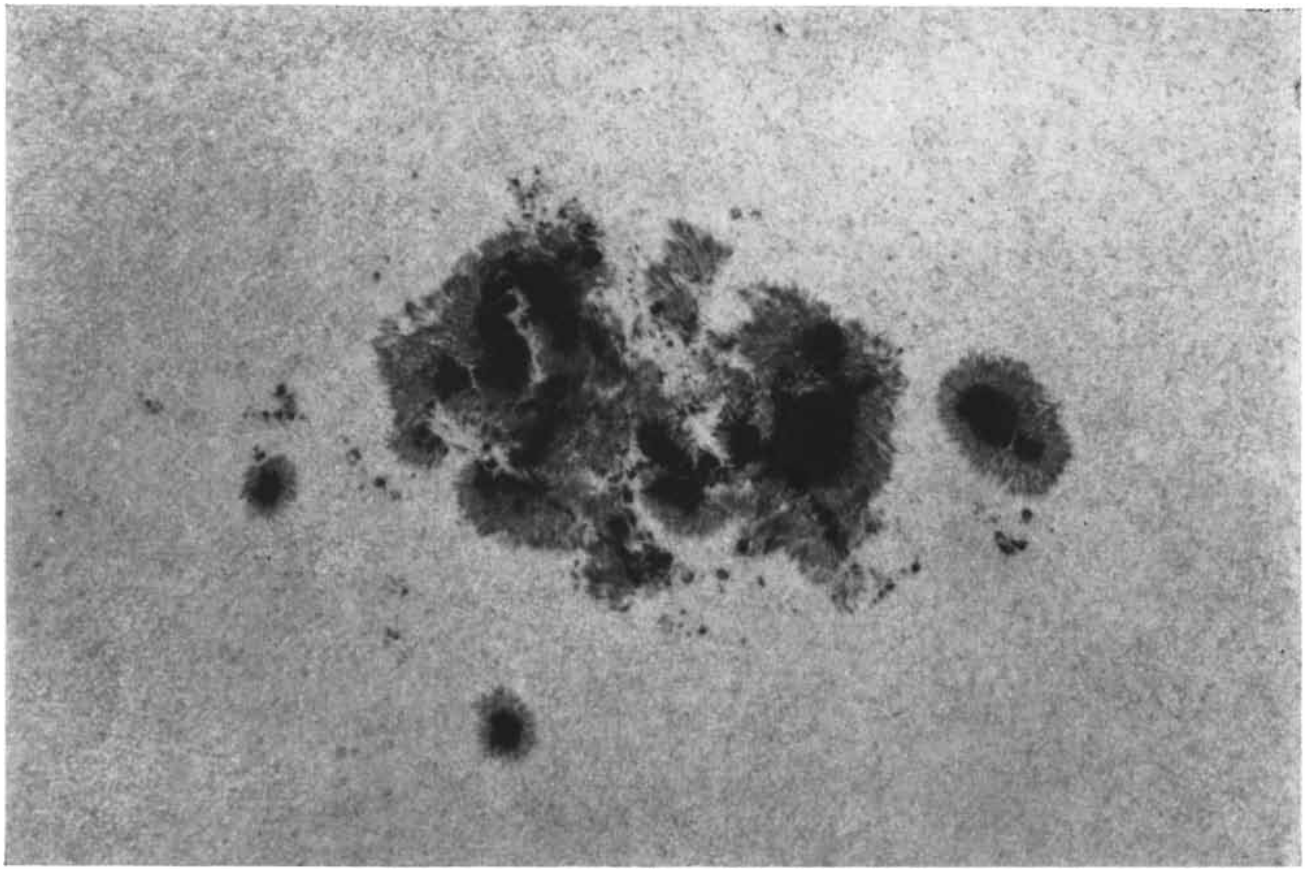
They eventually had to divide magnetic storms into two types: (1) the most violent ones, apparently stemming from sunspots, and (2) milder disturbances which come, as Julius Bartels of Germany first observed, at regular intervals of 27 days—just about the period of one complete rotation of the sun as we see it. The second type of storm lasts for days instead of hours. For a long time astronomers scanned the sun closely for some visible sign of the source of these dis-



SPICULES are small jets of luminous material that shoot out into the atmosphere of the sun. In this photograph the disk of the sun was blotted out by the coronagraph of the Colorado High Altitude Observatory.



SINGLE SPICULE was recorded by the coronagraph of the Colo-



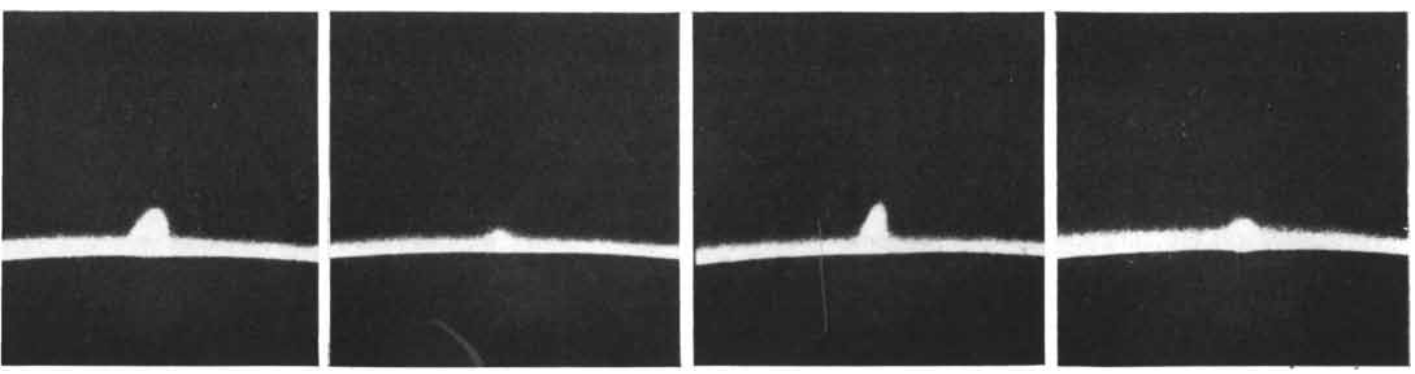
SUNSPOTS were photographed on May 17, 1951. This was an unusually large group of spots of the kind accompanied by terrestrial magnetic disturbances and auroras. The photograph was made with the 60-foot tower telescope of Mount Wilson Observatory.

turbances, but they found no clue that made sense. Sometimes the storms came when the sun's face was completely free of blemishes, sometimes just after spots had passed.

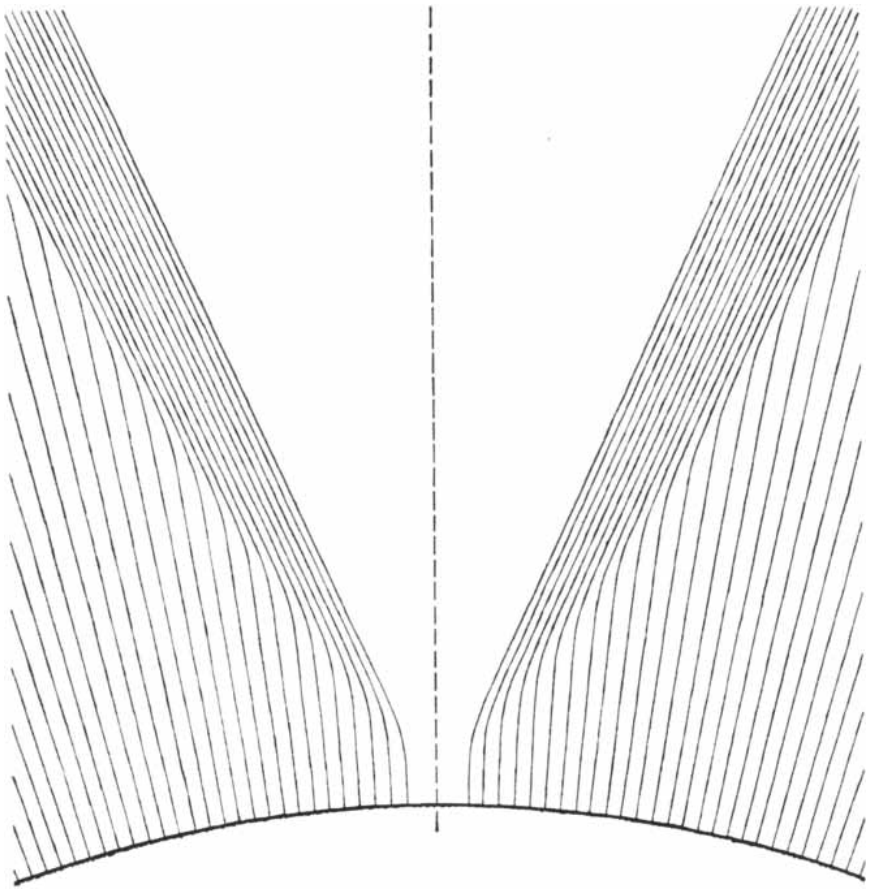
In 1944 C. W. Allen, an astronomer at the Commonwealth Solar Observatory in Australia, made a key discovery which showed how the pieces of the puzzle could be put together. But as is often the case in science, his clue to the solution came a little too early to be fully appreciated. Recently we at the Colorado High Altitude Observatory have taken up his suggestions and developed a tentative hypothesis which seems to give a consistent, plausible picture of the origins of both the periodic and the sunspot types of magnetic storms.

Allen's crucial discovery was that three days after a sunspot region crosses the center of the sun's face, magnetic storms of the periodic type often are suppressed. If the sunspot is small and inactive, there is likely to be a period of from one to five days when relatively few corpuscles arrive from the sun. It is as if a cone of space above the sunspot center has been swept clear of corpuscles; we have called it a "cone of avoidance." When the center of the cone passes over the earth, magnetic disturbance falls to a minimum; at its edges, the disturbance intensifies.

Allen concluded that sunspot regions in some way deflect corpuscular streams coming from undisturbed areas of the sun's surface. A sunspot area itself ejects a stream of corpuscles only when it is



rado High Altitude Observatory. The second photograph was made two minutes after the first; the third, five minutes; the fourth, seven minutes; the fifth, eleven minutes. The lifetime of this large spicule was 17 minutes. The average spicule lasts for four to five minutes.



CONE OF AVOIDANCE is depicted schematically. The arc at the bottom is the edge of the sun. In the middle of the arc is a sunspot. The magnetic field of the sunspot deflects the corpuscles streaming out of the sun so that they are concentrated at the edge of the cone.

large and active. When it does, the stream reaches the earth in one day and causes a violent magnetic storm. But the lesser streams from other parts of the sun's face, which are responsible for periodic storms, travel more slowly and take three days to reach the earth.

We have now added to Allen's picture some speculations based on his findings and on a discovery of our own concerning the probable source of the corpuscles responsible for the periodic storms. Some years ago, while making motion pictures of the edge of the sun with the coronagraph, which simulates an eclipse, I made some careful photographs of an edge which was almost completely free of the great tongues of eruption known as prominences. To my amazement, when I developed the film I found that the apparently smooth edge of the sun was studded with tiny, short-lived spikes of incandescent gas. These "spicules" play a part in our hypothesis.

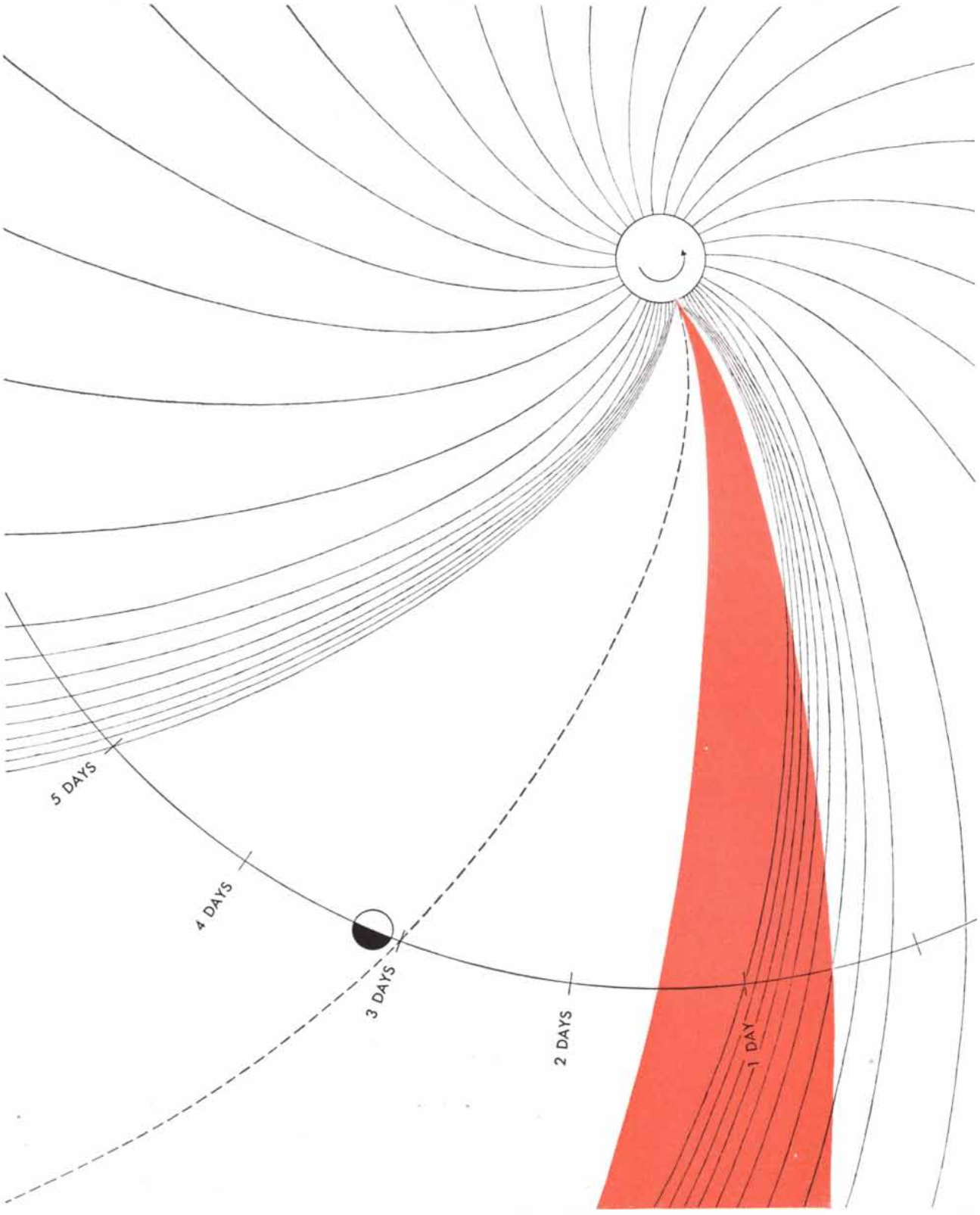
We suggest that the spicules, distributed all over the surface of the sun, shoot tiny jets of gas into the sun's atmosphere. The gas consists principally of hydrogen, dissociated into protons and electrons because of the high temperature. These particles, erupting from hundreds of thousands of jets, do not fly out in all directions but are focused and concentrated in streams by the weak general magnetic field of the sun's atmosphere. The corpuscles stream from the poles of the sun in diverging curves and escape, perhaps through their own kinetic energy, in the direction of the plane of the sun's equator. As they pass outward through the sun's atmosphere, their direction is influenced not only by the sun's general field but also by magnetic fields associated with sunspot regions. The clouds of ions are constrained to move parallel to the lines of force of these fields. As a result they fan out and leave the particle-free cones of avoidance that Allen observed. The fact that particles are concentrated at the edges of such cones is confirmed by the observation that the periodic type of magnetic storm on the earth intensifies just before and just after the lull that is believed to signalize the passing of the center of a cone of avoidance.

We postulate that the sunspot regions generate other streams of corpuscles quite separate from those originating from the spicules. The sunspot regions do not invariably produce such streams; some apparently are only weak generators of corpuscles. These cause no magnetic storm but merely shape the spicule streams around a cone of avoidance. Sunspot areas of the more active type, however, eject extremely powerful streams which fly straight out into space and apparently travel about two or three times as fast as the spicule particles; that is, at about three to four million miles per hour. Some of them may reach the velocities of cosmic rays.

Apparently even the most active sunspot regions are erratic in their production of corpuscular streams; at all events, they do not necessarily cause a magnetic storm each time they point toward the earth. On the other hand, the spicule streams focused toward the earth by local magnetic fields on the sun are more regular and persistent; such disturbances tend to repeat every 27 days or so as the sun makes a complete rotation and again turns toward the earth the zone from which the stream stems.

Our hypothesis is not the only possible explanation of all the observed facts. For example, K. O. Kiepenheuer of Germany has suggested that the sources of the corpuscles are not sunspots or spicules but certain hydrogen clouds in the sun's atmosphere known as "filaments." However, radio astronomy has recently yielded a discovery which strengthens our picture. The French astronomer J. F. Denisse and his German colleague Udo Becker have detected powerful emissions of radio energy coming from sunspot regions that produce violent magnetic storms, while little or no radio noise comes from spots associated with our cones of avoidance. The dense clouds of electrified particles that we have postulated as shooting forth from active sunspot regions might well produce strong radiations at radio wavelengths.

There are many investigations that may be made to test our hypothesis. Allen suggested that important information could be obtained if only it were possible to observe the sun's corona from day to day; he believes that the long white streamers in the corona are streams of corpuscles, and that if we could note when they point toward the earth, we could forecast magnetic storms. These streamers will be closely examined from now on, not only during lunar eclipses of the sun but also insofar as possible with the coronagraph.



HYPOTHESIS OF THE AUTHOR and his colleagues is also depicted. At the top is the sun, which rotates on its axis about once a month. At the bottom is the earth, which moves along its orbit in the same direction but much more slowly. The curved red area is a stream of high-energy corpuscles from a sunspot; they take about a day to reach the earth. The curved black lines are less energetic corpuscles from spicules that take about three days. The curved dotted line is the axis of the cone of avoidance. Thus over a period of five days the earth first moves through a region of normal corpuscular density, then is swept by the high-energy corpuscles, then by the low-energy corpuscles concentrated at the edge of the cone of avoidance, then by a region of subnormal corpuscular density and finally by the corpuscles concentrated at the other edge of the cone of avoidance. Actually the cone is usually observed only when a sunspot is inactive. All the corpuscles travel in straight lines, but the streams are curved by the rotation of the sun.

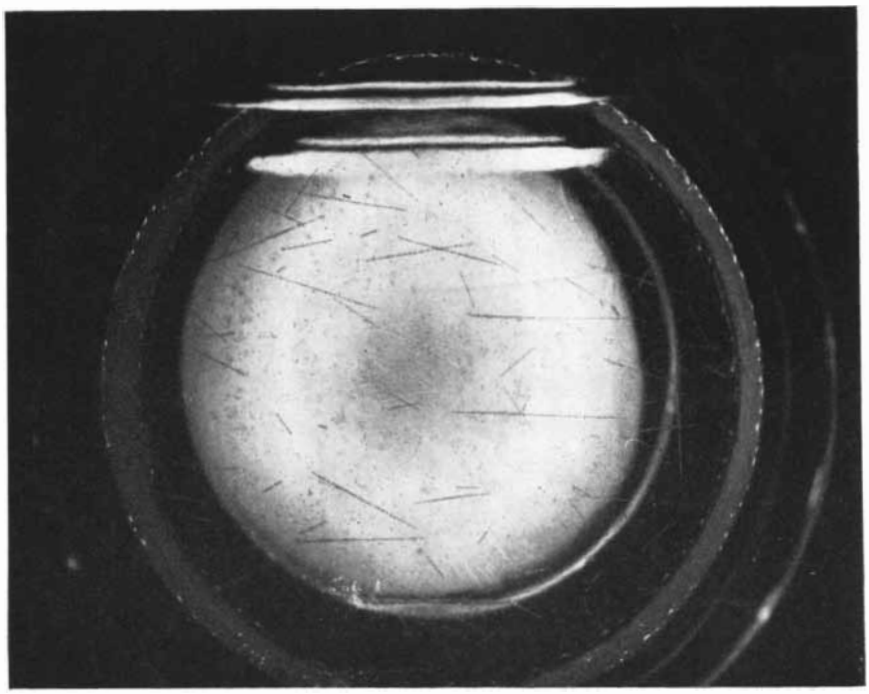
THE BUBBLE CHAMBER

The cloud chamber traces the path of a subatomic particle with droplets in a vapor. The new bubble chamber does the same with bubbles in a liquid. Therein lie certain advantages to physicists

by Donald A. Glaser

In their exploration of the submicroscopic world of atomic nuclei, physicists are like men groping in a dark cave with a flashlight that goes on for only an instant and each time lights only a tiny corner of the cave. Occasionally the flash catches some activity or event—either a familiar particle behaving in a familiar way or some strange new particle whose behavior is altogether baffling. From these scanty glimpses nuclear physicists are attempting to identify the particles and the forces at play in the dark, violent world of the nucleus of the atom. It would help if they had a better flashlight.

Let us look for a moment at the events they are trying to observe and at the observing devices that have been available up to now. Physicists are probing the nucleus by bombarding it with particles, preferably particles with enough energy to break up the nucleus into its constituent parts. The projectiles may come from cosmic rays, particle accelerators in the laboratory, nuclear reactors or other sources. When a high-energy particle hits the target nucleus, any of a number of different things may happen: it may ricochet off and leave the struck nucleus unchanged; it may break the nucleus into fragments; it may give birth to entirely new particles, or it may be absorbed. These events generally take place in something less than a millionth of a second. From that very brief glimpse the physicist seeks to determine the energy, the electric charge, the size or mass and the forces of interaction among the particles involved.



BUBBLE TRACKS in liquid hydrogen were produced by Luis W. Alvarez and his group at the University of California. Their 2.5-inch chamber, operated at about 400 degrees below zero Fahrenheit, was exposed to neutrons. Tracks show paths of recoiling protons.

He has had two ways of seeing and measuring these happenings. The first is the Wilson cloud chamber. In a chamber supersaturated with a vapor, a flying charged particle leaves a visible trail of liquid droplets, which condense on the ions the particle has produced by hitting vapor and gas atoms in its path. The density of droplets along the particle's track indicates its velocity and charge; its response to a magnetic field shows its momentum and whether its charge is positive or negative; its occasional disruption of the nucleus of an atom in its path, or its rebound from such a nucleus, tells something about the forces in the nucleus. Sometimes the particle breaks down ("decays") into lesser particles which make divergent tracks. But these interesting events occur only rarely in a vapor-filled chamber, because collisions in the gas are infrequent. To improve the chances of the particle hitting a nucleus, one can put a series of lead plates in the chamber or increase the pressure (*i.e.*, density) of its gas. Nonetheless, the cloud chamber has important limitations. The density of the track is very difficult to measure accurately. Particle tracks are lost from sight in the lead plates, so that the length of the track cannot be precisely calculated and details of collisions are hidden. After one particle has passed through, it takes a comparatively long time to clear the chamber for the next event, especially when the chamber is pressurized.

The second device for recording nu-

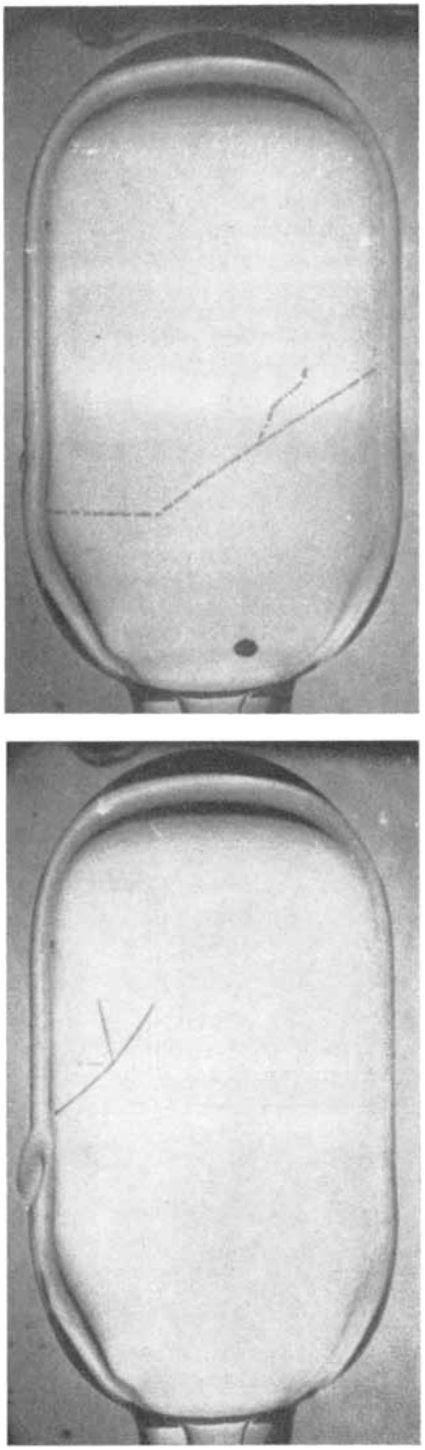
clear events is the photographic emulsion. It goes to the other extreme: it traps particles in a solid instead of in a vapor. In passing through the emulsion a particle leaves a trail of "exposed" silver grains which shows up on development. Nuclear physicists use special thick emulsions, stacked up in a number of layers to lengthen the tracks of particles passing through. The nuclear emulsion has several advantages: It is simple, compact and can be carried anywhere, even into the upper atmosphere by balloons and rockets. A particle charging into the dense emulsion has a high probability of colliding with nuclei; hence there is a good chance that the emulsion will show interesting events, including scattering, disintegrations and the formation of new particles. However, the emulsion also has its drawbacks. Its very density makes collisions so frequent and the particle path so crooked that the effect of a magnetic field cannot be measured. And from the moment it is manufactured an emulsion begins to collect random particle tracks from cosmic rays and terrestrial radioactivity; by the time the film is developed it is difficult to disentangle separate events and impossible to tell when the various tracks were made. Moreover, it takes tedious scanning under a high-power microscope to find the tracks at all.

Could some compromise be found which would eliminate the defects and combine the respective virtues of the cloud chamber and the emulsion? It would be handy to find a particle-trapping medium which would be dense enough to afford the frequent collisions and precise tracks of the emulsion, and flexible enough to be amenable to magnetic fields and to give the good-sized, single picture of the cloud chamber, with a quick recovery after each exposure. In May, 1952, I began to try a new approach to the problem, and I soon decided to explore the possibility of a liquid medium.

What kind of reversible process in a liquid could show the path of a flying particle and quickly erase the track after its passage? It would have to be a process that magnified the tiny effect of the atomic particle itself, as the condensation of droplets in supersaturated vapor magnifies the ionization produced by a particle in a cloud chamber. It occurred to me that a superheated liquid, like a supersaturated vapor, might provide the desired unstable equilibrium that could be triggered by a small stimulus to yield a large effect. Physical chemists have long known that in a clean, smooth-walled vessel a very pure liquid may be heated above its usual boiling point without boiling. When the superheated liquid does begin to boil, it erupts with considerable violence, sometimes smashing the vessel. In chemical processes subject to this hazard bits of broken glass or other "boiling stones" are often thrown in to provide triggering points for boiling and thus prevent superheating. I wondered whether a flying particle might, under suitable conditions, trigger the formation of the microscopic bubbles that start the boiling process. If so, it might make a visible track in a superheated liquid.

Before undertaking any experiments, it seemed worth while to consider the question theoretically to see whether the idea could possibly work and what liquids would be most promising to try. I started with the supposition that a charged particle passing through the liquid might produce small clusters of ions of the same sign (negative or positive). Pushed apart by their mutual repulsion, the ions might leave tiny cavities, or bubbles, in the liquid. If such a mechanism actually operated, the specifications for a liquid that could record the tracks of particles were clear: the liquid should be nonconducting, so that the ions would retain their charges; it should have low surface tension, so that the force tending to collapse a cavity would be weak, and it should have high vapor pressure, which would tend to enlarge each cavity formed in the liquid. Worked out in detail, the theory gave the rather sharp prediction that ether (the ordinary anesthetic), when superheated to about 285 degrees Fahrenheit, should work as a track-forming liquid.

I made the first test very simple, because the whole idea seemed a long shot. I sealed some pure ether in an apparatus consisting of two narrow glass bulbs (about four inches long and a tenth of an inch in inside diameter) connected by a capillary tube. The vessel was not completely filled with liquid: there was a little space left for vapor from the liquid ether. Now one of the bulbs was immersed in a hot bath at 285 degrees and the other heated to 320 degrees. As a result, the higher vapor pressure in the hotter bulb forced liquid into the other one so that the latter was filled with liquid. Since the heating raised the pressure within the vessel to considerably more than that of the atmosphere, the liquid did not boil. Then the hotter bulb was removed from its

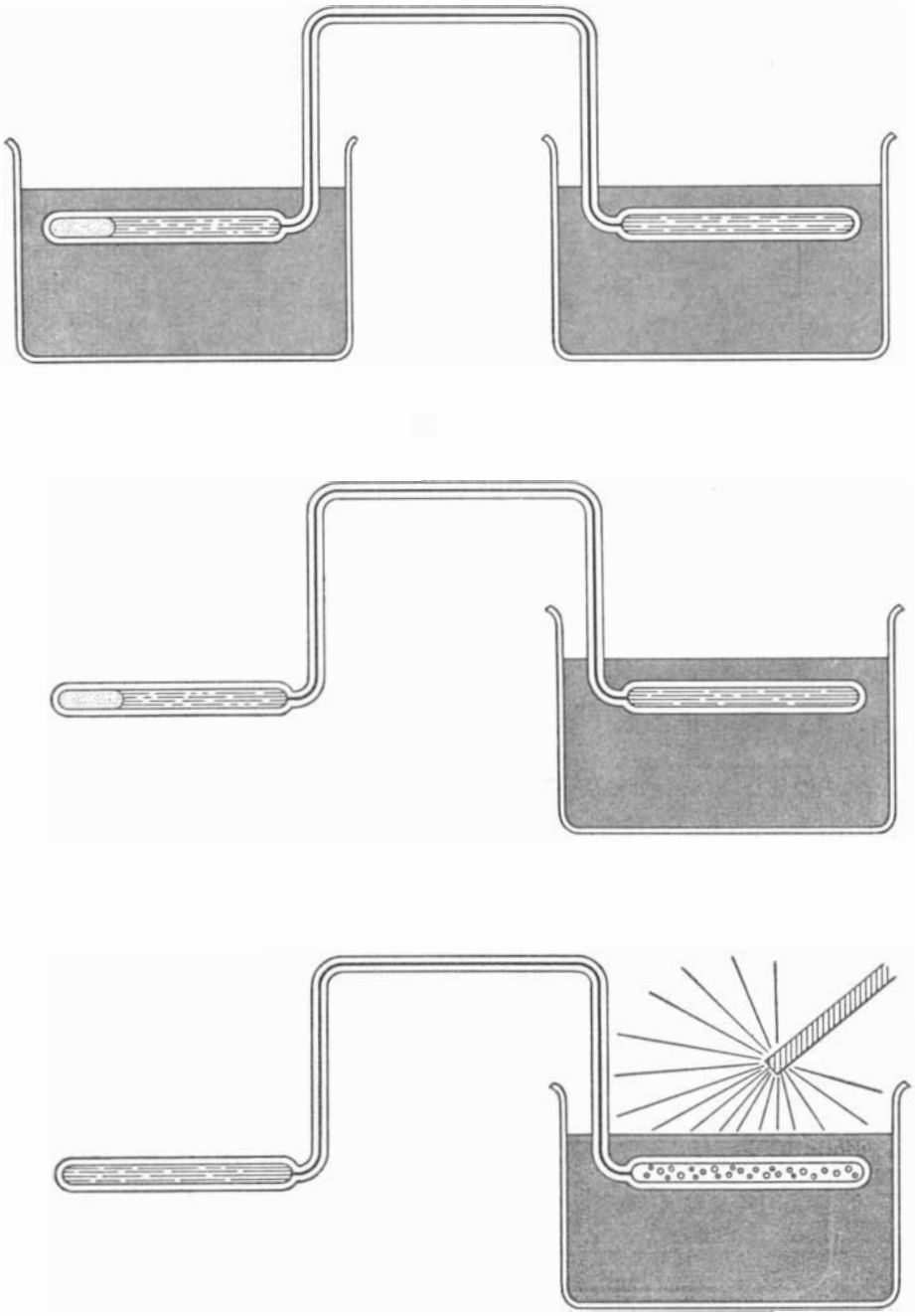


PENTANE-FILLED CHAMBER designed by R. H. Hildebrand and his colleagues at the University of Chicago demonstrates that different types of particles produced recognizably different tracks. In the top photograph a pi meson from a synchrocyclotron enters at the left, undergoes an elastic scattering, then ejects an electron (*wavy track*) from a pentane molecule. In the bottom photograph an incoming pi meson explodes a carbon nucleus and three slow, heavy charged particles are emitted. The density of bubbles along a track, which may be as high as 250 to the inch, is an index of the ionizing power of the passing particle.

hot bath. Its vapor quickly cooled and the pressure dropped to one atmosphere. The superheated liquid in the 285-degree bulb remained quiet for as long as several minutes. But when a bit of radioactive cobalt was brought near, it erupted instantly into violent boiling!

Further experiments with other liquids and other sources of radiation confirmed this discovery: ionizing radiation could indeed trigger boiling in a superheated liquid. We cannot say this proves the theory that electrostatic force forms the bubbles; it may be that the dash of a particle into the liquid simply adds a little triggering heat, like the plunge of a hot needle. But in any case the triggering action was a fact.

The next step was to find out whether the process could be localized so as to form a track of bubbles. This time I used a somewhat larger bulb (half an inch in inside diameter) filled with ether; it was connected by a capillary tube to a piston-fitted cylinder with a hand crank which could quickly lower the pressure. High-speed movies, at the rate of 3,000 pictures per second, were made of the happenings in the bulb when the pressure was reduced. Sure enough, the pictures disclosed a track of tiny bubbles when a particle darted through the superheated ether. The experiment also demonstrated that the larger the chamber, the shorter the time it can maintain its superheated condition, because of the greater likelihood of intercepting a stray bit of radiation. This bulb remained quiet for only a few seconds after the pressure was lowered.



FIRST EXPERIMENT demonstrated that particles can trigger boiling in a superheated liquid. When the left-hand, 320-degree bath was removed, the pressure in the sealed tubes fell from 21 atmospheres to one atmosphere and liquid ether in the 285-degree bath at right became superheated. The ether boiled when it was exposed to radioactive cobalt.

The bubble type of chamber soon proved to be a very sensitive recorder. Even fast mu mesons, which ionize only lightly, made visible tracks in the superheated liquid. The chamber was placed under four inches of lead and between two Geiger counters connected by an electronic coincidence circuit, so that whenever a particle passed through both counters (and of course the chamber between), the firing of the counters set off a flash, illuminating the apparatus for a camera whose shutter was left open in the darkened room. The purpose of the lead screen and the twin counters was to restrict the photographed events to cosmic rays, and the particles were known to be mu mesons.

By delaying the light flash to go on at a given time after the counters fired, we were able to photograph the bubbles at any stage of their growth. The bubbles grow to a tenth of a millimeter in diameter within a few microseconds after the particle has passed through the liquid. We also found that the number of bubbles along a given length of track depended sharply on the temperature.

The tracks of mu mesons are not very interesting, because these particles rarely break up atomic nuclei. We therefore sought a way to make the instrument photograph other events. When bubbles erupt in the superheated liquid, they emit a distinct "plink" sound. To use this sound as a trigger for the light flash, David C. Rahm, in our laboratory at the University of Michigan, clamped a phonograph pickup to the wall of the bubble chamber and connected it to an amplifier which flashed the light whenever the phonograph needle sensed a vibration. The method did not, however, yield sharp pictures, because sound travels so slowly that the bubbles in the chamber had grown too large by the time the picture was made.

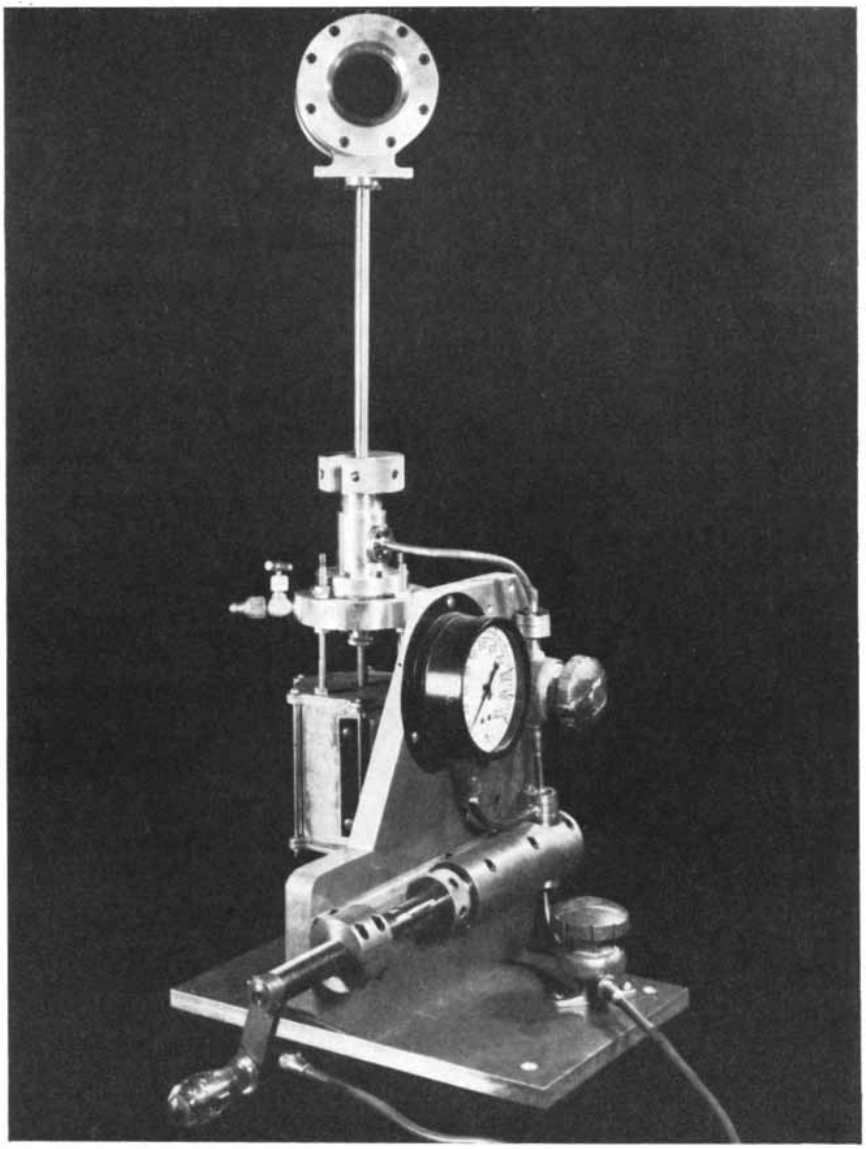
At the University of Chicago R. H. Hildebrand and his colleagues built a chamber like the one just described ex-

cept that they filled it with liquid pentane instead of ether. They exposed it to a beam of pi mesons from the Chicago synchrocyclotron. Their very beautiful pictures show that bubble tracks may be light or heavy, depending on the type of particle that produces them, and that the density of bubbles along a track is an index of the ionizing power of the responsible particle. Their chamber can be compressed and expanded once a second. It should be able to collect data very rapidly on the interaction of pi mesons with the nuclei of hydrogen and carbon atoms in the pentane.

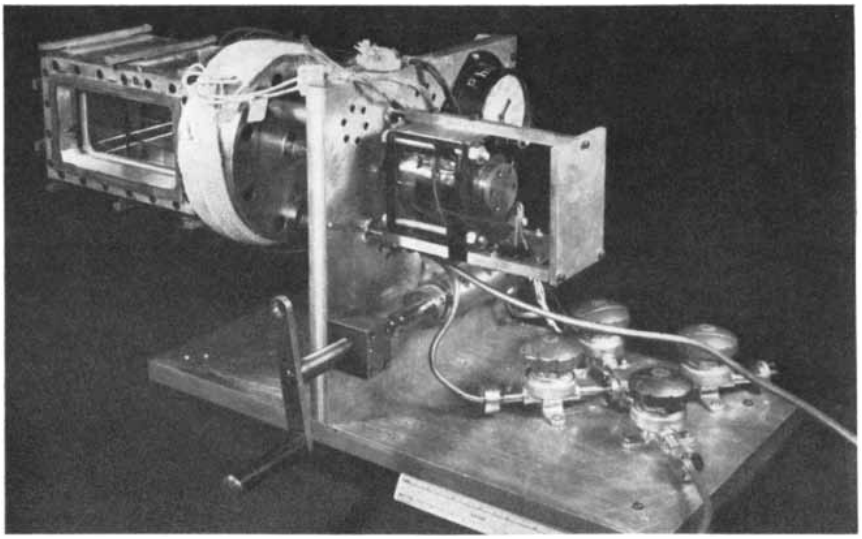
Having demonstrated that the bubble chamber idea worked, we proceeded to the task of building one large enough for practical laboratory use. Flat glass windows were needed to make good pictures. It turned out to be impossible to make an all-glass chamber strong enough to withstand the necessary pressure changes. It therefore had to be made of metal, with small glass windows. However, this introduced a serious problem: rough spots on the metal and at the joints caused the liquid to start boiling. The rise in pressure due to the release of vapor by the boiling at the wall counteracted the reduction of pressure when we expanded the chamber, so that it was impossible to attain the desired degree of superheating. We found that we could get around this difficulty by expanding the chamber very quickly. In other words, the volume of the chamber was increased faster than vapor was evolved at the wall. The desired drop in pressure and superheated condition was maintained for several thousandths of a second.

We first built a two-inch chamber of duralumin and glass, with a diaphragm, actuated by compressed air, which could fully expand the chamber in five thousandths of a second. The liquid remained sensitive for seven thousandths of a second. We then incorporated the same design features in a larger pentane-filled version in which the liquid volume is six inches long, two inches wide and three inches high. This chamber is now in use with the Cosmotron at the Brookhaven National Laboratory. We have made 400 excellent pictures of tracks of protons from this accelerator. Two of the pictures appear on the next page.

These track photographs are as easy to read as the best cloud chamber records and are about 10 times as accurate. The bubbles grow so fast that the tracks can be photographed before swirling motions in the liquid distort them. The



TWO-INCH CHAMBER is made of duralumin and glass. It connects through the thin pipe with a magnetically-operated valve which reduces the pressure in five milliseconds.



LARGEST BUBBLE CHAMBER built so far, measuring six by three by two inches inside, is being tested at Brookhaven National Laboratory. The glass window is at the left.

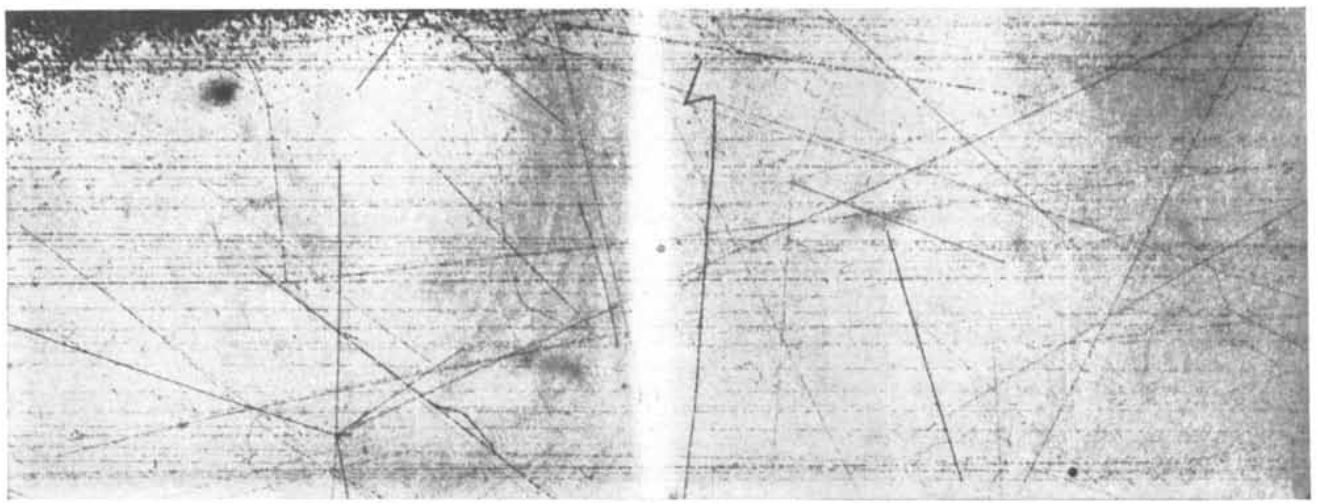
trails in cloud chambers are usually considerably distorted by convection currents. Also, the density of bubbles in a bubble-chamber track may be a better index of particle energy than the droplet density in a cloud chamber.

But the most dramatic difference is in the frequency with which interesting events are recorded. The six-inch bubble chamber catches as many of these as would an ordinary cloud chamber 140 feet long! A typical series of such events is shown at the left of the lower photograph below. A pi meson entered the chamber from the left, was stopped in the liquid and decayed to a mu meson; the latter, after traveling about three millimeters in the liquid, stopped and decayed into an electron. Such complete records of pi-mu-electron decays show up rarely in nuclear emulsions; in cloud chambers they are virtually unknown. (The path of a mu meson in a cloud chamber would be more than three yards long!) Yet the first 22 bubble-chamber pictures from Brookhaven, taken in 11 minutes, contained eight of these events. Among other interesting features in the pictures reproduced here is the destruction of a carbon nucleus with the creation of a pair of pi mesons. One especially inviting puzzle that still awaits analysis is the strange zigzag track down the middle of the upper photograph on this page.

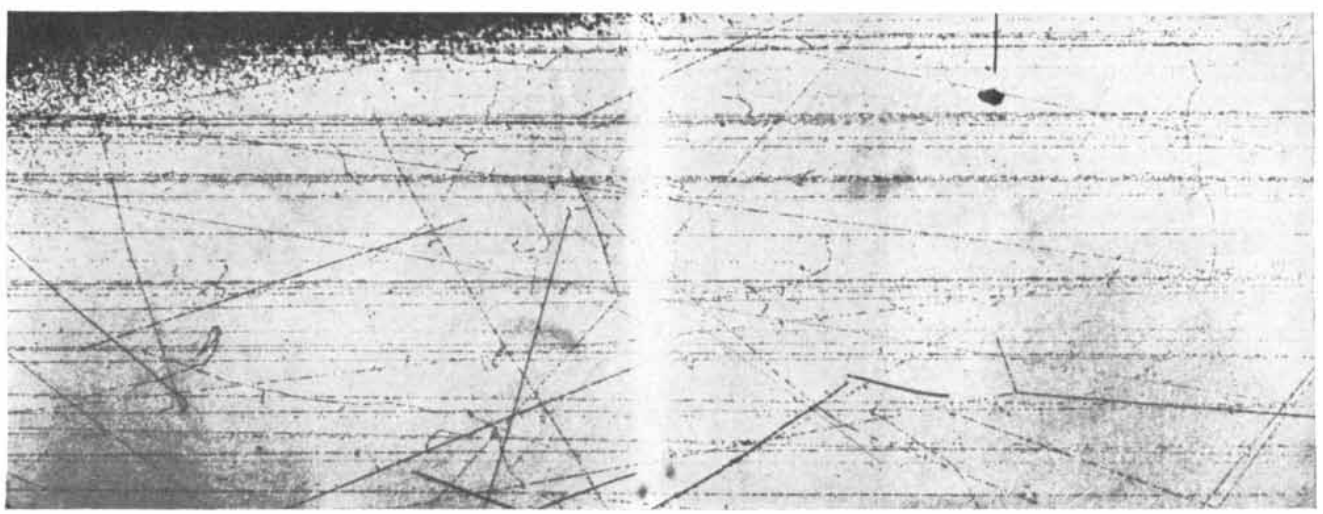
Another advantage of the bubble chamber is that it may be filled with a light-atom liquid, which does not deflect particles much and therefore will permit magnetic-field experiments, or with an extremely dense liquid, which will produce a great amount of scattering, as an emulsion does.

Often nuclear physicists wish to bombard a single "elementary" particle—*e.g.*, protons—to see what fragments may be produced. They direct the bombarding beam at liquid hydrogen as the target and observe the results by means of detectors placed around it. The bubble chamber makes it possible to have the target material within the chamber itself. Superheated liquid hydrogen will boil and show particle tracks. Luis W. Alvarez and his group at the University of California have made pictures of protons in the liquid hydrogen recoiling from collisions with incoming neutrons [*see photograph on page 46*].

It appears that the bubble chamber will become a standard detection instrument for work with the high-energy particle accelerators in laboratories, and that it will speed up the rate at which we can gain information about strange particles and nuclear forces.



BUBBLE-CHAMBER PICTURE shows the two-billion-electron-volt proton beam of the Cosmotron at the Brookhaven Laboratory. The protons enter the chamber from the left. At lower left a carbon nucleus has been disrupted. Zigzag track in the center is a mystery.



RARELY SEEN EVENT, the decay of a pi meson into a mu meson and then into an electron, was caught in this photograph. Pi meson enters just above center of left edge, moving down to right. Mu meson leaves a short track and electron goes off upward to left.

Kodak reports to laboratories on:

a great day for photography . . . a possibly outmoded philosophy . . . an idea for making extra copies of oscillograms

Faster, faster

Where this man sits and writes pamphlets about photography 15 footcandles hit his face. That's just within the lower limit of illumination recommended for office work. Nobody, of course, snapshoots at that low a level. But good gracious, this picture was made with a $6.95 camera (our esteemed *Brownie Hawkeye*), unassisted by any additional light source, at its one and only setting of *f*/15, 1/40th of a second! Imagine what an adjustable camera would have done under the circumstances.

How in the world, etc.? The catch is that our Brownie was loaded with a new kind of film, *Kodak Tri-X Film*. Not really a catch, for you, too, can now buy it at any film counter. Such husbandry of photons! Currently available in No. 620, No. 120, No. 135-36 exposure rolls, and No. 523 film packs. No sacrifice of graininess. Exposure index nominally 200 but not too meaningful because latitude is of a type the definition-framers hadn't anticipated. This is quite an announcement.

We also have a companion announcement about color. A new 35mm color film with approximately *thrice* the speed of *Kodachrome Film* has just gone on the market. To process it to full-color transparencies calls for no major capital appropriation and no chemical engineering talent but merely for a *Kodak Ektachrome Processing Kit, Process E-2*, priced at $1.80. (It's really operable at the home darkroom level, but if you'd rather not bother, your Kodak dealer can handle it for you for processing by processorsequipped to do the work.) This new film we identify as *Kodak Ektachrome 135 Film* (for 35mm miniature cameras, 20 exposures for $1.85) and *Kodak Ektachrome 828 Film* (for cameras like the *Kodak Pony* and *Bantam*, 8 exposures for $1). Photographic characteristics have been changed substantially from the sheet and roll film *Kodak Ektachrome* because the new film is intended to be viewed at large magnifications, as in projection, and the other isn't.

In sum:

1) The scope and even the style of black-and-white photography have been vastly extended by dispensing with the need for added light in many situations and in others permitting flash or flood lamp to bite far deeper into the gloom than ever before.

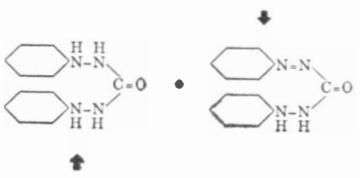
2) Color photography by 35mm camera can now be done in much less light than before, with results ready for inspection 65 minutes after the last shutter click.

It's a great day for photography.

Behind the quotes

"*s-Diphenylcarbazone*" (Eastman 4459) appears in our catalog with a cynical pair of quotation marks around it. The punctuation betokens our essential honesty, indicating we know that Eastman 4459 is not really s-diphenylcarbazone. It is a double compound of

s-diphenylcarbazone



and s-diphenylcarbazide.

Sure, we can separate them, but that would greatly bump up the price of the reagent. Outmoded though the philosophy may be, we still feel that the cost of a reagent is of some practical importance. Besides, we're not so sure that separation of the components of this reagent would be a good idea.

After all, analysts have been buying it from us for years for argentometric titration of cyanides and mercurimetric titration of chlorides in biological fluids. To confuse the name of this tried and true reagent just because some academically minded organic chemists happen to know that in half the molecules the nitrogen bond has been reduced—that strikes us as a dirty trick.

Nothing (short of selling you 10 grams of "s-Diphenylcarbazone" *for $3) would make us happier than sending you abstracts of the procedure for free. Also our List No. 39 of some 3500 Eastman Organic Chemicals, if you haven't received your copy as yet. Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).*

Plug

Reproduction is more to us than merely one of the basic biological functions; to us the word signifies the major market for our silver-sensitized paper. We read it literally to mean the copying of all manner of records and provide a large array of means, ranging from a little marvel of the age called the *Verifax Copier* (3 copies in 1 minute for less than 4¢ each) to simple sheets of *Kodagraph Contact Paper*.

A free plug for the latter, doubly welcome because we hadn't planted it, gladdened our eyes in a recent issue of *Electronics*. Little did it matter to us that the kind writer in his enthusiasm asserted a virtue for *Kodagraph Contact Paper* which even we have never claimed—that it requires only subdued room light instead of a proper darkroom for handling without danger of fogging. Just pleased that the fellow has a smart little scheme for using the paper in making inexpensive high-quality copies of cathode-ray tube oscillograms to include in manuals and laboratory reports.

For the details of his scheme, or for general guidance on the host of materials and methods for the photographic reproduction of intelligence, write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

Prices quoted are subject to change without notice.

This is one of a series of reports on the many products and services with which the Eastman Kodak Company and its divisions are . . . *serving laboratories everywhere*

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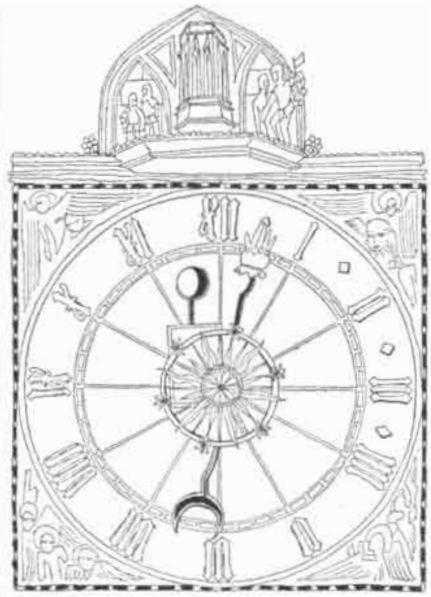


A.A.A.S. Meeting

The 121st meeting of the American Association for the Advancement of Science at Berkeley last month was notable for some emphatic talk on the security question. When retiring president Edward U. Condon, the latest victim of security investigations, rose to deliver his address, the assembly greeted him with a standing ovation. Warren Weaver, presiding president, introduced Condon as a victim of "sickness in our country." The harassment of Condon, he said, was "the horrid result of political pressure . . . and of the pathological arrogance of demagogues with small and nasty minds."

Before the meeting the A.A.A.S. board of directors had published a statement urging the Government to make a positive approach to security, with more emphasis on encouraging scientific output and less on "secrets." The theme was repeated by a number of speakers at the meeting. George W. Beadle, president for 1955, deplored the "tendency to extend security procedures to unclassified areas." He called on university administrations to "resist with vigor" attempts by the Government to control the selection of personnel working on unclassified research projects. Joel H. Hildebrand, president-elect of the American Chemical Society, said that "fear of attack by a Congressman" has caused officials to "withdraw support of research, involving no question of security whatever, that could yield great results of value in the relief of human suffering. In such a case the principal loser is the public, not the scientist." Vannevar Bush, president of the Carnegie Institution of Washington, in accepting the $1,000 William Procter Prize from the Scientific Research Society of America, observed: "We have useful men denied the opportunity to contribute to our scientific efforts because of their youthful indiscretions. Worst of all, we have the evil practice of ruthless, ambitious men who use our loyalty procedures for political purposes."

The Association elected Paul B. Sears, professor of botany at Yale University, to serve as its president in 1956. It elected a woman to its board of directors for the first time—Margaret Mead, anthropologist with the American Museum of Natural History.

More than 100 symposia were held on major topics, including resources and population, viruses, tissue differentiation, air pollution, water supplies, high-energy physics and mathematical statistics and probability.

A symposium of the American Psychiatric Association was devoted to two new drugs which were said to "represent a significant advance in psychiatric medicine." The "remarkable new sedatives" are reserpine, a plant alkaloid, and chlorpromazine, a synthetic preparation. They not only quiet mental patients but, according to the reports, compose and clarify the patients' minds so that they become accessible to psychotherapy. In more than 1,000 cases there was a high percentage of successes in treating anxiety and chronic schizophrenia which had failed to respond to other therapy. The psychiatrists emphasized that the drugs are not 100 per cent effective, that they do not in themselves cure mental disease and that their long-term value is not yet established. Among the physicians reporting were Leo E. Hollister of the Palo Alto Veterans Administration Hospital, Lester H. Margolis of the University of California School of Medicine, Anthony A. Sainz of the Iowa City Veterans Hospital and Nathan S. Kline of the Rockland State Hospital in New York.

The A.A.A.S. awarded its $1,000 Newcomb Cleveland Prize for an outstanding paper to Daniel Alpert of the Westinghouse Electric Corporation, who has developed a vacuum pump yielding a vacuum hundreds of thousands of times higher than any achieved previously. It ionizes gas particles and sweeps them away with electrostatic fields.

THE CITIZEN

Daniel I. Arnon of the University of California reported success, for the first time, in carrying out complete photosynthesis outside a living cell. He used isolated chloroplasts, the chlorophyll-containing particles of plant tissue.

Winston Harvey Price, of The Johns Hopkins School of Hygiene and Public Health, won the $1,000 Theobald Smith Award in medical science for his work on the epidemiology of rickettsial diseases and on the changes in virulence of rickettsial organisms [see "Rickettsiae," by Marianna R. Bovarnick; SCIENTIFIC AMERICAN, January]. The $1,000 John Scott Award went to Robley C. Williams of the University of California Virus Laboratory for his improvements in electron microscopy.

Some other papers at the meeting:

Paul Weiss of the Rockefeller Institute for Medical Research told of a new discovery concerning a mechanism by which the human body regulates its growth. Each organ of the body manufactures a specific substance which stops growth when it reaches a certain concentration. It is thought to produce this effect by combining with and thereby blocking compounds which otherwise would serve as templates for building new cellular material. Some growth-promoting substances apparently act by counteracting the braking substance.

The "law of the red shift," meaning the spectral shift of starlight which indicates that galaxies are racing away from one another and the universe is expanding, holds throughout space as far as the new 200-inch telescope on Palomar Mountain can see, reported Allan R. Sandage of the Mount Wilson and Palomar Observatories. In a 20-year study just concluded, nearly 800 galaxies were examined and all found to obey the rule of higher velocity with increasing distance. The most distant groups appear to be receding from the earth at 36,000 miles per second—about a fifth the speed of light.

Daniel Mazia of the University of California reported important new information on the chemistry and behavior of the mitotic apparatus, which is responsible for separating chromosome sets for the formation of two new cells when a cell divides. The apparatus, formed at the time of division, is a rather elaborate structure consisting of a spindle, two little bodies called centrioles

and other parts. Mazia succeeded in isolating the structure intact by dissolving the rest of the cell away, and learned to his surprise that the whole mitotic apparatus, complex as it looks under the microscope, is made of a single kind of protein. He also found that the protein molecules are linked together in chains and the chains packed together in fibrous bundles; presumably the structure is formed at the time of division from protein molecules already present in the cell. Mazia suggested that the two centrioles, one at each end of the apparatus, are responsible for organizing the structure by emitting a bonding substance which links the fibers side by side in bundles.

Multiple Jeopardy

After Edward U. Condon had been cleared of "security risk" charges for the fourth time (by an industrial security board representing firms with military contracts), Secretary of the Navy Charles S. Thomas last fall quickly overruled the board and asked it to reconsider the case. Last month Condon decided that he had had enough. He withdrew his application for clearance, resigned as research director of the Corning Glass Works and retired to Berkeley, Calif., where he will engage in private, nonclassified research for Corning and other clients.

Said Dr. Condon: "I am now unwilling to continue a potentially indefinite series of reviews and re-reviews. . . ."

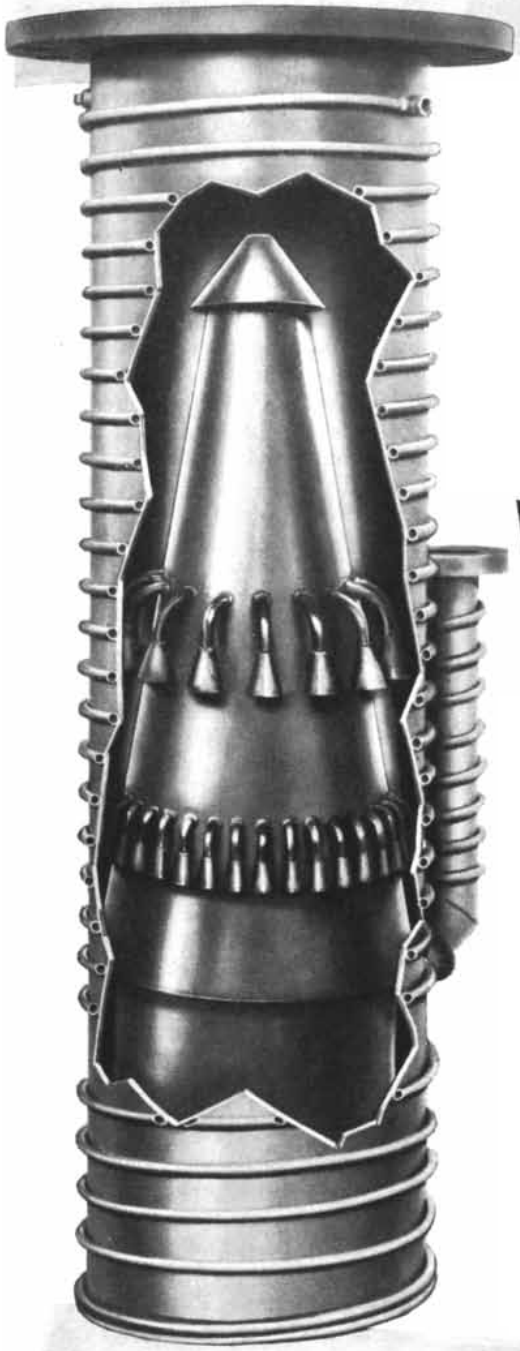
An editorial in the New York *Herald Tribune* expressed the sympathy of many for Dr. Condon's decision: "To go through with a test of one's reputation . . . is in all ordinary circumstances what is expected of an upright man. Yet are the circumstances ordinary when there appears to be no finality to a verdict? When decisions reached after careful investigation are thrown back, for no stated reason, into the crucible?"

On the Passion for Facts

The Reece Committee, ending its investigation of U. S. private foundations, last month brought in its expected verdict, which had been outlined by its chairman before the investigation began. It found the big foundations (Rockefeller, Carnegie, Ford *et al.*) guilty of, among other things, subverting U. S. ideals and fostering an "irresponsible mania" for seeking facts in social science.

The report of the House Special Committee to Investigate Tax-Exempt Foundations and Comparable Organizations

Major Advance in DIFFUSION PUMPS



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was signed by its chairman, B. Carroll Reece, and his two Republican colleagues, Jesse P. Wolcott and Angier L. Goodwin. The latter signed with "strong reservations and dissent from many of its findings and conclusions." The two Democratic members of the Committee, Wayne L. Hays and Gracie Pfost, dissented *in toto*, calling the conclusions a "crackpot view" and the investigation "a complete waste of public money."

The report declared that an "intellectual cartel" made up of professional foundation administrators has "promoted a great excess of empirical research as contrasted with theoretical research" in social science. It charged that some of the large foundations had shown "a distinct tendency to favor political opinion to the left," had promoted propaganda for "collectivism" and had "directly supported 'subversion' in the true meaning of that term—namely the process of undermining some of our vitally protective concepts and principles."

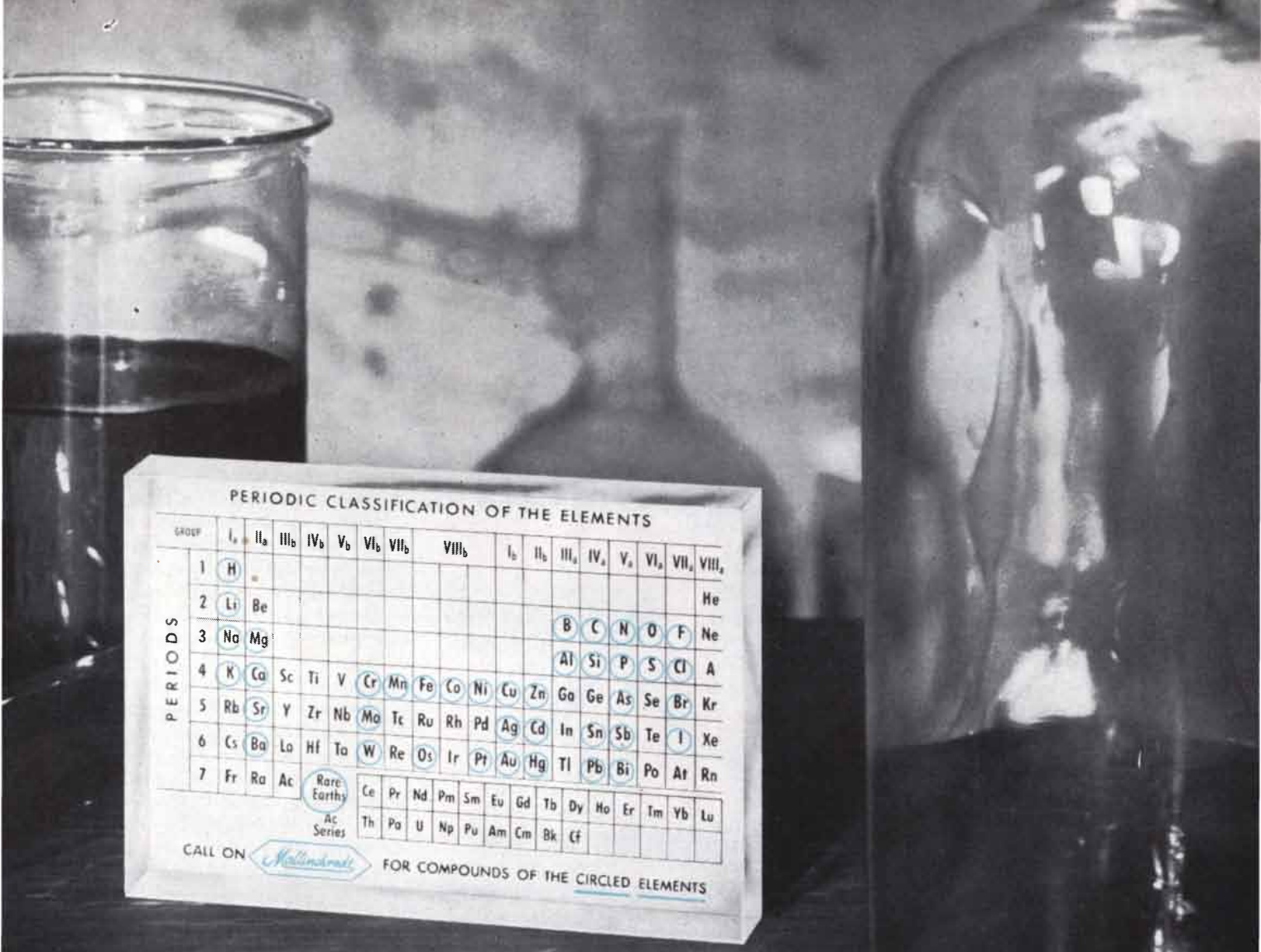
The Committee minority said, in part: "Some of the statements of fact and opinion contained in the report are untrue on their face, others are at best half-truths and the vast majority are misleading." The foundations, in the words of Dean Rusk, president of the Rockefeller Foundation, said: The conduct of the investigation violated "elementary principles of fairness and justice."

The New York *Times* said: "The sooner [the investigation is] forgotten, the better it will be."

Wonder Germs

"Virtually all the staphylococci that cause hospital infections are resistant to penicillin. Nearly three quarters of them are also resistant to streptomycin, aureomycin and terramycin." So said a recent lead article in the British journal *The Lancet*. The burgeoning of resistant strains of bacteria, especially staphylococci, and particularly in hospitals, has occasioned a good deal of anxious comment in the past few months.

Chester W. Howe, a Boston physician, reported in *The New England Journal of Medicine* that post-operative infections may actually be increasing because of extensive use of antibiotics in hospitals. Resistant bacterial strains, he explained, tend to replace the less virulent flora normally carried by hospital personnel, particularly in their nasal secretions. Also, surgeons operating under "antibiotic cover" may unconsciously relax their standards of aseptic technique. In several experiments hospital staphylococcus infection rates have been sub-



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stantially reduced by sterilizing the noses of staff members with drugs not in common use.

The New York County Medical Society warned: "If the present trend of overdosing with antibiotics continues, soon physicians may have little or nothing with which to combat infections, particularly in the case of staphylococci." *The Lancet* agreed with many authorities that combinations of drugs may be the best answer to resistant staphylococci, as they have been to resistant tuberculosis germs.

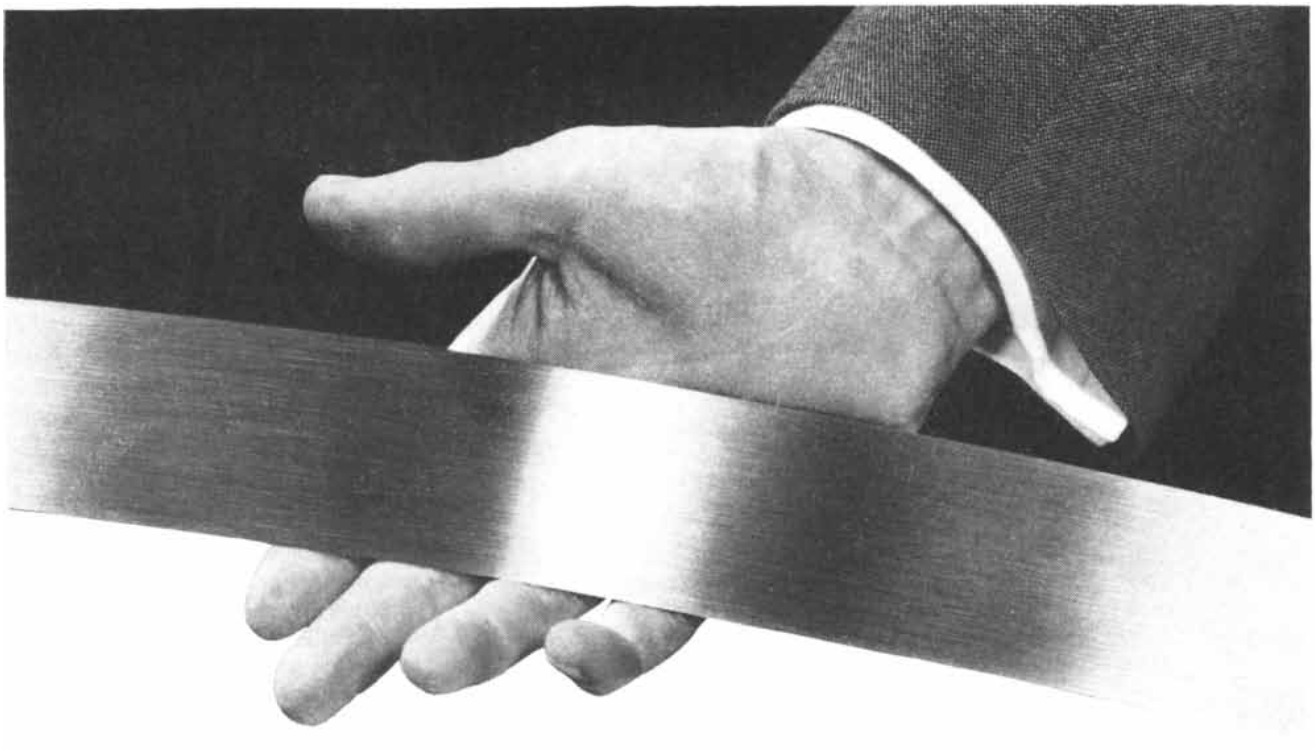
Chemistry of Behavior

An important advance in the attempt to connect mind with matter was announced last month. A team of psychologists and biochemists at the University of California discovered a "close relationship" between chemistry and behavior in rats.

The behavior involved is the animal's reaction to an unsolvable maze. The rat is confronted with a succession of double-branched forks along a path to a box of food. At each fork it must choose between a lighted and a dark alley, one of which leads to a dead end. After every run, the arrangement of lights and of dead ends is changed. When it finds there is no dependable route through the maze, the rat bases its choice of alleys on what the California psychologists call "hypotheses." Some individuals make a "visual hypothesis," preferring the light or dark route, others make a "spatial hypothesis," tending to go right or left. The tendency to be a visual rat or a spatial rat is hereditary.

David Krech, the psychologist who had devised this test, undertook a biochemical study with M. R. Rosenzweig, E. L. Bennett and Barbara Krueckel. They measured the concentration of the nerve enzyme, cholinesterase, in the brains of 20 rats which had been tested in the maze. The assay was made on tissue from the sensory and motor areas of the cortex. Half of the rats were strongly visual, half strongly spatial. In the motor region of their brains there was no significant difference between the groups in cholinesterase concentration. But in the sensory areas the spatial group had significantly more cholinesterase than the visual group.

Writing in *Science*, Krech and his colleagues suggest two possible explanations for their results: (1) cholinesterase activity may directly control the specific trait involved in dealing with this maze problem (visual *v.* spatial), or (2) higher concentrations of the enzyme may make an animal "more generally adap-



How temperamental can a piece of steel be?

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Perhaps defense production brings you new problems in the application or behavior of steel. National-Standard and Athenia offer you the kind of engineering and development service that has speeded production and cut costs for many and many a manufacturer.

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WORCESTER WIRE WORKS.. *Worcester, Mass.*	Round and Shaped Steel Wire, Small Sizes

tive," possibly more "intelligent." Tests of both of these notions are underway.

Electrochemical Sorting

A new, fast method for separating and purifying proteins has been developed by Alexander Kolin, a physicist at the University of Chicago. It is based on the fact that dissolved proteins, like a number of other substances, form either positive or negative ions depending on the acidity or alkalinity (pH) of the solution. In strongly acidic solutions the ions are positive, in strongly alkaline solutions, negative. There is some value on the acid-alkaline scale at which the protein molecules remain neutral. This is known as the isoelectric point, and is different for different proteins. Kolin's technique utilizes the difference.

A thin layer of protein solution, about three tenths of an inch across, is inserted between a pair of liquids, one acid and one alkaline, which are "buffered" to maintain a constant pH. Across the solution, therefore, the pH changes continuously from acid to alkaline. On the acid side, where the protein ions are positive, there is a positive electrode; on the alkaline side, a negative electrode. Thus the positive and negative ions are repelled by the electrodes and pushed together toward the narrow zone in which they have no charge. The location of the zone varies, depending on the isoelectric point of the molecule, so that each zone contains molecules of one kind only. The make-up of a protein mixture can be read from the pattern of concentration bands, and the pure materials can be extracted with delicate pipettes.

Kolin's method resembles the widely used technique of electrophoresis, which depends on differences in the rate at which various protein ions move in electric fields. The author claims two advantages for his approach. First, it is faster. A mixture of hemoglobin and cytochrome C was completely separated in two minutes; the same separation would take hours by electrophoresis. Second, it separates all the components, rather than just the fastest and slowest as in electrophoresis.

Kolin plans to apply his separation technique to other materials that have isoelectric points, such as cells, bacteria and viruses.

I.G.Y.

The world-wide geophysical research program called the International Geophysical Year does not start officially until August, 1957, but for many of the participating scientists it is already un-

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der way. A number of them are now in the Antarctic aboard the U.S.S. *Atka*, a Navy icebreaker, preparing for the 1957-58 U. S. program there.

One of the most ambitious efforts will be an attempt to establish an observatory on the South Polar Plateau, separated from the coast of the Antarctic continent by 700 miles of mountain ranges and glaciers. The *Atka* is now scouting for a coastal base to serve as a staging area for the observatory. The expedition is also examining the ocean icepack for possible observation sites and trying to determine whether snow fields can be compacted into airplane landing fields. The party will inspect Admiral Richard E. Byrd's installation at Little America to see whether any of the buildings and equipment abandoned there seven years ago are still useful.

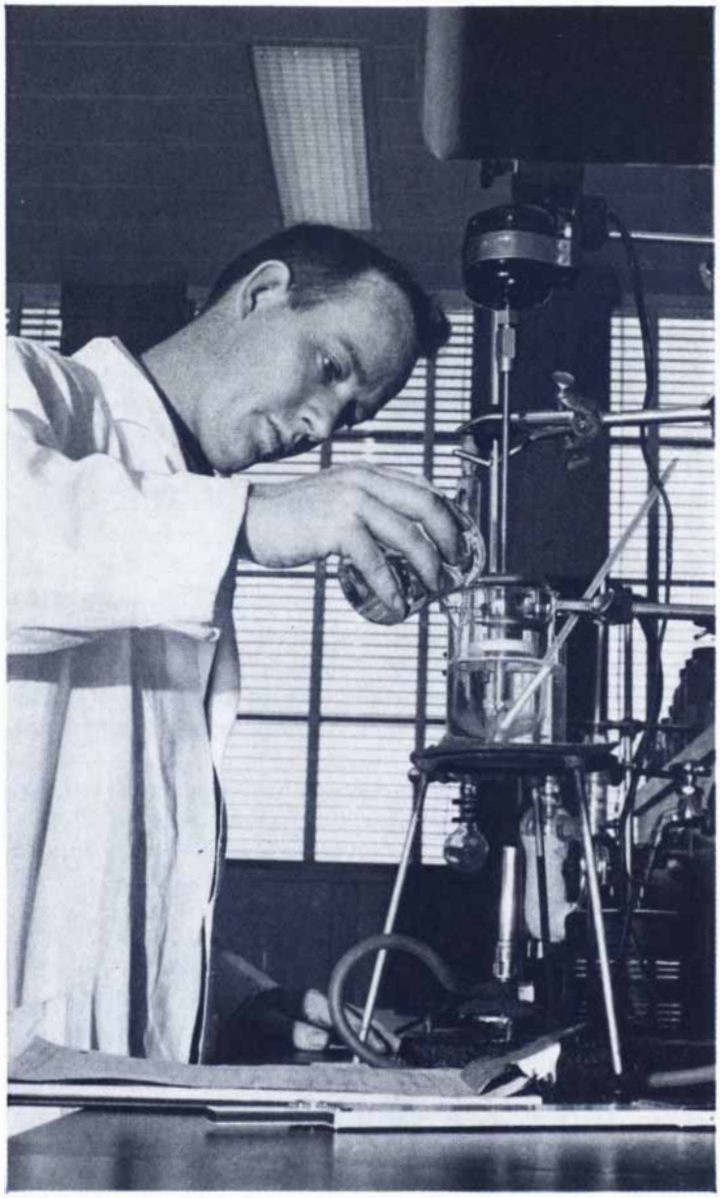
The U.S.S.R. and other Communist governments have just joined the I.G.Y., bringing the number of cooperating nations to 38. The Soviet Academy of Sciences urged the international committee of the I.G.Y. to expand its program to include studies of earthquakes, of the earth's weight and density and of the electric currents that flow through it.

Bigger and Better

Each major advance in the size and speed of electronic computers makes possible an attack on new questions which there was previously no use in asking. Such an advance was formally celebrated last month when the Navy accepted delivery from the International Business Machines Corporation of the Naval Ordnance Research Calculator (NORC).

John von Neumann, of the Institute for Advanced Study and the Atomic Energy Commission, said the new machine would make feasible forecasts of weather over an entire hemisphere 30 to 60 days in advance. The computations would take NORC only a day. Twenty-four-hour forecasts, which with the best previous computers took 24 hours, could be completed in four or five minutes. Calculation of the tidal circulation of all the oceans, including complex marginal motions near the shore, would be a few days' work for NORC, and the hydrodynamics of the earth's liquid core "becomes probably accessible for the first time."

NORC can do 15,000 complete arithmetical computations per second and has a memory with a capacity of 2,000 words. In a four-hour errorless test run the machine did more work than any previous calculator has performed during its entire lifetime, von Neumann said.



Only a thorough evaluation can give you the full scope of the Pluronics' benefits. Pictured here is a test to determine the cloud point of nonionic surfactants, and a check on the melting point of Pluronic F-68 . . . first 100%-active nonionic commercially available in flake, powder or solid form.

WYANDOTTE'S AMAZING, NEW PLURONICS*

A new series of block-polymer chemicals is changing the course of sales and profits for manufacturers of viscose rayon and cellophane, home and laundry detergents, shampoos, mechanical-dishwashing, dye-leveling and water-conditioning compounds — and the end is nowhere in sight.

For the Pluronics make it easy to formulate products that are completely dust-free, non-caking and exceptionally free-flowing; products that offer distinct advantages over competition.

What's new about the Pluronics?

The Pluronics are a new series of 100%-active nonionic surface-active agents, based on a chemical concept not previously used in the synthesis of nonionic surfactants. They provide an over-all balance of desirable properties: ease of formulation, stability, controlled sudsing, a range of surface-active properties, low hygroscopicity, dedusting properties, and a low order of toxicity.

The unusual flexibility of the Pluronics make them especially interesting . . . it is possible to prepare a Pluronic to meet any requirement of molecular weight or hydrophilic-hydrophobic balance, within the established range.

What's different about them?

The Pluronics are the first commercial example of a block-polymer-type surface-active agent . . . made from a hydrophobic polyoxypropylene base with hydrophilic polyoxyethylene groups attached to either end. This use of polyoxypropylene as the hydrophobic portion of the molecule is unique, the secret being to build a polyoxypropylene chain long enough to be water insoluble. The hydrophobic base may be varied in molecular weight, and any percentage of the hydrophilic groups can be added. The Pluronics range in molecular weight from 1800 to 8000. This compares with the usual range in molecular weight for surface-active agents of from 300 to 700.

(CONTINUED ON NEXT PAGE)

*REG. U.S. PAT. OFF.

What about formulating?

Pluronics are easy to formulate . . . you can choose from liquid, paste, flake, powder or solid-cast. Liquid Pluronics can be spray-blended by special spray systems, an ordinary sprinkling can, or nail-punctured drums suspended above mixing apparatus. Pluronics blend easily with common builders; permit you to compound a quality product using only solid materials.

Where are Pluronics used?

The Pluronics are already in commercial use in water conditioning, in the manufacture of viscose rayon and cellophane, in dye leveling, shampoos, boiler-water compounds, mechanical-dishwashing compounds, home and laundry detergents, and in metal-cleaning formulations. Promising new applications are being reported continually. The Pluronics have a wide range of characteristics. For example, L62 is a good wetting agent . . . F68 is an excellent dispersing agent . . . L64 combines a balance of wetting, dispersing and emulsifying characteristics that make it exceptionally effective as a detergent. These characteristics give the Pluronics unique advantages over other surface-active agents. They merit your full and careful evaluation. Brief summaries of a few of their uses are given here.

★ ★ ★

Flexibility of Pluronics helpful in metal cleaning

The field of metal cleaning is unusually complex, due to the many variables in the type of cleaning, the types of metals to be cleaned, types of soil to be removed, and the processing that metals are to receive after cleaning. Most metal-cleaning operations, therefore, require a cleaning compound designed to fit the particular process.

The Pluronics have proved especially valuable in metal-cleaning formulations for a number of reasons. Most important, perhaps, is their exceptional flexibility. With the Pluronics, you can tailor the product to meet your precise needs.

The Pluronics are stable and effective over the entire range of pH, in both acid and alkaline solutions. The suds range of the Pluronics is wide — from no foam to moderate foam. You can choose a Pluronic, or combination of the Pluronics, with the exact sudsing characteristics you require. Another important benefit: in electrocleaning, the controlled sudsing properties of the Pluronics preclude excessive hydrogen entrapment and reduce explosion hazards.

Test the Pluronics thoroughly . . . use the coupon for more information.

The Pluronics control suds in laundry detergents

Large-scale makers of laundry detergents have recently introduced compounds containing one or more of the Pluronics. Why? Because they found that the Pluronics, with their over-all balance of desirable properties, are the most versatile agents of their type available today.

Some of these properties are: controlled sudsing, ease of formulation, stability in solution, compatibility with a wide variety of materials, high detergency, and *permanent* dedusting effect with no moisture pickup.

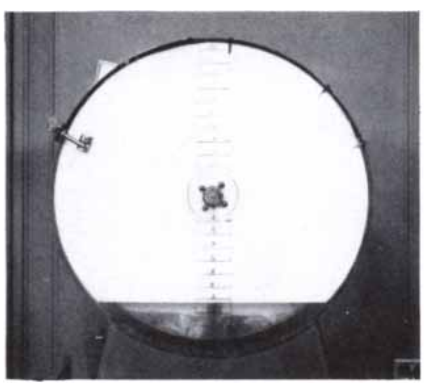
Pluronics' inherent flexibility makes it easy to formulate compounds with optimum characteristics. Suds level, carbon soil removal and whiteness retention can be varied easily to suit particular requirements.

Perhaps the Pluronics could give your product the same market advantage. Why not investigate today?

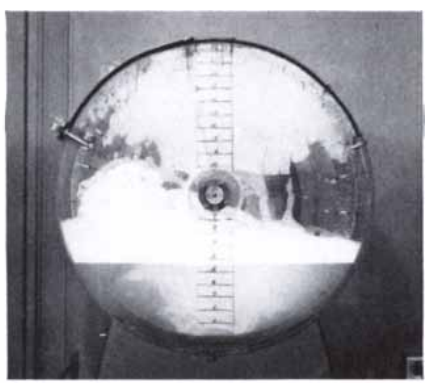
Pluronics important in water treatment

Commercial usage by major producers of boiler-water compounds has proved the Pluronics to be one of the most valuable recent developments in the industry.

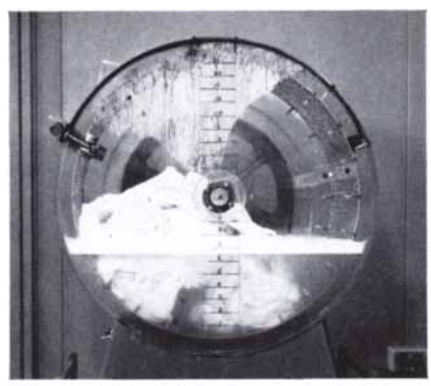
Compare suds levels of home detergents



High-sudsing property of typical popular detergent.



Action of low- or "controlled-sudsing" popular detergent.



Very low sudsing of new detergent containing Pluronics.

There are two main reasons for this: 1) their foam depressing characteristics, and 2) their exceptionally effective dispersing power for calcium and magnesium salts. Other properties of the Pluronics that have proved beneficial in boiler-water treatment, as well as in some water-conditioning applications, are: their compatibility and stability with acid or alkali solutions over a wide temperature range, and their unusually low order of toxicity.

Are these *your* requirements for a surface-active agent? . . . for more information, use coupon below.

Pluronics improve mechanical-dishwashing compounds

Nowhere have the Pluronics played a more dramatic role than in the mechanical-dishwashing field. Here they found an almost immediate acceptance, due to their unique combination of desirable properties. The most important are:

1. An ability to eliminate staining and streaking usually caused by improper rinsing.
2. Exceptional low-foaming properties.
3. Better, more permanent dedusting effect than other surface-active agents.
4. No increase in the hygroscopicity of the compound.

No other single nonionic surfactant can duplicate this unique combination of desirable properties. Formulators using the Pluronics in their mechanical-dishwashing compounds have a distinct product advantage — a product advantage that pays off in a distinct sales advantage.

If you manufacture mechanical-dishwashing products, you should investigate the Pluronics thoroughly . . . use coupon for further information.

What about stability?

The Pluronics are stable in both acid and alkaline solutions, even at elevated temperatures. Moreover, their surface-active properties remain relatively constant over the entire range of pH. Since the Pluronics are not precipitated by calcium or magnesium ions, their detergency performance in formulated products remains relatively uniform, regardless of the water hardness.

What about sudsing?

The Pluronics series offers a wide range of foaming properties, enabling you to choose a particular Pluronic with exactly the sudsing characteristics you require. Pluronics L61 and L62 are essentially nonfoaming, generating less foam than any other commercially available surfactant.

Pluronics L64 and F68 generate moderate foams, making them particularly useful in those applications where foam is desirable.

Pluronic L61 can be used effectively to depress the foam of any of the other Pluronics.

What about dispersing power?

Pluronic F68 and Pluronic L64 are exceptionally effective dispersing agents for calcium and magnesium salts. The Pluronics, by keeping these inorganic salts in suspension, reduce the amount of adherent hard water deposits in boilers and pipes when used in water-treating compounds. The use of the Pluronics also renders the scale that does precipitate softer and more easily removed, due to the Pluronics' rewetting effect.

(CONTINUED ON NEXT PAGE)

What users say about the Pluronics!

"We have found Wyandotte Pluronics valuable in our alkaline cleaning preparations, as well as in other formulations used for the preparation of metal surfaces."

Detrex Corporation, Detroit, Mich.

"The addition of a small amount of Pluronics to our mechanical dishwashing compounds has overcome some problems which we have been trying to solve for years."

Eastern Chemical Corporation, Reading, Pa.

"The Pluronics in our compound control the foam, provide improved rinsability, good detergency and better wetting. What more could we ask?"

Etsol Synthetic Products, Detroit, Mich.

"Recently, we tested the Pluronics, Wyandotte's nonionic surface-active agents. As a result, we are now using the Pluronics in certain areas of our water-conditioning service. They have definitely been an aid to us in solving water-conditioning problems."

W. H. & L. D. Betz, Philadelphia, Pa.

"We tested literally hundreds of products. None of them filled the bill. Then the Wyandotte representative suggested Pluronic F68. We found it fitted our needs exactly. There is no way of measuring in dollars the value of a development like this."

Allen B. Wrisley Co., Chicago, Ill.

What about rinsability?

The Pluronics provide maximum effectiveness as rinsing agents, in proportions as low as 2%. Laboratory evaluations, field tests and established commercial usage have shown the Pluronics to be superior in the promotion of free-rinsing — especially valuable in the mechanical-dishwashing field.

Staining and streaking due to improper rinsing have been decreased by as much as 90% by the inclusion of a very small amount of the Pluronics in mechanical-dishwashing compounds.

What about dedusting?

The dedusting effect of the Pluronics is much more permanent than that of many other surface-active agents, yet products incorporating the Pluronics remain free-flowing.

The liquid Pluronics, even at concentrations as low as 0.5% by dry weight of the formulation, are effective dedusting agents. They dedust not only during the compounding operations themselves, but also the finished product.

Compounders report that many dedusting agents lose their effectiveness after a period of time, whereas the use of half as much Pluronics gives effective permanent dedusting. This superiority is believed to be due to the much higher molecular weight of the Pluronics. They have no tendency to migrate.

What about hygroscopicity?

One of the problems of using anionic surface-active agents is the rapid increase of hygroscopicity in proportion to active-agent content. This hygroscopicity is also quite apparent in many of the nonionics.

An unusual feature of the Pluronics is their low order of hygroscopicity. Not only are the Pluronics relatively nonhygroscopic themselves, but they actually decrease the hygroscopicity of other components of formulations in which they are used.

For samples and more information . . .

The Pluronics make it easy to formulate products with optimum characteristics, products that are completely dust-free, non-caking, and exceptionally free-flowing, products with distinct advantages over competition. Evaluate them as a basis for an entirely new approach in formulating . . . the Pluronics may be the key to compounding concepts that open up new avenues of progress for your company. *But only a thorough evaluation can give you the full scope of the Pluronics' benefits.* For samples of the Pluronics, data sheets summarizing their physical and surface-active properties, and other technical and price information — call your Wyandotte representative or mail the coupon today. *Wyandotte Chemicals Corporation, Wyandotte, Michigan. Offices in principal cities.*

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Wyandotte Chemicals Corporation, Dept. 2525, Wyandotte, Michigan

Please send:

- ☐ Data on the use of Pluronics in metal-cleaning formulations
- ☐ Samples of Pluronics L61, 62, 64, F68 for metal-cleaning products
- ☐ Data on the use of Pluronics in home and commercial laundry detergents
- ☐ Samples of Pluronics L44, 61, 62, 64, P75, F68 for laundry detergents
- ☐ Data on the use of Pluronics in water-treating applications
- ☐ Samples of Pluronics L61, 64, F68 for water-conditioning compounds
- ☐ Data on the use of Pluronics in mechanical-dishwashing compounds
- ☐ Samples of Pluronics L61, 62, F68 for dishwashing products
- ☐ Have a Wyandotte representative call on me.
- ☐ Data on Pluronics for_____

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_____application

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The Yerkes Laboratories

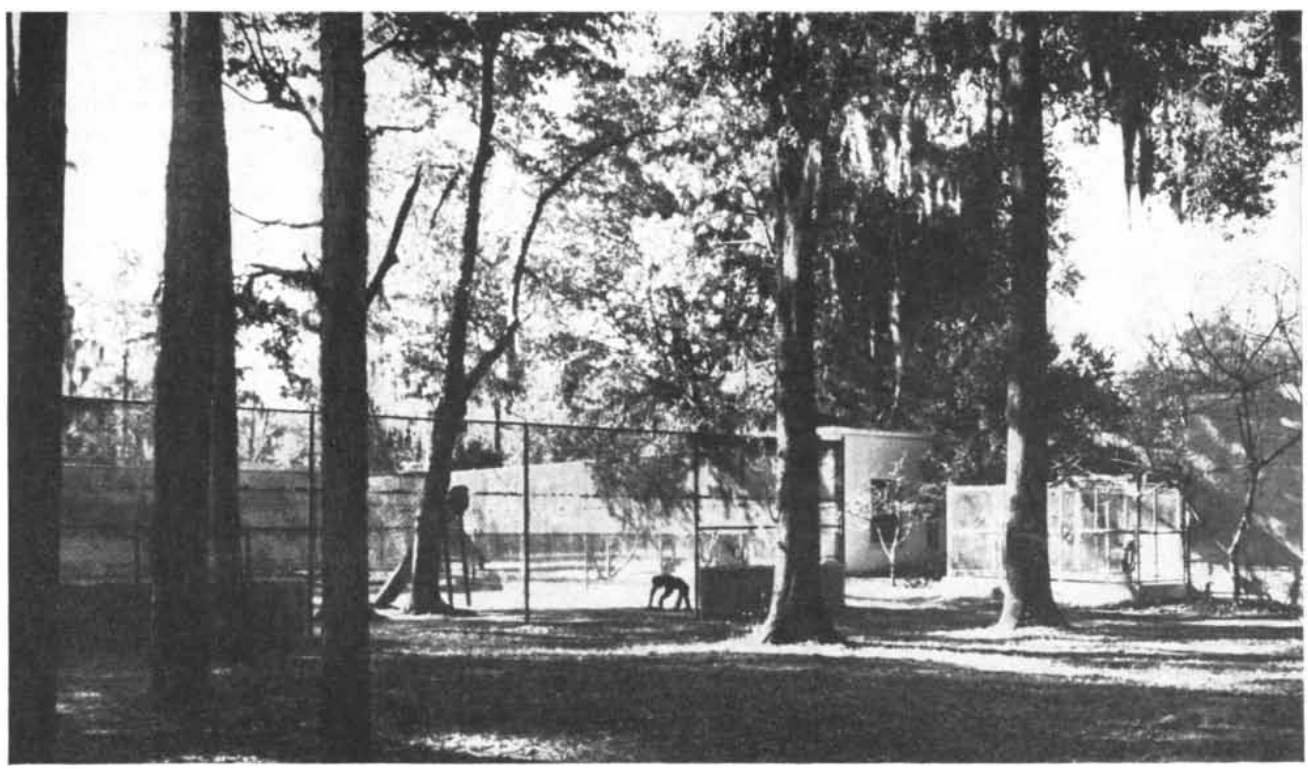
Not to be confused with the Yerkes Observatory of astronomy, they are dedicated to primate biology. Within their sunny Florida confines workers of many disciplines study the chimpanzee, and vice versa

by George W. Gray

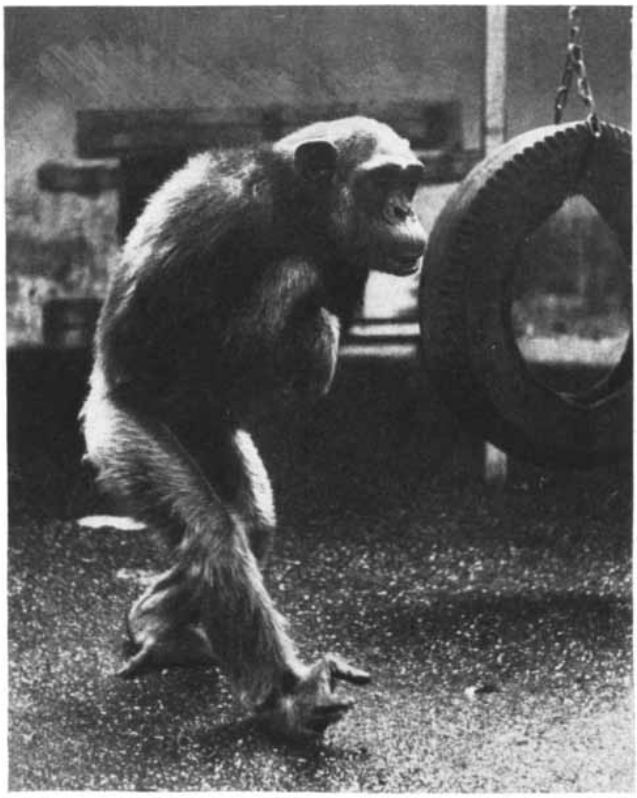
Fronting the public highway near Orange Park, Fla., not far south of Jacksonville, is a parklike development enclosed by a high woven-steel fence topped with an electrified wire. It is occupied by a cluster of modern buildings, which include offices, laboratories, a library and other working quarters of a scientific establishment. But the center of interest is a housing development to which these quarters are adjuncts. For here live nearly three score chimpanzees, forming perhaps the most remarkable nonhuman community anywhere on earth. Most of the inhabitants were born on the premises, and from birth have been reared and observed with elaborate care. There is a nursery for the youngsters, a maternity ward for expectant mothers, a small hospital for the sick, and a collection of spick-and-span apartments, each consisting of an indoor "bedroom" with a connecting outdoor "living room" cage, for the general population.

On the morning we arrived at the Yerkes Laboratories of Primate Biology, the colony was unwontedly quiet, for the residents were all locked in their bedrooms while attendants cleaned their cages with hoses and mops. When the housekeeping was finished, life resumed its normal stir. The dark forms of the Messrs. and Mesdames Anthropoid appeared in the cages; an occasional raucous howl or shriek rent the air. We set out to get acquainted with the colony under the escort of Henry W. Nissen, associate director of the Laboratories, who cautioned: "You'll find some vigorous characters, and as many different personalities as there are chimpanzees."

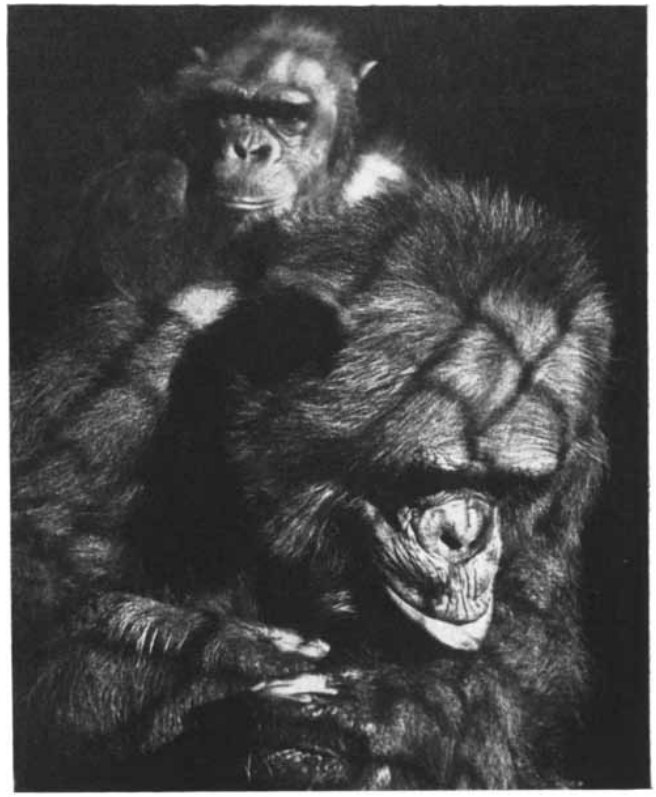
Appropriately, the first cage was occupied by Alpha, the first animal to be born here. She celebrated her 25th birth-



THE LABORATORIES are located near Orange Park, Fla. In the center one of the 60-odd chimpanzees walks across an outdoor pen. Most of the animals live in apartments consisting of an indoor and outdoor cage. The Laboratories also have a nursery and a hospital.



PATI is probably the oldest chimpanzee in the Laboratories. Her age is estimated at 34 years. She was presented by Rosalia d'Abreu.



BOKAR AND COMA are father and daughter. Bokar is in the foreground. He likes to slam his bedroom door to attract attention.

day last September. Alpha was drowsing in the sunshine; at our approach she arose and thrust long fingers through the wide mesh of the steel screen. It was an exploratory gesture, also an invitation to come a little closer. Dr. Nissen held out his sleeve so that she could reach the cuff links. She bent to the task with complete concentration, her sensitive lips moving in unison with her fingers as she undid the links and loosened the sleeve. When we offered a pencil and a piece of paper, she took them and began a crude scribbling on the concrete floor. We provided a penny, thinking it might be useful for drawing a circle, but she slipped the coin into her mouth. When we looked in on her again an hour later, she had the pencil firmly clasped between the toes of her right foot and fragments of the paper clutched in her left foot. As she saw us, she pursed out her lips to display the penny.

Alpha is friendly, even-tempered, level-headed but not brilliant. Her mother died at her birth, and the four-pound infant was taken into the home of a member of the staff and raised there through her first year. She has been the subject of many psychological experiments. Alpha now weighs 140 pounds, is about four feet, four inches in height, and has the characteristic brown eyes and beetling brow-ridges of her species. Chimpanzees are born with blue eyes which change to brown in a few weeks.

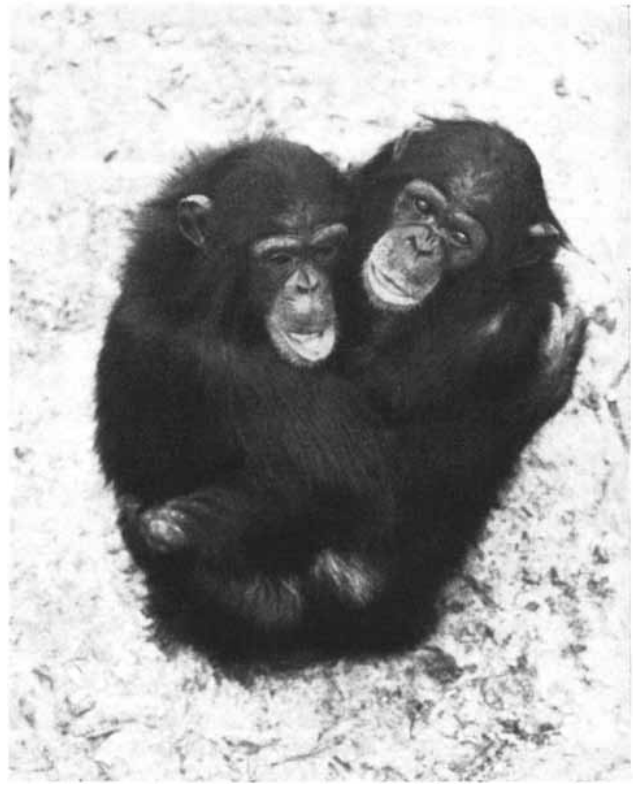
Alpha's eldest offspring is Alf, now 14 years old. He was in a nearby cage, dancing around and clapping his hands in a jovial effort to attract attention. Alf has inherited his mother's sunny disposition and is one of the most lovable and trusting apes of the Orange Park community. His maternal grandfather Pan was also a famous dancer and hand-clapper, so Alf comes by his showmanship naturally.

But the greatest clown of that morning tour was Ken. He is a husky 15-year-old, and as we approached he began a slow dance. Gradually the tempo speeded up until suddenly he leaped up, grasped a steel bar of the cage roof and drew himself up and down in a trapeze act, all the while bobbing his head in a comical way. After about a dozen of these contortions Ken dropped to the floor and crouched motionless, as though waiting for applause. During these gymnastics, Ken's consort Flora (a daughter of Alpha) sat quietly in a corner, as bored as any wife who has had to listen too often to the same joke.

The next cage housed Hal and Ami. As a child Ami was one of the most affectionate in the nursery, but during adolescence her personality changed radically, and now, at age 18, she is soured on the world. Nobody ever gets a welcoming gesture from Ami, and no one attempted any fingers-through-the-bars visiting with her. Hal's disposition is not much better. We stayed back from the cage, but, as it turned out, not far enough back, for suddenly Hal spat a six-foot stream of muddy water he had been saving for just such a target. We retreated to a washroom to swab off the spots, and then completed the tour without further mishap. Altogether we visited 58 chimpanzees, including babies in the nursery.

It is in the laboratory tests that the chimpanzees' individual personalities come into sharpest focus. For example, Bokar, a cage exhibitionist who will boisterously slam his bedroom door back and forth to attract a visitor's attention, shows indifference to the human species when the chips are down. He will go through the rigmarole of a problem for the bit of banana or other food reward that awaits a successful performance, but don't expect from him any spirit of cooperation. There are other hedonists like Bokar—Soda and Helene are exam-

DON AND GAMMA groom each other. Don, whose arm is at the left, has pulled most of the hair out of his arms, shoulders and chest.



LAD AND EASTER, who are five years old, hug each other. Hugging is common among the younger animals. It makes them feel secure.

ples among the females—who are interested only in the loaves and the fishes. The extreme misanthrope is Bula, who hates all human beings—and the longer she has known a man the sharper is her hatred. Bula has bitten more staff members than any other animal in the colony, but surprisingly she gets along well with fellow apes.

Some chimpanzees show stubborn streaks. Portia, an extremely keen problem solver, will frequently make a run of 10 to 18 correct solutions in a row, and then, right on the heels of this good performance, will perpetrate an unbroken run of errors. She calls the wrong turn so repeatedly that one can only conclude that she is missing purposely to foul up the experiment. In a different class from Portia, but equally difficult, is Rob. When the going is hard in a test, Rob will simply sit motionless, staring as in a trance. He has been known to huddle in one position for more than 30 minutes, with his legs extended and his arms rigid—a condition that approaches catalepsy in a human being. Indeed, some of the chimpanzees show behavior which a psychiatrist might call schizophrenic. They go through little rituals, crouching in a corner and rubbing a hand ceremoniously, or sitting motionless for hours in apparent catatonia—"just stir-crazy," as one staff man phrased it.

But many in the colony have a genuine liking for people, and these enter upon the tests with a seeming desire to work with the experimenter and to excel in performing the task. Wendy and her son Jed are of this type; so are Alpha and Alf and many others. They are warm-natured, openhearted, trustful and trustworthy—a pleasure to work with.

The chimpanzee colony is a world in itself—and mirrors traits which are all too familiar components of the human scene.

How It Came About

This unique outpost of biological research has been operating in the Florida savanna since 1930. The idea had been born 30 years earlier when Robert M. Yerkes, then 26 and a graduate student and instructor in psychology at Harvard University, began to dream of an institute where he could study the total biologic and psychic development of animals in relation to the environment. He conceived that the most useful subjects would be members of the order of primates, particularly the great apes, and he set out to learn all he could about these animals. Little was then known about them, and Yerkes traveled about to make personal observations at first hand in zoos and private collections. One of the largest collections was that of a wealthy Cuban woman, Madame Rosalia d'Abreu, who had assembled some 80 apes and monkeys on her estate near Havana. When she learned of Yerkes' interest, Madame d'Abreu invited the scientist to visit her pets. He spent several months there in systematic study. Chimpanzees seemed by all odds the most promising material for psychobiological research. They were more tractable than gorillas, more alert and cooperative than orangutans. In the summer of 1923 Yerkes bought two young chimps, recent arrivals from the Belgian Congo. He took them to his farm in New Hampshire, and within a few weeks they had won places for themselves in the household—but alas! before a year had gone Panzee was dead of tuberculosis and Chim of pneumonia.

Yerkes outlined his idea for an institute in a letter to *Science* in 1916 which evoked much interest, but not until 1924, when he was appointed to a professorship at Yale University, did he obtain backing for his dream. Yale agreed

to include a primate laboratory in its Institute of Psychology, and the Rockefeller Foundation soon afterward voted $40,000 for a four-year test of Yerkes' idea—the first of its continuing subsidies for the project.

The mortality of chimpanzees in captivity had been so great that many authorities doubted that a colony could be maintained to permit sustained research. The first task therefore was to determine whether or not the animals could be kept under conditions of experimental control. A few days after the Rockefeller grant was received, a ship bringing five young chimpanzees from Sierra Leone docked in Brooklyn. Yerkes, notified by telegraph, hurried to look them over and selected a three-year-old male and a four-year-old female, for which he paid $1,200. (The ages, of course, were only estimates.) This was the summer of the famous Scopes trial in Tennessee, in which William Jennings Bryan prosecuted a young high-school instructor for teaching Charles Darwin's theory of evolution, contrary to the law of the commonwealth. Yerkes named the male chimp "Bill," after the prosecuting attorney, and the female "Darwinia," soon shortened to "Dwina."

Bill and Dwina thus have the distinction of being the first "settlers" of the Yale anthropoid colony. They spent the summer on the Yerkes farm in New Hampshire. In September they were joined by another pair of chimps purchased from a ship's officer, who had picked them up in a West African port and was so fed up with the supervision of his pets by the time the ship reached Boston that he was glad to sell the two for $500. They were promptly named "Pan" and "Wendy," after the *Peter Pan* characters.

A brick barn on Prospect Street in New Haven was remodeled to house the four apes, and there it was soon demonstrated that the rearing of chimpanzees was feasible and the use of them in scientific research practicable. Before the four years were up, Yerkes began to look for a permanent site for the laboratory, and he decided it should be located in a more tropical climate. A survey committee of eminent biologists endorsed the expansion, and the Rockefeller Foundation appropriated additional funds to purchase a 200-acre tract at Orange Park, to erect buildings and equipment and to meet operating expenses of the laboratory for 10 years.

The new buildings were completed in the spring of 1930. The architect turned them over to the University on June 9, and the following day Bill, Dwina, Pan and Wendy arrived from New Haven. Dwina was pregnant and the staff was looking forward to the first birth in the colony. It occurred on September 11, when the baby Alpha was successfully delivered. Dwina, however, contracted puerperal septicemia and died two weeks later—the first recorded case of childbed fever in an anthropoid ape. Her pregnancy had afforded the first systematic observation of a chimpanzee's reproductive process from conception to birth. The ape's gestational period was determined to be 245 days, compared with 280 days for a human mother.

Gifts and additional purchases of animals, plus the returns from a gradually rising birth rate, increased the size of the colony. By 1941, when Yerkes retired as director, the laboratory population totaled 45. It was by far the largest collection of chimpanzees that had ever been assembled for use in scientific work, and the fact that more than half of them had been born in Orange Park was a testimonial to the success of the breeding program. The colony had grown in usefulness and in research results as well as in numbers. In 1942 the station was incorporated separately and named, in honor of its founder, the Yerkes Laboratories of Primate Biology. It ceased to be a division of Yale and was sponsored jointly by Yale and Harvard. Karl S. Lashley, professor of neuropsychology at Harvard, was appointed to succeed Yerkes as director, under a supervisory board of scientists.

Subjects for Research

"Compared with other laboratory animals, chimpanzees are expensive, not only in cost of maintenance but also in the time required for an investigation," says Lashley. "Their use is justified only in studies for which they have a unique value, and a major task of my office is to identify the problems for which these animals are the preferred subjects. Thus far the main investigations have been in the fields of cerebral function, comparative intelligence and sex physiology. Exploratory studies indicate that the apes may also be useful for the investigation of nutrition, aging, personality and psychopathology."

Asked to name the most important single contribution that has come from research in the Laboratories, Lashley answered that he would unhesitatingly select "Carlyle Jacobsen's discovery of the reduction of temper tantrums in chimpanzees by brain lesions." This discovery, which led to the human operation of prefrontal lobotomy, is indeed a landmark in modern neurological history. It provides a striking example of the unique value of the chimpanzee in certain fields of medical experimentation.

Jacobsen was a member of the Yerkes staff from 1930 to 1937 (he is now executive dean for medical education in the University of the State of New York). He was interested in psychoneurology, and a great deal of his work was focused on the function of the frontal lobes of the brain. When the research involved surgery, he had the collaboration of John F. Fulton, neurosurgeon and professor of physiology in the Yale Medical School.

In 1933 a study was begun with two chimpanzees of very different temperaments. Lucy was a calm and even-tempered six-year-old; Becky, a year or so younger, was an excitable neurotic who fell into a rage whenever she made a wrong choice in a test. Jacobsen made various tests of the two chimps' learning ability and memory. Then by a delicate operation he and Fulton cut out about half of the prefrontal area from each animal's cerebral hemisphere. After the wounds had healed, the intelligence tests were repeated, and the animals reacted pretty much as before—Lucy with deliberation and composure, Becky with tantrums when she failed to solve a problem and obtain the food reward. The experimenters then made the operation more radical: they removed the remaining half of the forepart of each animal's brain. In the case of high-strung Becky this produced an astonishing change. She was no longer annoyed when she made the wrong choice; she merely shrugged her shoulders and went on to the next test, quite indifferent to failure or disappointment.

Jacobsen and Fulton reported this experiment at an international medical conference in England in 1935. The Portuguese neurologist Egas Moniz expressed great interest in Becky's changed behavior. It suggested, he said, that anxiety states in men and women might be relieved by surgical means. And within a year Moniz, in collaboration with a Lisbon surgeon, had operated on 50 hopeless mental patients in Portugal. They did not remove tissue, as had been done with the apes, but severed the pathways between the prefrontal region and the brain stem by skillfully cutting the connecting nerve fibers. A fair percentage of the 50 patients reported relief from obsessions, fears, anxieties and other compulsive states. Other surgeons

STRIPED PAPER CHAMBER is used by Robert L. Fantz to test the vision of an infant chimpanzee that has been raised from birth in total darkness. The test is made by turning the chamber and observing whether the eyes of the animal follow the moving stripes.

TRANSLUCENT PLASTIC DOME is placed over the head of an infant chimpanzee which lives in darkness 22½ hours a day. This is done for the remaining hour and a half to assay the effect of light without objects on the development of visual perception in the chimpanzee.

took up the operation, and at latest accounts it is said to have assisted several thousand psychotic persons in many countries toward a more tranquil life.

"If the influence on the development of 'psychosurgery' ascribed to Jacobsen's experiment is correct," said Lashley, "then this single study has been worth more, in terms of the usual cost and returns of psychiatric research, than the entire investment in the construction and maintenance of the Yerkes Laboratories."

Studies of the Brain

The great value of Orange Park, the director went on, is not in spectacular discoveries but in the steady accumulation of data on fundamental problems. "Basic conceptions of instinct and of the nature of learning have been significantly modified, I think, by work done at the Laboratories. The studies of cerebral function have contributed to the development of an experimental attitude among clinical neurologists, as is illustrated by the Greystone project in New Jersey, with its systematic appraisal of the over-all effects, both good and bad, of prefrontal lobotomy."

Jacobsen's pioneering experiments were followed by other investigations of the great roof of the brain—the cerebral cortex. It is a structure which man shares with the chimpanzee, the monkey and other anthropoids. The human cortex is about three times as large as the chimpanzee's, which in turn is double or triple that of the monkey, but in each primate the familiar landmarks are found: a general division of the cortex vertically into two hemispheres, and subdivisions of each hemisphere into certain regions—the occipital lobe at the rear, the parietal lobe just above it, the temporal lobe at the side and the frontal lobe under the forepart of the skull.

Neuropsychology is Lashley's specialty, and since he came to Orange Park its studies of cerebral function and neurological structure have been conducted under his personal direction. Two examples suggest the scope and pertinence of this research.

The first is the study of "associative areas"—regions lying between the sensory and motor centers of the cortex. These associative areas are supposed to be the "storehouses of memory." It had been observed, for example, that patients with tumors or injuries in these areas often suffered agnosia—loss of the ability to recognize objects by touch, vision or sound. When Lashley took up his duties at Yerkes, few experimental studies of the associative cortex had been reported, and he decided to concentrate on this part of the brain. Since monkeys would serve for most problems, he confined the experiments to them except in explorations of the prefrontal cortex, where chimpanzees were used.

The results have been surprisingly negative. The monkeys were first trained in specific discriminatory habits: for example, in using the sense of touch, to choose a prism and reject a cylinder if both were smooth, but to grasp the cylinder and reject the prism if both were rough. When the animals had learned this lesson, portions of the associative area of the parietal lobe were removed from their brains. It was found that the monkeys discriminated between prism and cylinder quite as well as before the operation. A similar test was made of their discrimination between colors, and again injury to the associative area of the visual cortex failed to impair the animals' memory of the choice of colors. It was only when the temporal lobes were completely excised that serious defects showed up in vision and touch; partial removal had little effect. Similarly, the five chimpanzees whose prefrontal lobes were removed showed no loss of memory or learning ability.

"It seems clear," says Lashley, "that current conceptions of the function and mode of action of these so-called associative areas are due for a drastic revision. They are not 'storehouses of memory,' nor do they appear to have localized functions. Any part of the cortical region seems capable of carrying out the functions of the whole. Studies by my associate, Kao Lang Chow, have shown, for example, that the same nerve cells in the primary visual cortex that retain visual memories are also continually active in other functions connected with seeing."

Another project in neurological research with important human implications is focused on brain scars. The Navy is financing this study, because it is naturally interested in brain damage from wounds. Neurologists know that while a sizable portion of the human brain may be cut out without apparent ill effects, a very small lesion, such as a cut or a compression, may cause severe trouble—epilepsy, paralysis, agnosia. At the Yerkes Laboratories Paul J. Hutt and Hiroshi Odoi, under Lashley's direction, have performed scarring operations on 38 monkeys, using 13 different ways of in-

flicting injury. Only one produced any obvious change in behavior. A small lesion in the left convolution at the top of the temporal lobe caused severe disorganization of the animal's responses to stimuli. The location of the sensitive area has been pinpointed, and Hutt and Odoi plan to explore the matter further.

Body and Behavior

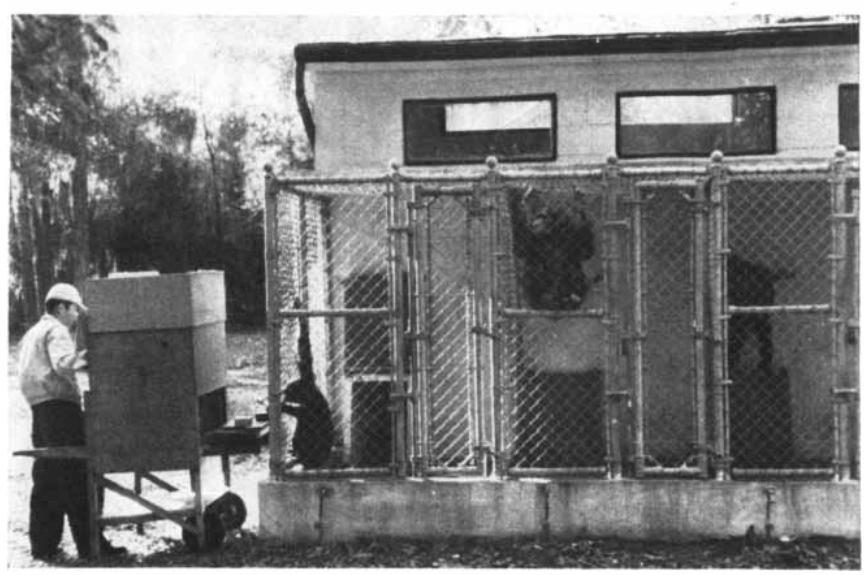
In 1939 Nissen began a long-term study of the physical and behavioral development of chimpanzees. He has been assisted by numerous associates over the years, and the research results fill many volumes of notes. In consequence of this study, more is known of the growth and development of the chimpanzee than of any animal below man, with the possible exception of the laboratory rat.

Sixteen infant apes, including several pairs of brothers and sisters, were separated from their mothers soon after birth and installed in the nursery, where they could be under continuous observation. Thirteen have now been followed into maturity. During this long period they were regularly measured, photographed, X-rayed and tested for pulse rate, heartbeat, respiration rate and other characteristics. In addition, the growth and development of other infants were followed somewhat less intensively.

The studies show that the physical growth curve of the chimpanzee fairly well parallels that of the human being, although man on the average is larger and heavier. Detailed comparison of the growth of the chimpanzee with that of other animals and man may lead to a surer understanding of the interrelations in the growth of different parts of the body, as determined by heredity and as modified by environmental factors.

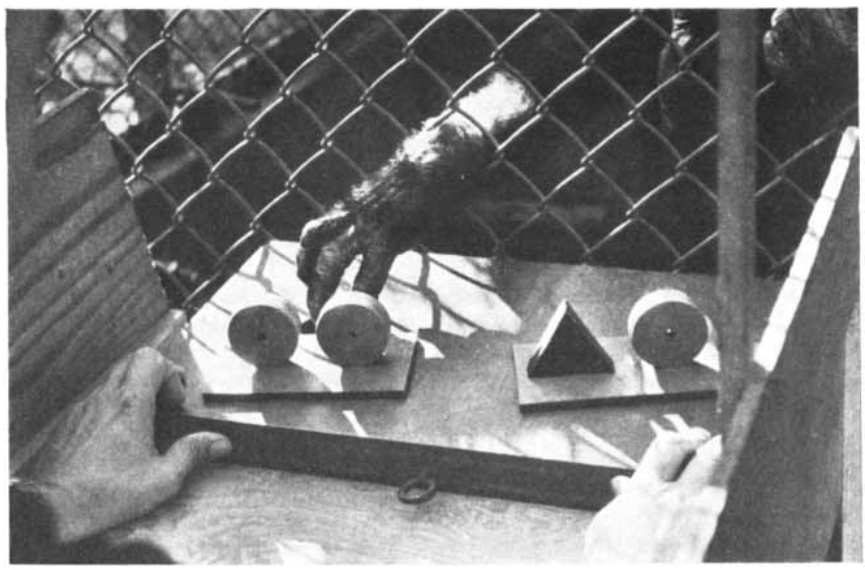
The study also includes a systematic observation of the sexual cycle, the time of ovulation and the pattern of sexual physiology and behavior. The influence of sex hormones on the temperament of primates has been investigated; the experiments show that dominance and aggressiveness increase under the influence of male hormones and decrease with female hormones. The program offers an opportunity to explore instinctive elements in sex behavior which it is believed may be generalized to man. Studies of pubescent individuals indicate that the chimpanzee's sex patterns are less stereotyped than those of lower animals.

The oldest chimp at Orange Park whose birth date is precisely known is Alpha, now aged 25. Wendy, bought by Yerkes in 1925, was estimated to be two years old then, which would make her

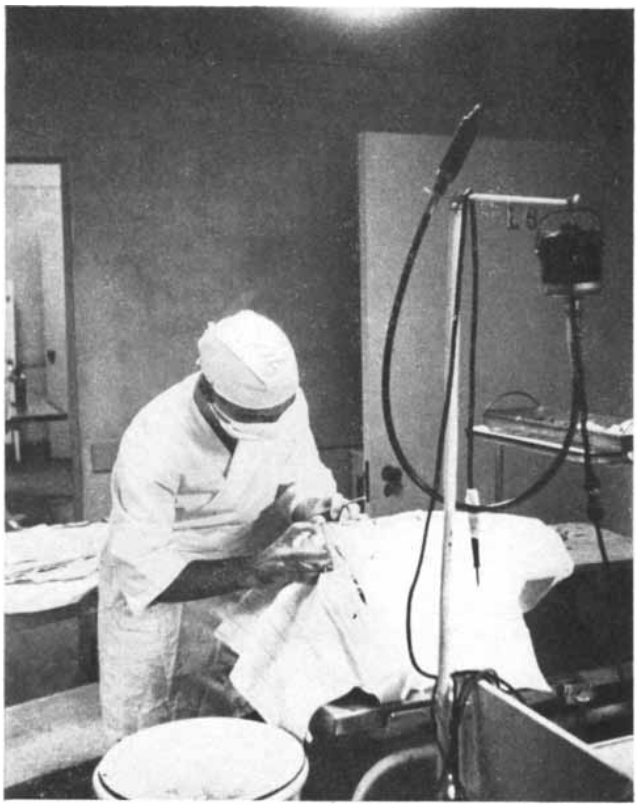


TEST APPARATUS is wheeled up to Kathy's cage by Hiroshi Odoi. On the shelf of the apparatus are two test objects. These cages house chimpanzees from three to seven years old.

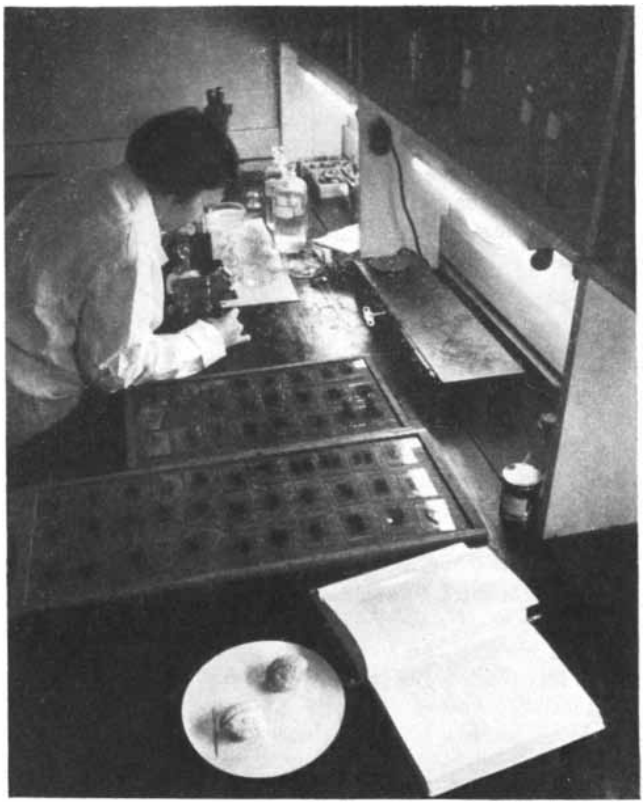
TWO BLOCKS on the shelf of the test apparatus are of different colors. Here Hank puzzles over which he must take in his hand in order to be rewarded with a bit of orange.



TWO PLAQUES, one bearing two different objects and the other two identical objects, are presented to Dolly. She is supposed to choose the plaque with the two identical objects.



OPERATION IS PERFORMED on a monkey by Jack Orbach to determine the effect of brain lesions on the behavior of the animal.



BRAINS ARE SLICED and examined by Ruth Orbach. Because chimpanzees are expensive, monkeys are used for most operations.

31. There is a still older member of the colony: Pati, a former pet of Madame d'Abreu who was presented to the Laboratories in 1931, is estimated to be 34. Nissen believes that the life span of the chimpanzee approaches that of man—somewhere between 50 and 60 years. Another quarter century at Yerkes should provide the answer.

In their study of the behavioral development of the chimpanzee, the Yerkes psychologists have attempted to follow their subjects with the same kind of observations that Arnold Gesell has made of the human infant. They have recorded such items as postural control, sensory-motor development, the beginnings of play, of social behavior and of more complex adaptive behavior. The investigators—Austin Riesen, Elaine Kinder and others—have found that the young chimpanzee develops more rapidly than a human infant in sensory and motor coordination, but it falls progressively behind in perceptual and manipulative ability. The ape's tendency to explore with lips and tongue rather than with the hands seems significant.

Social Behavior

Yerkes says that he has never known a chimpanzee who was naturally and persistently unsociable. "Even in its relations with human beings a young ape shows impressive friendliness once its timidity and natural caution have been replaced by confidence and trust," he observes. Chimpanzee youngsters readily accept other animals on friendly terms as playmates, but if the other animal shows fear it is almost certainly in for trouble. In his book *Chimpanzees*, Yerkes tells of putting a woodchuck in a large room with a five-year-old chimpanzee. "All might have gone well if the woodchuck had stood its ground when the chimpanzee approached. Instead, it scurried away, chased by the ape. Before long both became excited and began to use teeth and claws defensively. To save the woodchuck for later experimental use, it was necessary to remove it. One lesson is clear. If an animal is to get along with a chimpanzee, it must stand its ground calmly when approached, since retreat or other show of timidity encourages pursuit and aggression."

Instances of cooperation are numerous. On one occasion a caretaker brought some grape juice for Josie, a chimp who a few hours before had given birth to a baby. Josie took the grape juice in her cupped lower lip, but instead of swallowing it she turned to Wendy, who was watching expectantly in the next cage, and poured the lipful of juice into Wendy's extended lip. She did this again and again until the caretaker's cup was almost empty.

Then there is the story of how Moos, a youngster who had been ill, helped his "doctor." Because he was refusing hard foods, a staff member decided to examine Moos's teeth. The young ape cooperated fully, opening his mouth wide and allowing the examiner to probe wherever he wanted to. When, finding nothing wrong, the examiner turned to leave, Moos pulled the man back, raised his upper lip and pointed to an area of his upper jaw. Sure enough there was a slight swelling, and subsequent examination showed that a permanent tooth was in process of eruption.

Easter (born on Easter Sunday, 1949) began at an early age to show a mechanical turn of mind and a remarkable proficiency in escaping from his cages. One day an investigator took Easter out to train him in some learning tests. He locked in Easter's cage mate, Lad, to keep him from interfering with the experiment. Lad protested, whimpering and scratching on the locked door. Easter soon went to his rescue. Although the lock was an unfamiliar one—a long bolt passed through two eyes and secured by a nut screwed on the end—Easter soon

unscrewed the nut and freed his chum.

Nissen tells of a female chimpanzee who picked an attendant's pocket of his bunch of keys, tried the keys in the lock one after the other, finally hit on the right one and let herself out. After a half-hour exploratory tour of the grounds, she apparently became bored and allowed herself to be lured back. "It is almost certain," says Nissen, "that this animal had had no previous experience in the use of keys."

Chimpanzees habitually serve one another in the ritual of grooming. This is sometimes called "flea-picking," but erroneously, for a flea would find it difficult to get a footing on these sharp-eyed, sensitive animals, which daily examine their own skins and one another's in the search for foreign particles, pimples, abrasions, bits of loose skin and other excrescences. There is evidence that being allowed to groom is esteemed as great a privilege as being groomed. While grooming is primarily an act of toiletry, it often involves therapeutic services: the chimps extract splinters and other particles embedded in the skin, cleanse wounds and soothe injuries. Yerkes believes that grooming in the chimpanzee "represents a genetically important pattern of social response from which may have evolved some of our forms of social service." It may be a "forerunner of human hair and skin dressing, nursing, medical and surgical treatment."

Deprivation

The extent to which intelligent behavior is dependent on experience has been studied at Orange Park in various ways. One procedure has been to deprive subjects of practice in the use of a sensory faculty for a long time. Thus 12 chimpanzees have been raised in darkness. Snark and Alfalfa, a male and a female, were placed in a darkened room soon after birth and kept there, with the usual diet and care, for 16 months. When they were brought out, their eyes showed sensitivity to light but were unable to respond to complex patterns. Eventually, after many months, Alfalfa developed recognition of objects, but Snark's sight progressively dimmed and finally failed completely [see "Arrested Vision," by Austin H. Riesen; SCIENTIFIC AMERICAN, July, 1950]. Examination indicated that the optic nerve had degenerated. Tests with other chimpanzees showed that if an infant is allowed only an hour and a half of light each day, this brief daily use of its eyes is sufficient to develop sight.

"It appears," said Nissen, "that the improvement in seeing ability which takes place progressively from birth up to about five months is a matter of practice in seeing objects. We kept an infant chimpanzee under a plastic dome which gave unpatterned light but did not provide any objects or images to look at—and found that this animal was almost as badly off as those raised in total darkness. The ability to see is not an inherent endowment, but has to be learned through experience."

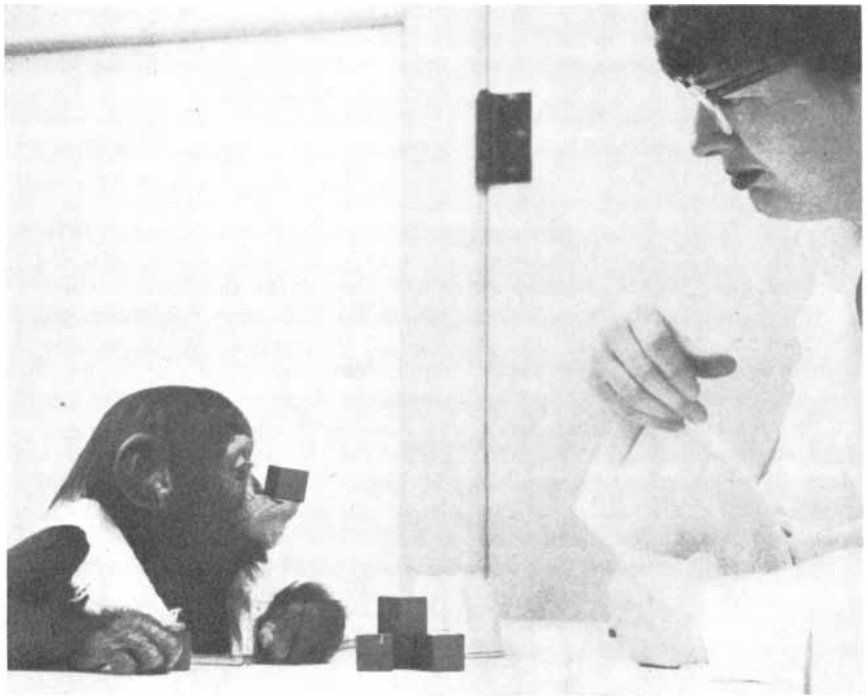
There have been other deprivation experiments, and each confirmed the conclusion that perceptual faculties do not come with the mere presence of sense organs but are acquired through use.

Viki

Suppose that one were to go to the other extreme and, instead of restricting a chimpanzee's experiences, give it the rich experience of upbringing in a human household as a member of the family. This experiment has been made by several researchers at Orange Park. One baby chimp lived in a home for a year, another for nine months, another for two and a half years. But far and away the most important "adoption" was that of Viki, born on August 28, 1947. Immediately after birth she became the subject of an experiment which was destined to last nearly seven years, to pile up an unprecedented wealth of information and pictorial records, and to make her the most engaging ape in the history of primate research.

When Keith J. Hayes completed his postgraduate work in psychology at Stanford University in the spring of 1947, he and Mrs. Hayes had a clear idea of what they wanted to do. As she recorded it in her book, *The Ape in Our House:* "If we ever found the opportunity we would adopt a newborn chimpanzee and raise it as a human in all respects, giving it everything the human child needs: loving care, security, playmates, toys and sympathetic guidance. We decided that such a chimpanzee must be observed constantly for its entire life span. During its course of development, its body and brain must be compared not only with human beings its own age, but also with caged apes. The home-raised chimpanzee would provide psychologists with an evaluation of basic anthropoid intelligence, and, in addition, its unique upbringing would prepare our subject for many studies never before possible."

Dr. and Mrs. Hayes did not have to wait long for the opportunity. Soon after he got his Ph.D. the young psychologist was offered an opening at Yerkes and told that an infant chimpanzee would be provided. Viki, the daughter of Vera and Bokar, was three days old when Mrs. Hayes first saw her in the Yerkes nursery. The sight startled her. The newborn baby "looked like a monstrous spider,



CUBE IS BALANCED by infant chimpanzee observed by Cathy Hayes Nissen. The manipulation of a cube is one of the tests used by Arnold Gesell to measure development of behavior.

VIKI imitates a photograph held by Mrs. Nissen. Viki is the chimpanzee, now dead, raised by Mrs. Nissen and her former husband, Keith Hayes. Man in the photograph is Dr. Hayes.

with long skinny arms and legs thrashing out from a solid potbelly. Most of her scant four pounds was concentrated in that middle, which was topped by an adhesive-tape navel dressing. The skin of her body was light brown, taut and shiny-smooth."

Six years of nurture and training in the Hayes home converted Viki into an 80-pound bundle of habits, skills and reasoning. She was able to match six-year-old children in solving many discrimination problems. She turned the switch of the electric fan, and when it failed to go on, she checked the wall socket and plugged in the wire. When a lamp remained dark after she had turned the switch, she removed the bulb and screwed in a fresh one. She wielded the carpet sweeper, dialed the telephone, applied her ear to the clock. The ticking of timepieces fascinated her, and once they found Viki on the floor holding her ear to a magazine picture of a watch.

At the age of three Viki performed with appropriate skill on such problems as form boards, peg boards, picture puzzles, block piling and buttoning. She solved problems which involved obtaining a prize by throwing a ball to knock it down, by pushing it out of a tunnel with a stick, by burning a string with a candle flame, by operating a light switch on the wall which released the prize magnetically from the ceiling, or by turning three levers in a certain sequence to open a box. The tests were given to four human children of the same age, and they excelled Viki only in the solution of the lever problem. A laboratory chimpanzee, nine months older, was completely baffled by all the tests except the one in which a ball was thrown to knock down the reward.

The one area in which the observers found Viki clearly and substantially inferior to human children was in language ability. "Although Viki learned to say a few words by the time she was three years old," explained Hayes, "she learned them with great difficulty, and the nature of her difficulty was significant. As an infant she babbled much less than human babies do, and even this vocalization had disappeared by five months of age. Since it appeared unlikely that she would speak spontaneously, we began a speech training program. The first step was aimed at teaching her merely to vocalize on command. The task was surprisingly difficult. It took her five months to learn to produce a hoarse staccato grunt, and it was quite unlike her normal spontaneous sounds.

"By manipulating Viki's lips we were able to make her say 'mama.' She learned to make the proper mouth movements herself and then was able to say 'mama' unaided—softly and hoarsely, but quite acceptably. By the time she was two and a half years old she had learned to pronounce approximations of the whispered words 'papa' and 'cup.' We did not manipulate her mouth in teaching these words, but simply insisted that she copy our example of a certain combination of play sounds. She soon learned to address the proper experimenter as 'mama' or 'papa,' and to say 'cup' when she wanted a drink."

Several years ago Dr. and Mrs. Hayes ventured this diagnosis: "When Viki is compared with various human individuals who display a similar degree of language deficiency, we find that she bears little resemblance to those whose trouble is caused by feeblemindedness or by abnormality of speech organs. But in certain respects she appears to resemble those cases, known as aphasics, whose deficiency is caused by abnormal brain structure, congenital or acquired. Like many aphasics, Viki is deficient in language comprehension as well as in speech, though here the deficit is less striking."

Even so, her powers of communication seemed remarkable. We visited her one afternoon in the yard of the Hayes home, about a mile from the Laboratories. Hayes, not present at first, arrived later in his car. As he drove up, Viki immediately began to click her teeth together. "That's her word for 'Let's go riding,'" Hayes explained, and answered, "All right." From the fenced-in yard she bounded through the house and emerged a few seconds later from the front door. After she had hopped into the car, Hayes said: "Close the window." Viki turned the handle and wound the window up about half way. "All the way," he commanded, and she wound it all the way.

She had other ways of communicating. "In her younger days," explained Hayes, "we used to carry extra diapers on automobile rides; so, when she wanted to go riding, she would bring a handful of diapers. After we removed the diapers from the bathroom, she brought a handful of cleansing tissue instead. A few evenings ago she began to tease for a ride. She clicked her teeth. Then she brought the tissue. I thought I would make her work a little harder, so I said, 'All right, if you get my scarf.' I had hung the scarf on a bathroom hook, but wasn't sure that Viki knew. She went directly to the bathroom, brought the scarf and started wrapping it around her neck. I said, 'No, put it on me.' And she did. Then I told her to get the door key. She had often led me to the desk, opened the drawer and pointed to the key, but she had never before actually taken it. Now she went instantly and brought the key. Then we went for our ride."

Another kind of communication is pictorial. "We can convey a message to her by drawing a picture, but Viki has shown no ability to draw pictures herself. Yet she has a fondness for mechanical things, and not only uses tools but invents them. This has always occurred in the realm of play. Once she noticed that an empty condensed-milk can rattled—there was a bit of loose solder inside. Later, having lost this can, Viki dropped a small hairpin through the hole of another can and made a rattle. On another occasion she made a sort of eolithic ax. While she was in the yard playing with a brick, the brick broke, leaving a nice sharp

edge. She used this piece for digging, pounding and cutting. Viki has used screwdrivers, hammers, saws, sandpaper and every sort of household tool. If the accustomed can opener won't work on an unfamiliar container, she is able to adapt to another tool and get the job done. She can handle things very precisely, pick up quite small objects and use fingers and thumb in opposition. She seems to appreciate fully such qualities as the strength of materials, weight and balance. I have seen her set a cup on the table, then notice that it is dangerously near the edge and move it to a safe position."

Our visit to Viki was on March 26 of last year. She was the picture of robust health, and in fact had grown so strong that a small cottage had been fitted up for her. There were a refrigerator, a dining table, can openers, electric fans—all her beloved gadgets. The plan was to install her there in May, supervising and observing her during the day and leaving her to sleep alone at night. But Viki never got there—and the cottage stands vacant and idle.

She was taken sick in late April, and in the course of the next three weeks physicians attended her. She was under barbiturate sedation during part of her illness, and on May 4 was given a transfusion of human blood—type O Rh-negative—with no ill effects. Despite 24-hour-a-day nursing she gradually grew weaker and on May 11 succumbed to epidemic encephalitis.

Ape Ailments

When chimpanzees at Orange Park need medical or surgical attention, a physician is called, for veterinarians are not trained in the ape's near-human anatomy and physiology. On one occasion a heavy steel slide fell on a chimpanzee and broke its left arm and pelvis. The chimpanzee was laid on a stretcher, put under anesthesia and taken by ambulance to a Jacksonville hospital. There, with five doctors and eight nurses in attendance, the broken humerus was set, and then the patient, still under anesthesia, was returned to the Laboratories. No one outside the group that attended him knew that the covered figure from Orange Park was not a human patient.

While the mortality rate at Orange Park has steadily declined in recent years, Viki's was the 62nd death, and the second caused by encephalitis. Dysentery and pneumonia have been the most frequent causes of death, but there has been a wide range of diseases; it appears that chimpanzees are susceptible to all the ills that man himself is heir to. This fact makes the animal of strategic value to medical research. Members of the colony have been used in extensive studies of bacillary dysentery and infantile paralysis; the polio investigation, which was carried on at the Yale Medical School, has involved a dozen of the more than 50 chimpanzees born at Yerkes in the last 10 years. A study of the effects of body radiation was recently begun at Orange Park under a contract with the Atomic Energy Commission. This research is seeking to determine what effects radiation may have on behavior and, if possible, to differentiate between general symptoms (such as postradiation nausea) and direct effects on the central nervous system. Ten chimpanzees, ranging from infants to mature adults, are the subjects.

Lashley is hopeful that the chimpanzee will be useful for exploring problems of human genetics. L. H. Snyder, the well-known human geneticist of the University of Oklahoma, spent two weeks at Orange Park studying differences among the animals in relation to their parentage. He suggested that selective breeding be used to develop distinct races differing in measurable physical or behavioral traits, and that these races then be crossed for study of genetic patterns. A program of this kind would extend over many generations. But it seems practicable, if funds for such a long-term project become available. The physical data accumulated on inherited characteristics such as skin pigmentation and body proportions, when combined with data on behavior, should provide material for a genetic analysis, especially if combined with a comparative study of racial types of chimpanzees in nature.

Warren Weaver of the Rockefeller Foundation has playfully suggested that research at the Yerkes Laboratories may not be unilateral. As to this we can only speculate, but irrespective of whether or not the chimpanzees are also studying the scientists, there can be no doubt that the Yerkes scientists are deeply absorbed in their subjects. The intricate variety and daily surprises of the research material are endlessly stimulating. Every hall of science is, of course, a place of preoccupation—the focus of adventurous curiosity, enthusiasm and dedication. But while there are hundreds of laboratories studying rats, dogs, guinea pigs and other conveniently available organisms, in all the world there is only one laboratory colony of the sensitive, near-human, almost embarrassingly intelligent chimpanzees—in other words, only one Orange Park.

GAME THEORY AND DECISIONS

In which Smith plays a game with Jones and Columbus plays a game with nature to illustrate how this comparatively new mathematical tool can be used to grapple with problems involving uncertainties

by Leonid Hurwicz

We are often forced to make decisions without complete information as to the consequences of the possible alternative actions. Such is the case, for instance, when an individual must decide in May whether to take his vacation in July or in August, when a nation must decide on the size of its defense program though uncertain about other nations' intentions, when a scientist must decide on a plan for an experiment. Uncertainty is present in many decision problems, big and little, routine and unusual.

Some problems involving uncertainty can be treated scientifically by means of the mathematics of probability. The modern sciences of genetics and physics are largely based on probability theory. But what of the innumerable kinds of situations in which the probabilities cannot be computed? Think, for instance, of Columbus' problem when his crew demanded that he turn back. Could he have evaluated the probability of finding land to the west before food and water gave out?

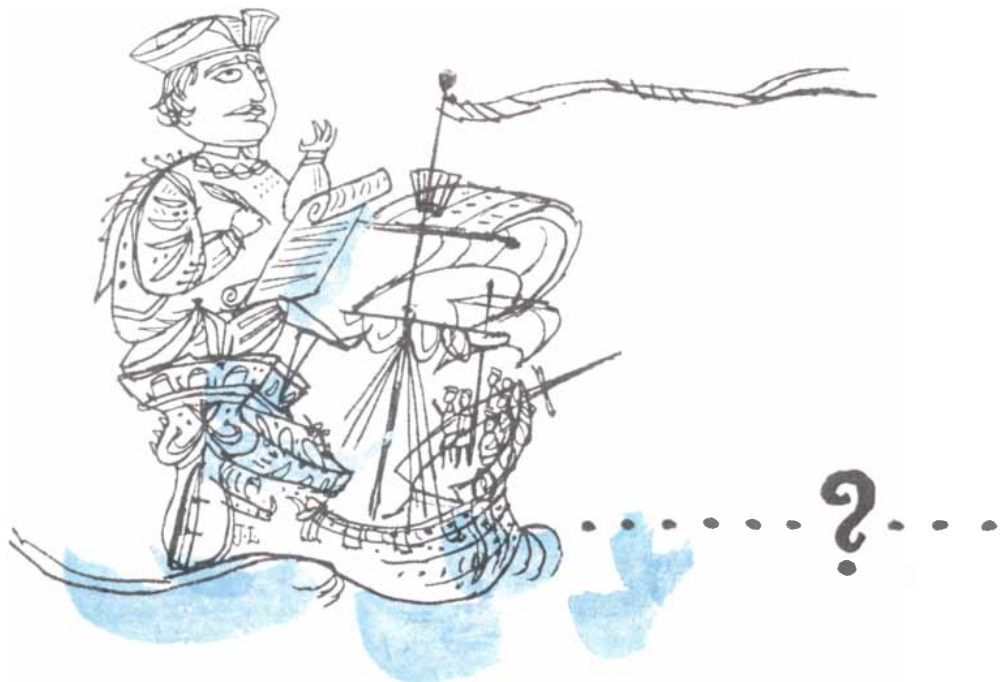
Within the last few years mathematicians have begun to develop a systematic theory of "rational" decision-making in problems involving such uncertainties. Like the probability theory, originally developed in the 17th century from studies of simple games of chance (*e.g.*, dice), the new theory has grown out of studies of a "laboratory model"—in this case certain simple games of strategy against a thinking opponent (*e.g.*, chess and poker).

John von Neumann constructed the theory of games in the 1920s (earlier the mathematician Emile Borel had also had some ideas on the subject), but the subject did not achieve prominence until the publication in 1944 of the now classic *Theory of Games and Economic Behavior* by von Neumann and the economist Oskar Morgenstern. The theory then "caught on," and there has been a multitude of studies and papers developing it in a great many directions.

The theory of games and the theory of decision-making met on the territory of statistical inference. It had occurred to Abraham Wald, one of the founders of modern statistics, that statistical inference could be thought of as a game played against nature by the statistician attempting to uncover its secrets. Wald's principle of "minimizing the maximum risk," indeed, turned out to be equivalent to a principle of choosing a strategy in a game.

Game theory is so complex and heavily mathematical that it cannot be presented in a comprehensive fashion in one article. But many of us are not so much interested in the details of the theory as in its underlying logic, and of that one can get a rough idea from some simplified examples.

Among games of strategy it is convenient to distinguish between games of pure chance and what we shall call games with strategic uncertainty. In a game of pure chance (*e.g.*, dice) wheth-



Could Columbus have used the theory of games to

er a player wins or loses, and how much, depends only on his own choices and on luck. In a game with strategic uncertainty (*e.g.*, poker) he must think about an additional factor: What will the other fellow do? Our main interest is in games involving strategic uncertainty, but we shall find them easier to understand if we first devote some attention to how one might apply general principles of "rational" conduct to games of pure chance.

Suppose that I am invited to place a bet on the outcome of a simultaneous throw of two dice: I will be paid $10 if two aces (single dots) show, otherwise I shall have to pay $1. Should I accept the bet? To answer, we start by doing a little computing. On the average a double ace will appear once in 36 throws. Hence I can expect that in 36 throws I shall win $10 once and lose $1 35 times. The "mathematical expectation" would be a loss of $25, about 69 cents per throw. If all I cared about was the mathematical odds, I would obviously refuse to bet on such terms, since my expectation when not playing is zero—which is better than minus 69 cents! In fact, if I cared only about the mathematical expectation, I would insist that if I am to pay $1 whenever I lose, I ought to be paid at least $35 when the two aces come up; for only then would I be, in terms of my expectation, no worse off than if I refrained from betting.

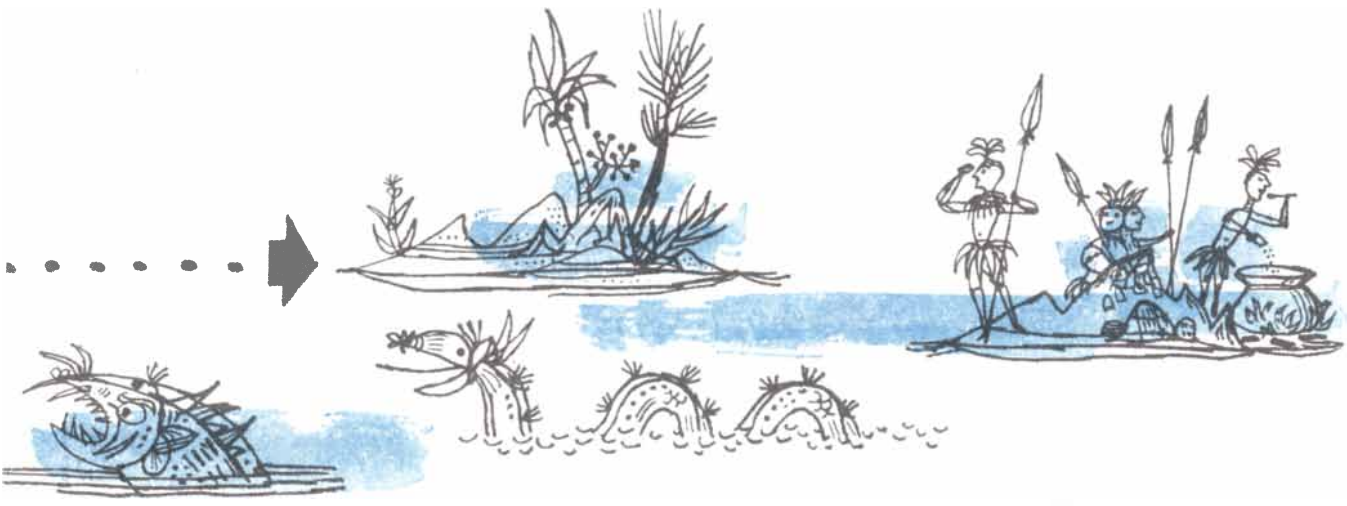
But we know that people do make bets on a roulette wheel or in a lottery where their expectation is negative, *i.e.*, where, on the average, they must expect to lose. Of course, one could say that this only shows how irrational they are. Yet simple examples will show that a reasonable person will sometimes refuse a bet with a positive expectation and accept one with a negative expectation.

Imagine, for instance, a rich man who has walked far from his house, is tired and plans to take a bus home. The bus fare is 20 cents and it so happens he has only 20 cents in his pocket. At this point someone offers him the following bet: A coin will be tossed; if heads come up, he will be paid $1, if tails come up, he will have to pay 20 cents. In other words, he is offered five to one on what should be an even money bet. Yet we can be pretty sure that the rich man would not be lured into the game, for winning a dollar would mean very little to him, but having to walk home would be a darned nuisance.

Thus the amount of money one can expect to win or lose per throw is not all that matters. What does matter is the amount of satisfaction (or discomfort) associated with the possible outcome of a gamble. If one is willing to measure satisfaction in numerical units, there is a way to explain the rich man's decision in mathematical terms. Suppose that walking home would mean to him a loss of five units of satisfaction while winning a dollar would mean a gain of only three units of satisfaction. In units of satisfaction rather than in dollars his expectation on each toss of the coin would be negative.

On the other hand, the expectation in terms of satisfaction units may be positive when that in terms of dollars is negative. Imagine that it costs $2 to buy a ticket in a lottery where there is one chance in a million of winning a million dollars. Since one would have to bet $2 a million times in order to win a million dollars once, on the average, the expectation here is minus one million dollars, or minus $1 per drawing. But to a person with drab prospects in life the gain of one million dollars might mean, say, 10 million units of satisfaction as against only four units being lost when $2 is paid out. For such an individual the outcome in a million drawings, *in satisfaction units*, would be 10 million minus four times one million, which amounts to an expectation of gain of one and a half units per drawing.

Is it meaningful to speak of satisfac-



ide whether it was really worth while to sail on?

Rabelais's Judge Bridlegoose couldn't see the dice

tion units? Isn't satisfaction an inner psychological phenomenon that defies numerical measurement? It turns out that such measurement is possible if one is willing to postulate that the individual will always try to make his decision so as to maximize the expectation. Of course we have to construct a satisfaction scale, but, as in measuring temperature, we are free to select the zero point and the unit arbitrarily. Suppose, for instance, that I locate the zero of my scale at my present money holdings and decide that a $10 gain would mean one positive satisfaction unit. Imagine, further, that I am offered $10 for a correct call on the toss of a coin at various odds and that I am unwilling to bet $8, eager to bet $4 and more or less indifferent as to betting $7 against the $10. Assuming that my behavior is consistent with choosing the course of action leading to highest expectations, it must be that to me a loss of $8 means losing more than one unit of satisfaction, a loss of $4 means losing less than one unit of satisfaction and a loss of $7 is just about equivalent to one unit of satisfaction. Thus my satisfaction scale can be constructed by experimental methods.

In what follows the numbers in our examples can be interpreted as units of satisfaction. But readers who feel some reluctance to indulge in satisfaction measurement may prefer to think of the units as dollars.

The idea of computing expectations in terms of satisfaction units dates back at least to Daniel Bernoulli, who in the first half of the 18th century formulated a concept which he called the "moral expectation." Now the computation, with the new approach via maximizing expectations, has been put on a rigorous theoretical basis by the recent work of von Neumann and Morgenstern, Jacob Marschak, Milton Friedman, L. J. Savage and others, while Frederick Mosteller and others have done some interesting experiments.

Let us proceed to games possessing strategic uncertainty. If you knew the chances of the other fellow's playing one way or another in a poker game, you could determine the best strategy simply by computing expectations as in a game of chance. But in most social games peeking is frowned upon. It is precisely this lack of knowledge as to the opponent's probable strategy that gives poker its additional element of uncertainty and makes it so exciting.

In order to get a better picture of the problem, we shall consider an artificially simple game. Jones plays against Smith. Jones is to choose one of the three letters A, B or C; Smith, one of the four Roman numerals I, II, III or IV. Each writes his choice on a slip of paper and then the choices are compared. A payment is made according to the upper table on the opposite page. The figure zero means that neither pays; a positive number means that Smith pays that amount to Jones; a negative number, that Jones pays Smith. Thus if Jones chooses A and Smith chooses II, for example, Smith pays Jones $100.

Let us put ourselves in Jones's shoes and see how he might make his choice. If he peeked and knew what Smith had chosen, the answer would be simple; for instance, if he knew Smith had selected II, he would choose A, because C would get him only $2 and if he chose B he would have to pay Smith $1,000. Suppose that Jones happens to know only that Smith has eliminated III and IV and the chances are even as between I and II. If he played A, his expectation would then be minus 50 (dividing minus 200 plus 100 by 2); if he played B, it would be minus 500 (0 minus 1,000 divided by 2); if he played C, the expectation would be 1½ (1 plus 2 divided by 2). Thus in terms of the expectation C is the best choice.

But ordinarily Jones will have no such information. Nonetheless there are principles which can guide his play; we shall present a few of them. The first is "the principle of insufficient reason," associated with the names of the mathematicians Thomas Bayes and Pierre-Simon de Laplace. This principle would require that Jones behave as if Smith were equally likely to make any of his four choices. He would compute his expectations on that basis, and would find that if he chose A his expectation would be 49.5, for B it would be 0 and for C it would be 2.5. Thus A would be the best choice.

If Jones is an optimist, he might make his choice on the basis of another principle we shall call "visualize the best." In that case he would choose B, because it offers the opportunity for the largest pay-off ($1,000).

On the other hand, Jones may be a conservative man, even a pessimist. It would then be natural for him to follow the "visualize the worst" principle, named by mathematicians "minimax," because it amounts to minimizing the maximum possible loss—the principle suggested, as we have seen, by Wald.

Pascal applied mathematics to gambling

JONES'S CHOICE	SMITH'S CHOICE I	II	III	IV
A	−200	100	300	−2
B	0	−1,000	1,000	0
C	1	2	3	4

JONES'S CHOICE	SMITH'S CHOICE I	II
A	−200	100
B	0	−1,000

Smith v. *Jones*

Jones would then choose C, for while it affords no possibility of a large gain, its "worst" is a gain of 1.

Similar computations on Smith's behalf would show that the principle of insufficient reason and the "visualize the best" principle lead to the choice of II, while "visualize the worst" favors I. We should note that under no principle would it make sense for Smith to choose IV, because I is superior to IV if Jones chooses A or C and just as good as IV if Jones's choice is B. In the jargon of the decision theory, IV is "inadmissible." Similar comparison shows that III also is inadmissible. Thus the principle of insufficient reason, postulating that all four of Smith's choices are equally likely, is actually ruled out for Jones; he knows that Smith will never play III or IV.

Suppose that Smith knows Jones to be of the "visualize the best" school. He can collect $1,000 from Jones by playing II, anticipating that Jones will play B according to the optimistic principle. On the other hand, if Jones gets wind of this reasoning by Smith, he may switch to A and win $100. Thus a stable pattern of behavior is not likely to be established.

But things are strikingly different when both players visualize the worst, so that Jones plays C and Smith plays I. In this case it makes no difference whether the two players know each other's strategy; they can still do no better than play C and I, respectively. In other words, the "visualize the worst" principle apparently is spyproof—if either player had hired a spy to find out the other's strategy, he would have wasted his money.

Now it is easy to construct a game in which this principle seemingly is not spyproof. For instance, suppose we give each player only two choices—the first two choices of the preceding game, with the same pay-off schedule [*see lower table at left*]. In the new game if both players visualize the worst Jones will choose A and Smith I. But now if Jones knows that Smith is operating on this principle, he will switch to B, because he would lose $200 by playing A and break even by playing B. Certainly Smith has good reason to guard against espionage.

So it seems that the "visualize the worst" policy is not always spyproof after all. But at this point one of the most ingenious ideas of the theory of games enters the stage. The idea is to let chance play a role in the choice of strategy, that is, to use a randomized or "mixed" strategy.

Suppose that Jones marks A on 10 slips of paper and B on three slips, then mixes them up very thoroughly and proceeds to draw blindly to determine his play. What is his expectation? On the average he will play A 10 times and B three times in 13 games. If Smith were to play I all the time, Jones would lose 200 units 10 times and break even three times, thus losing 2,000. If Smith were to play II all the time, in 13 games Jones would, on the average, gain 100 units 10 times and lose 1,000 units three times; the total net loss again would be 2,000. Were Smith to alternate between I and II, whether according to a system or at random, Jones's expectation would still be minus 2,000 for 13 games. Thus his randomized strategy would yield the same result no matter what Smith did—and the result would be better than the worst he could expect (a loss of 200 per game) if he played A all the time, which, on the "visualize the worst" principle, is the best of the "pure" (nonrandomized) strategies.

This example shows that a mixed strategy may be better than the best pure strategy. It does not, of course, imply that any strategy using random choices has this property. The fact that the slips were marked A and B in the ratio 10 to 3 was of crucial importance. Had there been five As and five Bs to draw from, for instance, the outcome would have been inferior to playing "pure" A. It can be shown by algebraic computation that the 10-to-3 ratio yields the optimal strategy for Jones.

Let us now recall that what started

us on the investigation of the mixed strategies was the fact that Smith's best "pure" strategy, namely I, was not spyproof. With mixed strategies in the picture, has the situation changed? To answer the question we must first find Smith's optimal strategy, which turns out, like Jones's, to be of the mixed variety; in his case he must play I and II in the ratio 11 to 2. On the assumption that Jones plays A, this mixture gives Smith the expectation of a gain of 2,000 units in 13 games (11 times 200 plus 2 times minus 100). And his expectation is exactly the same if he assumes that Jones will play B; Smith then wins 1,000 twice and breaks even 11 times for a total gain of 2,000 in 13 games. Indeed, it would make no difference if Jones were to alternate, in any manner whatsoever, between A and B. Thus Smith's strategy is spyproof in the sense that it would not help Jones to know that Smith was playing I and II in the ratio 11 to 2; Jones could still do no better than play 10 As to three Bs.

The preceding example illustrates a general phenomenon discovered and proved by von Neumann: in "zero-sum" two-person games (*i.e.*, in games where the amount lost by one player equals the amount gained by the other) the "visualize the worst" principle is spyproof provided mixed strategies are not disregarded.

Let us go back to Columbus and see whether the theory of games would have helped him in his dilemma, or at least how it might have formulated the problem for him. We start by setting up in table form Columbus' two possible choices (to turn back or keep going), the uncertain factual alternatives (that land was near or not near) and the probable consequences of Columbus' decisions in either case [*see top table at right*]. Now as an experimental approach suppose we assign very hypothetical and preliminary values in satisfaction units to the various consequences [*middle table at right*]. That is to say, let us assume that Columbus, attempting to envisage how disappointed he would feel if he later learned that he had turned back on the verge of discovering land, appraises this disappointment as a loss of 50 satisfaction units; that he values the saving of life by turning back from a hopeless quest as a gain of 20 satisfaction units, and so on. Let us also make one further assumption: that Columbus feels he can make some kind of estimate as to the probability of land being near.

If he supposed that the chances of land being near were 3 to 1, he would compute the expectation of "satisfaction" (actually dissatisfaction!) from turning back as follows: 3 times minus 50 added to 1 times 20 and the sum divided by 4—*i.e.*, minus 32.5. In other words, if he turns back, the net expectation is a loss of 32.5 satisfaction units. On the other hand, if he keeps going, the expectation is a loss of 175 satisfaction units (3 times 100 added to 1 times minus 1,000 and the sum divided by 4). Since the expectation of loss in going on is so much greater than that in turning back, Columbus' decision would be: better turn back. On the basis of the satisfaction values we have postulated, it would have taken a probability of 9 to 1 that land was near to induce Columbus to keep going.

Would he actually have insisted on such high odds in favor of success? If not, it must be that the satisfaction units we have assigned to the various possible consequences are unrealistic; perhaps we have overvalued Columbus' fear of death and undervalued his eagerness for the

COLUMBUS' DECISION	ACTUAL LOCATION OF LAND: LAND NEAR	ACTUAL LOCATION OF LAND: NO LAND NEAR
TURN BACK	PROBABLE LATER DISAPPOINTMENT	LIFE SAVED
KEEP GOING	PROSPECT OF GLORY	PROSPECT OF DEATH

COLUMBUS' DECISION	ACTUAL LOCATION OF LAND: LAND NEAR	ACTUAL LOCATION OF LAND: NO LAND NEAR
TURN BACK	−50	20
KEEP GOING	100	−1,000

COLUMBUS' DECISION	ACTUAL LOCATION OF LAND: LAND NEAR	ACTUAL LOCATION OF LAND: NO LAND NEAR
TURN BACK	−1,000	20
KEEP GOING	500	−500

Columbus v. *nature*

prize of discovery. We may therefore construct another table of values which might be considered more realistic [*see lowest table on the opposite page*]. On this new basis a probability of 3 to 1 that land was near would have been sufficient to make Columbus decide to keep going.

But what if he had no idea as to the chances of land being near? The theory of games and decision-making would still have offered him several means of calculating his expectations. He might have followed the principle of insufficient reason, the strategy of "visualize the best" or the strategy of "visualize the worst." On the basis of the satisfaction figures in our last table Columbus would have found it worth while to keep going no matter which of these principles he applied. But on the basis of the first figures [*middle table*] he would have turned back unless he belonged to the "visualize the best" school—which may not be too unrealistic an assumption.

It may seem strange that principles for making decisions should be served cafeteria style—take your choice. Is there not some way of proving that only one of these principles is truly rational? A great deal of thought has been devoted to this problem, mainly via attempts to find logical flaws or paradoxes which would eliminate one or another of the principles from consideration. For instance, it has been argued that nature, being presumably nonmalicious and not out to inflict maximum loss on its "opponents" (investigators), might well use an "inadmissible" strategy though a smart player would not. Also, some argue that there is no need for spyproofing against nature, and this raises doubts as to whether a principle leading to the use of randomized strategies is reasonable. In defense of the rationality of randomized decision-making, one is tempted to recall Rabelais's Judge Bridlegoose, who decided lawsuits by the throw of dice and was known for his wisdom and fairness until his failing eyesight made him commit errors in reading the spots. (Less facetious arguments in favor of randomized decision-making also are available!)

The development of methods for rational decision-making where uncertainties exist certainly has a long way to go. The field is still rife with differences of opinion. Nevertheless, it is highly instructive to study the tools we have, and particularly to notice how often the various principles, despite the difference of their underlying assumptions, all lead to very similar if not identical conclusions as to the best decision to take in a given situation.

BONE

The rigid framework of the body is a remarkably active and versatile tissue. Of current physiological interest is its dual function in maintaining the level of calcium in the blood

by Franklin C. McLean

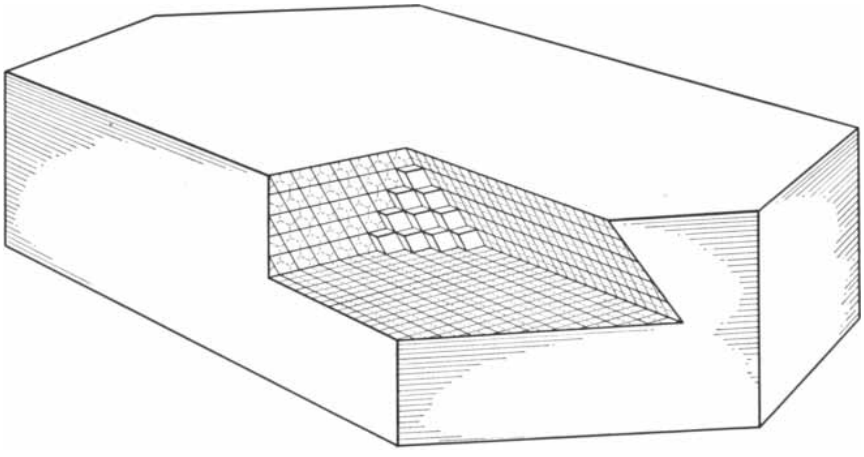
Bone is a busy and in many ways quite amazing tissue. It houses the factory (the bone marrow) that produces most of the cells in the blood; it stores minerals and doles them out as needed to other parts of the body; it repairs itself after an injury; it grows, like any other living tissue, until the body reaches adulthood. Not the least of its wonderful properties is the fact that while it is growing and constantly building itself, it also serves as the rigid structural support for the body, like the steel framework of a building. Some years ago I was vividly reminded of this while the Grand Central Terminal in New York City was being rebuilt. During the whole reconstruction, which took several years, trains ran on schedule in and out of the station; the terminal functioned as usual. Just so, as the bones are being built, the body goes on with its normal daily activities.

The key to bone's unique manner of growth and to its outstanding quality—hardness—is its mineral building material, often called the "bone salt." For a century this mineral has been a subject of controversy and thorny investigation. It has now become possible at last to describe the nature of the mineral and its physiological functions in the body. The mineral is composed chiefly of calcium, phosphate and carbonate. Especially interesting is its calcium. The mechanism by which bone takes up, stores and releases calcium into the blood in measured amounts to keep the level constant forms a fascinating chapter in modern physiology which will be the subject of this article.

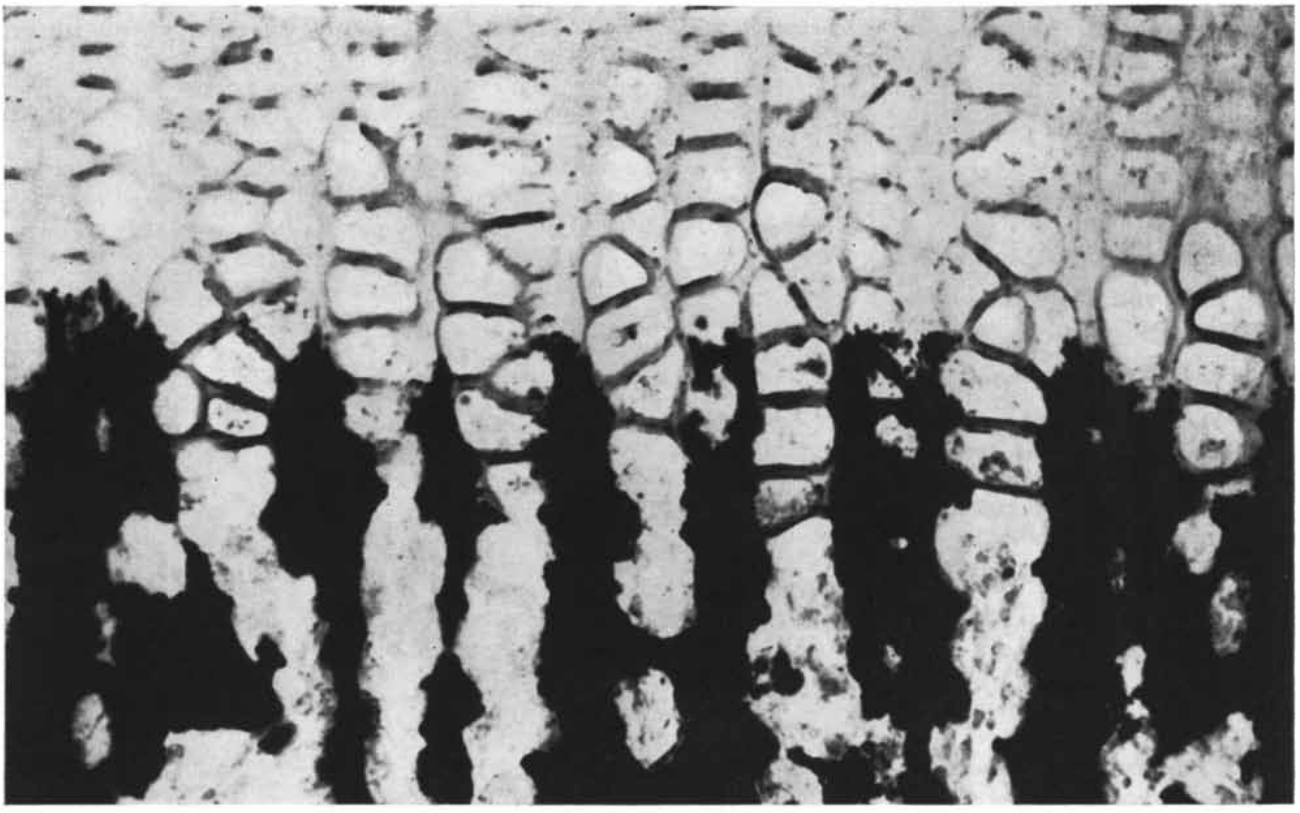
A bone grows by a continual process of tearing down and building up a little at a time. As it grows, it steadily becomes stronger. Its growth in thickness and growth in length go on by somewhat different methods. The body's long bones, for example, grow in thickness as follows: bone-destroying cells called osteoclasts erode the inside of the bone, enlarging the marrow cavity, while bone-forming cells called osteoblasts at the same time build up the bone on the outside. Fractures of bone are repaired by much the same method: first a soft, fibrous scar, called a callus, provisionally joins the broken ends; then osteoblasts gradually replace this soft tissue with hard, new bone. Meanwhile osteoclasts trim off any fragments or jagged edges of bone that might interfere with function and any excess bone made during the rebuilding.

Growth in length takes place by a method more like the extension of a tunnel under a river than the rebuilding of the Grand Central Terminal. During the childhood period before it reaches full growth, every long bone is capped near each end by a disk of cartilage. One might think of the disk as corresponding to the chamber in which tunnel drillers work and which advances as they bore under the river. The disk grows in thickness away from the bone, and as it grows, bone-forming cells coming in from behind convert the rear part of the cartilage into bone—like men coming up with concrete to replace mud in the wake of the tunnelers. The cartilage disk is made up of columns of cells in a honeycomb-like structure [*see photograph at the top of the opposite page*], so that the advance of the bone is like myriads of parallel tunneling operations rather than a single one. Each operation removes a column of cartilage cells and deposits a hard mineral, comparable to concrete, in the tunnel walls. Eventually, as each long bone reaches its predetermined limit of growth, the cartilage stops growing and is completely replaced by bone.

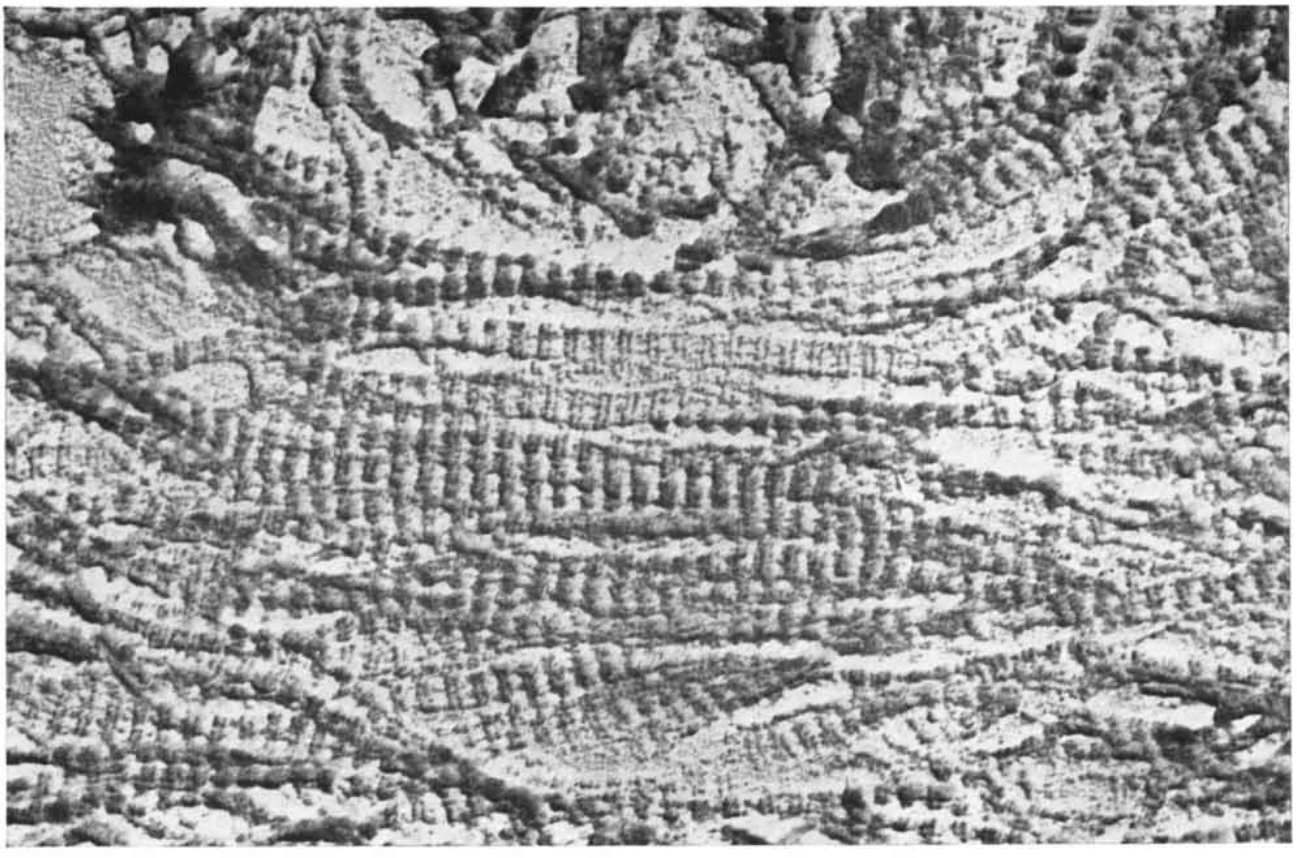
Nature has designed the growth system and the structure of bone to give the



CRYSTAL of bone is hydroxyapatite. This model of a single crystal is cut to show the unit cells of its molecular structure. The model enlarges the crystal some five million times.



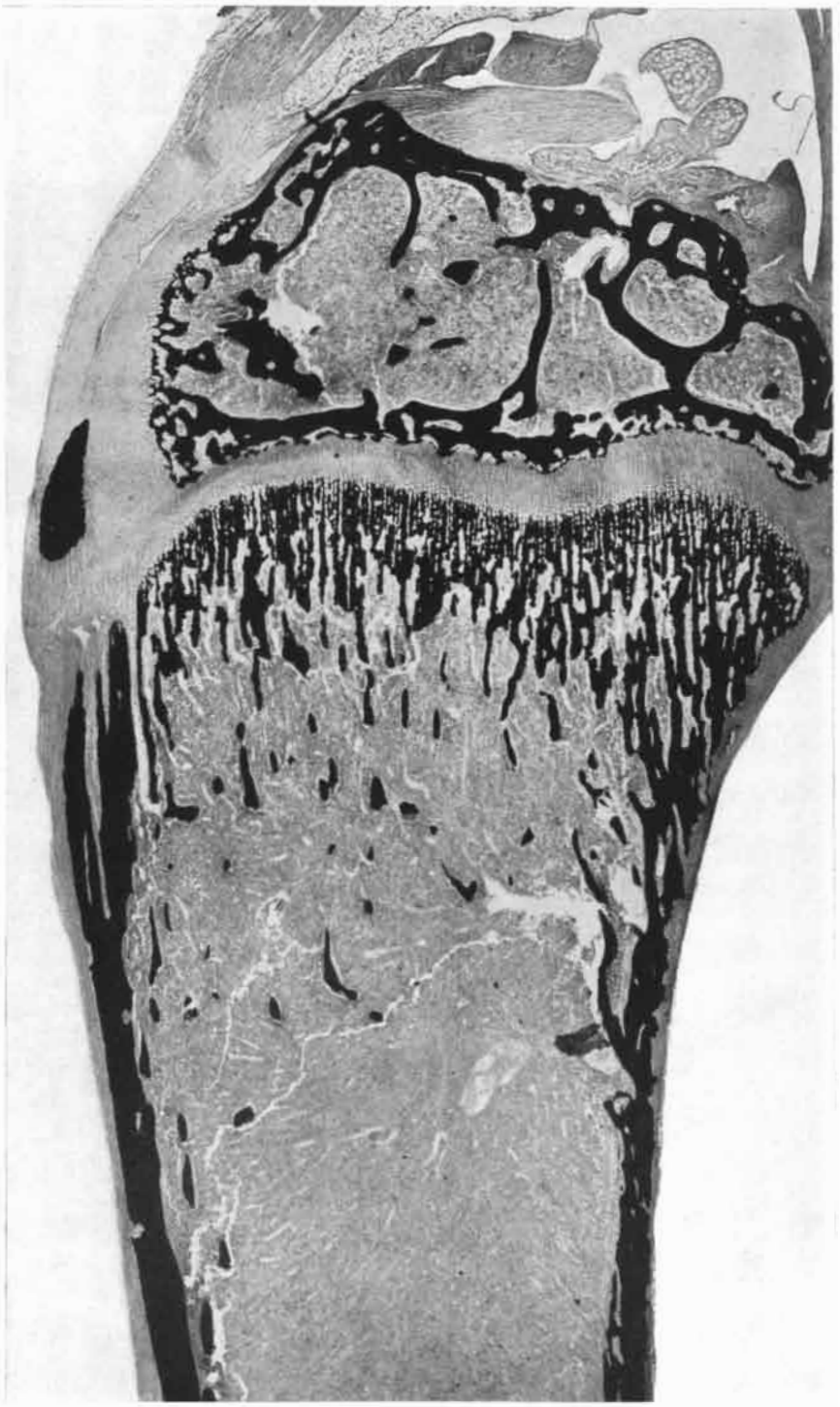
CARTILAGE DISK at the end of the leg bone of a puppy is shown in longitudinal section by this photomicrograph. The cartilage is the light material at the top. The dark material at the bottom is the bone, which tunnels into the cartilage during growth.



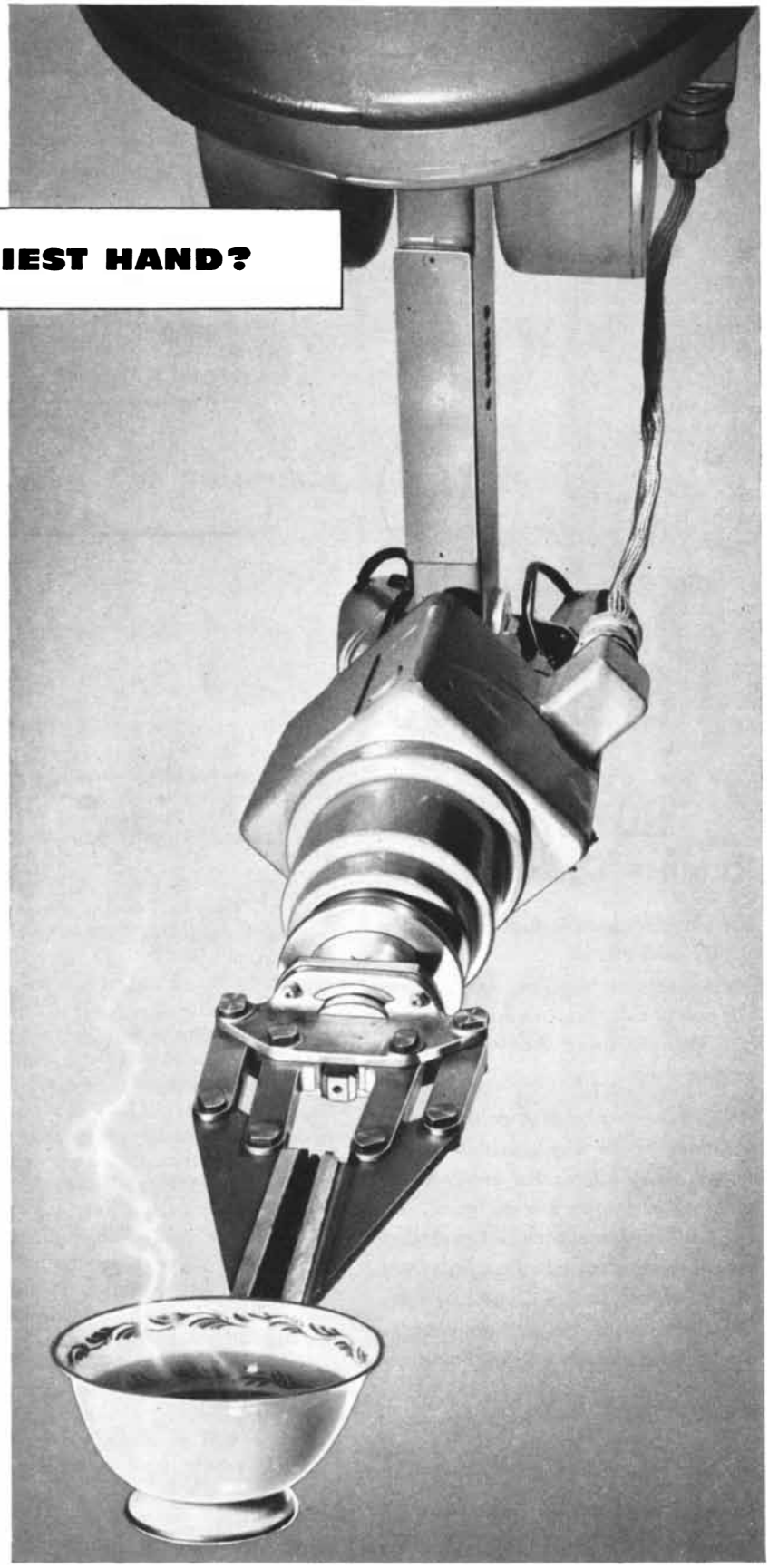
COLLAGEN FIBERS in a human leg bone are shown by this electron micrograph. Normally the fibers are obscured by crystals, but here they have been made visible by removing the calcium from the bone. The electron micrograph was made by R. A. Robinson.

greatest degree of support with minimum weight. The bones are hollow, in accord with the well-known engineering principle that a given weight of a rigid material is much stronger in the form of a tube than as a solid rod. But the space within the bones is not wasted; it is filled with the blood-forming bone marrow.

As we have noted, bone is built largely of a mineral, deposited in an organic matrix. The mineral includes not only calcium, phosphate and carbonate but also citrate, water and small amounts of other elements, especially sodium, magnesium, potassium, fluorine and chlorine. It resembles certain minerals widely distributed in rocks; indeed, it has the crystal structure of the apatite family of



GROSS ANATOMY is shown by this longitudinal section of the upper end of a leg bone of a rat. The gray band running from left to right above the center of the picture is the cartilage disk. The black material is the stained bone, which here again may be seen tunneling into the cartilage. The gray material running down the center of the bone is marrow.



WORLD'S HANDIEST HAND?

ANY motion of the human hand and arm can be duplicated (and sometimes improved upon) by the *General Mills Mechanical Arm*. Nearly every atomic energy installation in the country is now using this versatile instrument to perform hazardous operations safely.

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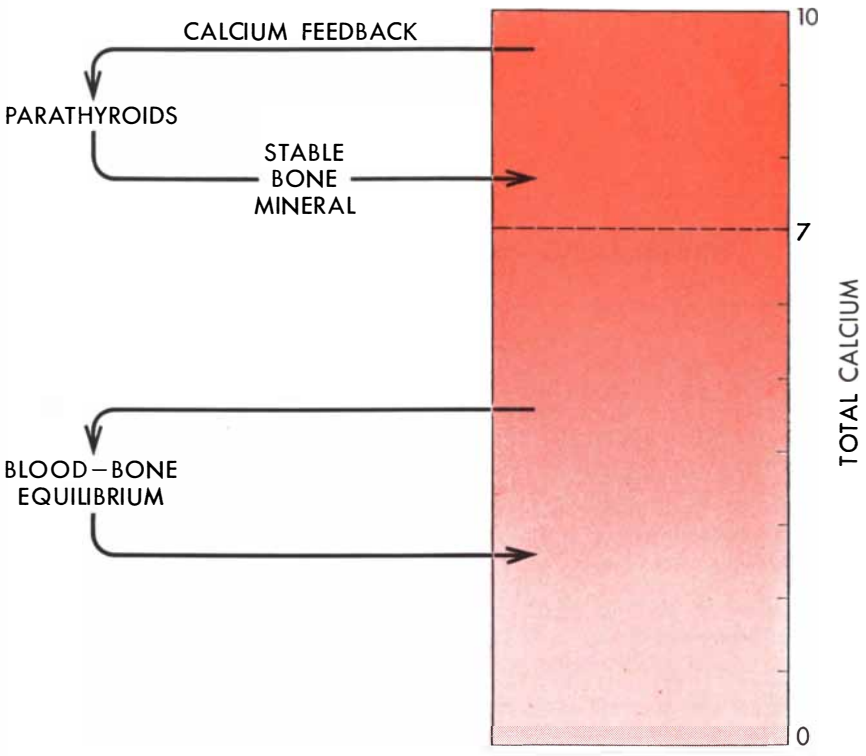


FEEDBACK MECHANISM regulating the level of calcium in the blood is illustrated in this diagram. The normal concentration of calcium in the blood plasma is 10 milligrams per 100 cubic centimeters. Seven milligrams of this is supplied by the fraction of bone mineral between the bone crystals. When the level falls below 10 milligrams, the parathyroid glands secrete a hormone which promotes the release of calcium from the stable crystalline reserve.

minerals. The most abundant mineral of this group in nature is fluorapatite.

The crystals of the bone mineral, as analyzed by X-ray diffraction studies, seem to have a chemical composition like that of fluorapatite, except for hydroxyl (OH) groups in place of the fluorine. The hydroxyapatite has the formula $3\,Ca_3(PO_4)_2 \cdot Ca(OH)_2$. This accounts for the calcium and phosphate, but where are the carbonate and citrate, the other chief constituents of bone mineral?

The location of these substances has been one of the chief sources of controversy. It used to be thought that the bone mineral was a single compound, joined molecule to molecule continuously throughout the bone. There is now, however, abundant evidence that the mineral is discontinuous and inhomogeneous in structure. It may be compared to a wall of bricks and mortar. The bricks are the crystals of hydroxyapatite; the mortar is largely made up of carbonate and citrate ions, both of which are too large to be admitted to the crystals of hydroxyapatite. Included in the mortar are other ions found in bone —chiefly sodium and magnesium, as well as a fraction of the calcium. Running through it also are the fibers of the organic matrix, made up of a protein known as collagen. And the remaining space in the mortar is filled with a semi-liquid substance which transports materials to the bone mineral from the circulating blood and *vice versa*. A tracer dye or radioactive material introduced into the blood stream soon reaches much of the bone mineral through this fluid medium.

The two fractions of the mineral—the crystals and the intercrystalline portion —have markedly different physical and chemical properties. The crystals are relatively stable in structure and resist solution in aqueous fluids, but are subject to rapid ion exchange reactions at their surfaces. They are extremely small: in a single gram there are so many crystals that their surface areas are reported to add up to more than 100 square meters. Calculations from these figures lead to the rather startling conclusion that the total surface area of the crystals of bone salt in the skeleton of a 154-pound man exceeds 100 acres!

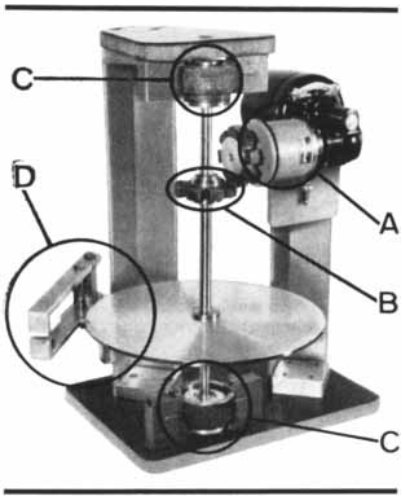
The intercrystalline fraction, estimated to make up about 4 per cent of the mineral by weight, is much more soluble than the crystals, and its metallic elements, notably calcium, are easily re-

Carboloy Trends and Developments for Design Engineers:

How to simplify design with permanent magnets
How to slow down wear with cemented carbides

Model demonstrates permanent-magnet functions

Even to design engineers, permanent magnets are often a puzzle. But most engineers do know that permanent magnets can simplify design and improve their products — reduce size and cost, too. To demonstrate some of the basic functions of permanent magnets, Carboloy magnet engineers developed this working model. (See it at our Booth 530, IRE Show, New York, March 21-24.) Here's what it demonstrates.



Magnetic control of torque. The adjustable, frictionless hysteresis brake (A), which transmits torque to turn the vertical 8-pole magnet, is an example of how Carboloy® permanent magnets can *convert mechanical motion to thermal energy.* Here, as in the following applications, there is no physical contact between the magnets and the component being controlled.

Magnetic driving. The vertical magnet drives the horizontal 8-pole magnet (B) at the same speed transmitted by the hysteresis brake . . . another use of the principle of converting mechanical motion to thermal energy.

Magnetic suspension. The aluminum disc and shaft assembly is suspended and held in position by two pairs of concentric, ring-type Carboloy magnets (C), located at the top and bottom of the shaft. This *mechanical holding principle* is also used for snap action, separation, and lifting.

Magnetic braking. Utilizing eddy current effect, the brake assembly (D) establishes magnetic fields of opposed polarity to the field of the braking mechanism . . . thus, when pivoted into position, it controls the speed of the disc and shaft. The eddy current effect — like instrument action, motor action, acoustic action, and electron beam control — is derived from permanent magnets' ability to *convert electrical energy to mechanical motion.*

In addition, permanent magnets can also *convert mechanical motion to electrical energy* (generator action, magneto action, sound pickup). Our magnet engineers can give you technical assistance in the design and application of Carboloy permanent magnets. Write for Magnet Design Manual PM-101 and Technical Data Sheet PM-116.

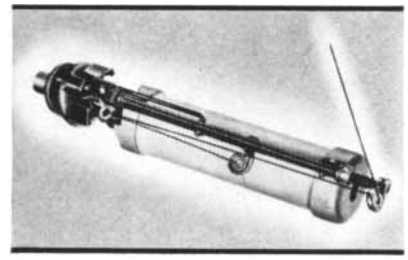
Cemented carbides are an engineering material

To those who think of cemented carbides as exclusively a material for dies and cutting tools, this will be news: *Design engineers* are finding thousands of uses for cemented carbides as an *engineering material.* That's because where friction, erosion, corrosion or abrasion occur, carbides outlast steel from 10 to 50 times . . . and in some cases even outlast the machine they are protecting.

Carbides are the hardest metals made by man — second only to the diamond in hardness. With their high hardness, they combine many other physical properties important to the designer: high transverse rupture strength, high compressive strength, high modulus of elasticity.

Carboloy cemented carbides are made in a wide range of grades . . . hence, almost any combination of physical properties can be produced. Standard grades are stocked in a variety of sizes and shapes; and any combination of grade, size and shape can be made to fit particular design requirements.

Here are some of the many applications where designers are utilizing carbides' unique properties to reduce sharply America's annual multimillion-dollar wear bill: sandblast nozzles, paper-slitting knives, textile guides (shown above), powder metallurgy dies, petroleum balls and seats, tabulating machine wear parts, ceramic molds, gages, pulverizer blades and fishing reel bearings.



These are just samples of the wear problems our engineers have solved. Let us help you with your design problems involving wear. And we can also assist with designing into your product our other Created-Metals: Hevimet (for high density and radioactive shielding uses), Thermistors (for minute temperature control), and vacuum-melted metals.

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turned to the circulating blood by simple solution.

More than 99 per cent of the calcium of the body is in the bones. But calcium is also important to the body in other respects. It is necessary for the clotting of blood, for the beating of the heart, for the contraction of the skeletal muscles and for the normal functioning of the nervous system. To insure that these functions are carried out continuously in an optimum manner, the concentration of calcium in the blood plasma must be maintained at an approximately constant level. This is accomplished by a self-regulating mechanism which draws on the large reserve of calcium in the bones.

Everyone is familiar with the fact that warm-blooded animals have a thermostatically controlled mechanism which automatically keeps the body temperature relatively constant in spite of large fluctuations in the temperature of the external environment. In recent years such self-regulating processes have acquired the name "feedback." The condition that is being regulated is itself the stimulus activating the regulatory mechanism; information about the output is fed back to an earlier stage of the process so as to influence its action and thereby control the output. The role of feedback in the regulation of the calcium-ion concentration in the blood plasma is only now beginning to be understood in all its implications. The regulating system is rather complex, and can be best understood in terms of a mechanism made up of two parts.

I am writing this in a large room in a Vermont house during a cold spell. At one end of the room is a fireplace, which supplies a fairly constant amount of heat to the room, but only as long as I keep it supplied with fuel; it has no self-regulatory mechanism. At the other end of the room is a gas-fired floor furnace, controlled by a thermostat. Whenever the temperature of the room drops below a certain level, the thermostat feeds this information back to the furnace and heat is supplied by automatic control. Thus the room is heated from two separate sources, one of which is automatic and the other not.

Similarly bone furnishes calcium to the blood plasma in two ways, one of which is not regulated physiologically. Like the fireplace that delivers a constant amount of heat to my room, the labile part of the bone's mineral structure—the intercrystalline fraction—yields up a considerable and constant supply of calcium to the blood. It does so by

simple solution, and this traffic between the bones and blood depends only on chemical dynamics. The exchange goes on with extraordinary rapidity; under certain conditions as much as 100 per cent of the calcium in the plasma may be replaced every minute. This exchange alone can keep the level of calcium in the plasma at 70 per cent of the normal calcium content—the normal level being about 10 milligrams per 100 cubic centimeters.

The rest of the calcium is supplied, in just the amount needed to maintain the normal level, by means of a feedback mechanism involving the parathyroid glands—four tiny bodies embedded in the thyroid. When the level of calcium ions in the plasma falls below normal, the parathyroid glands increase their secretion of hormones. The hormones, in turn, promote the dissolution of components of bone. Thus they are able to wrest calcium from the stable crystals, as well as from the labile fraction of the bone mineral. Like the thermostat in my Vermont house, which is able to call on an independent source of fuel, the parathyroid hormone has access to a source of calcium not readily soluble in an aqueous medium.

It is probable, although this is still somewhat controversial, that the parathyroid hormone exerts its influence by controlling the activity of the bone-destroying cells, the osteoclasts. How these cells dissolve bone is not understood. One current hypothesis is that they may remove calcium from the bone mineral by forming a chelating agent—the recently discovered type of compound that has the ability to grasp metallic ions and take them out of a substance in which they are strongly bound [see "Chelation," by Harold F. Walton; SCIENTIFIC AMERICAN, June, 1953]. The prototype of these agents, commercially named Versene, has a much greater affinity for calcium than does the bone mineral itself; a Versene solution readily dissolves calcium out of the bone crystals. There is no positive evidence that osteoclasts actually produce a chelating agent. But it may well be that the body does form such an agent to dissolve the crystals of the bone mineral.

This brief article has touched on only a few highlights of the current research on the physiology of bone. The subject is now beginning to come into its own, and it is opening up fresh perspectives which suggest interesting new investigations and should lead to a better understanding and more effective treatment of bone disorders.

EARS FOR COMPUTERS

Audrey (which stands for Automatic Digit Recognizer) can "hear" 10 numbers and 16 of the 40 basic sounds in English, but has a little trouble with those spoken by people other than one of her designers

by Edward E. David, Jr.

How often, on waking of a cold morning, we have wished for a robot we could command to shut the bedroom window. To design a machine that could "hear" and "understand" speech is certainly an old dream of mankind. In our age of technology we can think of myriads of ways to put such a machine to work—from printing a dictated speech to answering the telephone or operating a factory on spoken commands.

Some recent experiments suggest that we may at last be on the way to making the dream a reality. This article will describe an experimental computer which can "recognize" some elements of speech, can discriminate between the spoken numbers from zero to nine and can translate a code number into a command to perform a given task.

A machine of this kind obviously needs three things: an "ear" to "hear" speech, a "brain" to interpret it and "muscles" to carry out the appointed task. These components are at hand: a microphone can hear, a computer can interpret properly prepared data, and a motor can do the work. The problem is to analyze speech into its meaningful sounds and design a computer which will recognize the meanings.

Just what kind of information is there in human speech? And what are the characteristics that make an English word understandable whether it is spoken in the treble of a child in Tennessee or in the very different accent and pitch of a farmer in Maine? Clearly some properties of the spoken word are necessary for understanding, others irrelevant. Such qualities as pitch, inflection and loudness or stress convey shades of meaning, but to begin with we shall do well if we can identify the key features that would enable the machine to "recognize" words.

A human being, by combining manipulations of the vocal cords, oral and nasal cavities, tongue, mouth, teeth and lips in various ways, can make hundreds of different sounds. But only about 40 distinct sounds are used as the basic building blocks of English speech. Our language has, for example, some 10 common vowel sounds, illustrated by the following words or syllables: heed, hid, head, had, hod, hawed, hood, who'd, hud (as in Hudson) and heard. Each of these words is identifiable even though it may be pronounced in slightly different ways by different speakers (for example, "hoid" or "herd" for heard). The 40 basic sounds are called phonemes, and phoneticians have adopted symbols to represent them.

The question is, can a computer be made to distinguish these 40 phonemes from one another and derive meaning from a sequence of them? The first requirement is to translate an acoustic wave into some measurable physical representation. Recently developed devices which make speech "visible" have suggested how this may be done. One such device records the energy "spectrum" of a person's speech; that is, it analyzes the sound at a given instant into the relative amount of energy at each frequency in the band covered by the speaker's voice [*see top illustration on page 94*]. By electronic means it makes each energy concentration visible as a dark spot on a paper sheet. As the recording proceeds, the series of spots form dark bars [*see bottom illustration on page 94*]. These bars show how the pattern of energy distribution changes as the speaker utters successive sounds.

Since the pattern changes at about the same rate that a speaker enunciates phonemes (about 10 per second), we can suppose that each given pattern represents a phoneme. The problem then is to identify each phoneme with a specific pattern. This is not a simple matter, because the frequency pattern combines the phonemic characteristics of the sound with irrelevant qualities of the individual speaker's voice, such as pitch; a man, a woman and a child produce different bar positions in pronouncing a given phoneme. However, it has been found that the ratio of the bar positions tends to be more nearly the same for the types of voices than the positions themselves; hence the bar ratios may, in a crude way, identify phonemes.

It is interesting that the human ear, as physiologists have discovered, performs an energy-frequency analysis of incoming sounds and transmits the data to the brain cortex. It may be that the brain recognizes a phoneme by "matching" the pattern of incoming sound with its own pattern for pronouncing it.

In designing a voice-actuated machine, one might logically use electronic coincidence circuits which would measure the bar ratios and match them with a set of predetermined coincidences stored in the machine to identify the phonemes. A second coincidence detector would assemble the phonemes received from the first one and similarly match a series of them with stored sequences to recognize words.

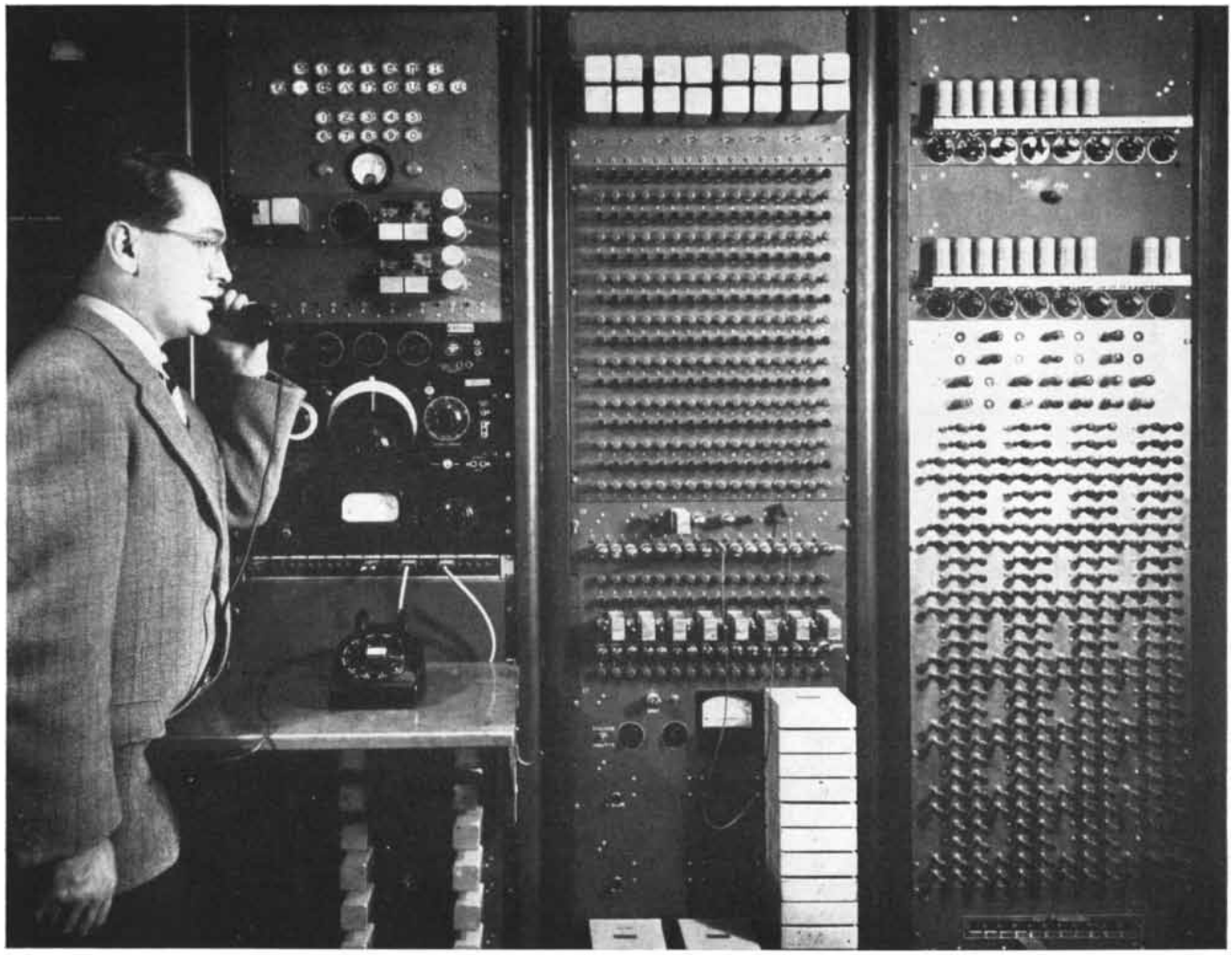
Unfortunately it is found that the bar ratios do not identify phonemes, as spoken by different subjects, with sufficient reliability to permit the building of a finely discriminating machine. It may be easy enough to distinguish among a few commands using very different sounds; for example, there would be little difficulty in discriminating be-

tween the commands "open" and "shut." But phonemes or combinations of them that sound much alike (*e.g.*, "shut" and "shoot") are too perplexing.

Reliability might be greatly improved by considering the dynamic aspects of speech; that is, instead of attempting to identify a phoneme merely from the static measurement of the speech wave at a given instant, we might also take into account the preceding and following values of the bar ratios. The study of interactions among phonemes—the phonemic context—may well help in their identification. This promising idea is being investigated by many researchers. But for the present the machine to be described here is based on the available energy-distribution method.

The situation that confronts us, in effect, is that the machine must make sense out of speech which is contaminated with a great deal of structure which is superfluous for understanding and makes it difficult to recognize the essentials. Two means are available to circumvent this difficulty. The first, already mentioned, is to limit the machine's vocabulary to easily distinguishable words. The second is to make use of the redundancy of human speech. We generally use many more words and phonemes in speech than we need to convey our meaning in writing (compare it with the abbreviated language of a cablegram, for instance). It is this redundancy in common speech that enables us to understand what people are saying even when their words are distorted by emotion, poor pronunciation or speech defects. Similarly a machine may be expected to extract the correct meaning from a sentence or phrase even though it might be uncertain about individual words or phonemes. Both methods—the limited vocabulary and the linguistic context—have been utilized, though not simultaneously, in the machine now to be described.

This machine, built at the Bell Telephone Laboratories, is called the Automatic Digit Recognizer, or "Audrey." It was originally constructed to recognize just the words denoting the digits from zero to nine. In order to do this, the computer has stored in it the energy-frequency patterns of the 10 words as enunciated by the machine's chief designers, K. H. Davis and S. Balashek. When the machine "hears" a word, the incoming sound is first analyzed by a group of circuits into its spectral distribution. This information is then fed to the computer, which compares it to each of the stored patterns and calculates which is the nearest "match." Within about a fifth of a second the machine lights a bulb that indicates which digit has been spoken. The machine always picks the most probable choice, unless the incoming sound has practically no

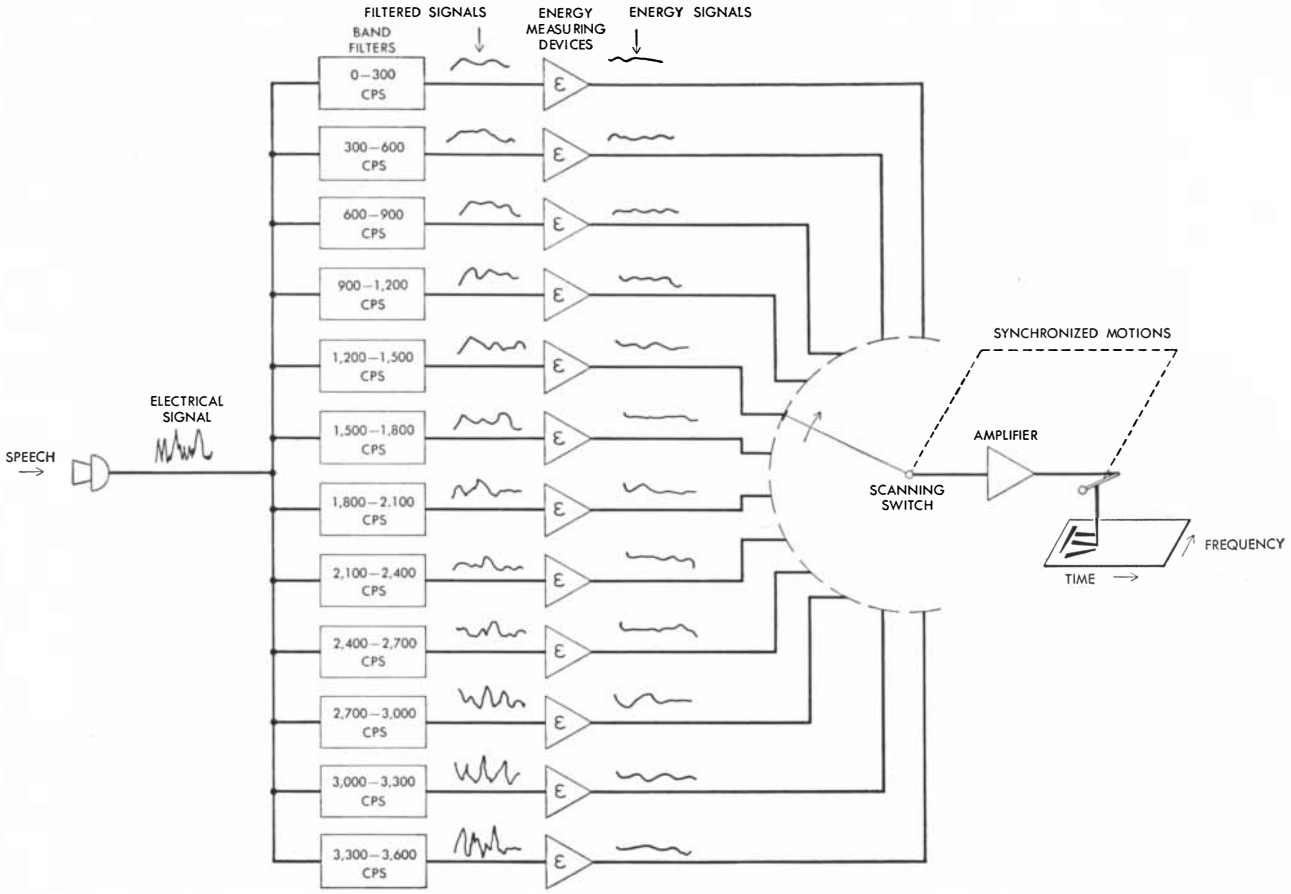


AUDREY is photographed at the Bell Telephone Laboratories with S. Balashek, one of its chief designers. Just above and to the right of Balashek's head are four rows of symbols representing the sounds the machine can recognize. The bottom two rows indicate numbers; the top two, 16 basic sounds of English speech. As Balashek says "a" as in "had," the corresponding symbol lights up.

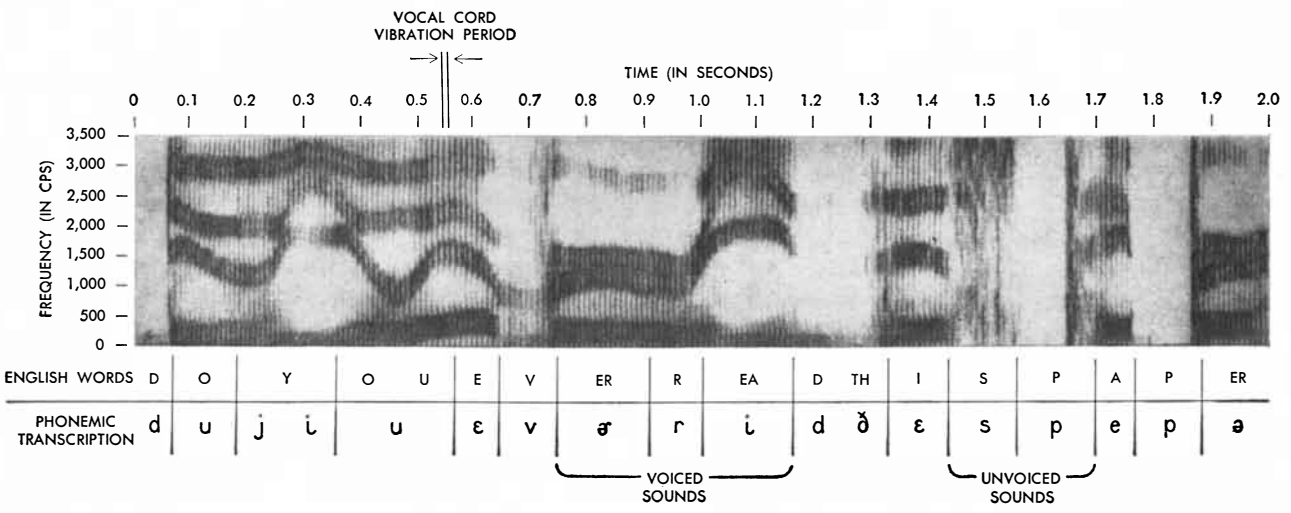
resemblance to any of its stored patterns; in that case it simply gives no answer.

Audrey makes few mistakes when Balashek speaks to her, but she responds incorrectly about 10 to 30 per cent of the time to other males. Probably her general performance would improve if the patterns stored in her were averaged from a number of speakers instead of from only two. Audrey's construction does not permit her to respond well to females' or children's voices. However, the addition of further circuitry might enable her to do so.

The same signals that operate the indicator lamps can be used to ring telephones or perform other tasks coded into the machine's number language. Also, an automatic printer can record the numbers on paper as they are spoken. Such a function might be useful for ap-



SOUND SPECTROGRAPH makes speech visible by dissecting it with 12 filters, each of which passes a band of frequencies in the range covered by the speaker's voice. The relative amount of energy in each band is then recorded on a moving paper tape (*see below*).



SOUND SPECTROGRAM is the record produced by the sound spectrograph. This spectrogram records the words: "Do you ever read this paper?" The words are related to the spectrogram by the line immediately below it. Below this line are the corresponding phonemic symbols. The vertical component of the spectrogram is frequency in cycles per second; the horizontal component is time.

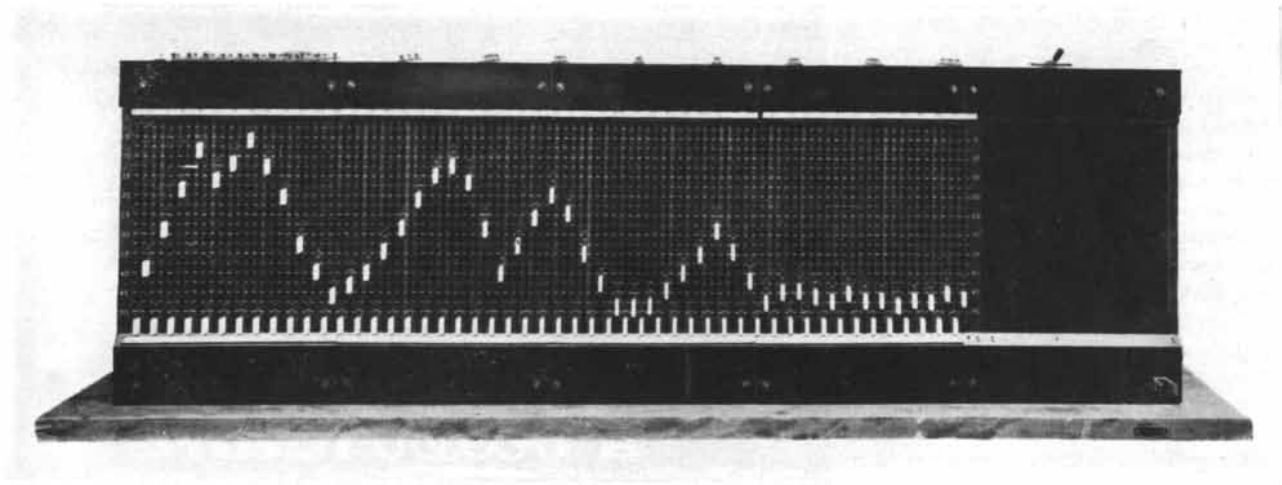
plications in which large amounts of data have to be recorded in a readily available form.

Audrey has recently been modified so that she can speak a language which contains 16 phonetic elements. Although these elements do not necessarily correspond to phonemes, Audrey's efforts to reproduce human speech are surprisingly understandable. This feat is accomplished with the aid of the listener, who recognizes the words from the context.

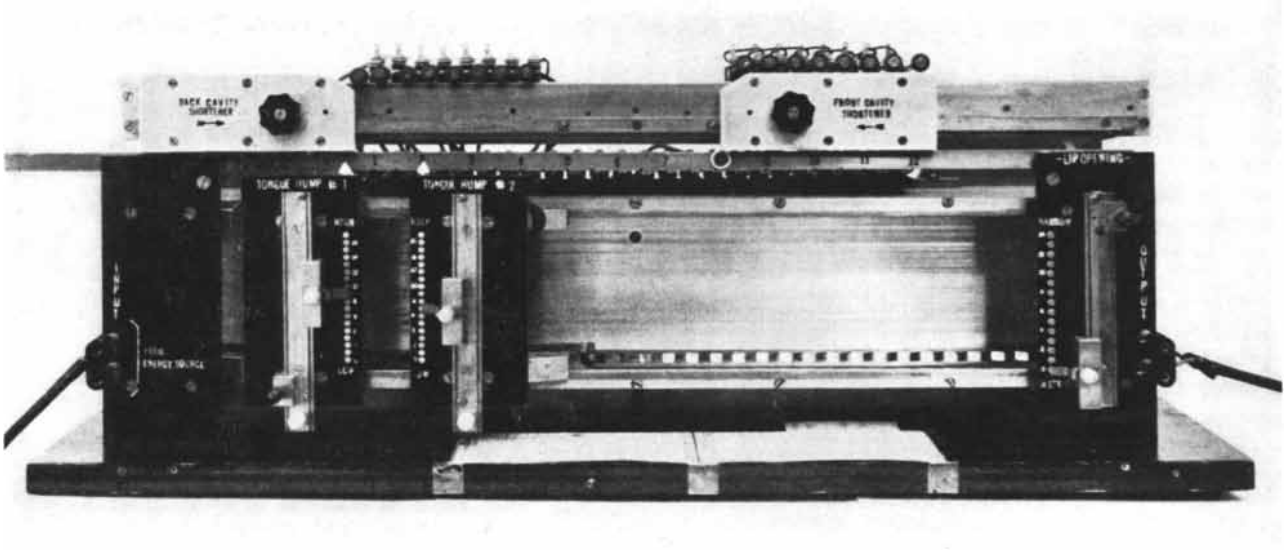
Audrey represents a first step toward a voice-typewriter which would automatically translate the spoken to the printed word. To design a machine which could accurately transform a phonemic transcription into printed English words, with the usual spelling, seems too much to hope for in the near future, but it seems a reasonable present objective to build one that will produce a printed phonemic English easily read by the average person after he has had a little training.

Even this initial step toward an automatic written transcription of speech will be an important aid in communication. Consider for a moment the communication links between our cities. Like pipelines, these channels have a limited capacity. The latest microwave relay system has a capacity, or band width, of four million cycles per second for each channel. This is just enough to transmit one television program, or several hundred telephone messages (each requiring a band width of 3,500 cycles per second) or some thousands of telegraph messages (each using a band width of 170 cycles per second). The wider the band width, the more expensive the circuit. Hence there is a strong incentive to reduce the signals that must be transmitted for a given message or program so that they will use a smaller part of the channel capacity.

Some years ago H. W. Dudley of the Bell Laboratories invented a device, called the Vocoder, to compress voice signals. The raw speech is passed through a bank of 10 or more filters which produce corresponding signals indicating the energy distribution as a function of time. Such signals can carry nearly all the information present in the original speech, yet each occupies a band of only 30 cycles; all 10 can be transmitted over a 300-cycle band. At the receiving point an "inverse" piece of equipment remakes the speech according to the energy picture it receives. Thus the Vocoder reduces to about one tenth the band width necessary to send speech. The processing introduces some



TONE GENERATOR is employed at the Bell Telephone Laboratories to produce vowel sounds. Each of the white keys corresponds to a different frequency. The low frequencies are at the left; the high frequencies, at the right. The amplitude of each frequency can be controlled by raising or lowering the key. In this photograph the keys are set to produce the vowel sound "a" as in "had."



ELECTRICAL VOCAL TRACT can produce both vowel and consonant sounds. It operates by means of electrical analogues to five parts of the human vocal tract. These analogues are labeled: Back Cavity Shortener, Front Cavity Shortener, Tongue Hump No. 1, Tongue Hump No. 2 and Lip Opening. By adjusting their settings, various combinations of vowel and consonant sounds are produced.

distortion, so that the reproduced speech is not of sufficiently high quality for some applications, such as radio broadcasting. But it could serve satisfactorily in uses such as military communication.

Dudley envisioned an even more efficient compression system based on a computer somewhat like that which later took form in Audrey. He suggested that the system would break speech down into phonemes, transmit signals representing the phonemes and reconstruct the speech from phoneme building blocks available in a synthesizer at the receiving end. In other words, coded signals rather than the phoneme symbols themselves would be transmitted. It is estimated that in an idealized system the coded signals corresponding to speech could be sent with good fidelity over a band of no more than 10 cycles per second, though engineering factors would argue against carrying bandwidth reduction to this extreme. In the elementary form of the system envisaged by Dudley, the transmitted speech would be entirely artificial, devoid of the inflection or other characteristics of the original speaker's voice. As we have mentioned, the Audrey computer can be used to reduce speech to a series of phonetic elements. Signals corresponding to the elements could be transmitted to a distant point in a band of about 30 cycles per second. In order to restore some of the naturalness and quality of the original speaker, Audrey has acquired a pitch circuit which permits her to reproduce inflections. This information can be sent with an addition of only 20 cycles per second to the band width.

The computer equipment and circuits that are needed for such a system may seem too expensive, but as a matter of fact a great deal of electronic circuitry is already in use in communication systems throughout the country, and it has justified its cost. Moreover, experience

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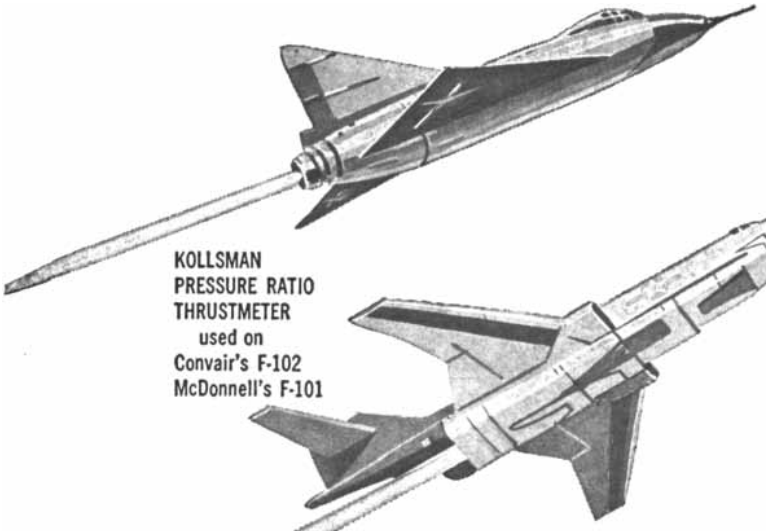

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Plant Movements

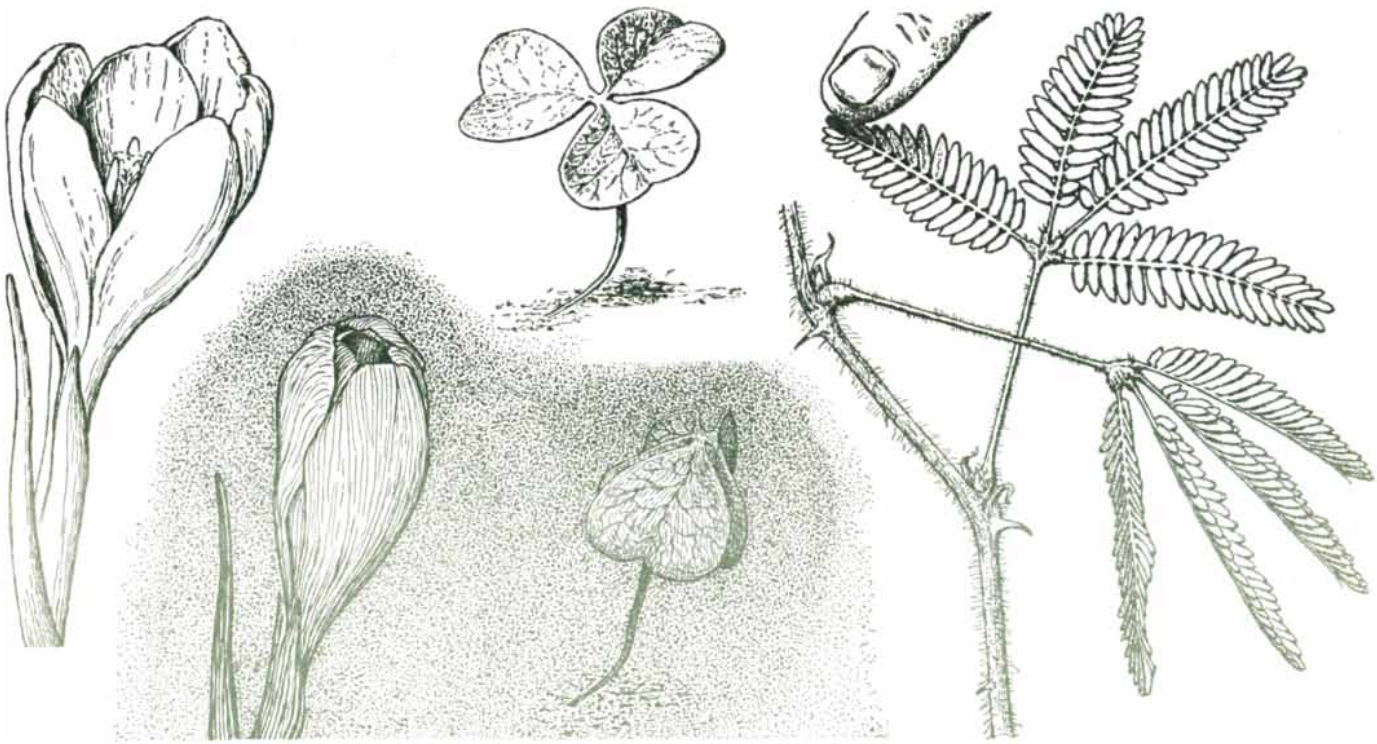
Most plants stay in one place, but their parts twist, bend, open or close. And one kind of plant can move 99 times its own length in a second, which for a man would work out to 400 miles per hour

by Victor A. Greulach

Almost anyone asked to tell the differences between plants and animals would mention that animals move while plants do not. Even in the restricted sense of locomotion this is not quite true. Some animals, such as corals, sponges and sea squirts, spend their entire adult lives in a fixed position, while many plants are able to move freely from place to place.

The slime molds slither about over old logs and stumps by means of pseudopodia, much as an amoeba would. Many species of diatoms swim under their own power; through a microscope they can be seen gliding along in stately dignity like a ship in the distance. They are believed to move by the streaming of protoplasm along a slit in the side, rather in the manner of a sidewheel steamer. But most of the perambulating plants move themselves by means of the long, whiplike structures known as flagella (or cilia when the organism has a great number of them). The flagella-using plants include some species of algae and bacteria, swimming spores of various algae and fungi and the swimming sperm of plants, mostly the plant species without seeds.

Locomotion by flagella is more rapid than by protoplasmic streaming. Some of the plant organisms using it reach a speed of nearly three feet per hour. This may not seem fast to us, but in relation to the size of these microscopic creatures it is stupendous. A man running the 100-yard dash in 9.3 seconds travels about seven times his height per second, and an F-68 Sabrejet at 650 miles per hour moves 25 times its length in a second. The zoospore of one fungus covers its own length as fast as a Sabrejet; the



EXAMPLES of movements are shown in this illustration. The first and second drawings show the nastic movements of the crocus, which opens by day and closes by night. The second and third drawings show turgor movements in oxalis. The fourth drawing shows the sensitive plant, the leaves of which collapse rapidly when they are touched. This is also due to a turgor effect. The sixth drawing

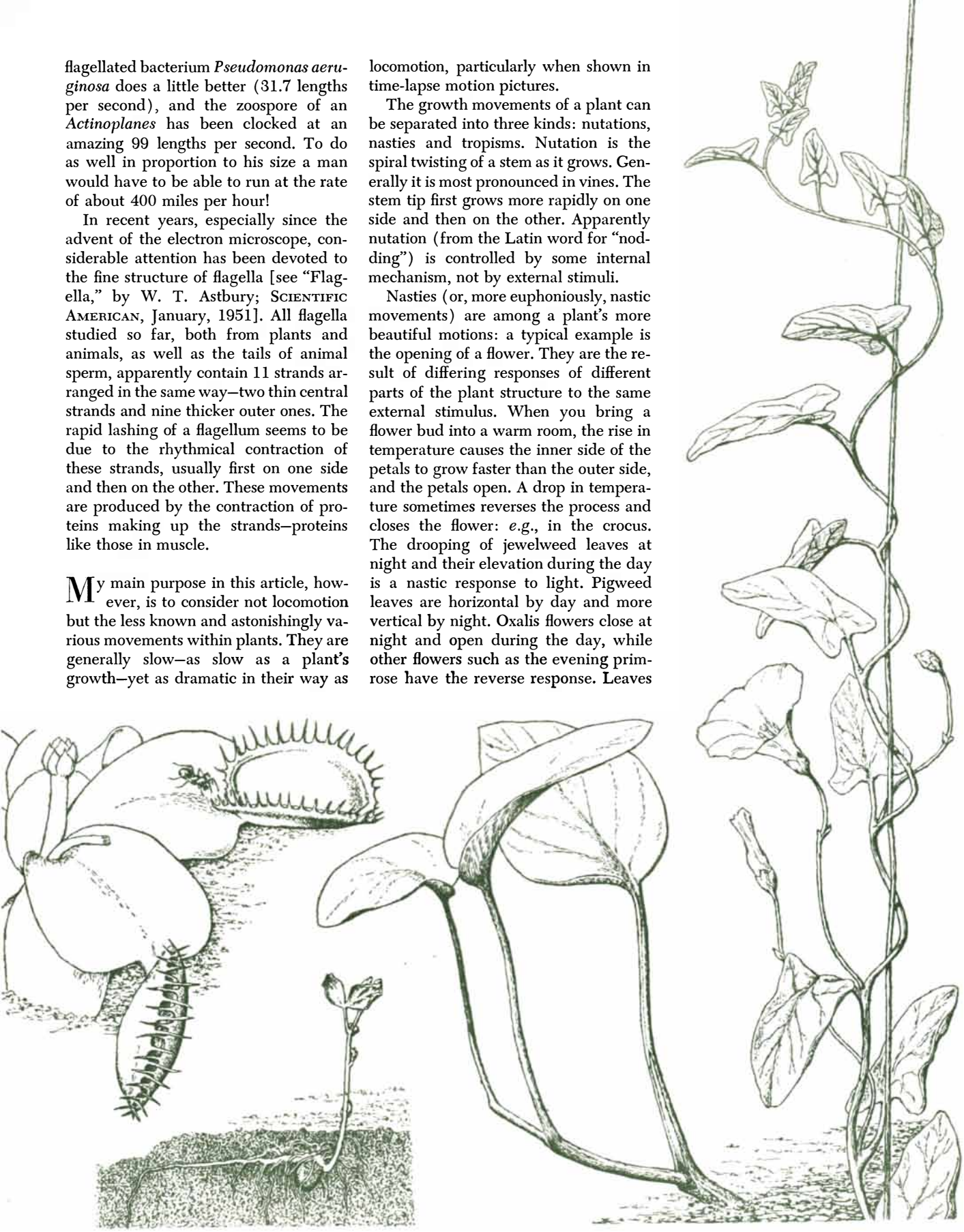
flagellated bacterium *Pseudomonas aeruginosa* does a little better (31.7 lengths per second), and the zoospore of an *Actinoplanes* has been clocked at an amazing 99 lengths per second. To do as well in proportion to his size a man would have to be able to run at the rate of about 400 miles per hour!

In recent years, especially since the advent of the electron microscope, considerable attention has been devoted to the fine structure of flagella [see "Flagella," by W. T. Astbury; SCIENTIFIC AMERICAN, January, 1951]. All flagella studied so far, both from plants and animals, as well as the tails of animal sperm, apparently contain 11 strands arranged in the same way—two thin central strands and nine thicker outer ones. The rapid lashing of a flagellum seems to be due to the rhythmical contraction of these strands, usually first on one side and then on the other. These movements are produced by the contraction of proteins making up the strands—proteins like those in muscle.

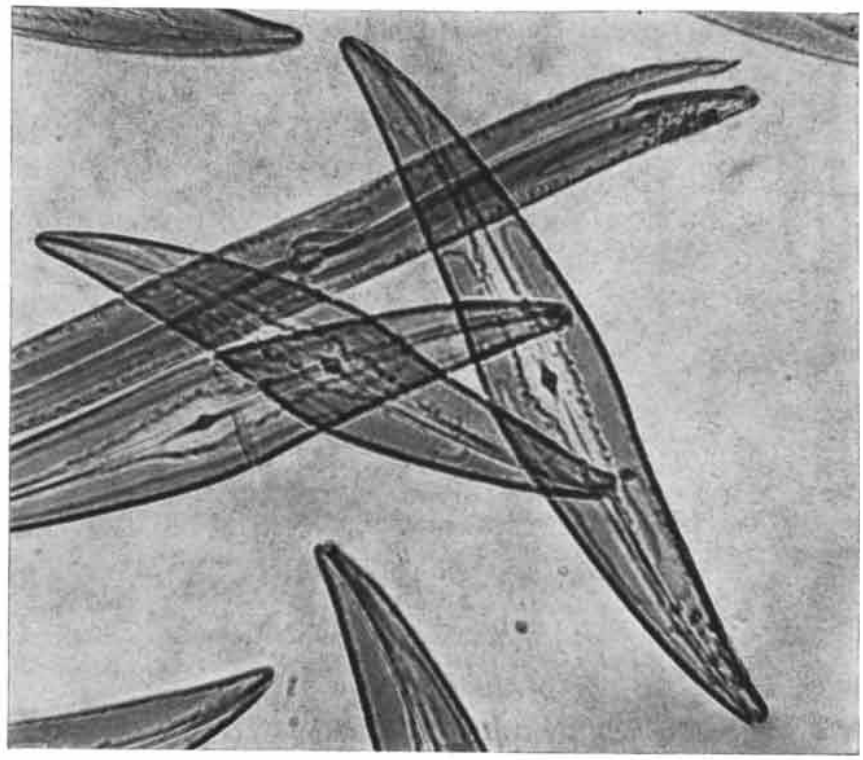
My main purpose in this article, however, is to consider not locomotion but the less known and astonishingly various movements within plants. They are generally slow—as slow as a plant's growth—yet as dramatic in their way as locomotion, particularly when shown in time-lapse motion pictures.

The growth movements of a plant can be separated into three kinds: nutations, nasties and tropisms. Nutation is the spiral twisting of a stem as it grows. Generally it is most pronounced in vines. The stem tip first grows more rapidly on one side and then on the other. Apparently nutation (from the Latin word for "nodding") is controlled by some internal mechanism, not by external stimuli.

Nasties (or, more euphoniously, nastic movements) are among a plant's more beautiful motions: a typical example is the opening of a flower. They are the result of differing responses of different parts of the plant structure to the same external stimulus. When you bring a flower bud into a warm room, the rise in temperature causes the inner side of the petals to grow faster than the outer side, and the petals open. A drop in temperature sometimes reverses the process and closes the flower: *e.g.*, in the crocus. The drooping of jewelweed leaves at night and their elevation during the day is a nastic response to light. Pigweed leaves are horizontal by day and more vertical by night. Oxalis flowers close at night and open during the day, while other flowers such as the evening primrose have the reverse response. Leaves



shows the rapid turgor movement of Venus'-flytrap. The seventh drawing shows the geotropic response of a pea seedling. Planted horizontally, it bends and grows vertically. The eighth shows the phototropic response of philodendron, in which the leaves of the plant turn toward the light in a mosaic pattern. The last drawing shows the touch-oriented twining movements of the bindweed.



DIATOMS are single-celled plants. These diatoms, which are enlarged some 700 diameters, move by means of extruding protoplasm through the narrow opening that runs fore and aft.

can be made to bend downward by treatment with plant hormones or by exposure of the plant to ethylene or other similar gases. As little as one part of ethylene per 10 million parts of air makes tomato leaves bend down, so this plant can be used as an extremely sensitive test for gas leaks.

Of all the growth movements of plants, the most interesting are their tropisms—turning or bending in response to some outside stimulus. Everyone knows that a plant growing in a window bends toward the outdoor light. To explain this behavior by saying that the plant is seeking light is to credit the plant with a purposeful intelligence it does not possess. Actually the plant turns toward the light because the light reduces the concentration of growth hormone, or auxin, on the more brightly lighted side of the stem; as a result the darker side grows more rapidly and the stem bends. The light stimulus acts on the terminal bud where the auxin is produced, not on the stem itself. In the case of ivy growing on a wall, this tropism has a fascinating consequence: the shading of the leaf stalks by the leaves causes the stalks to bend in such directions that the leaf blades face the light with a minimum of overlapping, hence they are arranged in a mosaic.

Gravity is responsible for the tropism that makes a plant's stems and roots grow vertically. If a plant is placed in a horizontal position, the stems will bend upward near the tip and the roots will bend downward. Again auxin is responsible. When a stem lies horizontal, the auxin becomes more concentrated on the lower side. This causes the stem to turn upward, but it has the opposite effect on roots, because a concentration of auxin that promotes the growth of stem cells inhibits the growth of root cells.

Were it not for gravity tropism, called geotropism, agriculture would be impractical. Geotropism enables us to plant seeds any side up with confidence that the stems will come up. If plants grew only in the direction of the growing point on the seed, they might emerge from the ground at every conceivable angle, and the stems might even grow downward while the roots stuck up into the air.

Some plants, particularly twining vines and tendrils, have a tropism to contact. When a tendril touches a solid object, the cells on the side away from the contact suddenly elongate more rapidly, while those on the side of contact may shrink; so the tendril coils around the object. The response occurs within a minute or so, indicating that pressure effects as well as growth may be involved.

The general belief that plants have a tropism to water which makes their roots grow toward moist soil seems to be

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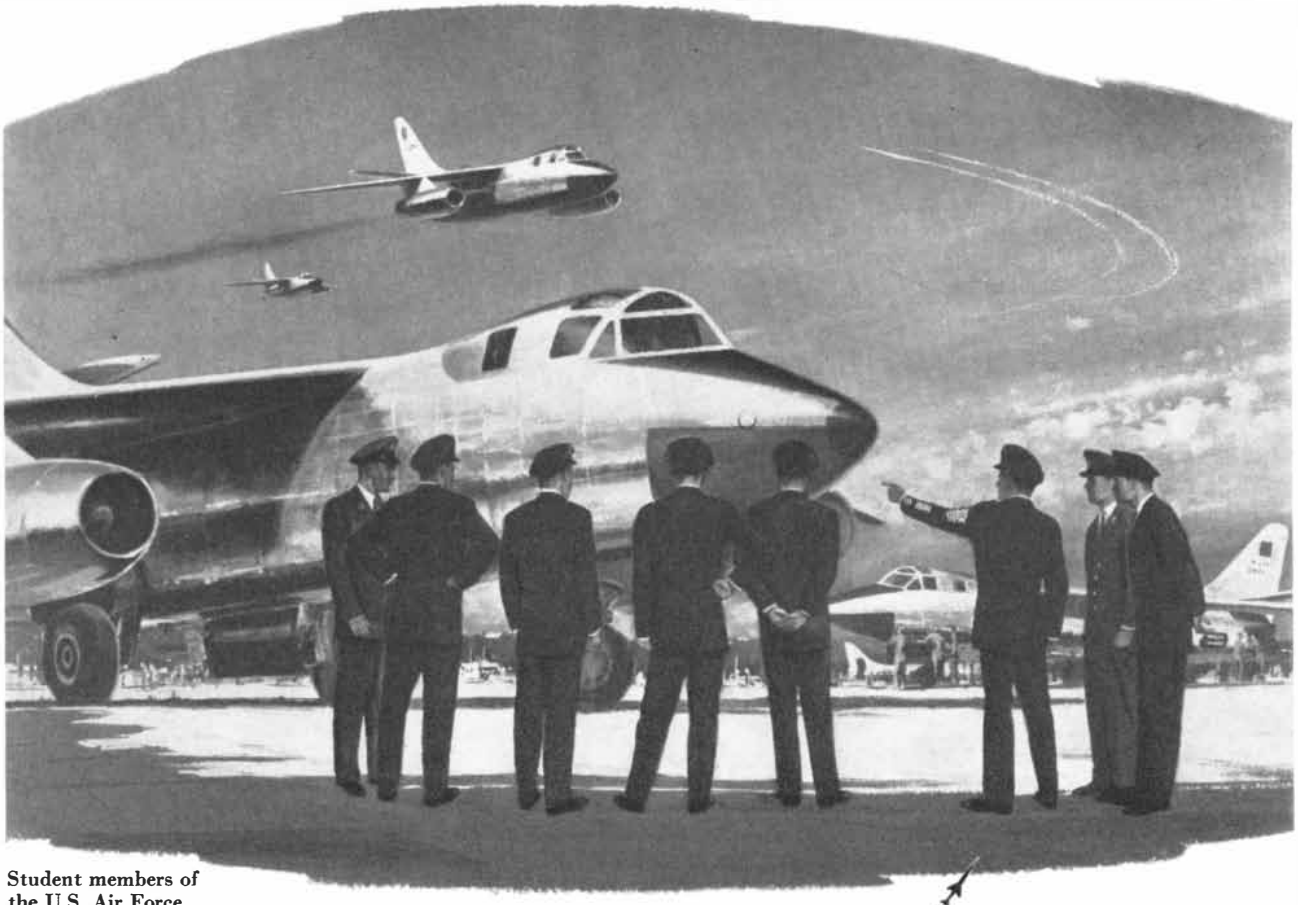

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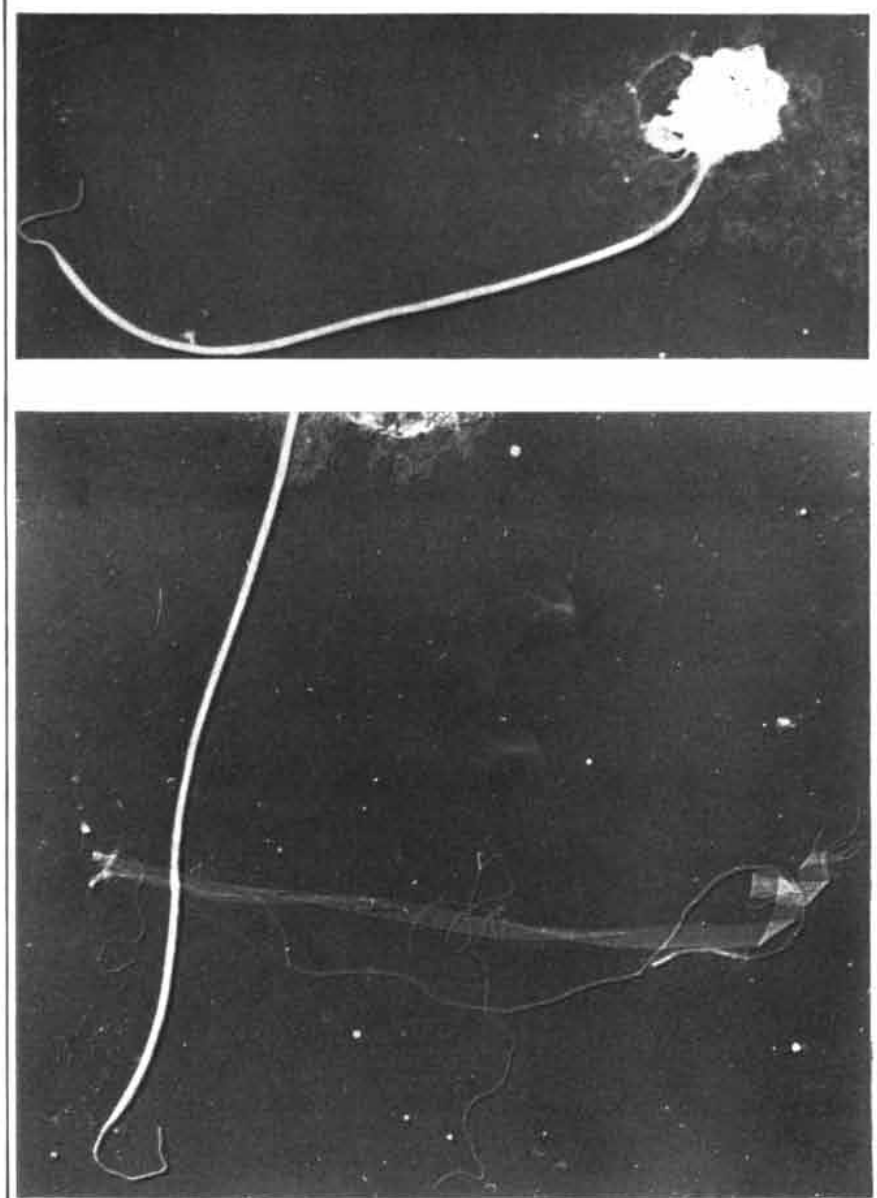
wrong. Recent research indicates that growth of roots by attraction toward water occurs only to a limited extent in a few species of plants, if at all. The reason that roots grow so thickly in moist soil, especially around drains, is simply that this environment favors the development of the rootlets already there.

We now come to movements produced by the swelling and shrinking of cells—called turgor movements. The agent here is water: diffusing into and out of cells, it inflates or deflates them, and it may raise the internal pressure in some plant cells to as high as several hundred pounds per square inch. Practically all leaves have pores which open when their guard cells are swollen with water and close when the guard cells are deflated, at night or when they lack sufficient water. The loss of pressure at night is connected with the halting of photosynthesis. When the morning light comes, the photosynthetic activity of the plant results in conversion of the insoluble starch in the guard cells into soluble phosphated sugar. The cells take up more water and swell.

A familiar example of turgor movement is the so-called "sleep movements" of plants of the legume, oxalis and other families. At night, or when water is short, their leaflets fold together. The reason is that they lose the support of the cushion-like swellings at the base which



FLAGELLUM propels the fungus *Rhizophidium* through the water. At the top is an electron micrograph which enlarges the cell 7,500 diameters. At the bottom an intact flagellum may be seen at the left. From left to right is a flagellum which has separated into 11 fibrils.

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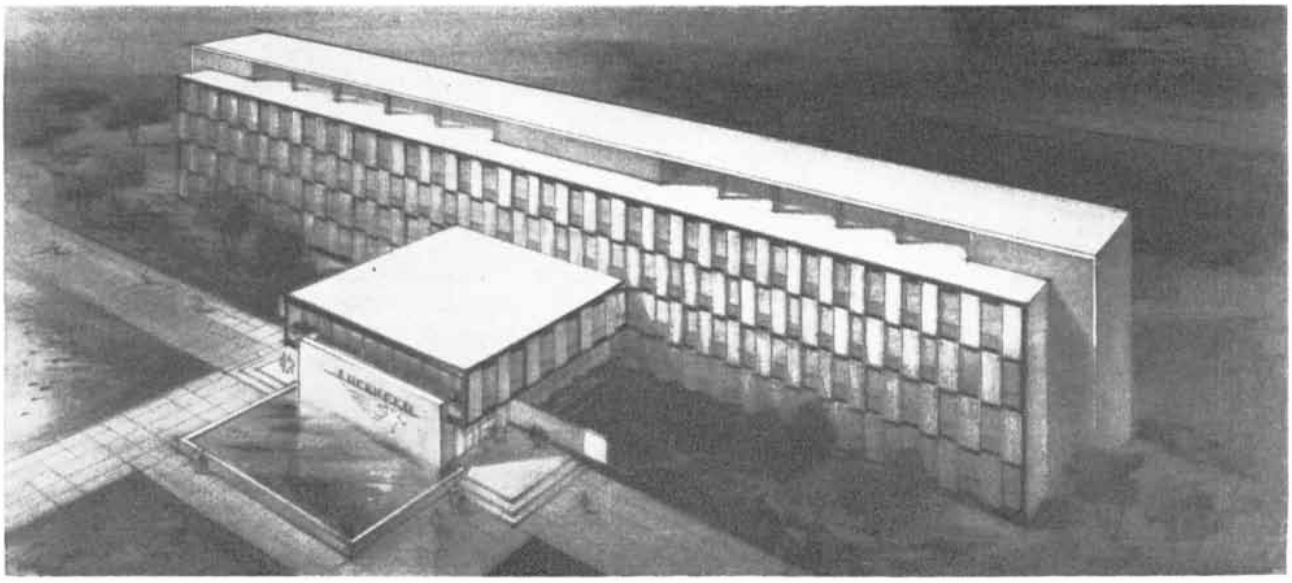

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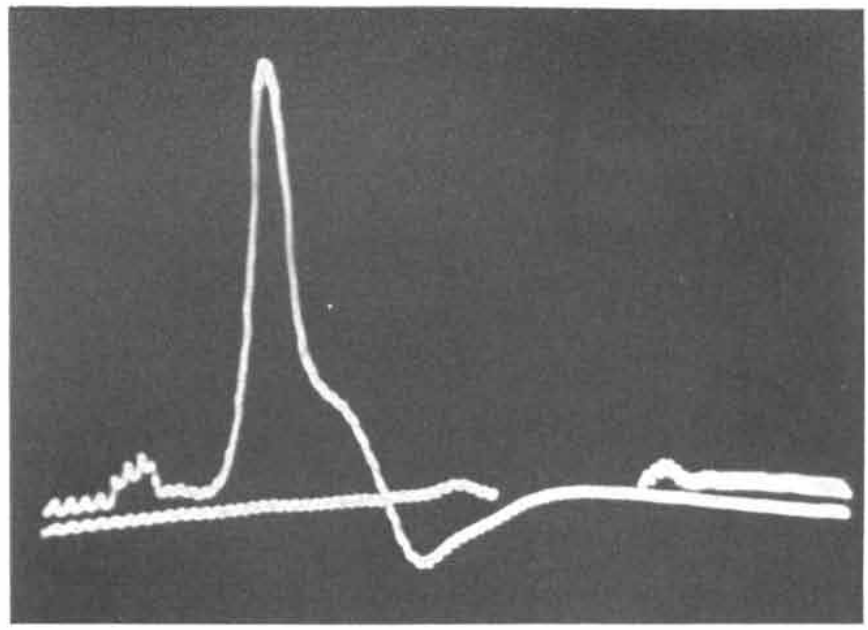


ELECTRICAL ACTION POTENTIAL released by bending a trigger hair of Venus'-flytrap is recorded by oscilloscope trace. The maximum represented by the tall peak is .13 volt.

ordinarily hold leaves and leaflets firmly erect. Another example is the rolling up of grass leaves in dry spells; they roll into a tube because certain rows of cells along their epidermis lose water more readily than others.

There are plants that exhibit much more rapid and spectacular turgor movements. The sensitive plant (*Mimosa pudica*), so called because it is sensitive to touch, shuts its leaves very rapidly when stimulated by a touch, by heat, by electricity or by ether. Sometimes you can see one pair of leaflets after another close in sequence as the impulse travels down the leaf.

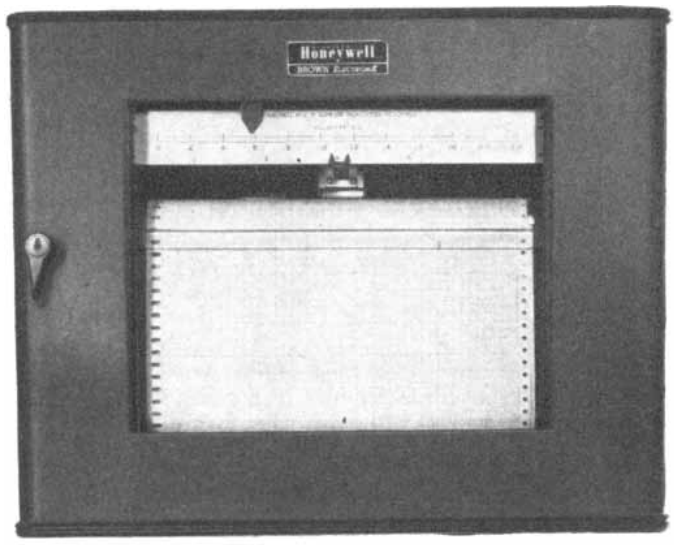
In the barberry plant the lower parts of the pollen-bearing stamens are sensitive to touch. When an insect touches them, the stamens suddenly snap inward, dusting the insect with pollen. In the flowers of the trumpet creeper, catalpa and some other plants, a touch causes the two halves of the stigma to come together. If the stigma becomes covered with pollen during the process, the two halves remain together, but if no pollen was trapped, the halves separate within a few minutes.

Venus'-flytrap, an insect-eating plant native only along the Carolina coast, has a complex set of movements. Its leaves, hinged along the midrib, rapidly close together when their upper surface is touched. Usually it takes two separate touch stimuli, spaced 1.5 to 20 seconds apart, to make the leaf close; it shuts within half a second after the second touch. When it traps an insect or other protein-containing object, the leaf remains closed and proceeds to squeeze its prey by pulling its edges together.

The aquatic bladderwort is another insect eater with rapid turgor movements. On its stem are many small sacs about the size of a pinhead. Each of these "bladders" is a trap, and it is set by being partly collapsed, like a squeezed rubber ball. It has a hinged trapdoor with a sensitive trigger. When a swimming insect or other small animal stimulates the trigger, the trapdoor suddenly swings upward and inward. A rush of water sweeps the animal into the bladder, and the door promptly closes. Inside, the insect dies and is digested. In the meantime, however, the trap is reset, and it may reopen to catch a second insect.

Still another insect-trapping plant is the sundew, which has small, sticky leaves with long tentacle-like hairs on the upper surface. When an insect becomes stuck on the leaf, the hairs bend around it, and as soon as the tips of the hairs touch it, the plant begins to secrete digestive enzymes. These hair movements are growth movements rather than turgor movements.

All these plant movements—locomotive, nutatory, nastic, tropistic, turgor and so on—are in addition to the usual restless traffic that goes on in any organism: the flow of water and food, the diffusion of substances in and out of cells, the multitude of biochemical reactions. The plant in the field, far from being a creature which toils not nor spins, is a veritable beehive of activity.



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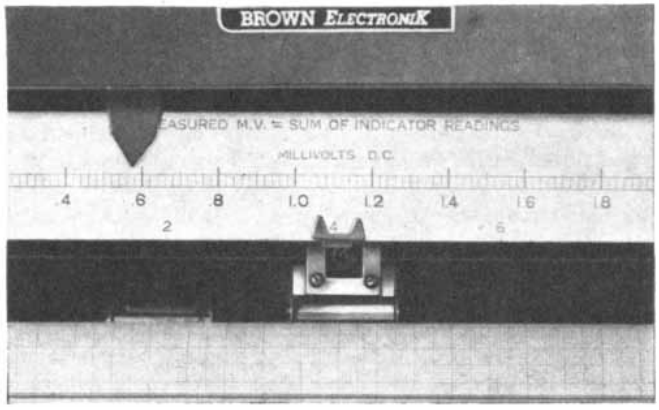

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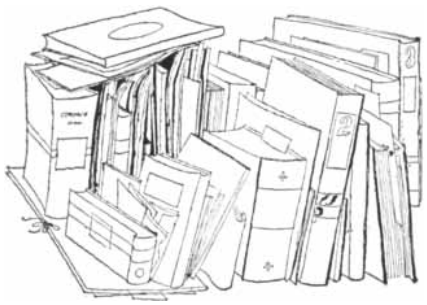


BOOKS

A biography of a remarkable figure of the 19th century: John Stuart Mill

by James R. Newman

THE LIFE OF JOHN STUART MILL, by Michael St. John Packe. The Macmillan Company ($6.50).

John Stuart Mill, economist, philosopher, social reformer and child prodigy, was one of the remarkable men of the 19th century. How remarkable and how interesting has never before been so fully brought out as in this admirable biography by Michael St. John Packe, a history scholar of Magdalene College, Cambridge University. Mill has lacked neither biographers nor admirers; he was enormously influential in economic, political, social and philosophical thought, so that even today, 70 years after his death, few names are more familiar than his to educated persons; he wrote a celebrated autobiography which tells a great deal about his mental development and intellectual life. Yet to a large extent the man himself has remained veiled and forbidding. There was much about him that was obscure—about his personality, his friendships, his long-drawn-out love affair with Harriet Taylor, which for 20 years or more nourished the gossip of London society. The source materials which could shed new light on these matters and fill in many gaps of information were long withheld from public scrutiny by Mill's stepdaughter and her niece, and were later scattered when offered at auction. Fortunately, these materials have been reassembled and with their help Packe has undertaken a full-scale portrait. I cannot say that he has made plain everything that was not plain before, nor are all his conclusions and appraisals equally compelling. But he has written a fascinating, sensitive book which brings into full view a hitherto half-hidden figure. Packe's Mill is a man who moves you, whom you like and dislike and pity as well as admire.

The prodigiousness of prodigies blinds us to their other traits. What lives inside the marvel is apt to be forgotten. But Mill the man is inexplicable if one fails fully to take into account his incredible childhood. His father, James Mill, was the eldest son of a Scotch shoemaker and of an energetic woman who had determined that her first-born should be well educated and rise in the world. James did not disappoint her. He became a journalist and scholar and married a pretty girl with a dowry of 400 pounds. In 1806 he produced a son—John Stuart—and in 1808 met Jeremy Bentham. The second event profoundly influenced the consequences of the first. James Mill became a close friend and disciple of Bentham, the founder of Utilitarianism, who held as the *summum bonum* the greatest happiness of the greatest number and believed that there was no limit to the benefits a good education could confer. The two men set out to make of young John, then only three years old, a worthy disciple for their cause and an experimental proof of their theories.

James treated the tender mind of his son as a blank sheet upon which he could write what he liked. At three the boy began to learn Greek words. When he had mastered a vocabulary, he was introduced to Aesop's Fables. Next came Herodotus, then Xenophon. At age seven John read Plato's *Dialogues*, which, he later felt, "would have been better omitted, as it was totally impossible I should understand [them]." His father was not the most patient of men; moreover, "he demanded of me," wrote John, "not only the utmost that I could do, but much that I could by no possibility have done." Yet if the son was not spared, neither was the father. There was nothing to which he would not submit to further the child's education. He told the boy what to read, heard his lessons, discoursed with him on long walks, drilled him in arithmetic. In the evenings they sat together on opposite sides of the table in the crowded living room, with one baby sister "howling in one corner" and another in another, John studying his Greek and James grinding away at a *History of India* he was writing. As there was in those days no Greek-English lexicon, John incessantly interrupted his father to ask the meaning of words. It is not surprising that the *History*, which was to have taken three years, took 10.

John soon started reading on his own: biographies, accounts of voyages and explorations, histories, political works, the plays of Terence, the *Iliad* and the *Odyssey*, a translation of Plutarch, Aristotle's *Rhetoric*. At five "he was able to engage Lady Spencer, wife of the First Lord of the Admiralty, in an animated comparison of Wellington and Marlborough"; at six and a half he composed a Roman history in 1,500 words. Books of amusement were not denied to him. *Robinson Crusoe* was his chief delight; his father went so far as to borrow for his son the *Arabian Nights*, *Don Quixote*, Maria Edgeworth's *Popular Tales* and a "book of some reputation in its day," Brooke's *Fool of Quality*.

In John's eighth year "the pulse of his learning quickened." He added Latin, algebra and geometry to his curriculum. He raced through Cicero, Horace, Livy, Virgil, Ovid and Juvenal. Before he was 12 he had pierced the mysteries of trigonometry, conic sections, the differential calculus and other portions of higher mathematics. In this field he was mostly on his own, because his father was not much of a mathematician. John continued avidly to read history and to compose ancient histories, including a full-scale analysis of Roman constitutional law, all of which he later destroyed "in contempt of my childish efforts." His father interested him in the pleasures of poetry with Pope's translation of the *Iliad*. He read it again and again, attempted to write verse in the same style, turned to Greek poetry, then to Milton, Goldsmith, Gray, Cowper, Spenser, Scott, Dryden, Burns. The boy was required to teach his little sisters and brothers, of whom in time there were eight. When he was eight and just beginning Latin, his sister Wilhelmina, aged five, became his pupil in classics, and he was responsible for the answers to questions on Latin grammar put to her by her father. Wilhelmina was not retarded; she read Cornelius Nepos when she was six, and dabbled in Caesar; the

other children kept pace—from Ovid to cube root—but Packe warns against concluding they were erudite. In fact, "in later life they were under the impression that their own education had been somewhat sketchy."

John was coached most thoroughly in economics, logic and political theory. When he was 13 he was taken through "a complete course of political economy," including lectures on Ricardo delivered by his father on their walks in the country. The intricate subject of money was carefully gone into, and lessons in logic became part of the daily fare.

In 1820, when John was nearly 14, his father decided that he had taught his son all he could, and that the only thing left for the boy to learn was "how to take his place with other human beings." This was not easy, because John had been quarantined from other boys lest they corrupt him with their "vulgar modes of thought and feeling," and he had been trained to know rather than to do. However, in spite of his training John was a modest, likable youngster; though inclined to be dogmatic, he had no conceit and always ascribed his accomplishments to his early education.

It was arranged to expose him to the outside world by sending him to France to live for six months with Bentham's brother Samuel, who had a family of children somewhat older than John. The trial was successful beyond expectation. The Benthams ran a relaxed, cheerful, agreeably disordered household, and in time John adapted himself to its ways. He went on picnics, attended peasant dances, visited the circus, looked through a telescope, became interested in botany. A French tailor fitted him for more fashionable clothes; a gentlewoman taught him piano. Fencing, riding and dancing were added to his accomplishments, though it cannot be said he cared for these pursuits. He cut down on his mathematics and caught more butterflies, studied less logic and practiced more sleeping. Six months stretched into a year. When he returned home in July, 1821, he was not the same boy. He had not lost his interest in intellectual pursuits, but he had glimpsed new sights that thrilled him, learned to live outside the confining circle of his childhood, seen in their daily habit the working folk hitherto known to him only "within the graphs of political economy." The

Mill as he appeared shortly before his death in 1873

wonder child had outgrown its test tube.

John's godfather, Sir John Stuart, had left 500 pounds to send him to Cambridge, but his father decided that the University had nothing to teach the boy. He was probably right. When John was 16 he accepted an invitation to speak before the Cambridge Union. "His massive power in disputation, uttered from a flimsy body in the creaking tones of 16, stilled the brittle oratory of the adolescent giants. He left a great impression." John founded a society of his own, named the Utilitarian Society, and its five members met fortnightly for three years to debate serious matters.

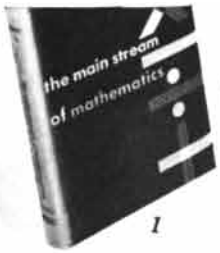
In 1823 he was given a post as a junior clerk with the East India Company. He remained with that agency for 31 years until his retirement. Mill rose to the position of Chief Examiner, the highest in his department, and was very well paid. Thus financial security, like almost everything else, came to him early.

Another event, which might be said to have completed his education, occurred in 1823, when Mill was 17. He was arrested for distributing "obscene literature." The circumstances did him credit. The famous reformer Francis Place, campaigning against Malthus' harsh "natural" correctives to over-population, had published and distributed a birth control pamphlet titled "To Married Working People." Young Mill visited Place one day, filled with horror by two things he had seen while walking to his new job at India House: a strangled newborn baby abandoned in St. James's Park, and criminals dangling from the gibbet at the Old Bailey. Place gave him some of his broadsheets, and Mill with a friend undertook to strew them through London. The boys were caught and brought before the Lord Mayor. He lectured them on their outrageous attempt "to corrupt the purity of English womanhood," sentenced them to 14 days and then let them go after a day or two. Years later, when he had grown famous, Mill met the Lord Mayor at a banquet. "The Lord Mayor beamed civilly; 'I have had the pleasure of sitting opposite you before, Mr. Mill,' he said. Mill agreed tartly: he would have a happier memory of the occasion, he replied, if the Lord Mayor had been as quick then as he was now in perceiving opposites: for he would have been able to discriminate between an attempt to prevent infanticide and the promotion of obscenity."

Mill's autobiography depicted his childhood as "a weary drudgery," his home as "cheerless, godless, silent and afraid." But Packe makes clear how much Mill owed to his father, not only intellectually but also for his character, ethical outlook and social idealism. Mill never failed to finish what he started; he had an enormous capacity for work, and he was usually engaged in a dozen undertakings besides his regular job at India House. Articles, reviews, polemics, essays flowed from his pen on subjects ranging from the libel laws to the theories of Coleridge, from the economics of labor to the metaphysics of Sir William Hamilton, from contemporary politics to Tennyson's poetry. The journals to which he contributed sometimes paid him for his work, but often it was he who kept the journal going by digging into his pocket. Mill was unfailingly generous; he never forgot the examples set by Bentham, Place and others who had saved his father and family from poverty. Though he was far from wealthy, he gave money freely to charitable organizations, to workingmen's libraries, to the Woman's Suffrage Society, to "a Wiltshire poacher under prosecution," to girls' schools, to the Drinking Fountain Association, to indigent writers and philosophers of every shade of opinion. The prickly, hapless mathematician and philosopher Auguste Comte, half madman, half genius, gained from Mill's generosity, as did also the even more offensive Thomas Carlyle.

It may be urged, of course, that whatever Mill did for Carlyle was paltry in light of the latter's magnificent equanimity in the famous affair of the burned manuscript. He had lent Mill the completed manuscript of the first volume of his *French Revolution*, the product of five months' literary labor. Mill took it home, read it, and then with incredible carelessness swept the sheets, together with some old papers he was clearing out, into a bin for "kitchen use." The stove consumed the lot, leaving only a few charred pages. Carlyle, who had destroyed even the notes of his work before sitting down to write, as was his habit, carried off the catastrophe with unexampled generosity and understanding. "I feel," he wrote Mill, "that your sorrow must be sharper than mine. . . ."

As an adult Mill began to find the friendship of which he had been deprived as a child. At the age of 20 he fell into a profound mental depression, suddenly discovering that he was incapable of feeling. After some months the crisis passed: "I was no longer hopeless," he wrote, "I was not a stick or a stone." The experience brought a change in outlook. Thenceforward he gave to his sympathies and passions a greater role. He recognized that he needed companion-



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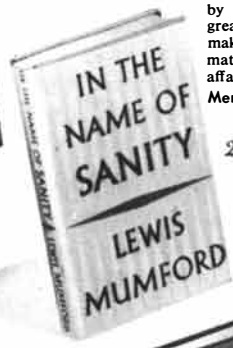

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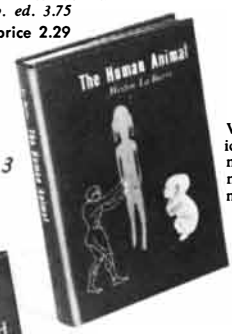

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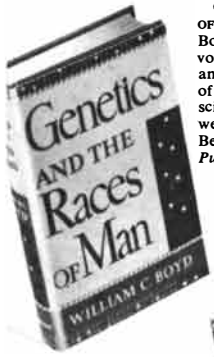

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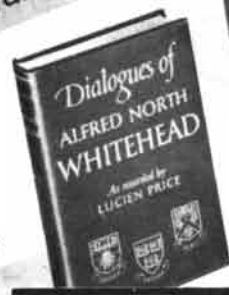

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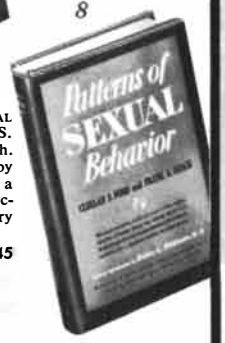

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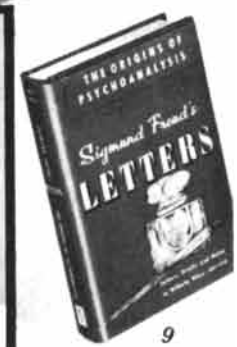

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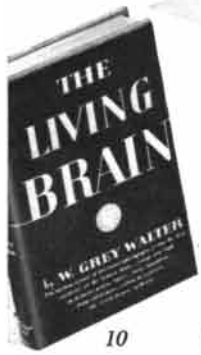

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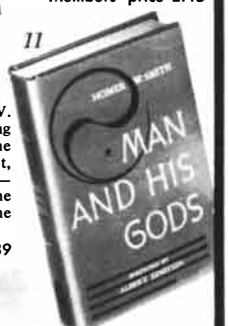

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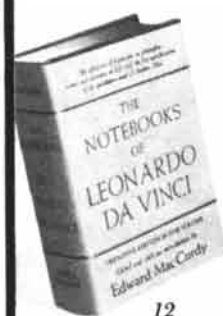

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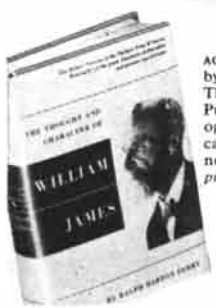

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ship and he sought it. He mixed more in society. The historian George Grote, the psychologist Alexander Bain, the poet John Sterling were among those who became his close friends. In time he also fell in love.

At 24 Mill met Harriet Taylor, a young, beautiful, poetic, passionate, proud, clever woman whom Carlyle described as a "living romance heroine, of the clearest insight, of the royalest volition. . . ." She had faults which Carlyle portrayed no less vividly—"she affects, with a kind of sultana noble-mindedness, a certain girlish petulance." This was a minor matter. More distressing was the fact that when Mill met her she was already married. Her husband, a prosperous London merchant who adored his wife, was destined to become the most long-suffering husband of history, denied even the satisfaction of being forthrightly cuckolded. The instant Mill laid eyes on Harriet "a passion sprang out of the bushes like a hundred Ashantees, and he was carried away captive." For 20 years they were lovers, but if all the biographers, including Packe, are right, they were lovers living in a state of "technical innocence." Harriet was the kind of girl who knew how to manage her relations with two men, giving neither exactly what he wanted but each enough to make him reluctant to give up what he had. Her husband first tried to break up the affair. When Harriet outtalked him, he resigned himself to the wretched, lonely life of a husband of convenience. Harriet spent a good part of each year in her country house or traveling in Europe with Mill, and even when she lived with her husband in London, Mill came twice weekly to dine and Taylor trotted off to his club to spare the lovers' feelings.

Mill knew that divorce was impossible and settled for inspiration and companionship. (Harriet eventually became his wife in 1851, two years after her husband's death.) Packe tries hard to convince us that Mill was not undersexed but was prepared to deny the appetite of the flesh for the higher spiritual pleasures of abnegation. But I do not find Packe very enlightening or original on this aspect of the affair. There comes to mind Carlyle's brilliantly disagreeable question when Mill, who was always ailing, took a trip abroad with Harriet to try to mend his health: "They are innocent says Charity, they are guilty says Scandal: then why in the name of wonder are they dying brokenhearted?"

Packe does, however, succeed in making abundantly clear how profoundly Harriet influenced Mill's views. Within a few years after they met, their companionship had become as close intellectually as emotionally. He extended her horizons and she passed meticulous judgment on his ideas. "From 1846 onwards," Packe writes, "Mill's entries in his chronological list of published works are marked with increasing frequency as a 'joint production with my wife,' and the *Political Economy* is so styled. The influence she had gradually extended over him now ended in complete ascendancy, and his further writings were 'not the work of one mind, but of the fusion of two.' " It was a good influence; of this there can be no question. John Mill was a reasoning man, a scientific and "severe" thinker, but without much sense of the concrete or much poetry. Harriet supplied these qualities to his work; it was she who never permitted him to relax his vigilance against social injustice, who "helped to keep him a radical and a democrat."

Mill's best-known writings are *A System of Logic*, *Principles of Political Economy* and his famous essay *On Liberty*. Packe scarcely gives more than the gist of Mill's writings and offers no critique in any real sense. Mill's *Logic* had as its main object the "rehabilitation of induction." He was a mechanist. He shared the 19th-century confidence in the final reducibility of the most diverse phenomena to mechanical actions. He adopted as a grand hypothesis the uniformity of nature, and as another major assumption the "Law of Universal Causation" which holds that "every event, or the beginning of every phenomenon, must have some cause, some antecedent, on the existence of which it is invariably and unconditionally consequent." Mill went so far in embracing the inductive method and rejecting the notion of absolute truths that he dismissed the conclusions of geometry as mere deductions from arbitrary assumptions which are neither necessary nor true. As for the rest of mathematics, he held it to be founded on a science of numbers which consists only of "experimental laws based on the evidence of the senses."

The *Logic*, like the *Political Economy*, was an immensely successful and influential book. At Oxford and Cambridge it was for a half-century the "groundwork of natural science," says Packe. Its shortcomings, which are serious, arise in part from the fact that Mill "claimed for reason more than it could achieve," in part from the inadequacies of his notions of psychology. He hoped, of course, to apply his principles of logic to man and society, always of greater interest to him than the sciences themselves, and the concluding portions of his book are devoted to these considera-

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tions. But here he was soon mired in classical dilemmas and difficulties. It was all very well to say that human behavior was a phenomenon subject, like the behavior of a gas or the revolution of a planet, to causal laws, but where did this leave the freedom of the human will? Mill was unable to resolve the dilemma without, as Packe says, bending his logic. The results were not satisfactory, but the attempt is noteworthy in demonstrating once more that Mill, though a worshiper of reason, was "first of all a humanist who carried the stern standard of utilitarianism into philosophy itself." He would not accept conclusions "repugnant to the interests of mankind," whatever the cost to logical consistency.

And so again in the essay *On Liberty*. It is "more of a hymn or incantation" than an impeccably reasoned discourse. Written jointly with his wife, this essay, perhaps more than any other of Mill's works, retains its stature today. Its outlook is eclectic. Mill was incapable of glossing over the dilemmas of freedom. The individual's rights and the needs of society, majority rule and minority opinions, "the tyranny of a few" and the "rough justice of the many," the evils of collectivism and the immorality of *laissez faire*—these were the conflicts and incompatibles he could not reconcile and would not deny. On one point, however, he was clear. Both morality and self-interest required the encouragement of minority opinions, the preservation of individual differences. It was important, he advised Bertrand Russell's mother, Lady Amberley, to "establish a character for strangeness." But individuality was not likely to thrive under the rule of the greatest number. He had read and admired Alexis de Tocqueville's *Democracy in America*, and he had taken to heart its warnings. Even as he worked for the advancement of the mass of men, for the enlargement of their power, he feared the accompanying pressures toward conformity.

"The worth of a State, in the long run, is the worth of the individuals composing it; and a State which . . . dwarfs its men, in order that they may be more docile instruments in its hands even for beneficial purposes, will find that with small men no great thing can really be accomplished; and that the perfection to which it has sacrificed everything, will in the end avail it nothing, for want of the vital power which, in order that the machine might work more smoothly, it has preferred to banish."

Disraeli contemptuously called Mill a "finishing governess" when he first

heard him speaking in Parliament. Disraeli was right, and other unflattering things could justly have been said of Mill. He was cold and dogmatic; he was capable of great cruelty to his mother and sisters, whom he despised; he was not a philosopher of the first rank; he was a codifier rather than an innovator. Nevertheless he was an admirable figure—courageous, independent, unswerving in his dedication to human welfare and the principles of liberalism, always stately and elevated in his outlook on public questions, one who used his superb intellect only for good. Packe has shown him to us as an archetype of civilized man. We have need of such finishing governesses.

Short Reviews

AMERICAN SCIENCE AND INVENTION, by Mitchell Wilson. Simon and Schuster ($10.00). Wilson is a physicist who once worked with Enrico Fermi; he is also a novelist whose *Live with Lightning* was well received. In this volume, consisting of a thousand pictures and 130,000 words of supporting text, he presents a history of the machines and theories of ingenious men, from sailmakers' tools and Benjamin Franklin's stove through Willard Gibbs's phase rule to synchrocyclotrons. His account is varied, enjoyable and instructive. There is fun in it, and clearly-imparted information for those who wish to read as well as browse. Like all such jumbo packages, it is at times thoroughly bewildering. Not every contrivance or concept here recorded is equally well explained—Gibbs's terrifying phase rule, for example, remains as snarled as ever. This is a very good book, worth owning, but it could have been better.

NANGA PARBAT, by Karl M. Herrligkoffer. Alfred A. Knopf ($5.00). Nanga Parbat—meaning the naked mountain—is an awesome colossus standing at the far western end of the main Himalayan chain. It is 26,600 feet high, with no surrounding peaks to detract from its supremacy, and it rises so sharply in an almost unbroken sweep from the plains below that it is the highest single mountain face on earth. Many attempts have been made to climb it, beginning in 1895 with the ascent by the famous mountaineer A. F. Mummery. He disappeared with two porters and was never seen again. Six more unsuccessful expeditions followed. A German expedition in 1934 lost 11 men; in another, three years later, 16 men were crushed in their sleep by an avalanche. Nanga Parbat earned

its reputation as the killer mountain. At last in 1953 a German-Austrian party got to the top. More precisely, one of their number, Hermann Buhl, a clerk in a Munich sporting goods store, did it. He set out alone from an advance camp and after an almost incredible journey lasting 40 hours, in the course of which he lost his food, his sleeping bag and most of his tools and equipment, he clambered to the top and got back alive. On the way he was forced to spend the night standing in sub-zero temperature on a ledge a few inches wide. The climbing history of Nanga Parbat and the detailed story of the last expedition are told in these pages by its leader. It is an exciting account, a mixture of straightforward reporting and more personal expression. But there are unpleasant overtones. The mountain climbers were churlish in their treatment of porters, and the 1953 expedition was unsurpassed in the ability of its members to fall out among themselves and engage in bitter public recriminations once the glorious adventure was ended. The injunctions and other brawling seem now to have subsided, with general agreement that while Buhl may not be a pukka sahib, he is a peerless climber.

JANE'S FIGHTING SHIPS, 1954-1955, edited by Raymond V. B. Blackman. McGraw-Hill Book Co. ($23.00). The world's navies continue to swell and so does *Jane's.* In this 56th edition there are 535 new illustrations of new or converted warships, bringing the total to well over 2,500. Numerous additions to the technical data and notes describe the latest scientific and engineering developments. Among these advances are high-speed turbines, giving better performance with lighter weight; lightweight Diesel engines; nuclear-powered engines; hydrogen peroxide plants; steam catapults; gun mountings, gun controls and weapons "which are becoming separate engineering installations in themselves." The increase in complexity of warships has, as *Jane's* points out, presented the authorities with a serious problem in the shape of a shortage of qualified engineers. Undoubtedly there have been changes in the requirements since the gallant Captain Corcoran commanded H.M.S. *Pinafore.* Some other items of intelligence in this year's edition: the latest ship's guns have three times the previous rate of fire; Great Britain has built no aircraft carriers, battleships, cruisers, destroyers or large warships of any kind since the end of the Second World War; the U. S. Navy today is equal to all the major navies of

the world put together; the U.S.S.R. now has 400 submarines, some of which have a range of 20,000 miles and a speed of 20 knots; U. S. atomic submarines will have three deck levels and will be capable of being propelled by either atomic power, Diesel engines or electric motors.

THE PICTURE OF EVEREST, edited by Alfred Gregory. E. P. Dutton & Co., Inc. ($10.00). Here is an album of some 40 color photographs of the country of Nepal and the highest mountain in the world, taken by members of the 1953 British Everest expedition. Many of the shots are so breathtaking that one almost reaches out for the climber's oxygen equipment. The principal photographer represented is Alfred Gregory, but there are a number of fine pictures by other members of the expedition, including Sir Edmund Hillary, whose photographs at the top of Everest have deservedly become world-famous. This is a book no lover of mountains and mountain-climbing can possibly do without.

DESIGN OF THE UNIVERSE: THE HEAVENS AND THE EARTH, by Fritz Kahn. Crown Publishers, Inc. ($5.00). Kahn, who is known for his earlier book *Man in Structure and Function*, presents a popular survey of the physical sciences: physics, chemistry, astronomy and cosmology, geology, meteorology. Despite numerous minor inaccuracies, oversimplifications and garish or confusing illustrations, this is a very readable book—fast-moving, written with infectious zest and amazingly comprehensive. Kahn rushes in where many physicists fear to tread and manages to put on a good show for those who are not too captious.

THE COLLECTED WORKS OF C. G. JUNG, four volumes, edited by Sir Herbert Read, Michael Fordham and Gerhard Adler. Pantheon Books, Inc. ($17.00). These are the first four volumes of a collection which will present in English all the works of the famous Swiss psychologist. The translations have been skillfully executed, and the typography and book production are fully up to the admirable standards of Pantheon's Bollingen Series. One of the volumes, called *Psychology and Alchemy*, has 270 remarkable illustrations, largely drawn from old alchemical tracts, and but for the support of the Bollingen Foundation would normally sell for two or three times the price listed.

SOVEREIGN REASON, by Ernest Nagel. The Free Press ($5.00). One of the clearest of contemporary thinkers pre-

sents a collection of 16 of his essays dealing with problems of the philosophy of science. The book includes critical studies of the work of Charles S. Peirce, John Dewey, Alfred North Whitehead, Bertrand Russell and Sir Arthur Stanley Eddington. The apt title of the collection is from an epigram of Thucydides: "It is a habit of mankind to entrust to careless hope what they long for, and to use sovereign reason to thrust aside what they do not fancy." Professor Nagel makes a worthier use of sovereign reason to expose muddled ideas, sentimental self-deceptions, "malicious philosophies of science," inconsistencies of theory and man-made perplexities and dilemmas. He brings to his task a sense of humor and an admirable gift for plain talk. His book is an intellectual treat for thoughtful readers.

COAL, by Wilfred Francis. St. Martin's Press, Inc. ($17.50). The author summarizes the results of research conducted here and abroad on the development, structure and chemistry of plant life during the period in the earth's history when the great coal deposits were laid down, the transformation of different types of plant tissues into different types of coal, the chemical content and physical characteristics of deposits in various parts of the world. The comprehensiveness of treatment and the many first-class illustrations make this an indispensable work for students of fuel technology and coal chemistry.

THE GIANT CACTUS FOREST AND ITS WORLD, by Paul Griswold Howes. Duell, Sloan and Pearce, and Little, Brown and Company ($7.50). This readable, handsomely illustrated nature book is based upon field trips taken by the curator of the Bruce Museum of Greenwich, Conn., and his wife to the cactus belt in southwestern Arizona. The author describes the incredibly wonderful giant saguaros of the region; the villages of kangaroo rats; the pack or trade rats that "guard their trashy homes with cholla spines"; and beetles and the weevils that destroy the cacti; the ground squirrel and the cottontail that play together in the desert; the rattlesnakes, Gila monsters, chuckwallas and geckos; the desert mantises; the short-horned grasshopper (whose Latin name is *Trimerotropis pallidipennis pallidipennis*); the amazingly varied and interesting bird life. The book has many fine photographs, drawings and a full-color plate of 41 kinds of desert birds; also a useful chart showing who gets eaten by whom in the cactus forest.

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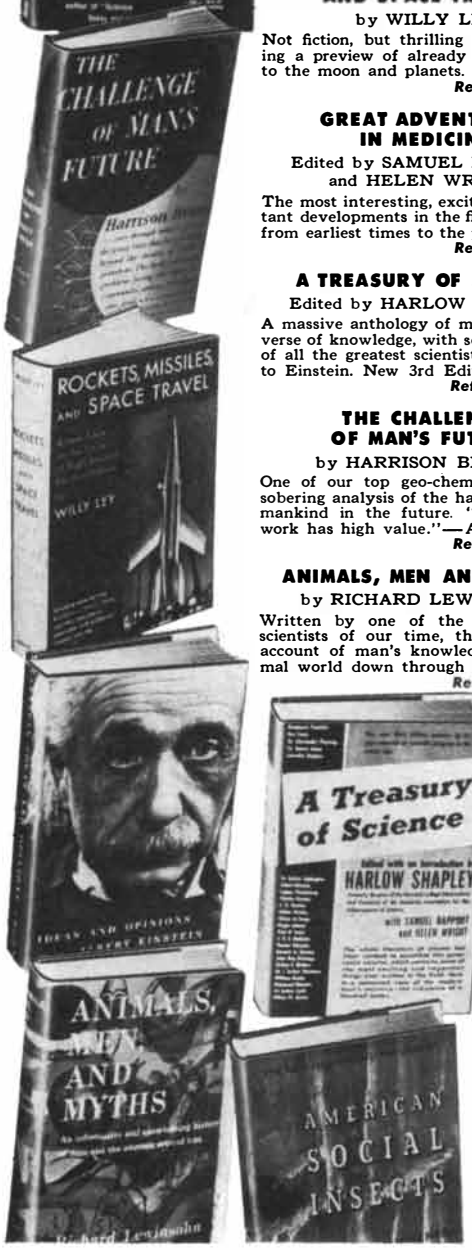

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THE AMATEUR SCIENTIST

About tiny mineral specimens and other matters, including a troublesome puzzle

Conducted by Albert G. Ingalls

If you are an apartment dweller who cannot resist the lure of rocks, the chances are that you have a space problem. Joseph F. Burke, a business executive and amateur mineralogist of New York City, found a solution. He succeeded not only in clearing his den of 500 pounds of specimens but also in discovering a fascinating new side of his hobby.

"The solution," he writes, "is micromineralogy. My present collection contains more than 500 different minerals but it weighs less than two pounds. The entire collection can be carried easily in a briefcase—along with a microscope and other accessories. Instead of the so-called 'bragging rocks' that arouse envy at mineralogy club meetings, you work with chips ranging in size from small marbles to pinheads. You identify these by microphysical and microchemical methods and make them up into 'micromounts' for observation under a low-power microscope. Everything is scaled down but the fun. Some of the finished mounts enter your collection and others are reserved for exchange—just as in macromineralogy.

"I started out as a big rock man, hooked by the same lure that first attracts most amateurs—gem stones. About 20 years ago my morning newspaper announced that huge garnets and tourmalines were turning up in rubble coming out of the Eighth Avenue subway tunnel, then under construction. It seemed an opportunity to get rich quick. After investing a lot of lunch hours in the project, however, my dream faded. I had found only two good specimens and they were not worth much on the gem market. More important, I met several similarly inspired 'excavation prospectors' and we fell into the habit of ranging the city in search of other diggings. The sidewalks of New York may not be paved with gold, but they certainly cover a wide variety of gems. To date the five boroughs have produced modest numbers of garnets, amethysts, agates, tourmalines, emeralds and aquamarines, plus scores of minerals such as rutile, pyrite, magnetite, calcite and some 160 others, a number of which are rare.

"We soon found it difficult to examine a rock without wondering how it got that way and why. Gradually we learned how to take rocks apart and examine their constituent minerals. More than 2,000 different minerals have been described. Some are single elements, gold for example, but most take the form of chemical compounds, such as silicon dioxide, the clear glassy rock commonly known as quartz.

"Weathering and the forces of erosion, we learned, do a lot of the disassembly work for you. Pink granite, for example, often weathers into beach sand that may contain fine grains of clear quartz, black magnetite and ilmenite, and glassy red fragments which are miniature garnets. You find a lot of it along the eastern seaboard. Take a small horseshoe magnet along on your next trip to the beach and pass it over a thin layer of sand spread on a sheet of paper. You will doubtless find that it will attract certain of the black grains. These will be particles of magnetite—tiny lodestones. Float one on a miniature raft of wax paper. If the surface of the water is still, the raft will align one of its dimensions with the earth's magnetic field and you will have a small compass. The other kinds of grains lend themselves to equally interesting experiments.

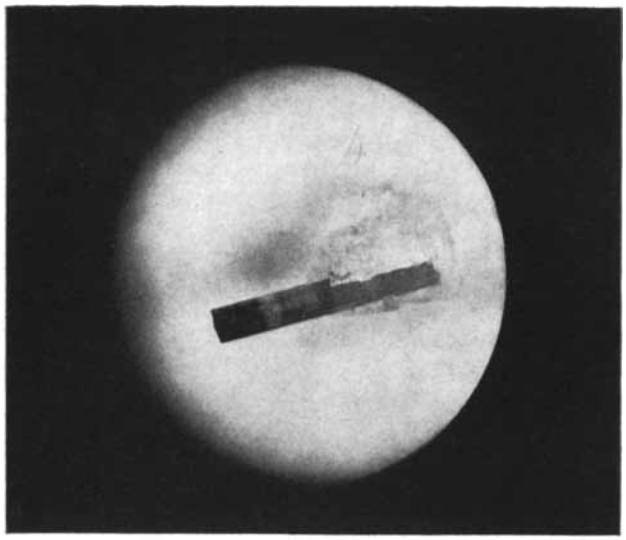
"By the time the Eighth Avenue subway opened for business, my den had become crowded. Nice specimens are generally embedded in a matrix of minerals which are either in your collection already or in which you have no immediate interest. You take the whole rock home anyway for trimming and dressing at your convenience. So the pile grows, and your space problem grows with it.

"At about this stage I was presented with a new idea. While I was browsing through the mineral collection of the Staten Island Institute of Arts and Sciences one afternoon, the late William T. Davis, one of the founders, joined me. He asked how my hobby was progressing, and after hearing about the cramped quarters, suggested: 'Why not go in for micromounts?' He pointed out that if your interest goes beyond mere rocks, you can get as much information and satisfaction from chips as from boulders. An inexpensive 10-power microscope will enable you to cut your collection to a small fraction of its present size and, incidentally, free a lot of top-grade material for exchange with other amateurs.

"One look through a borrowed microscope convinced me. It disclosed superb clusters of tiny crystals—far better and more easily identifiable than the few large crystals one might see with the naked eye. Thus the microscope is a powerful tool for identifying minerals.

"To get started in micromineralogy you need little equipment: a rock, a microscope, a small floodlamp for lighting the specimen and a few trimming tools. You first locate the most interesting area in the rock and then chip off and trim a piece. The microspecimen may range from a sixteenth to a half inch across. The dressing tools that will facilitate the job include a small hammer, a vise, assorted dental picks (retired from professional service), a pair of side cutters and perhaps a file or two. Other supplies, such as carbon tetrachloride for cleaning the specimen, will usually be found in the kitchen.

"When cleaned, the dressed specimen is ready for assembling into a micromount: a pillbox of plastic or cardboard in which a short length of cork is cemented for supporting the specimen. It is desirable to standardize the dimensions of your micromounts. Boxes of uniform size stack nicely. If you mount each specimen so that the face you want to look at is at a fixed depth in the box, say a sixteenth of an inch, you can interchange the specimens on the stage of



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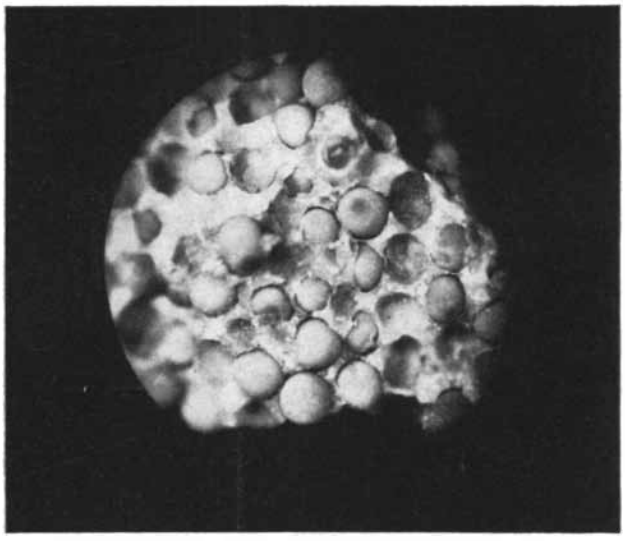

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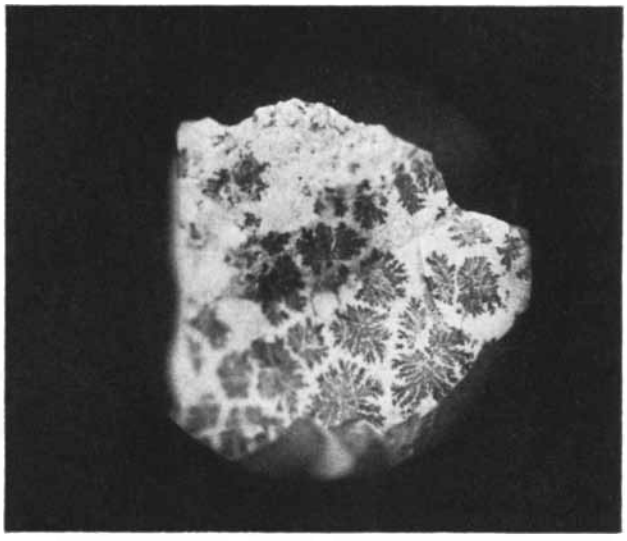

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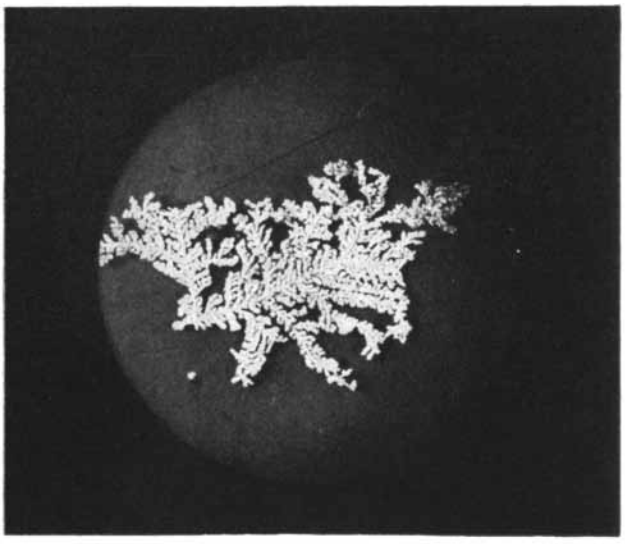
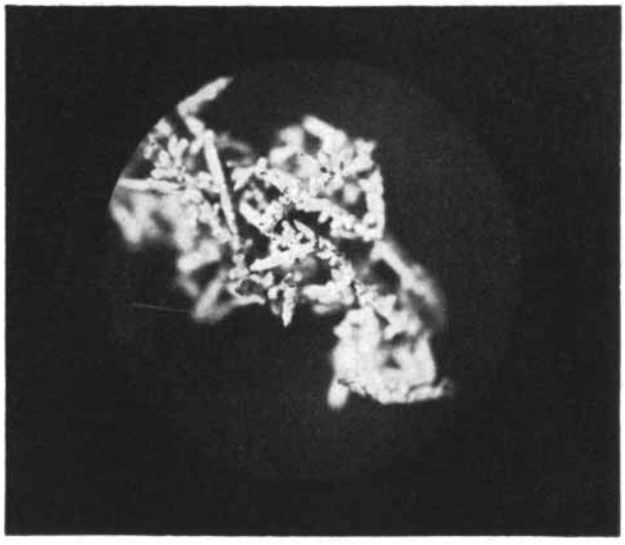
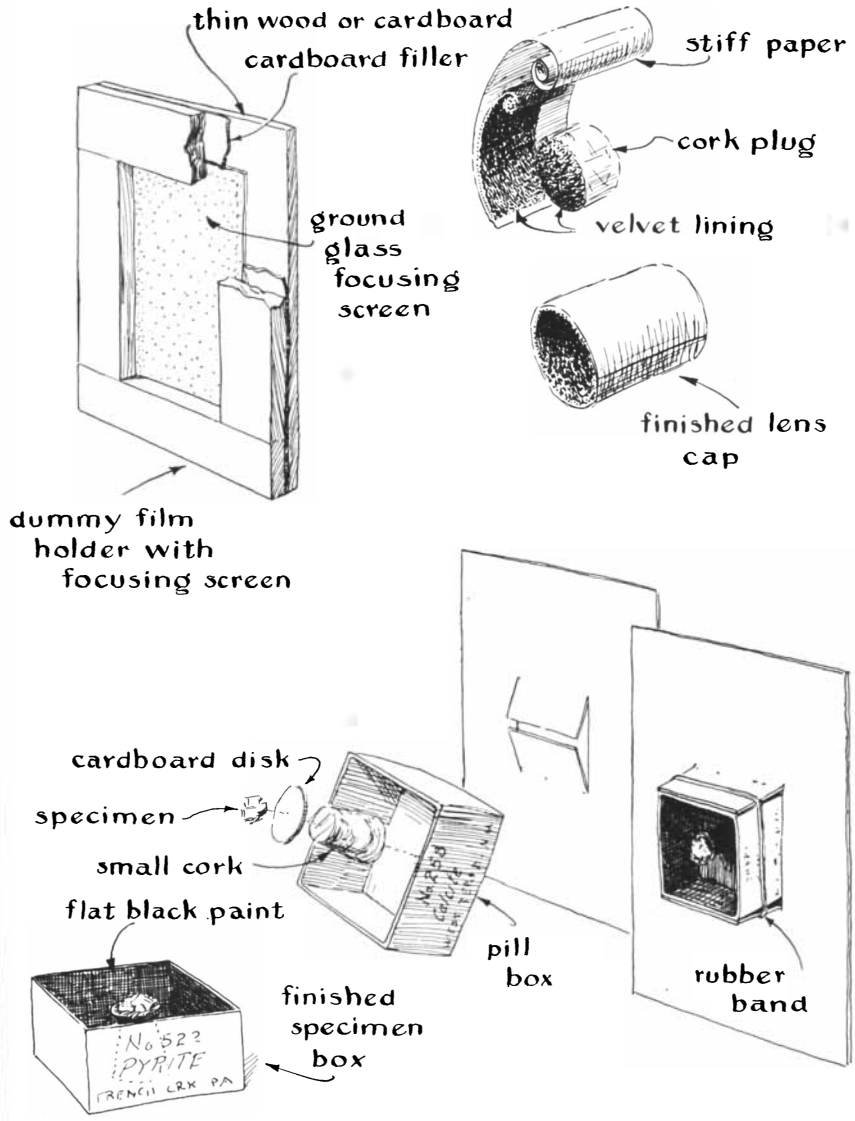


Gold (Manhattan, Nevada)



Copper (Broken Hill, New South Wales, Australia)



Mostly how to mount a micromineralogical specimen

the microscope without refocusing the instrument. This is called 'parfocal' mounting, and it saves a lot of time when, for example, you are searching your collection for a specific type of crystal, surface texture or color to match an unknown mineral.

"My boxes measure approximately one inch square by five eighths of an inch deep. You can procure such boxes from a drug supply house. When purchased by the gross they come in a cardboard container measuring about four by four by six inches. You will also need a supply of corks in the quarter-inch and three-eighths-inch sizes. Other supplies include a tube of quick-drying cement, a bottle of India ink and a sheet of hard-surfaced cardboard. If some of your minerals are speck-sized, you will also want a package of specimen pins (they replace the corks as supports) of the kind used by entomologists for mounting insect specimens.

"In preparing the micromount, first cement a matching disk of cardboard to the small end of a cork. This subassembly, together with the inner face of the box, is then blackened with India ink to reduce unwanted reflection. Next cement the under face of the specimen to the cardboard disk. When the cement has set, measure the height of the mounted specimen and cut it to parfocal length by trimming the bottom of the cork. Then give the freshly cut end a coat of cement and center it in place against the bottom of the box. A pin thrust up through the center of the bottom and into the center of the cork will

act as a positioning jig. Finally label the side of the micromount and its top with the serial number previously assigned to the specimen in your notebook.

"Photography affords a further means of compressing your collection. This is not to say that pictures are substitutes for specimens. Modern color prints, however, can prove highly useful on field trips where a bagful of micromounts would prove impractical. Photomicrographs in color are surprisingly simple and inexpensive to make.

"The objective lens of your microscope will serve as the lens of the camera for making these photographs. Details of the camera's construction are illustrated by the group of drawings on the next page. The size of the camera varies with the focal length of the objective and the enlargement that you desire. If you construct the camera around a plateholder four by five inches and use an objective of 20 millimeters focal length, for example, an eighth-inch specimen will fill a negative placed approximately 25 inches from the optical center of the objective. The correct length for the camera is found by multiplying the equivalent focal length of the objective (etched on the barrel) by the desired diameter of the photograph and dividing this product by the diameter of the area of the specimen which is to be included in the picture.

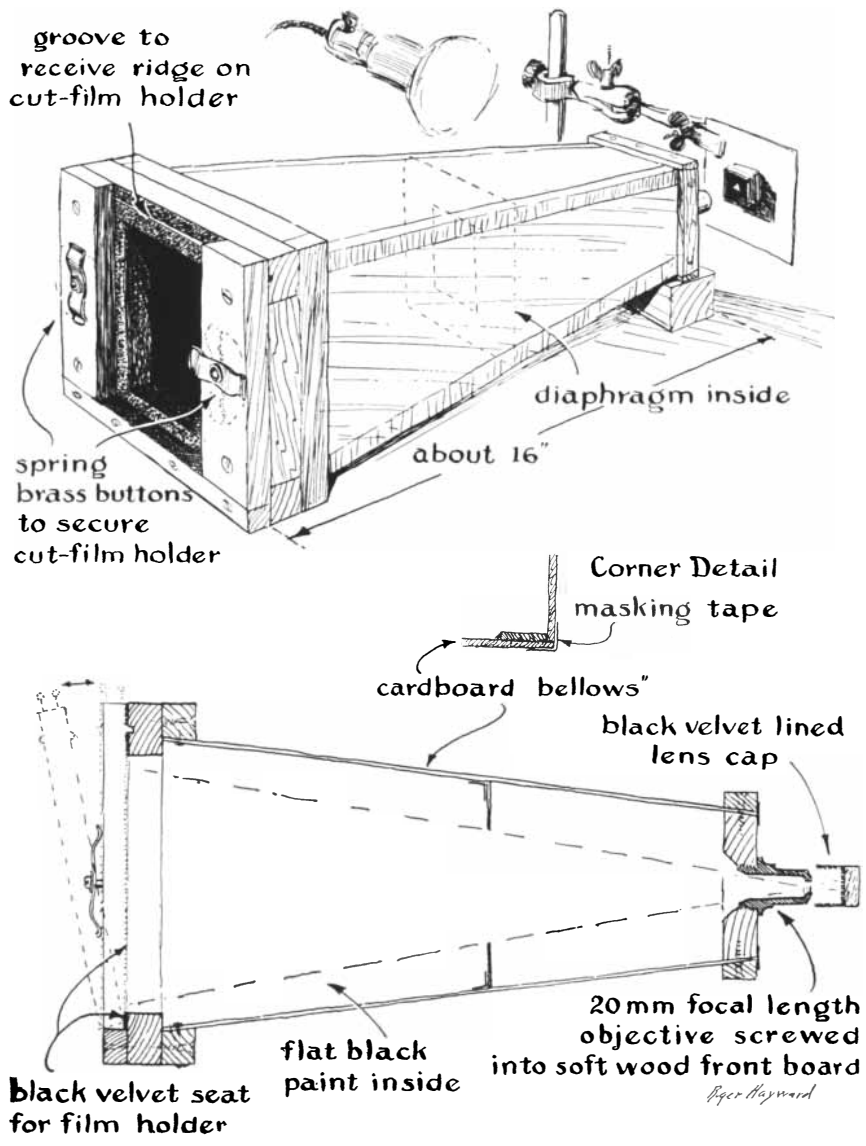
"A simple lens cap will serve for a shutter, because the exposure time will be relatively long—from a few seconds to a few minutes, depending upon the speed of the film and intensity of the light. The exposure must be determined experimentally. The photomicrographs on page 121 were made under a light intensity equivalent to that of a No. 5 photoflash operating at 18 inches. The exposure time for Super XX film was one second.

"In constructing the camera do not fail to include the rectangular diaphragm shown in the center of the lens extension. It protects the negative from light reflected by the walls, which may amount to as much as 4 per cent at grazing incidence, even though the interior is finished in flat black. Bellows-type cameras do not need diaphragms, because the corrugations deflect the incident rays. Make certain, also, that the frosted surface of the ground glass is in the same plane, relative to the plateholder, as that normally occupied by the emulsion. If this precaution is not observed, the pictures will be out of focus. Focusing, incidentally, is accomplished

by sliding the specimen toward or away from the objective.

"A bound set of color prints of your collection will multiply its usefulness. On the back of each photograph you should write the name of the mineral, the crystal class to which it belongs and notes on its environment, physical properties, composition, distinguishing characteristics and tests. The set will make an invaluable supplement to conventional field guides, such as Edward Dana's *Minerals and How to Study Them* and Frederick Pough's *A Field Guide to Rocks and Minerals.* It will also save time by enabling you to make a quick check of some detail without disturbing the collection.

"In the course of building up a collection of micromounts and identifying specimens, a beginner will discover many fascinating table-top tests. Some minerals, such as crystallized quartz and tourmaline, are piezoelectric: they develop electrical charges on opposite crystal faces when subjected to stress applied either mechanically or by unequal heating. If such crystals are dusted with a mixture of finely powdered red lead and sulfur forced through a silk screen by a blast of air, the particles will separate and settle on the charged faces, the sulfur clinging to the positive face and the red lead to the negative. During the momentary frictional contact between the silk and the powder, the silk has robbed the red lead of some of its electrons and has given up electrons to the sulfur. Thus the two kinds of powder take on charges of opposite polarity.



Details of a camera for micromineralogical photography

A homemade bellows closed by two thicknesses of silk stocking makes a convenient duster.

"Other interesting tests make use of the property known as fluorescence. Certain minerals, when viewed under ultraviolet light, glow with a characteristic color. Inexpensive lamp bulbs designed especially for emitting ultraviolet light are now available from dealers in electrical supplies. Reference texts written for amateur mineralogists describe many other tests, including those for hardness, chemical behavior, radioactivity and similar identifying characteristics, which will keep an amateur busy for a lifetime even if he limits his prospecting to pebbles found in his own block."

In his article on making a microscope, in this department for June, 1954, Kenneth Uitti asked for a simple home method of anodizing aluminum for black optical goods. A. F. Stalcup, an amateur microscope and telescope maker of Clinton, Iowa, recommends the following technique:

"The only critical requirement in this process is cleanliness. The parts to be anodized must be scrupulously clean, as well as the aluminum conductors leading to the anodizing cell and all vessels used for mixing and storing solutions. Whenever possible, polish the work with No. 400 sandpaper, crocus cloth or a high-speed buff charged with polishing compound. Remove all grease, cutting oils, tool coolants and the like.

"The following equipment should be set up in advance so that you can plunge the work into the bath as quickly as possible after polishing while the surfaces are fresh and uncontaminated. This helps to assure a uniform coating of oxide during the anodizing process.

"The anodizing cell must be made of a substance which will not react with the solution. It can be an old battery jar, large fishbowl, glazed stoneware crock or similar container. It must be large enough so that the work can be immersed completely.

"The cell is filled with a 4 to 6 per cent solution of sulfuric acid. This concentration is not critical. Remember to exercise due precaution. Add the acid to the water, *never the water to the acid!* Next, connect the work to the anode or positive side of a six-volt storage battery by means of an aluminum conductor. Aluminum clothesline will do, but polish it before you use it. The negative side of the battery is similarly connected by an aluminum conductor to a piece of the

purest aluminum available. A large sheet of aluminum kitchen foil will work, but be sure to double it several times to give it strength. Then clamp the foil to the conductor tightly to assure a good electrical connection. The cathode area should be equal to or larger than the area of the work. Remember that you must not permit any metal other than aluminum to make contact with the sulfuric acid solution.

"The work and cathode are now plunged into the solution and permitted to anodize for about 30 minutes. The time is not critical. Be sure the work and cathode do not make contact in the cell, for that would short-circuit the battery.

"In the meantime bring a solution of black Diamond or Rit dye to a boil. One 25-cent package of dye to three quarts of water is about right for pieces the size of a microscope barrel.

"At the end of the anodizing period remove the work from the anodizing solution, pass it under a stream of filtered tap water and immediately plunge it into the boiling solution of dye. Work as quickly as possible. Let the part remain in the boiling dye for about 30 minutes. Upon removal from the solution, the part will present a sickly gray appearance, but don't become alarmed. As soon as it is cool to the touch, wash off the surplus dye and rub the work down with a soft cloth. It will be blacker than a stack of black cats at midnight! Do not attempt to give a polish to any surfaces that may be critical with respect to reflection. With almost no effort on your part, they will take a beautiful polish."

From time to time readers submit amusing mathematical and scientific puzzles to this department. They always turn out to be variations, new or old, of ancient classics, for there is only a handful of basically different puzzles and they have long been known. But some of them may not be familiar to the present generation. We publish this month a classic submitted by Alvin von Auw, a professional journalist and amateur botanist.

Mr. von Auw gives you 12 ball bearings, and remarks that 11 are identical in weight, but the twelfth is slightly off weight. He also gives you a balance, each pan of which has a maximum capacity of five balls. You are permitted three and only three weighings. The object: Single out the odd ball and state whether it is heavier or lighter than the remaining 11.

(If the problem begins to cost you too much sleep, a stamped, self-addressed envelope sent to this department will get you the answer.)

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A STUDY OF THE ANTI-SCIENTIFIC ATTITUDE

FLUORIDATION OF WATER. HEARINGS BEFORE THE COMMITTEE ON INTERSTATE COMMERCE, HOUSE OF REPRESENTATIVES, EIGHTY-THIRD CONGRESS, SECOND SESSION, on H. R. 2341. United States Government Printing Office, 1954.

WATER FLUORIDATION: REPORT OF THE COMMITTEE OF THE ST. LOUIS MEDICAL SOCIETY. *Missouri Medicine*, Vol. 51, pages 124-142; February, 1954.

REPORT OF THE AD HOC COMMITTEE ON THE FLUORIDATION OF WATER SUPPLIES. National Research Council, 1951.

CORPUSCLES FROM THE SUN

GEOMAGNETISM. Sydney Chapman and Julius Bartels. Clarendon Press, 1940.

RELATIONSHIP BETWEEN MAGNETIC STORMS AND SOLAR ACTIVITY. C. W. Allen in *Monthly Notices of the Royal Astronomical Society*. Vol. 104, No. 1, pages 13-21; 1944.

SOLAR CORPUSCLES RESPONSIBLE FOR GEOMAGNETIC DISTURBANCES. Jean-Claude Pecker and W. O. Roberts in *Journal of Geophysical Research*, Vol. 60, No. 1; March, 1955.

THE BUBBLE CHAMBER

CHARACTERISTICS OF BUBBLE CHAMBERS. D. A. Glaser and D. C. Rahm in *The Physical Review*, Vol. 97, No. 2, pages 474-479; January 15, 1955.

PROGRESS REPORT ON THE DEVELOPMENT OF BUBBLE CHAMBERS. D. A. Glaser in *Nuovo Cimento*, Vol. 11, Series 9, Supplement No. 2, pages 361-368; 1954.

SOME EFFECTS OF IONIZING RADIATION ON THE FORMATION OF BUBBLES IN LIQUIDS. Donald A. Glaser in *The Physical Review*, Vol. 87, No. 4, page 665; August 15, 1952.

THE YERKES LABORATORIES

THE APE IN OUR HOUSE. Cathy Hayes. Harper & Brothers, 1951.

CHIMPANZEES: A LABORATORY COLONY. Robert M. Yerkes. Yale University Press, 1943.

PERSISTENT PROBLEMS IN THE EVOLUTION OF MIND. K. S. Lashley in *The Quarterly Review of Biology*, Vol. 24, No. 1, pages 28-42; March, 1949.

GAME THEORY AND DECISIONS

THEORY OF GAMES AND STATISTICAL DECISIONS. D. H. Blackwell and M. A. Girshick. John Wiley & Sons, Inc., 1954.

FOUNDATIONS OF STATISTICS. L. J. Savage. John Wiley & Sons, Inc., 1954.

THEORY OF GAMES AND ECONOMIC BEHAVIOR. John von Neumann and Oskar Morgenstern. Princeton University Press, 1947.

BONE

BONE: AN INTRODUCTION TO THE PHYSIOLOGY OF SKELETAL TISSUE. Franklin C. McLean and Marshall R. Urist. The University of Chicago Press, 1955.

A TEXTBOOK OF HISTOLOGY. Alexander A. Maximow and William Bloom. W. B. Saunders Company, 1952.

EARS FOR COMPUTERS

THE CARRIER NATURE OF SPEECH. Homer Dudley in *The Bell System Technical Journal*, Vol. 19, No. 4, pages 495-515; October, 1940.

THE INFORMATION-BEARING ELEMENTS OF SPEECH. Gordon E. Peterson in *The Journal of the Acoustical Society of America*, Vol. 24, No. 6, pages 629-637; November, 1952.

REMAKING SPEECH. Homer Dudley in *The Journal of the Acoustical Society of America*, Vol. 11, No. 2, pages 169-177; October, 1939.

PLANT MOVEMENTS

THE CARNIVOROUS PLANTS. Francis Ernest Lloyd. Chronica Botanica Co., 1942.

LEAF MOVEMENTS IN MIMOSA PUDICA L. Marvin Weintraub in *New Phytologist*, Vol. 50, No. 3, pages 357-382; January, 1952.

THE POWER OF MOVEMENT IN PLANTS. Charles Darwin. D. Appleton and Company, 1898.

THE AMATEUR SCIENTIST

MINERALS AND HOW TO STUDY THEM. Edward Salisbury Dana. John Wiley & Sons, Inc., 1949.

A FIELD GUIDE TO ROCKS AND MINERALS. Frederick H. Pough. Houghton Mifflin Company, 1953.

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