SCIENTIFIC AMERICAN

INSECT IN AMBER

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November 1951

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What's cooking...

WHAT'S COOKING in the seething, white-hot inferno of this electric arc furnace?

The fingers? No, they *simulate what's doing* the cooking.

These fingers represent giant rods of carbon—or graphite, carbon's refined cousin—that carry the heat-creating electricity into the furnace. Only carbon or graphite in the form of huge electrodes can do this, and stand up under the terrific temperature of 6,000 degrees or more!

Here, in this roaring cauldron, these fiery fingers are making the alloying ingredients for stainless steel. They are also used to make other tough and hard varieties of fine steel.

But steel making is only one important way in which carbon and graphite serve industry. Carbon arcs fire the furnaces that make calcium carbide—a source of acetylene for many modern plastics and chemicals. Motion picture screens are illuminated by the brilliant light of the carbon arc. And without carbon we wouldn't have dependable, long-life dry batteries for flashlights, radios and hearing aids.

Furnishing carbon and graphite products for an almost endless number of industrial uses is but one of the many jobs of the people of Union Carbide.

FREE: *Learn more about the interesting things you use every day. Write for the 1951 edition of the booklet "Products and Processes" which tells how science and industry use the ALLOYS, CARBONS, CHEMICALS, GASES, and PLASTICS made by Union Carbide. Ask for booklet N.*

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BUSINESS IN MOTION

To our Colleagues in American Business . . .

The fact that a Revere Distributor is now celebrating its 125th anniversary year is an indication of the service the company has given its customers through those years. It is also another proof of the essential function performed by distributors for American industry. Most goods, whether industrial materials such as copper and copper alloys, aluminum alloys, iron and steel, or consumer articles such as refrigerators, radio and television receivers, kitchen utensils and ranges, go through the hands of distributors. Generally speaking, only the large buyers are in a position to purchase direct from manufacturers, who do not find it economical to handle the smaller orders. Yet those orders when pooled in the hands of an organization set up to handle them attain sizable totals, and hence a good distributor account is exceedingly attractive to a large manufacturer such as Revere.

A distributor serves not only the factories from which he buys. He also performs an invaluable service to his customers by making quickly available to them the products they require. A machine shop, for example, may need only a few hundred pounds of brass rod; there is a distributor within easy reach who can furnish it almost immediately. Or a contractor may want a few pieces of steel pipe and a thousand feet or so of copper water tube. Again, the distributor has them. A metal products distributor has to carry such items and an infinite number of others. The Revere Distributor who started in business 125 years ago actually has in stock 53,000 different items, cataloged, indexed, and held in warehouses ready for immediate shipment throughout its territory. Each month this stock is drawn upon by 5,000 to 8,000 customers, each order relatively small. There are many Revere Distributors with similar stocks and offering equal service.

To keep this distributor's warehouses filled with a balanced inventory, 18 people are required in his purchasing staff, which includes specialists in various kinds of materials, machines, tools and supplies. And to serve customers with information, quotations and the like, 25 salesmen are on the go constantly, calling on manufacturers, contractors, builders and stores throughout the busy industrial area in which the distributor operates. The large business done by the company is in great contrast to that of 125 years ago, when it was little more than a hardware store. The enterprise has grown in the American tradition of freedom to prosper in accordance with the principles of reliability and efficiency, fair dealing and integrity in performing a desired function.

Revere Distributors are selected for their ability to serve, and also chosen as to location, so that no matter where you are in this big country of ours, there is a Revere Distributor within easy reach. Today metal stocks may be short due to defense demands but manufacturers are doing everything possible to keep distributors supplied.

If you buy from distributors we suggest you remember that they are not only "central stockrooms," but have a great deal of special knowledge about the products they sell and can give you much helpful advice. Not only that, through the Revere Distributors you can be put in touch with the Revere Technical Advisory Service, which will cooperate with you on matters concerning the selection and fabrication of the Revere Metals. Our distributors, and those of every other manufacturer, render many essential services, both to those to whom they sell, and to those from whom they buy. The distributor system as it operates in the United States arose in response to the need for it. Today it fulfills that need more effectively than ever before.

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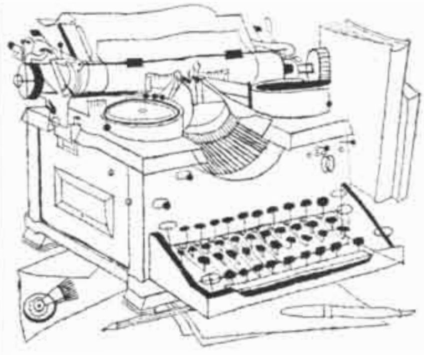

LETTERS

Sirs:

In your September issue, entitled "Human Resources of the U. S.," Karl T. Compton lists six steps to be taken to alleviate the shortage of engineers. One of these concerns the supposed impression existing among college eligibles that the engineering profession is overcrowded.

Turning for a moment to Dael Wolfle's article, we find, according to distributions plotted on page 45, that approximately half the college graduates are distributed in the top 10 per cent of the population as represented by people in the Army. It therefore seems reasonable to suppose that persons of college caliber must be aware of the well-publicized engineering shortage. At least they are aware of the publicity.

But would they not also be aware of the relatively poor financial rewards awaiting the young engineer? It is true in at least one case known to me that the real starting pay of a technician (inexperienced) is greater than that of an engineer. Wouldn't one solution to the shortage be to raise engineering salaries so that (a) top-flight men can afford not to move into administrative positions and (b) young engineers do not drift from school directly into other lines of endeavor in order to support their families?

STUART JUROW

Flushing, N. Y.

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Sirs:

The article by Karl T. Compton entitled "Engineers" is very interesting and timely. The author, however, does not mention the relatively low salaries industry pays its engineers, especially the older experienced men, as a cause of the shortage. That, in my opinion, is one of the chief causes. There is a shortage of industrial employers willing to pay the price for good engineers.

I believe that a study will show that the effective purchasing power (salary, cost-of-living index, income tax) of an engineer today, say, with 25 years' experience compared with a like engineer in 1939 is down to about three-fourths of the 1939 level. On the other hand, the effective purchasing power of lawyers and doctors with 25 years' experience is up about one-third over the 1939 level.

Premium pay for overtime, which few engineers get, is one way to raise the level of engineers relative to factory workers, draftsmen, and others who draw premium pay for overtime.

A way to relieve the shortage of engineers immediately is to permit engineers in good health to continue to work after age 65, the compulsory retirement age in most industries. It seems that industry would rather go shopping for younger inexperienced men than to pay the salaries required by older experienced men. In several instances of which I am personally aware, men aged 65 retired by industry immediately took positions with consulting engineering firms, a college and a public utility.

There is not much incentive today for a young man to spend four years in an engineering school when he has nothing to look forward to but a rapidly leveling-off salary *v.* age curve, overtime with no premium pay, non-engineering work and routine detail to drag along, and a forced retirement at age 65 when he might be able and would like to continue working at the job he likes best.

D. C. HOFFMANN

Lansdowne, Pa.

Sirs:

The ratio of the earnings 50 years ago of college professors to the earnings of

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SINCLAIR RESEARCH LABORATORIES—nine buildings containing the most modern testing equipment known—have contributed many of today's most important developments in petroleum products, production and refining. Under the Sinclair Plan, the available capacity of these great laboratories is being turned over to work on the promising ideas of independent inventors everywhere.

An Offer of Research Facilities to Inventive Americans Who Need Them

The Sinclair Plan is opening up the Company's great laboratories to every American who has an idea for a better petroleum product

INVENTIVE Americans are often at a loss today. Not because of any lack of ideas, but because of a need for expensive facilities to find out if and how their ideas work.

This was no obstacle in our earlier days. The Wright Brothers designed their first airplane with the help of a foot-square homemade "wind box"—and the plane flew.

In contrast, the man with a new idea in airplane design today often needs a supersonic wind tunnel costing millions.

In short, science and invention have become so complex that a man with an idea for a better product often needs the assistance of an army of specialists and millions worth of equipment to prove his idea has value.

Within the petroleum field, the Sinclair Plan now offers to provide that assistance.

Under this Plan, Sinclair is opening up its great research laboratories at Harvey, Illinois, to independent inventors who have sufficiently good ideas for better petroleum products or for new applications of petroleum products.

If you have an idea of this kind, you are invited to submit it to the Sinclair Research Laboratories, with the provision that each idea must first be protected, in your own interest, by a patent application, or a patent.

The inventor's idea remains his own property

If the directors of the laboratories select your idea for development, they will make, in most cases, a very simple arrangement with you: In return for the laboratories' investment of time, facilities, money and personnel, Sinclair will receive the privilege of using the idea for its own companies, free from royalties. This in no way hinders the inventor from selling his idea to any of the hundreds of other oil companies for whatever he can get. Under the Plan, Sinclair has *no control* over the inventor's sale of his idea to others, and has *no participation* in any of the inventor's profits through such dealings. Moreover, it is a competitive characteristic of the oil business that the new products adopted by one company are almost invariably adopted by the whole industry. This means that the very fact of his agreement with Sinclair should open up to the inventor commercial opportunities which might otherwise be hard to find.

How to proceed: Instructions on how to submit ideas under the Sinclair Plan are contained in an Inventor's Booklet available on request. Write to: W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 630 Fifth Avenue, New York 20, N. Y. for your copy.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*

SINCLAIR—A Great Name in Oil

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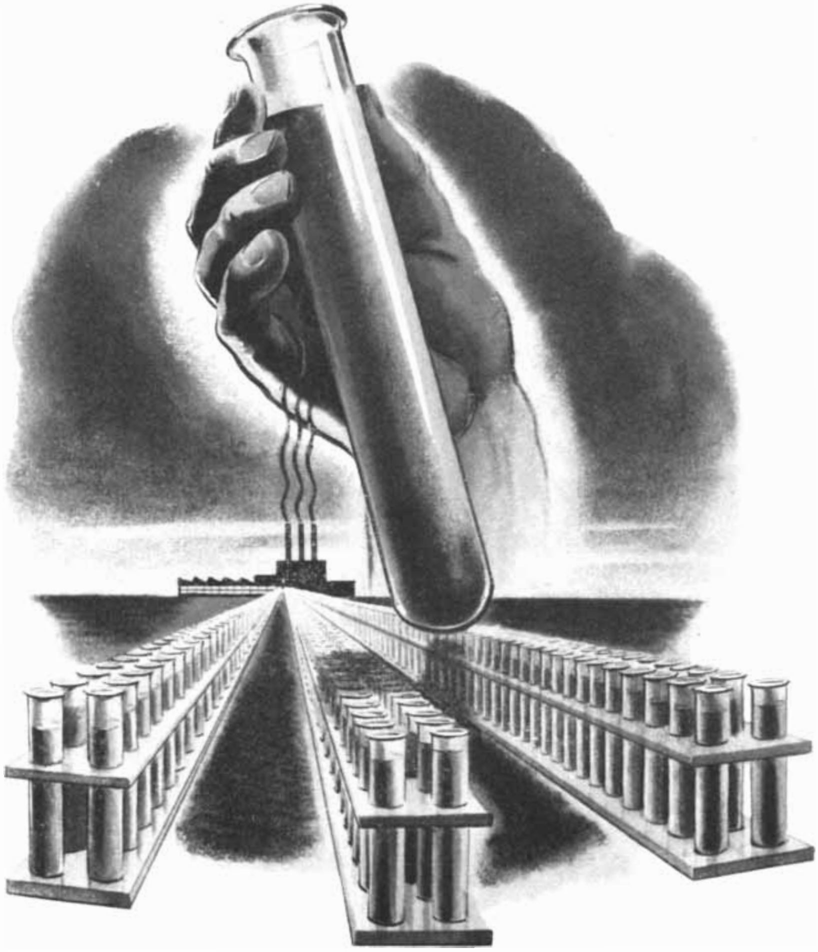

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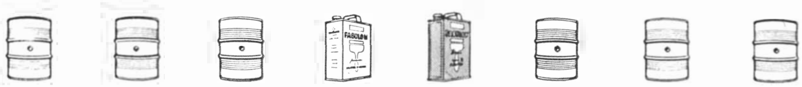

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laborers compared with the ratio today may help in explaining why so many bright young people don't care for professional training. The few facts at hand indicate that 50 years ago a college professor received five to eight times the money received by unskilled laborers.

Young people may reason that if machinists, carpenters, plumbers and so on are paid as they are paid today, why spend four to ten years to learn a profession that pays no more. . . .

H. D. GOODALE

Williamstown, Mass.

Sirs:

May I enter a friendly protest with respect to the general tone of the September *Scientific American* which deals with "Human Resources of the U. S.," because, as it seems to me, the emphasis is too much on the immediate and too little on the forward-looking.

If one were writing on the coal resources of the U. S., it would not suffice to list the number of operating coal mines; yet this is essentially what has been done with respect to human resources in the issue under consideration.

In my book *The Human Frontier* I tried to set forth what I believe to be patently true, namely that when we become wise enough to make a concerted study of human beings, employing all possible means and refusing to be hedged in by disciplines, we will find that our human resources are vastly greater than we thought and incidentally very different.

We can never appreciate what our human resources are until we know people better than we do. For example, we will find, I firmly believe, that the "lump-of-dough" concept of intelligence (some have big lumps, some middle-sized and some little lumps) is grossly oversimplified and misleading, because there are many facets to intelligence (as Dr. Wolfle indicates but does not emphasize), and in order to have an intelligent idea as to how effective people will be at different jobs, we must know something about these different facets. Phi Beta Kappas or Ph.D.'s cannot be *counted on* to make good business managers, good statesmen, good scientists, good engineers, good physicians or even good teachers. Yet in all these fields people are working "with their brains."

Your human resources issue is a valuable number and should direct attention to a problem of incomparably great importance. I wish that it could have stressed more pointedly the tremendous possibilities that lie in the future.

ROGER J. WILLIAMS

University of Texas
Austin, Tex.

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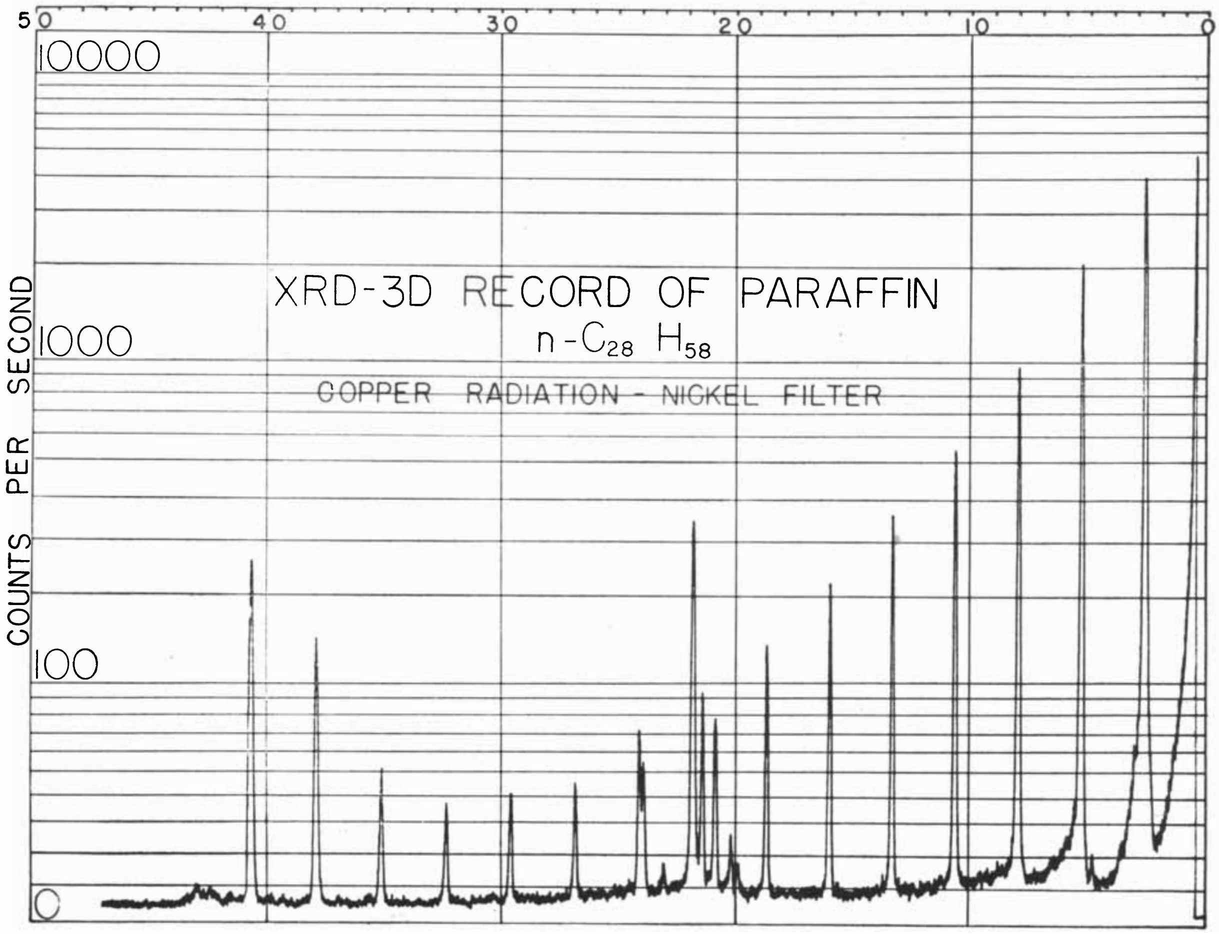
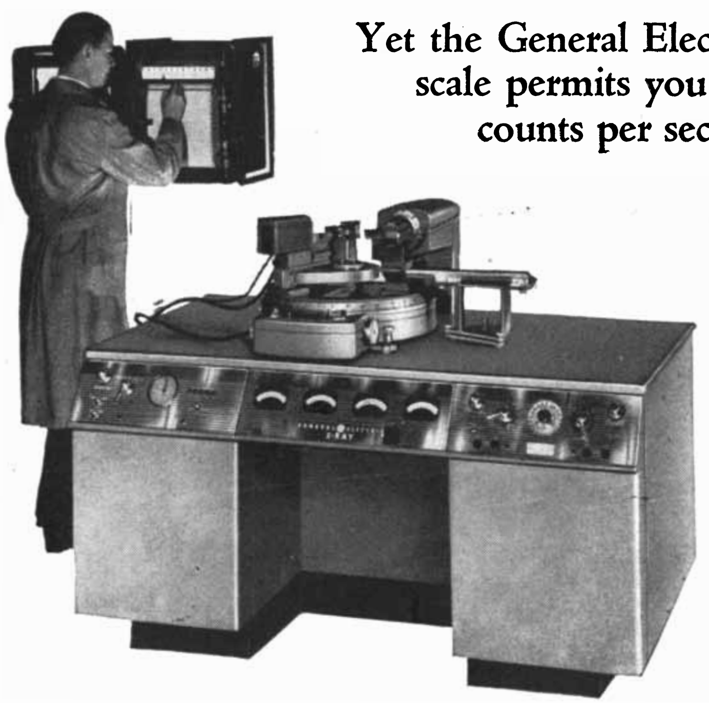
It would take a chart 13 feet high to give you this range of reading on a linear scale...





Yet the General Electric XRD-3 logarithmic scale permits you to read from 2 to 10,000 counts per second on a single 10-inch scale

GE X-RAY

Having a dynamic response range of zero to ten thousand counts per second—the XRD-3 accurately records a wide range of intensities. Ratios of several thousand to one are easily visible on a single chart, contrasted to one hundred to one on a linear scale. No need to search for strongest line before beginning run. No off scale peaks to cause repeat runs. No confusion of multiple linear scale ranges.

The XRD-3 is designed to satisfy your diffraction needs for both film and direct recording technics. Write for booklet "Analytical Applications of X-Ray Diffraction Using Direct Measurement Technics." X-Ray Department, General Electric Company, Milwaukee 14, Wisconsin, Rm. TT-11.

GENERAL ELECTRIC

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basic ingredient of water-tight concrete

CONCRETE THAT CONTAINS a controlled amount of air is about 300% more resistant to the passage of water. It is also easier to work, has better surface texture, is more durable when exposed to frost action.

The Dewey and Almy product which controls the amount of air in concrete is Darex AEA, one of a group of related products developed in our laboratories for the concrete industry. Today, Darex AEA is being used on all types of concrete construction . . . is considered by many concrete technologists as one of the most revolutionary advances in the history of portland cement concrete.

Whenever you have a voice in specifications for buildings, highways, dams or other concrete construction, suggest concrete that contains Darex AEA: another example of the many Dewey and Almy *Chemical, Rubber, Plastic Products Keyed To Basic Human Needs.*

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50 AND 100 YEARS AGO

NOVEMBER 1901. "For years hydrogen remained the one so-called permanent gas, but no sooner had its volatility been subdued than it was found that helium, a gas but newly discovered, had a still lower critical point, as it refused to liquefy even at the temperature of −262 deg. C. By its aid, however, it is hoped that before many years a temperature within about 5 deg. of the absolute zero will at last be reached. Expensive as the liquefaction of hydrogen has been, that of helium will necessarily be much greater."

"Until the owner of an automobile has run his machine over a wide variety of roads, and under many conditions of traffic, he should be content with a speed of 12 to 18 miles an hour, and then as he becomes a more perfect judge of speed and distance it will be time enough for him to open the throttle. As matters are now going we are likely to have the same experience with the automobile as with the bicycle. Unless the restrictions as to speed are imposed, accidents will become more frequent as the number of owners increases. Restrictions by law are frequently irksome, and are apt at times to be unreasonable; hence it is to the interest of automobilists as a body to voluntarily keep down speed both in town and country to a safe limit."

"It has become the fashion to sneer at submarine vessels in some quarters, but English technical journals do not indulge in the practice, for they see in the growing fleet of French submarine vessels a distinct menace to English commerce. There are 29 submarine boats now, of the electric type, in France, and five of other kinds, and they are constantly increasing in numbers. *Engineering* says that if 100 of these vessels were let loose at night in the Channel, they would be capable of establishing themselves in favorable positions before daylight and do incalculable damage to British commerce; it thinks that the submarine boat has increased the dangers from torpedoes tenfold."

"During the last century the population of France has grown from 25,000,000 to 40,000,000, Germany from 20,000,000 to 55,000,000, Russia (partly from annexation) from 40,000,000 to 135,000,000, the English population of the British Empire from 15,000,000 to 55,000,000, and the United States from rather over 5,000,000 to nearly 80,000,000. All together the growth is, in round numbers, from 170,000,000 to 510,000,000; the space which at the beginning of the century was occupied by one person must now accommodate three."

"Charles E. Munroe has been designated by the Royal Academy of Sciences at Stockholm to nominate the American inventors and discoverers in the science of chemistry who may desire to compete in the annual distribution of prizes which is made under the will of the late Alfred Nobel."

"An Italian engineer, M. Triulzi, has devised a special instrument, the cleptoscope, whereby it is possible for the crew of a submarine boat to ascertain what is progressing on the surface while submerged. The instrument comprises a tube fitted with crystal prisms in a special manner."

NOVEMBER 1851. "We have rather been consoling ourselves with the idea that our recent railroad enterprise was greater than that of all other nations together. This seems to be a mistake, for the Continent of Europe, mixed up with despotic governments, appears to be as truly alive to the importance of railroad communication as the most go-ahead of all our states. Belgium has 532 miles of railways, 353 of which have been constructed and worked by the State, the remainder by different private companies. In France there are 1,818 miles of railway under traffic, 1,178 miles in progress and 577 miles projected. In Germany there are 5,342 miles of railway in actual operation, 700 in progress and 2,414 miles projected. In Russia a railway from Warsaw to Cracow, 168 miles in length, is in operation; one connecting Warsaw with St. Petersburg, 683 miles in length; and one of about 400 miles, from St. Petersburg to Moscow, is in progress. In the kingdoms of Sardinia, Spain and Portugal, railways are only in prospect."

"There has not, within the knowledge of the settlers on the Upper Missouri, been such a general prevalence of ague and fever as during this fall. From old Fort Kearney down through Missouri to St. Joseph (and the country is populous), scarcely a house or family was not afflicted with the disease, or typhoid

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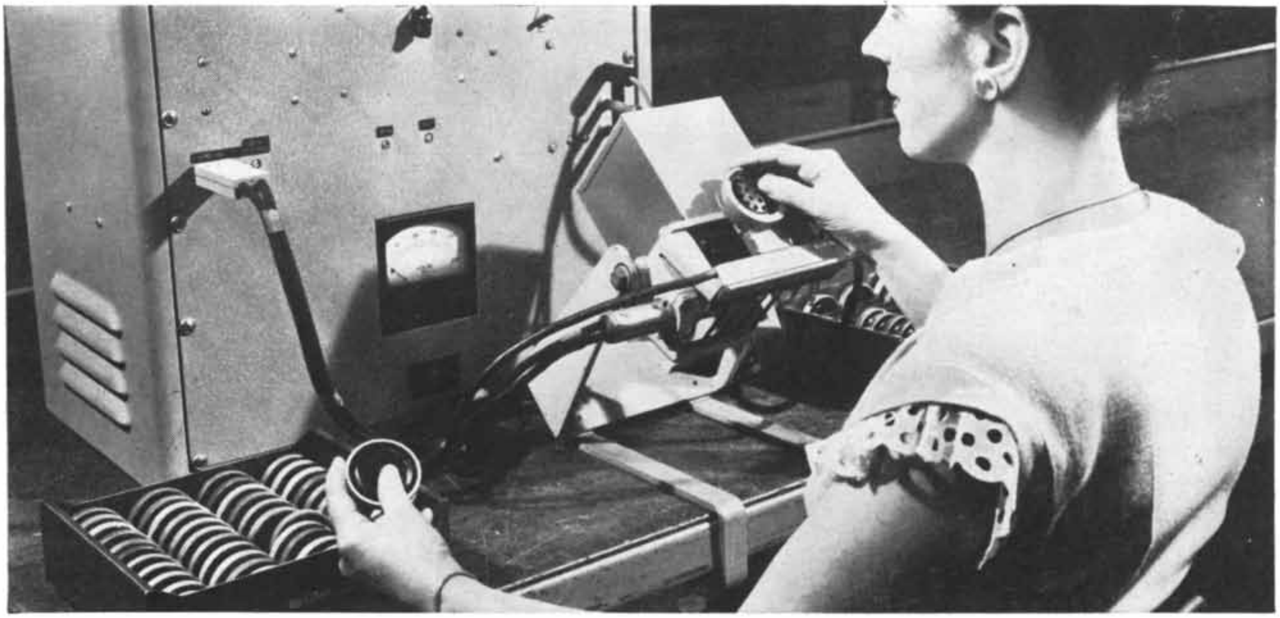

This Western Electric employee mounts a transmitter in the test fixture which is swung down to face an artificial mouth at 45-degree angle, just as transmitters are held in use. More than a million transmitters are tested each year.

This mouth speaks to millions

At Bell Laboratories a scientist employs a condenser microphone to check the sound level from another type of artificial mouth, used in transmitter research.

To serve the changing needs of telephone subscribers millions of telephone sets have to be moved each year. Before being put back into service most of them are returned to the Western Electric Company's Distributing Houses where they receive a thorough checkup.

Western Electric engineers needed a rapid method of testing transmitters over a range of frequencies. At Bell Telephone Laboratories, scientists had just the thing—a technique they had devised for fundamental research on transmitters. In co-operation with these scientists, Western Electric engineers developed the practical tester in the illustration.

The transmitter is removed from the handset and put in front of an artificial mouth which emits a tone that swings several times per second over a band of frequencies. A signal lamp tells whether the transmitter is good. Each test takes 5 seconds.

This new tester illustrates how Bell Laboratories research and Western Electric manufacturing skill team up to maintain your telephone service high in quality yet low in cost.

BELL TELEPHONE LABORATORIES

• EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

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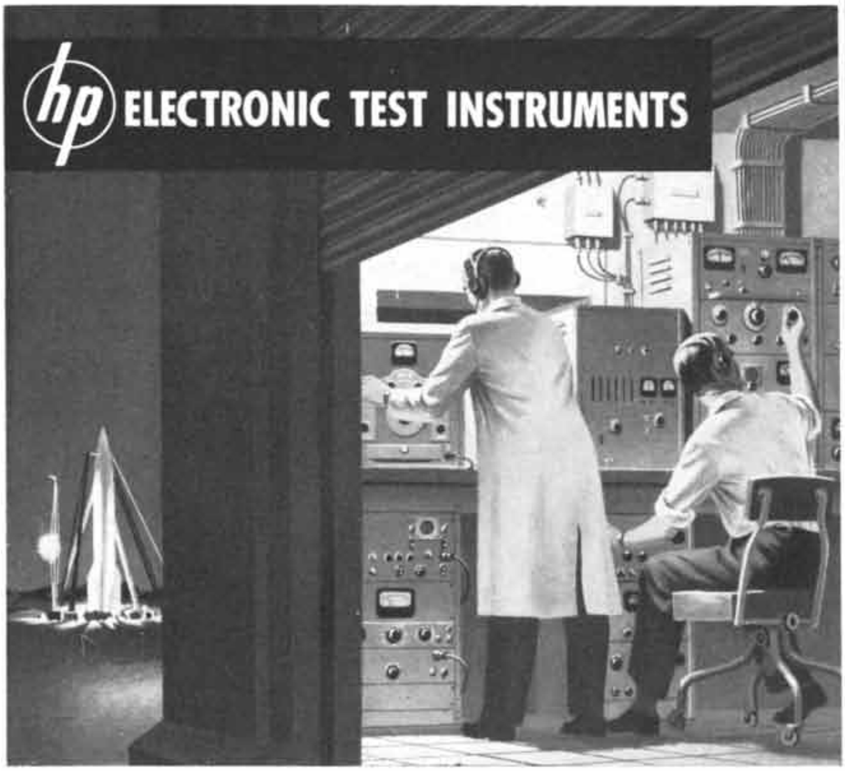

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fever in some shape or form. Whole families, who have for years enjoyed uninterrupted health, were prostrated with the disease. The prevalence of this disease is attributed to the long-continued high water in the Missouri and its tributaries."

"Mr. McCormick, the inventor, is reported to have contracted in England for the manufacture of 500 reapers to be in readiness before next harvest, at which time he intends visiting England to dispose of them. He has also a very extensive establishment engaged in manufacturing them in Chicago, Ill. During the fall of 1850, he manufactured 1,600, principally for the Western trade."

"There is a mountain of very pure iron ore near to Lake Superior. It exists there in such abundance, and is of such an extraordinary quality, that, in a late report of United States geologists, this prophecy was made in regard to it. Says the report: 'This region possesses an inexhaustible supply of iron ore of the best quality, removed from 12 to 30 miles from the lake shore, and it is to this source that the Great West will ultimately look for the finer varieties of bar iron and steel.' "

"If the boats of the Erie Canal, 5,015 in number, were placed in line, they would reach from Albany to Utica, a distance of 83 miles. The distance achieved by this enormous fleet, in the year, is equal to 3,600 voyages across the Atlantic—transporting more than 3,000,000 tons, which is 26 times the quantity carried by the railroads which run along the banks of the canal. The value, in money, of the property transported by the canal in 1850, was $156,000,000."

"A very interesting experiment has been lately performed at the Hotel Dieu of Lyons. A female was brought into the hospital who had been seized with violent hemorrhage. Her condition seemed desperate. Death appeared imminent, inevitable. Doctor Delorme suggested transfusion. This was at first combatted by the other physicians as offering no chance of success, but was finally assented to, as, the case being a desperate one, it could do no harm, even if it did no good. The proper vein in the arm of the sufferer was then opened, and a fine canula, or tube, was introduced to some length. The other end of the tube was then fitted to the syringe in which was the necessary quantity of pure human blood. The operator then gently forced into the veins of the dying woman the revivifying fluid. Soon after, she recovered, in a great degree, her senses and eyesight. The patient has since been regularly improving, and the cure may be set down as complete."

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... from Du Pont Polychemicals Department

CRYSTAL UREA

helps turn wood waste into building board

In making this new building material, wood waste is bonded with a urea-formaldehyde adhesive and molded into panels under heat and pressure. You can nail these panels, put screws in them, cut them with saws. They have a high insulating value, great structural strength and are resistant to both moisture and fire. Adhesives made with Urea are low in cost. They resist mold, fungus and water and are nonvolatile. They set rapidly at low temperatures and pressures.

Crystal Urea's properties make it a valuable chemical for other industries, too—for example, in pharmaceuticals, finishes, and explosives. And they suggest many new applications. A few possibilities are: as a stabilizer for cellulosic and vinyl plastics, as an intermediate for cosmetics preparation and in fire-resistant electrical insulation.

Your business may find opportunities for profitable future use in Du Pont Crystal Urea . . . or in many of the other Polychemicals products. There are more than 100 of them—organic acids, amides, alcohols, ammonia, esters, resins, solvents and plastics.

Although demand for many of these products now exceeds supply, we will gladly discuss the availability of experimental quantities for developmental work.

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Technical bulletins on Crystal Urea and the chemicals and plastics used in your industry are available. Each product bulletin in the booklet presents physical and chemical properties, description, specifications, uses and possible applications, bibliography and other data. Write us on your business letterhead for your copy—and please tell us the name of your industry.

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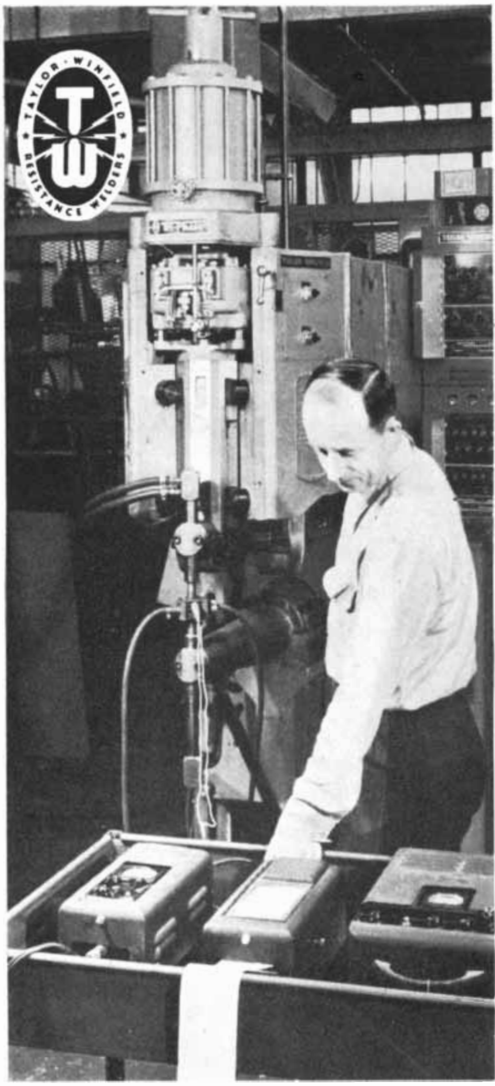

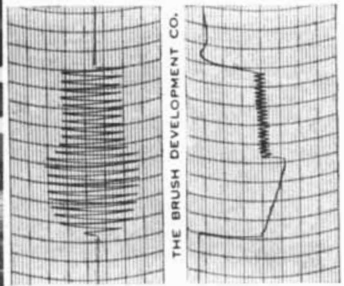

Chart of welding cycle on Taylor Winfield welder shows 60-cycle A-c input current at left, D-c welding current at right. This Brush Analyzer consists of A-c amplifier, D-c amplifier, direct-writing oscillograph.

welding specifications a problem?

BRUSH ANALYZER RECORDS WELDING CURRENT AND TIME EXACTLY

● The Taylor Winfield Corporation, manufacturer of resistance, spot, seam, and butt welders, makes sure of correct current and timing calibration on each spot welder before shipment.

While a sample weld is being made, a Brush Analyzer records amplitude and timing of both input current and welding current on the same chart. By observing the wave shapes, Taylor Winfield inspectors calibrate controls quickly and surely. Production time is saved, and correct results assured.

Maintaining welding specifications is difficult with "rule-of-thumb" adjustment, particularly on metals such as aluminum. Brush Analyzers can give you written proof of welding currents, or of electrode pressures.

Investigate Brush instruments for studies of d-c or a-c voltages or currents, strains, displacements, light intensities, temperatures, and other static or dynamic conditions. Write for information. The Brush Development Company, Dept. B-5, 3405 Perkins Avenue, Cleveland 14, Ohio, U. S. A. *Canadian Representatives:* A. C. Wickman (Canada) Limited, P. O. Box 9, Station N, Toronto 14, Ontario.

THE Brush DEVELOPMENT COMPANY

PIEZOELECTRIC CRYSTALS AND CERAMICS • MAGNETIC RECORDING
ELECTROACOUSTICS • ULTRASONICS • INDUSTRIAL & RESEARCH INSTRUMENTS

THE COVER

The photograph on the cover shows a fly that was trapped in the gum oozing from an extinct pine tree some 60 million years ago (*see page 56*). Later the gum hardened into amber which has almost perfectly preserved the external skeleton of the insect, even to the tiny hairs on its legs. The amber was found near the Baltic coast of East Prussia. In order to make the fly clearly visible the amber was cut into a small slab with two parallel surfaces. When the surfaces were polished, one of them was cemented with Canada balsam to a microscope slide. The square translucent frame about the fly is a microscope slide cover glass that was cemented to the other surface. The fly is an extinct species belonging to the genus *Pseudosphegina* and the family *Syrphidae,* of which there are many living representatives. The specimen is in the collection of the Museum of Comparative Zoology at Harvard.

THE ILLUSTRATIONS

Cover by Richard Wolters

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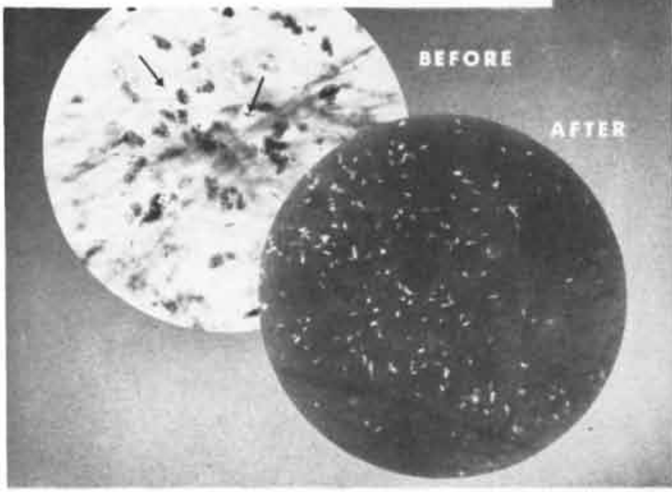
PROBLEM: Air headache

ANSWER: Headaches haunted military pilots prior to World War II. Just being up in the air was blamed for the trouble. Then someone suspected the goggles and put them on non-flying personnel as a test. Their heads ached, too. The problem was put up to scientists at American Optical Company. They worked out a corrected lens formula solving the problem for the Air Corps.

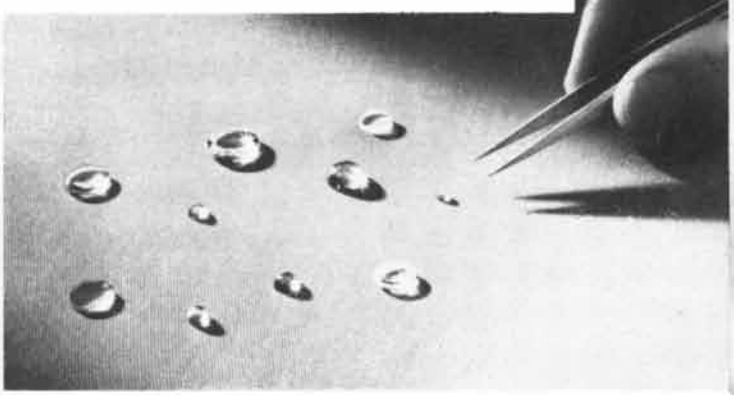
PROBLEM: A surer test for tuberculosis



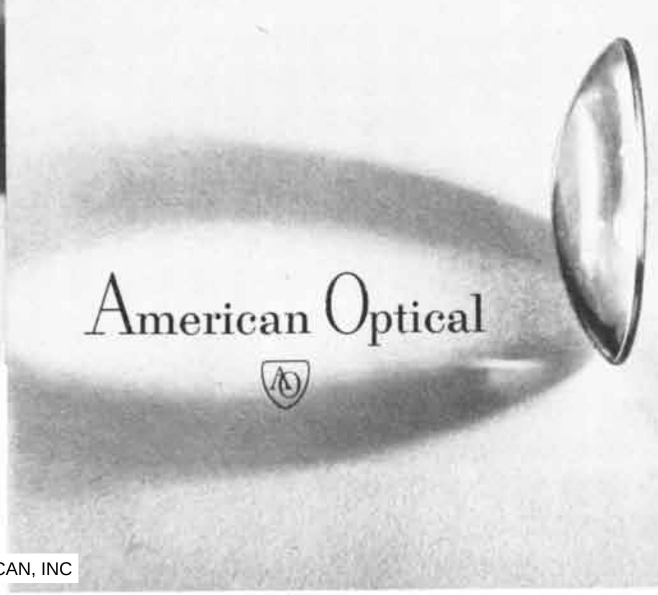
MAGNIFIED 350 TIMES.

ANSWER: Formerly, TB bacteria were hard to see even under a powerful microscope. Now, by an improved technique, TB bacteria are made to fluoresce under ultraviolet light — glow yellow against a dark background. Their presence is more easily detected. American Optical scientists helped develop this speedy, accurate method of searching.

PROBLEM: Accuracy to a millionth of an inch



ANSWER: Optical lenses *must* be accurate. The only way we could achieve such accuracy was to make our own precision checking instruments . . . interference test plates, accurate to one millionth of an inch. Test plates check optical surfaces in contour projectors, spectrometers, microscopes. Write us about your development problems. American Optical Company, 14 Vision Park, Southbridge, Mass.



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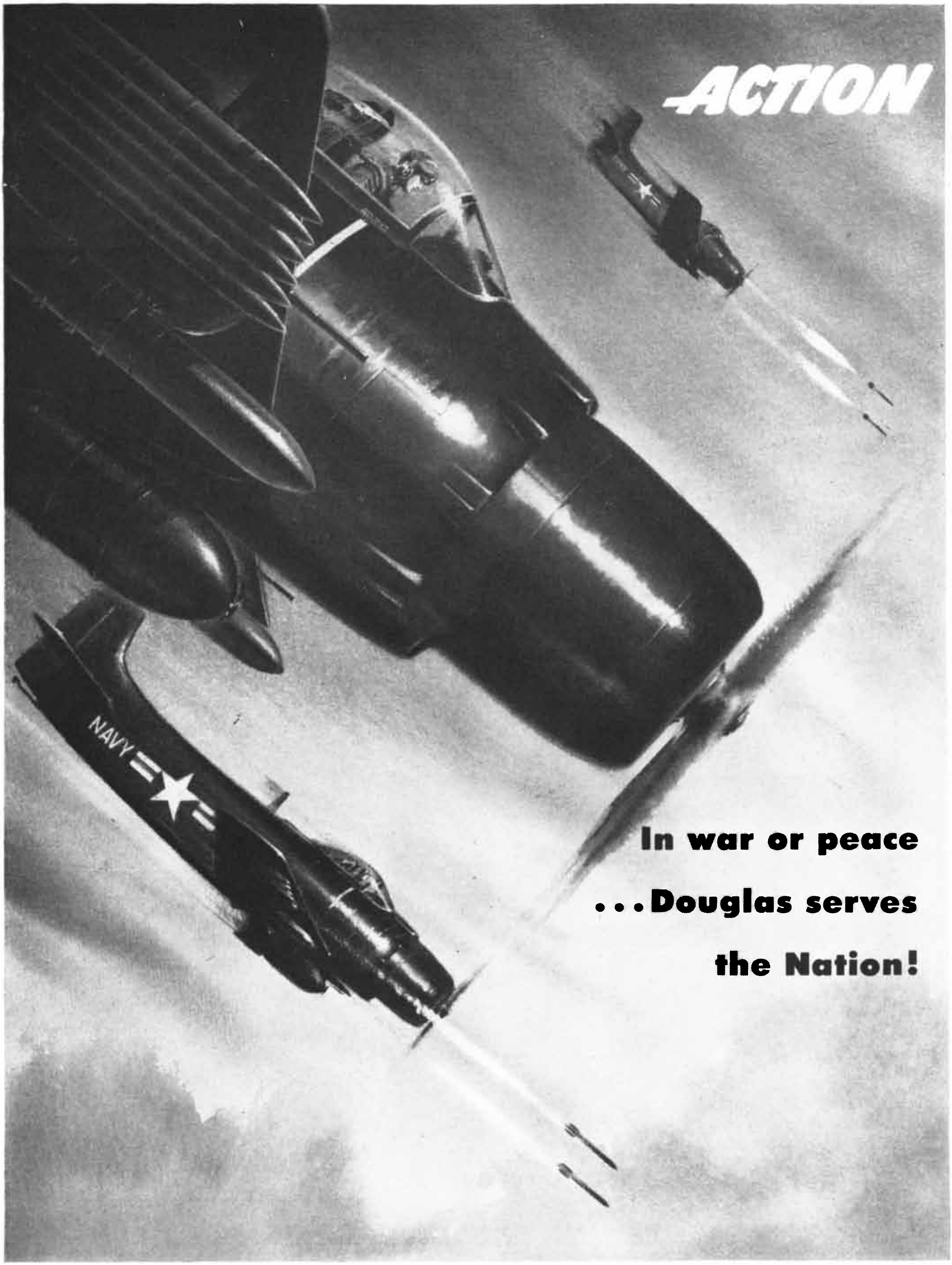

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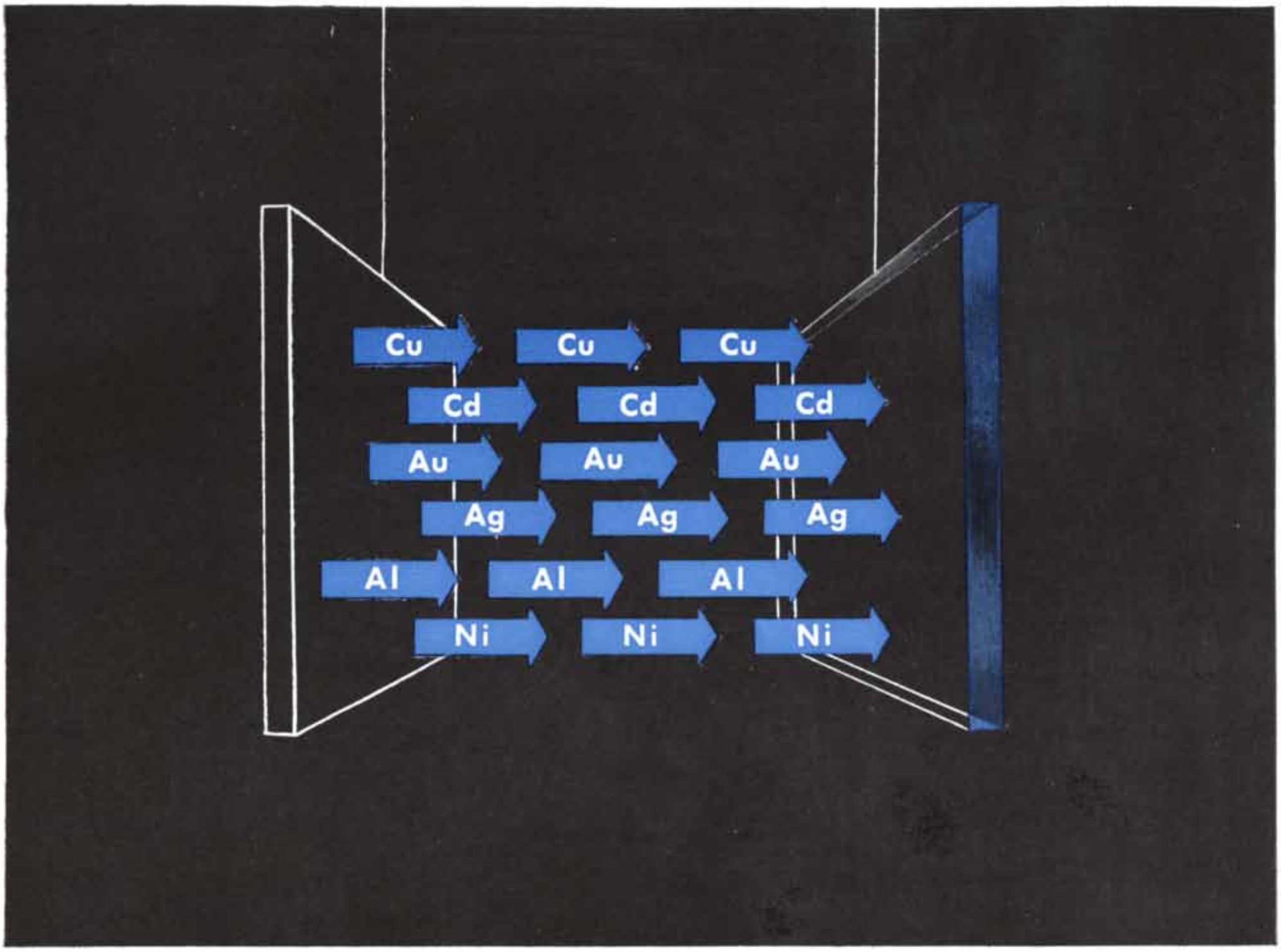

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Since plastics ordinarily do not conduct electricity, a way had to be found to form a conductive coating. The trick is turned by first roughening plastic parts, then dipping them in a chemical sensitizer. This is followed by application of a thin bond coat of silver by means of chemical reduction in solution.

Actual electroplating begins here. On the outside of perforated drums revolving in a special electrolyte, copper anodes furnish ions which migrate through the holes in the drum to the parts tumbling inside in contact with electrodes in the drum base.

Silver, gold, tin, or other metals are firmly and permanently plated on the resulting copper plate. After a final buffing, the high polish and long-wearing smoothness of the metals are advantageously wedded to the lightweight and corrosion resistance of plastics.

An interesting and useful stage of the plastic-plating process permits many variations in the final color of the products.

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Data furnished by Plastiplate Co., Inc., South River, N. J.

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DEPARTMENTS

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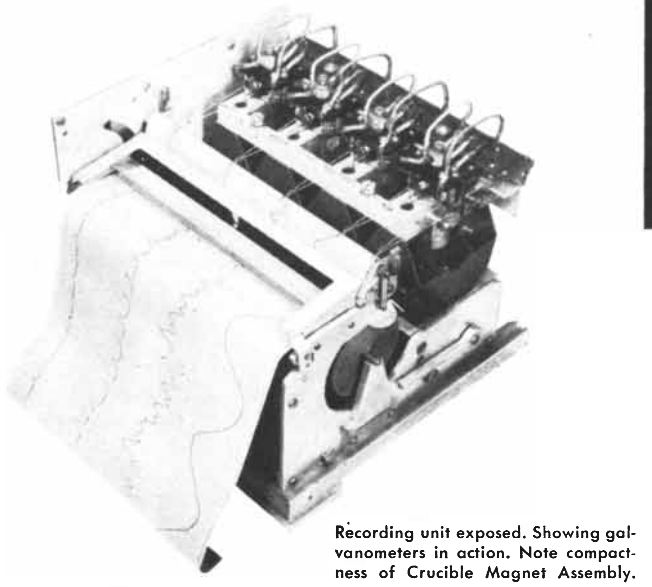
What's New at CRUCIBLE

about permanent alnico magnets



Recording unit exposed. Showing galvanometers in action. Note compactness of Crucible Magnet Assembly.

When Sanborn Company of Cambridge, Massachusetts, big name in recording equipment, first started working on the design and construction of their new "Poly-Viso" Recorder, they ran into a magnet problem.

This recorder makes available permanent simultaneous tracings on one piece of paper of four different kinds of information which, for the first time, are directly written, in rectangular coordinates. That meant that Sanborn needed four separate but compact galvanometers. Crucible was called in, and here's the way Crucible magnet specialists solved the problem.

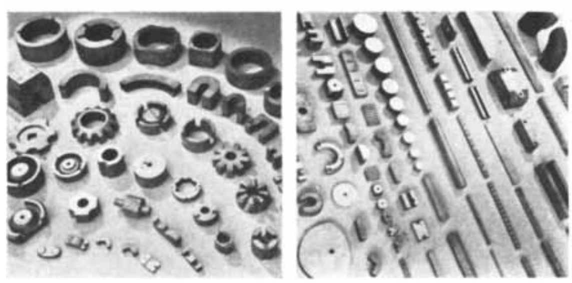
After careful study of the limits of the equipment, a master magnet was designed that consisted of four pairs of magnetic poles cast on a single base. This eliminated the need for bolting four magnets together, and reduced the amount of space required by the galvanometer assembly. An added feature of this special magnet assembly is a unique and exclusive Crucible method of strengthening the pole pieces of the individual magnets so as to retain maximum field strength. This also adds to the sensitivity of the galvanometer assembly.

The Sanborn "Poly-Viso" Recorder is used in both the biophysical and industrial fields for the measurement of pressure, flow, temperature, strain, values of AC or DC voltage or current, and the like. Because such quantities are directly recorded, immediate analysis can be made of many problems. Also, records can be run at any one of eight selectable speeds.

Engineering Service Available

Crucible's part in Sanborn's far-reaching development is but one example why Crucible has maintained, for more than half a century, a position of leadership in the specialty steel field. Your permanent magnet problem will receive the same experienced consideration from Crucible's unsurpassed staff of metallurgists and production specialists. Please give full details. Crucible Steel Company of America, General Sales Offices, Oliver Building, Pittsburgh, Pa.

Complete console unit. Recording assembly is to the left.



Example of shapes and sizes of Crucible Permanent Alnico Magnets.

CRUCIBLE first name in special purpose steels

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SCIENTIFIC AMERICAN

NOVEMBER 1951 VOL. 185, NO. 5

NATURAL GAS

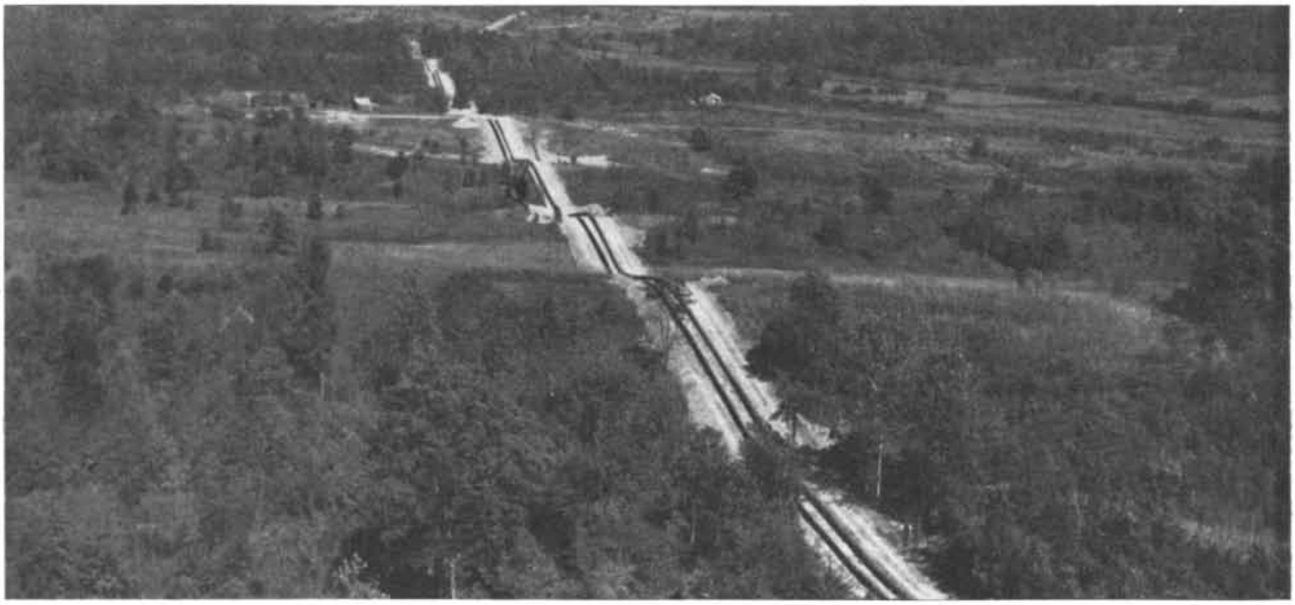
In terms of energy the U. S. has more of this cheap, clean, convenient fuel than petroleum. A rapidly growing network of pipelines now bears it to almost all parts of the nation

by James J. Parsons

During the past few years community after community in the U. S., and millions upon millions of householders, have seen the coming into their homes of a new fuel—natural gas. The dramatic story of the building of great new pipelines, which are bringing this fuel for the first time to all parts of the country, is well known. But few people realize just how great a change this development has made in the nation's energy economy. The U. S. consumed well over six trillion cubic feet of natural gas last year. In terms of energy units this was equivalent to four times the total amount of hydroelectric power generated in this country. Natural gas supplied nearly a fifth of the nation's total energy consumption from all commercial sources, and it would have accounted for a much higher proportion if it had been available everywhere in sufficient quantity to meet the expressed demands for it. Indeed, the demand for this cheap, clean, convenient fuel seems to be insatiable. For most of the major uses of energy—house heating, water heating, cooking, generation of electricity—it has become a serious competitor of coal, oil and water power.

The day may not be far distant when natural gas will be more important to our economy than petroleum. We have more abundant supplies of it, for one thing. Our proved reserves of recoverable natural gas now amount to more than 185 trillion cubic feet. This is the equivalent in heat units of over 30 billion barrels of oil, which is some 5 billion barrels more than our total proved reserves of petroleum itself. Moreover, exploration and new discoveries are increasing our known reserves of gas at a faster rate than those of petroleum, and as we probe deeper into the earth's crust we are likely to find more new gas than oil.

As petroleum becomes harder to find, natural gas will increasingly take its place not only as a heating fuel but as a source of gasoline and as the raw material of the great chemical industries now based on petroleum. By a modified Fischer-Tropsch process natural gas can



NATURAL GAS PIPELINE of the Texas Gas Transmission Corporation lies beside its trench in the hills of Tennessee. The pipeline, which stretches 800 miles from Texas to Ohio, was built at a cost of $73.5 million.

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be converted into gasoline or Diesel fuel; this is already being done on a commercial scale at the new Carthage Hydrocol plant in Brownsville, Tex. More important, the hydrocarbons of natural gas can serve as raw materials for a wide range of chemical products, including synthetic fibers, synthetic rubber, alcohol, plastics, insecticides and ammonia fertilizers.

NATURAL gas is another instance of the classic Cinderella story that is so familiar in the history of science and technology. It was long a troublesome, despised stepchild of the petroleum industry (just as uranium used to be cast aside as an unwanted by-product of mining for radium or vanadium). All petroleum fields contain some natural gas, both in solution in the oil and as free gas trapped with it in the reservoir. During the early years of oil-well drilling in this country vast amounts of gas were vented into the air and lost forever. Oil companies eventually found it worth while to use some of the gas as a means of increasing oil production: pumped back into depleted wells to build up pressure, it keeps the wells flowing and prolongs their productive life. But not until the late 1920s did natural gas begin to receive serious consideration as a fuel.

That this odorless, colorless gas was an excellent fuel had long been known; the town of Fredonia, N. Y., had employed it to light street lamps more than 125 years ago. The difficulty that stood in the way of its general use was that the great gas fields, mostly in the Southwest, were far from the nation's industrial centers. There is only one way to transport natural gas, and that is by pipeline. Although the fuel itself was cheap, it could not be piped to markets at a low enough cost to enable it to compete with coal or oil. Around 1927, however, the development of methods for manufacturing thin-walled seamless steel pipe of large diameter, and revolutionary improvements in compressors, made the piping of gas practicable. From gas fields in the Texas Panhandle pipelines were laid to Chicago, Detroit, Minneapolis and Denver. But the depression halted the building of pipelines, for the cost of oil and coal fell so low that natural gas could not compete.

It was World War II, with its enormous demands for fuel, that launched the natural gas boom. As coal and oil rose in price, gas regained its competitive position. By 1943 gas had become less expensive than either of the other fuels in markets, such as Chicago, where it was available by pipeline. The precipitating event that started a renewal of pipeline construction was a critical gas shortage in the winter of 1943-1944 in the Pittsburgh-West Virginia industrial areas, which had been using natural gas from the declining Appalachian fields. To relieve the shortage a 1,265-mile line was built from Corpus Christi to West Virginia. This line for the first time brought natural gas from the great reservoirs in the Southwest to the industrial East. It was the forerunner of a network of gas lines that was to spread rapidly over the entire nation.

At the end of the war the Big Inch and Little Inch pipelines, which had been built by the Government to carry crude oil from Texas and Louisiana to the Eastern Seaboard, were converted to transport gas. Of the many new natural gas lines built since the war the most spectacular is the 1,840-mile, 30-inch tube from the Rio Grande Valley to New York City—the longest gas transmission line in the world. This $200 million colossus taps 54 separate fields in the fuel-rich Gulf Coast region and delivers gas to a huge complex of homes and industry in the Northeast. All told, the major pipelines built or authorized since the end of the war have raised the capacity for delivery of natural gas to markets from 2.8 billion cubic feet per day to more than 9 billion, and proposals for new lines on file with the Federal Power Commission will raise this figure to well over 10 billion. We now have 315,000 miles of natural gas pipelines in this country—more than the total mileage of all our railroad lines. By early 1952, when the lines to New England are completed, every part of the country except the Pacific Northwest will be within reach of the natural gas transmission network.

Natural gas is found, as we have noted, in petroleum fields, where the gas is associated with oil. But there are a number of gas fields in the Southwest where natural gas occurs alone, and these account for the largest part of our proved gas reserves. The biggest natural gas field in the country, and possibly in the world, is the Hugoton field underlying the former Dust Bowl of southwestern Kansas and the Oklahoma Panhandle. Other major "dry-gas" fields are in western Texas and the Gulf Coast of Texas and Louisiana.

NATURAL gas is a mixture of hydrocarbons of the paraffin series, mainly methane (CH_4). This light gas is the one that is wanted as the piped fuel; hence before natural gas is put into the pipelines, it is stripped of all its heavier hydrocarbons. Among these by-products are the so-called "natural gasoline" and butane and propane, which are used as bottled gas and as raw materials for many chemical products. After methane has been stripped of these liquid fractions (they become liquid under certain pressure conditions), the gas is often cycled back into the reservoir several times to be re-enriched and bring up more of the heavy hydrocarbons. In an oil field this reinjection of the stripped gas also serves to maintain pressure and permit more complete recovery of the petroleum. There are now over 350 cycling and natural gasoline plants in the Gulf Coast and Mid-Continent fields—some of them enormous establishments representing investments of several millions of dollars.

The stripped natural gas that is delivered to consumers at the end of the pipeline is a remarkably economical, high-energy fuel. It has nearly twice as much heat value as manufactured gas made from coal, yet costs less per cubic foot. The Eastern utilities companies that have been converting from manu-

INTERSTATE PIPELINES for natural gas, most of which have been

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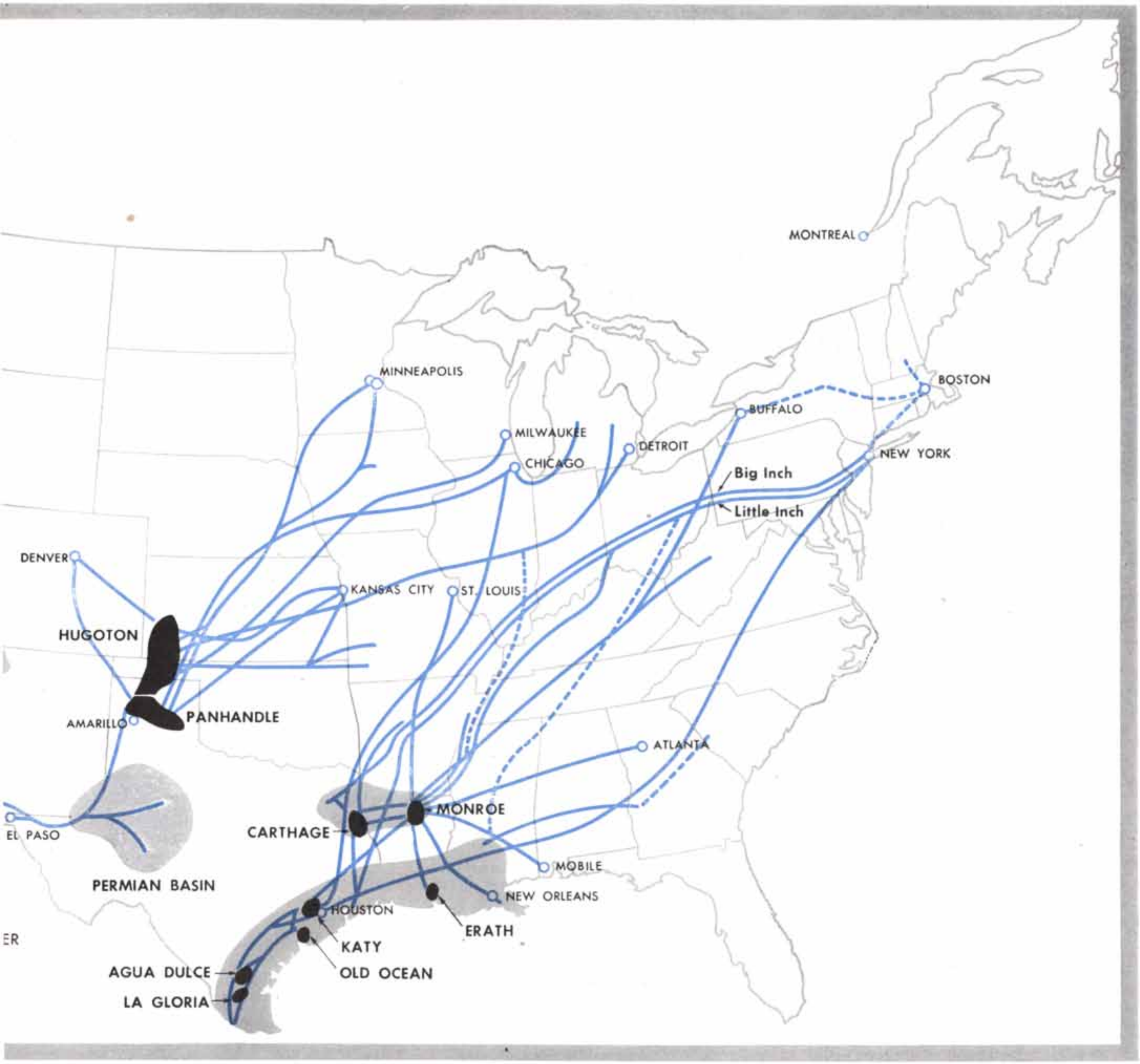

laid during or after World War II, are shown in blue on this map. They carry gas from the fields of the Southwest under pressures as high as 1,000 pounds per square inch. The names of fields are given in heavy type.

factured to natural gas have realized enormous savings in operating costs, but these are partly offset by the necessity for changing over domestic appliances to handle the richer fuel. Many companies have avoided this expense by blending manufactured and natural gas to form a mixture of intermediate heat value that can be burned in present equipment.

The great and sudden expansion of the nation's dependence on gas as a fuel has, of course, brought some problems. A major one is the daily and seasonal fluctuations in demand. Unlike coal or oil, gas cannot readily be stored on the premises in a bin or tank to be drawn on according to need. Gas comes directly from the pipelines, and the capacity of the lines is limited. The amount of gas packed into the pipes can, however, be adjusted over a fairly wide range by varying the pressure in the line. The gas transmission companies have adopted the practice of packing the lines to higher than normal pressure when the Weather Bureau forecasts cold weather, in anticipation of the expected sharp rise in demand for house heating. But packing cannot take care of the large seasonal rises in demand by industry, which in most areas consumes more than half of the natural gas. Many industrial customers may have their gas supply discontinued without notice in emergencies. As a long-range solution to the problem the pipeline companies are now developing large gas-storage reservoirs near the big industrial centers. Usually they use depleted old gas and oil fields for this purpose. One of the largest of these underground reservoirs is being developed at a cost of $30 million in an empty old gas field 30 miles southeast of Pittsburgh. It will hold a circulating gas supply of 60 billion cubic feet, the equivalent of nearly 100 days' delivery capacity of both the Big and Little Inch. Many new holes are being drilled into the field as outlets, and by means of feeder pipes the reservoir will be able to deliver up

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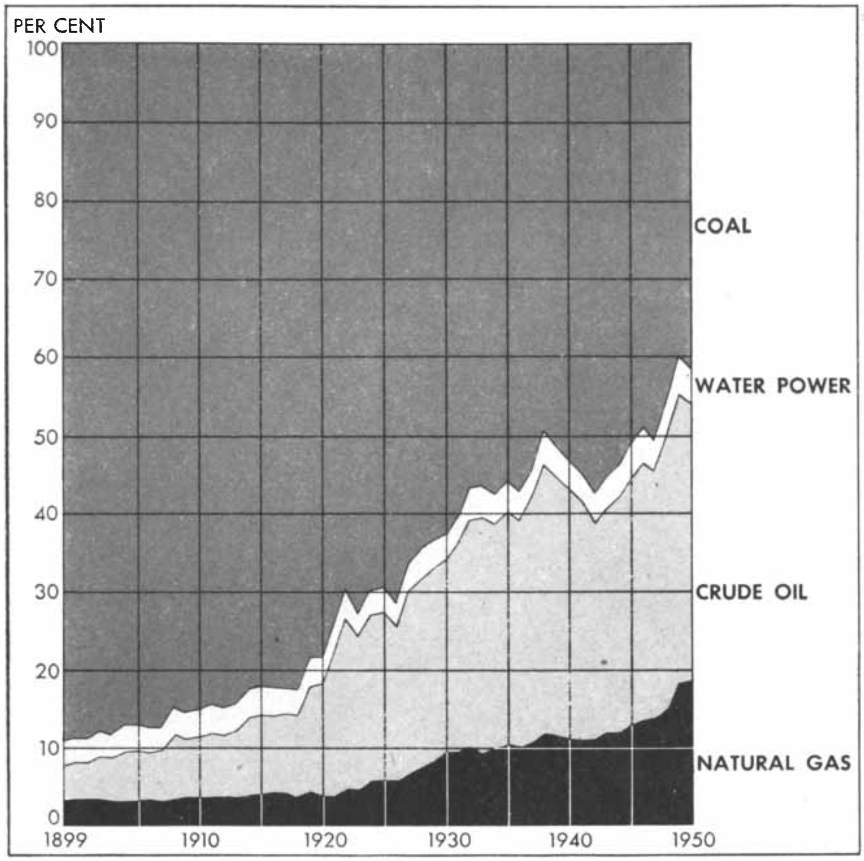

PERCENTAGE OF ENERGY contributed to the total requirement of the U. S. by water power and the various mineral fuels is shown in this chart.

to 400,000 cubic feet of gas a day to the Pittsburgh area.

THE piping of gas from the Southwest has turned the fuel economy of some regions of the country topsy-turvy. A notable example is California. Not long ago it was the nation's leading petroleum-producing state. Yet since 1948 California has been importing huge amounts of natural gas from Texas and New Mexico. The reason for this paradox is that the state has found that its own natural gas, which occurs chiefly in oil fields, is needed to maintain pressure and production in its oil wells. As a result California utility companies have had increasing difficulty in buying natural gas in their own state. The fact that this great oil-producing state, once the nation's leader, should today be forced to go as far as Texas and New Mexico for more than half of the natural gas it burns is a dramatic illustration of the disquieting rate at which the nation is using up its fuel resources.

Perhaps the most important issue raised by the piping of gas from the Southwest is the future of the Southwest itself. The Gulf South has no coal or water-power resources to speak of; its only sources of energy are the oil and natural gas that it is now exporting in vast quantities to other parts of the country. Its own industrial future necessarily will depend on these resources. In a Federal Power Commission report issued in 1948 Commissioners Leland Olds and Claude Draper pointed out that "the result of depletion of the main fuel reserve of the Southwest through siphoning its natural gas to the Northeast will be to remove the main basis for the hopes for industrial decentralization." And from the standpoint of basic economy it would obviously be more efficient to use the gas in industrial plants near the fields than to pipe it at great expense to other areas; in New York or Chicago natural gas may cost 10 times as much as at the Texas fields from which it is piped. In sending its own fuel to areas that have plenty of coal and water power but buy gas simply because it is cheap, the Southwest is almost literally carrying coals to Newcastle.

The Gulf South has recently begun to show concern over the wisdom of continuing this unrestricted export of its fuel. To discourage such exports Texas is currently considering a minimum price law which would raise the price of natural gas and reduce its competitive advantage over coal and oil in distant markets. Minimum prices for natural gas are also advocated as a conservation measure. It is claimed that because of low prices at the field a great deal of gas is either wasted entirely or used not as a fuel but for "inferior" purposes such as manufacturing carbon black, which last year consumed about seven per cent of the natural gas sold in the nation. For these reasons state regulatory bodies in Kansas and Oklahoma have recently fixed the minimum price of natural gas in the field at seven and eight cents per thousand cubic feet. The power of the states to establish minimum prices for natural gas has been upheld by the U. S. Supreme Court. In doing so the Court apparently restricted the price-control powers of the Federal Power Commission.

For heating, cooking and other household uses natural gas is so superior, because of its high heat value and cleanliness, that it will probably continue to gain favor over coal and oil. But the extent to which it is utilized as a fuel by U. S. industry will depend on how it competes in price with other fuels, including not only oil and coal but also synthetic gas made from coal.

OUTSIDE the U. S. there has been comparatively little exploitation of natural gas so far. The great petroleum provinces of the Middle East and Venezuela of course have huge amounts of gas, but they are too far from major industrial centers to reach them by pipeline and to market the gas profitably. In Europe several large cities have begun to use natural gas from local fields since the end of the war; among them are Moscow, Bordeaux, Toulouse, Genoa, Milan, Turin and Venice. Some natural gas development is also going on in Latin America: Argentina has recently completed a 1,055-mile pipeline from fields in the southern part of the country to Buenos Aires, and Mexico is getting gas via pipeline from Texas and from its own Caribbean coastal fields. But the largest development is occurring in Canada. Recent gas and oil discoveries in the prairie provinces of Western Canada seem destined to have a major impact on the fuel economy of northern North America within a very few years. Natural gas reserves amounting to more than eight trillion cubic feet have already been located in the province of Alberta, and new discoveries are expanding the proved reserves at a rapid rate.

A Canadian subsidiary of a Texas oil company has applied for authorization to build a 2,240-mile, 30-inch pipeline from Edmonton and Calgary to Montreal, which would be the longest gas transmission line ever built. The Alberta Petroleum and Natural Gas Conservation Board also has under consideration four other applications for lines to pipe gas from Alberta to the Chicago area and the U. S. Pacific Northwest.

James J. Parsons is assistant professor of geography at the University of California.

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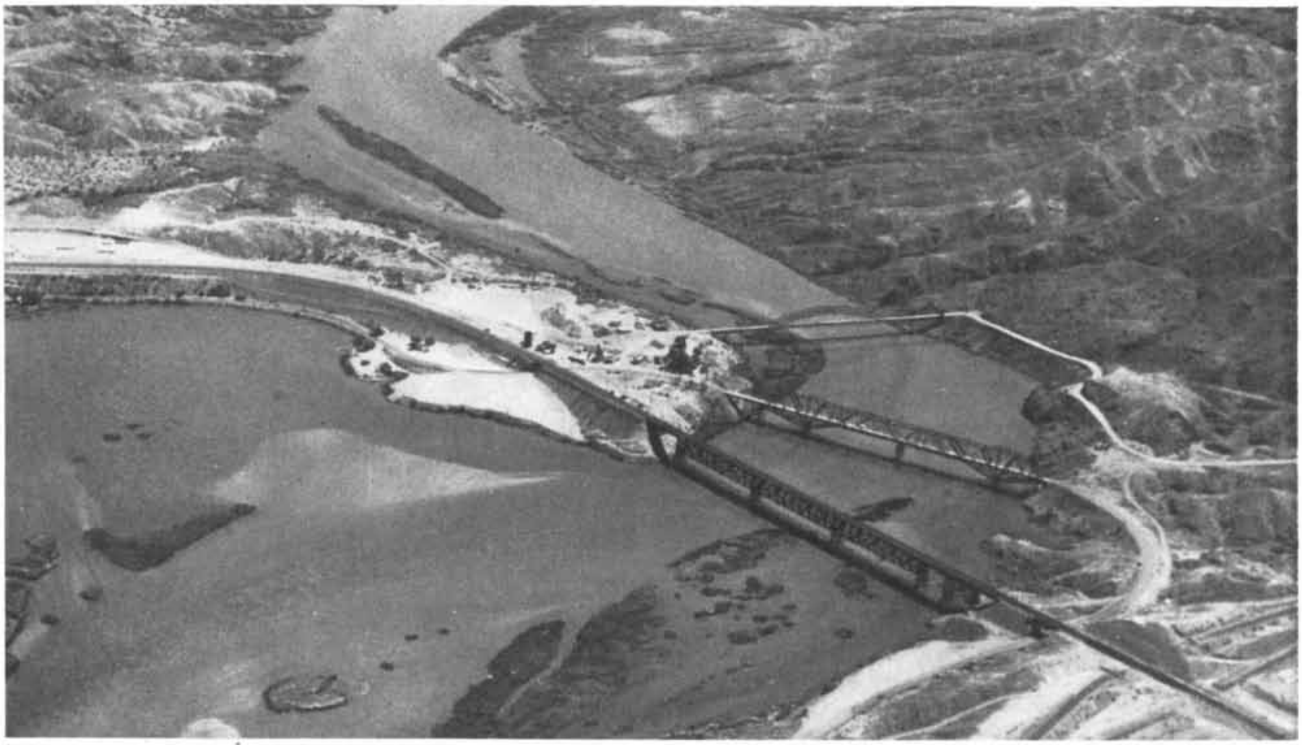
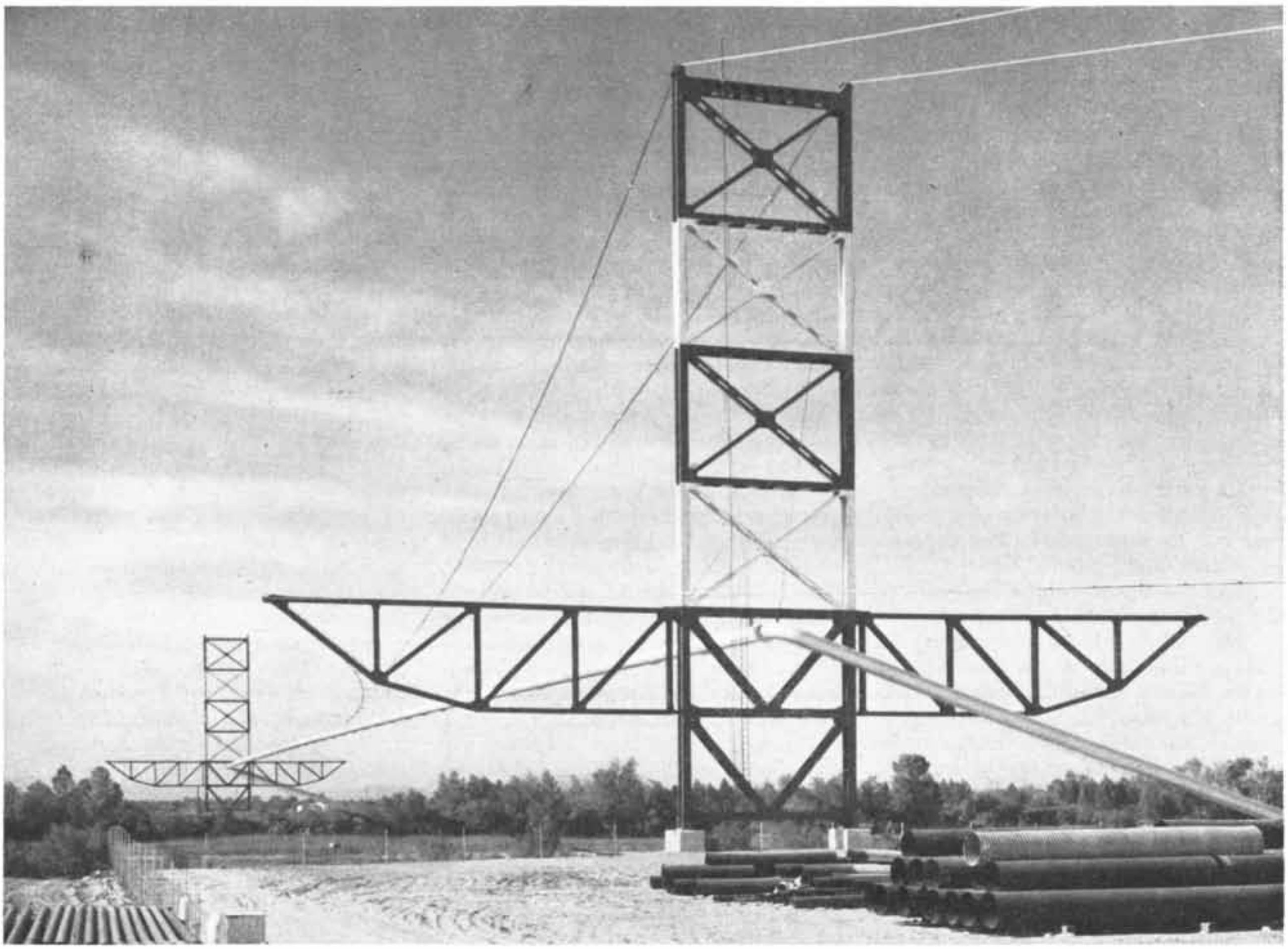


PIPELINE BRIDGE of the El Paso Natural Gas Company, the uppermost of the three bridges shown in this photograph, crosses the Colorado River near Topock, Ariz. Arizona is at the left and California at the right.



SUSPENSION BRIDGE carries another pipeline of the El Paso Natural Gas Company across the Colorado River. This pipeline, which conducts gas from Texas to Southern California, was photographed at Blythe, Calif.

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Rh and the Races of Man

The troublesome blood factor, the incidence of which varies in different parts of the world, is a means of tracing human blood relationships that have been lost in the mists of time

by William C. Boyd

THE races of man used to be studied mainly by explorers and anthropologists, who journeyed to the far corners of the earth to examine them. Today they can also be studied by explorers who need look no farther than the test tubes in their laboratories. The investigators who are conducting this new kind of exploration are serologists, and their explorations are carried out on samples of blood. From this rich material they can obtain precise information on the genes of human populations in all parts of the world. Chiefly responsible for making such studies possible was the discovery of the Rh factor in the blood.

Fifty-one years ago a young Viennese pathologist named Karl Landsteiner found that human blood was not the same in all individuals—that it could be classified into several different types, now known as A, B, AB and O. It was many years before much attention was paid to this discovery; until the beginning of the First World War people were sometimes given transfusions without a check of their blood type, sometimes with fatal results.

But when in 1940 Landsteiner and Alexander S. Wiener discovered the Rh factor, the response was very different. By then the blood was much better understood, and so were the genetic mechanisms of the blood groups. Medical investigators almost immediately gave intensive study to the Rh factor, for it was soon recognized to be responsible for the fatal infants' disease called erythroblastosis fetalis, which may attack the child of an Rh-negative mother and an Rh-positive father. And serologists, realizing the value of the Rh factor as a genetic tool, promptly began to examine the blood of American Indians, Asiatics and various other human populations to see whether they differed in the frequency of the Rh genes.

More than eight Rh blood genes have now been identified. There is no general agreement yet on a system for naming them; the symbols used here will be those devised by Wiener. They designate the Rh genes as r, r′, r′′, r^y, R^z, R^o, R^1 and R^2. The Rh-negative gene is r.

It was soon found that the proportion of Rh-negative individuals ranges from 13 to 17 per cent among peoples of European stock, meaning the white inhabitants of Europe, America and Australia. The question arose: Would other races be found to have a similar incidence of the Rh-negative type? The first studies done on American Indians showed they do not; in fact, pure American Indians are in the fortunate position of having no Rh-negative genes at all. No case of erythroblastosis has been found among Indians.

Nearly all modern anthropologists believe that the American Indians originally came from Asia. If this is true, their blood types should show similarities to the types to be found in Asia, just as their physical appearance resembles in some respects that of the Mongoloids. Studies were made on the Rh types of the Chinese and Japanese to test the hypothesis, and they showed that these peoples have a very small percentage of Rh-negative individuals—so small that the Rh genes in the samples may have been contributed by just a few persons, thought to be "pure," who were actually of mixed European-Asiatic ancestry. Erythroblastosis also seems extremely rare or unknown among these peoples.

The Rh explorations were next taken up by workers in Australia. Taking advantage of the air transportation in the Pacific provided by the air forces during the Second World War, they had samples of blood from various Pacific peoples flown to their laboratories so that it arrived in suitable condition to be tested. They examined the bloods of Indonesians, Filipinos, Australian aborigines, Papuans, Maoris, Admiralty Islanders, Fijians, New Caledonians and Loyalty Islanders, and did not find a single sample of Rh-negative blood.

The next region to be explored was Africa, once called the "Dark Continent" —an appellation which is no longer quite so apt. Tests on American Negroes in New York City had suggested that Negroes have about half as much Rh-negative blood as do white Americans. This was confirmed by the studies of African Negroes.

If we plot all these data on a map of the world as pieces of a puzzle, a general picture now begins to emerge. We can divide the world into three great regions. The peoples of Asia and the Pacific have no Rh-negative genes. The Europeans and their descendants do have them, in about 16 per cent of the population. The inhabitants of the great continent of Africa have about seven per cent Rh-negative—half as much as possessed by the Europeans.

It is a matter of great interest that the people of Egypt, a gateway between Africa and Europe, stand between the Europeans and the Africans in their Rh inheritance. Two sampling studies show that about 10 per cent of the Egyptians have Rh-negative blood.

WHERE did the Europeans get their Rh-negative genes? Obviously this is a most difficult question to answer, but a gleam of light suddenly appeared when a South American investigator of Basque descent tested a group of Basques in South America. He found that 28 per cent of them had Rh-negative blood—far more than the average among Europeans. The Basques have long been known to be the remnants of a people older than the other inhabitants of Europe. They speak a language not known to be related to any other, and they have been in France and Spain for a very long time. They jealously kept their blood "pure"; a girl who married outside the Basque race found herself disowned by her parents. It seems reasonable to suppose, however, that although the Basques have managed rather successfully to maintain their own racial purity, they must have mixed with other Europeans to some extent during their long history. If the Basques had a high percentage of Rh-negative genes, in any mixture with other Europeans they must have contributed a certain frequency of these genes to the European stock.

If we postulate that it was the Basques who brought the Rh-negative gene to Europe, we have only pushed our difficulty back one step. Where did the Basques themselves get the gene? And why has the gene not been eliminated by natural selection? Assuming that there are two Rh genes in a population, one positive and one negative (a convenient

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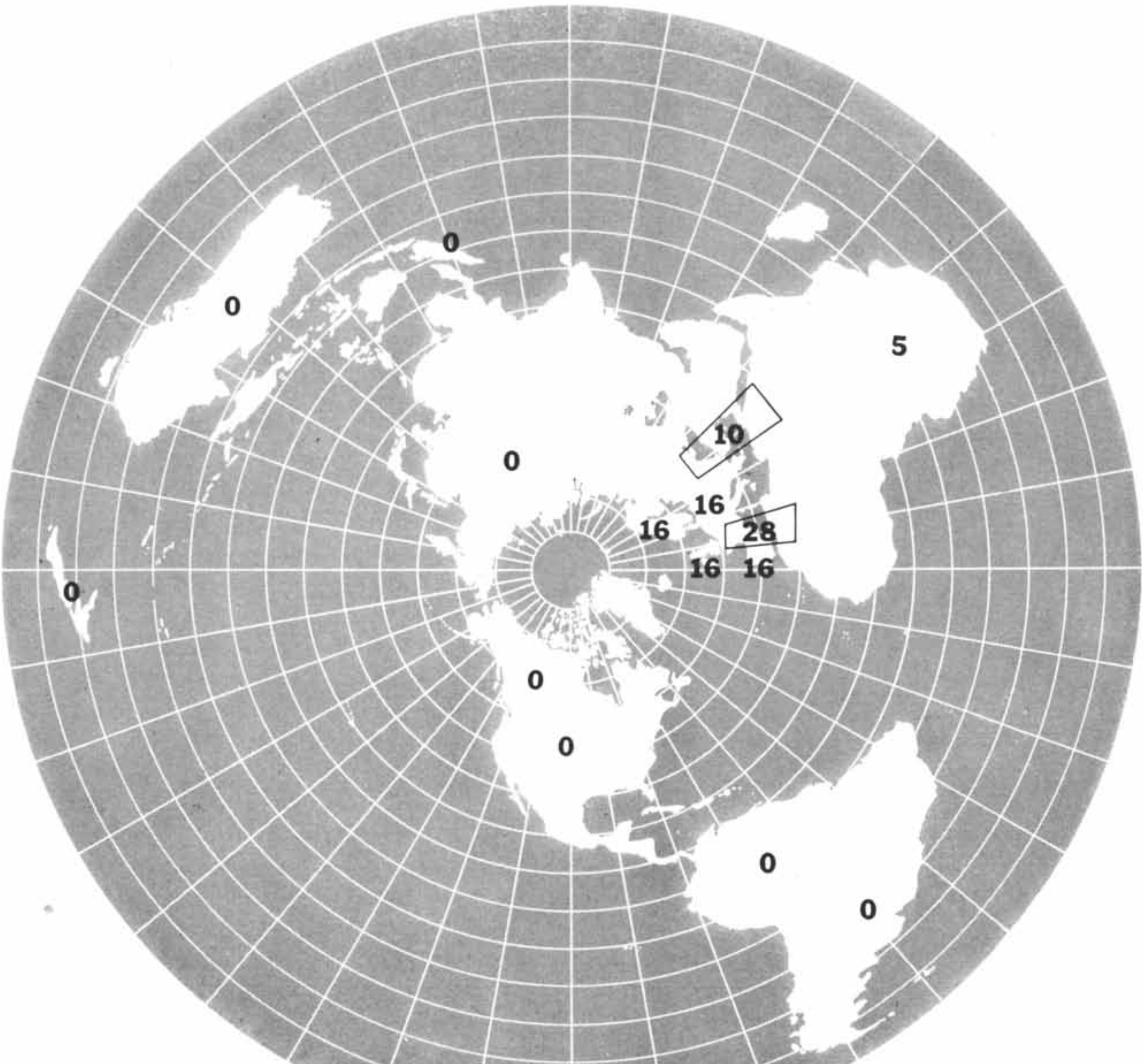
oversimplification), selection due to deaths of children from erythroblastosis will mean that the only possible condition of equilibrium is one in which the two genes are of equal frequency. Furthermore, this is an unstable equilibrium. The situation is like that of a wooden cone balanced on its tip; push it ever so slightly and it will fall over. Any accidental variation in either direction will start a process which will lead to complete elimination of either the Rh-negative gene or the Rh-positive gene. This argument assumes that mothers of erythroblastotic children leave fewer descendants than the average. However, the British geneticist Ronald A. Fisher has questioned that assumption. He believes that a family which had lost a child would have a strong tendency to replace the child by having one or more extra children, and that in many cases Rh-negative women might have larger families than their Rh-positive sisters. Fisher has even suggested that this tendency to compensate for the loss of children by having large families may actually be increasing the Rh-negative frequency among the Basques.

ANTHROPOLOGISTS have now begun to examine some of the rarer Rh genes in their study of populations. One of the most significant is the R^o gene. This gene seems to be almost an identifying mark of the African peoples; among the Bantu of South Africa it is the most common of all the Rh types, whereas it occurs in only about two per cent of a European stock. (In speaking of Africa, of course, we mean Africa south of the Sahara Desert, because the people of North Africa and Egypt belong primarily to Europe, that is, the old Mediterranean civilization of which the Romans and Phoenicians formed a part.)

In the white population of England and the U. S. there are several rare Rh genes that occur with frequencies of only one per cent or so but are nevertheless important identifying factors. These genes, with few exceptions, are uniformly absent from the Asiatic and Pacific native populations. In fact, the genetic



Rh-NEGATIVE GENE occurs in different percentages in the various populations of the world. Each number on this map indicates the percentage of the earliest known inhabitants of that region who have Rh-negative blood.

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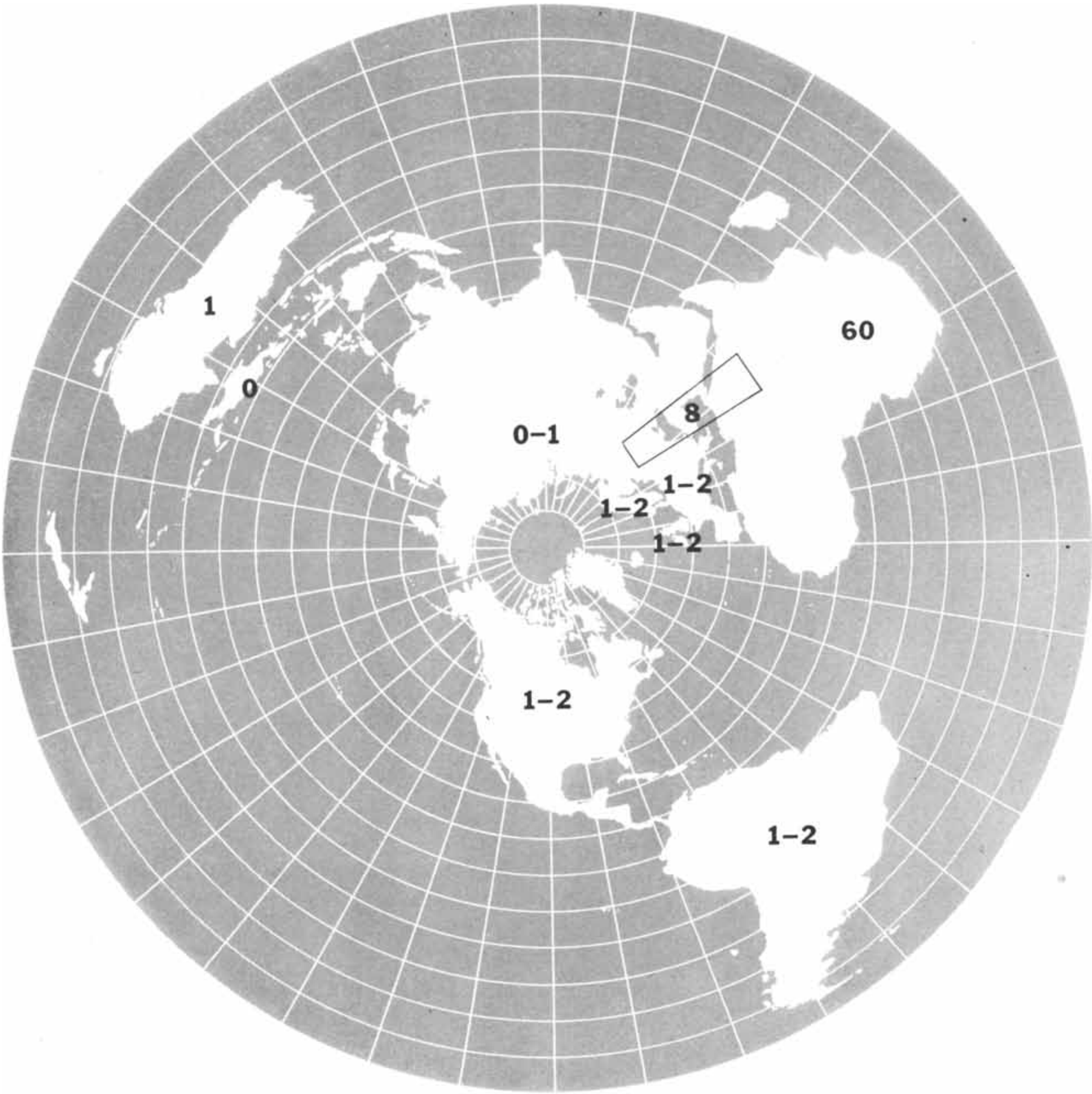
situation seems to be much simpler in the Pacific than here, for the peoples of that part of the world have only three Rh genes in any considerable amount, in contrast to the eight or more in our own population. The reason for this difference is, at present, a matter for speculation. Perhaps in the Pacific, some parts of which were peopled in relatively recent times, the missing genes never arrived; on the other hand, it may be that they have been eliminated by natural selection.

There is one rare Rh gene that does show up with unusual frequency among the Asiatics. The R^z gene, which occurs in less than one per cent of Europeans, is present in five per cent or more of the American Indians and the Australian aborigines. R^z may be called an Asiatic gene, in somewhat the same sense as R^o may be termed an African gene, although it never reaches the same frequencies.

The Rh factors are not the only new blood factors that have been found since the discovery of the classical blood groups. Actually eight independent gene systems have been discovered, largely by British workers. When reagents for these become generally available, it will become possible to determine several million different types of individual blood, and it is not beyond the bounds of possibility that we shall be able to identify a person by his blood almost as surely as by his face.

Attempts have been made to trace the history of the Rh types back further than their occurrence in *Homo sapiens.* If man and the chimpanzee, for instance, are common descendants of some remote common ancestral type, we might expect to get some information about the Rh genes by testing chimpanzees and other anthropoids. Wiener tested 10 chimpanzees and found that they all appeared to possess an Rh-negative gene. This would suggest that the Rh-negative factor may be older than the human race as we know it. It is possible, however, that this gene has arisen independently in chimpanzees and man. We know from studies on Egyptian mummies that the blood groups are certainly more than 5,000 years old.

The interpretation of these facts depends on one's particular theory of hu-



R^0 GENE has a distribution of its own differing from that of the Rh-negative gene. As in the map on page 23, each number on this map indicates the percentage of the earliest known inhabitants of that region with R^0 blood.

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man evolution and one's views about anthropology in general. Geneticists who study populations are today convinced that probably four main agencies have operated to produce the geographical differentiations which account for our present human races. These mechanisms are mutation, selection, genetic drift or isolation, and mixture between races, possibly even between different species. We do not know whether selection is acting to increase or decrease the frequency of the Rh-negative gene or any of the other blood factors.

That genetic drift may account for the loss of genes is suggested by the example of the American Indian. Pure-blooded American Indians have no type B blood, although in Asia, from which they are believed to have come, it is common. It is tempting to suppose that B has been lost in the Indians simply by a genetic accident or series of accidents.

To illustrate how this might happen, let us suppose that we have a relatively small population of about 100 or so coming from Asia to America. We then have two possibilities: First, there is a random chance, though a small one, that none of the 100 migrants happened to have B blood. Thus the new population would never have this gene. The second possibility is that an individual of group B did arrive in America but left no descendants or had children who happened to belong to group O, which would be quite possible if he had one gene for B and one for O. The University of Chicago geneticist Sewall Wright has shown mathematically that accidents of this sort can play an important role in the evolution of natural populations.

Could we account for the loss of the Rh-negative gene in a similar way? This seems much more doubtful, because the enormous population of Asia seems to have little, if any, of this gene, and yet we have no record of their having migrated to Asia from any other place; in fact, the probabilities are that man originated in Asia or Africa or some region combining the two. It would seem more likely that selection, rather than genetic accident ("drift"), may account for the absence of the Rh-negative gene in the Asiatics. If this is true, it leaves us with the problem: Why has selection not eliminated the gene from the Europeans? Possibly it is now doing so but has not yet been operating long enough to show much effect. It may be that selection against the Rh-negative gene is more intense in dense populations. Asia has long been densely populated, whereas the modern European is obviously separated by only a relatively short time from the Neolithic hunters who wandered in small hordes through the forests.

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	Number of Persons Tested	FREQUENCIES OF Rh TYPES (PER CENT) rh cde	Rh_1 CDe	Rh_2 cDE	Rh_1Rh_2 CDe/cDE	Rh_0 cDe	rh′ Cde	rh″ cdE	rh′rh″ Cde/cdE	Rh_1Rh_z Cde/CDE
BASQUES	167	28.8	55.1	7.8	6.0	0.6	1.8			
"WHITES" (France)	501	17.0	51.7	13.6	13.0	3.6	0.4	0.8	0	D
CZECHS (Prague)	181	16.0	50.3	11.6	11.6	1.1	0.6	0.6	0	0.6
"WHITES" (Hollanders)	200	15.4	51.5	12.3	17.7	1.5	1.5	0	0	0
"WHITES" (England)	1,038	15.3	54.8	14.7	11.6	2.3	0.6	0.7	D	
SAO PAULO (Brazil)	138	15.2	55.2	10.1	11.6	5.8	1.4	0.7		
"WHITES" (Australia)	350	14.9	54.0	12.6	16.6	0.6	0.9	0.6	D	0
"WHITES" (England)	927	14.8	54.9	12.2	13.6	2.5	0.7	1.3		0.1
"WHITES" (U.S.A.)	7,317	14.7	53.5	15.0	12.9	2.2	1.1	0.6	0.01	
SPANISH (Barcelona)	223	13.0	63.2	13.0	9.4	0.5	0	0.5	0	0.5
"WHITES" (U.S.A.)	766	12.5	54.7	14.9	13.9	2.2	0.9	0.5	0	0.1
"ARABS" (Baghdad)	300	10.3	50.3	13.7	15.7	8.3	1.0	0.7	0	0
PUERTO RICANS	179	10.1	39.1	19.6	14.0	15.1	1.7	0.5	0	
NEGROES (U.S.A.)	223	8.1	20.2	22.4	5.4	41.2	2.7	0	0	
NEGROES (U.S.A.)	135	7.4	23.7	16.3	4.4	45.9	1.5	0.7	0	0
ASIATIC INDIANS (Moslems)	156	7.1	70.5	5.1	12.8	1.9	2.6	0	0	
SOUTH AFRICAN BANTU	300	5.3	27.0	0	2.3	64.3	1.0	0	0	
CHINESE	132	1.5	60.6	3.0	34.1	0.9	0	0	0	
JAPANESE	150	1.3	37.4	13.3	47.3	0	0	0	0	0.7
JAPANESE	180	0.6	51.7	8.3	39.4	0	0	0	0	
INDIANS (Mexico, Tuxpan)	95	0	48.1	9.5	38.1	1.1	0	0	0	3.1
INDIANS (Ramah, N. M.)	105	0	40.0	17.1	36.2	2.9	0.9	0	0	2.9
INDIANS (Ramah, N. M.)	305	0	28.5	20.0	41.0	0.7	3.0	0	0.7	6.2
INDIANS (Utah)	104	0	33.7	28.8	37.5	0	0	0	0	
INDIANS (Brazil)	238	0	22.7	19.3	53.2					4.8
INDONESIANS	200	0	74.0	2.5	22.5	0.5	0	0	0.5	0
FILIPINOS	100	0	87.0	2.0	11.0	0	0	0	0	
AUSTRALIAN ABORIGINES	100	0	53.0	21.0	15.0	4.0	1.0	0	0	6.0
AUSTRALIAN ABORIGINES	234	0	58.2	8.5	30.4	1.3	1.7	0	0	
PAPUANS	100	0	93.0	0	4.0	0	0	0	0	3.0
MAORIS	32	0	25.0	31.0	41.0	3.0	0	0	0	
ADMIRALTY ISLANDERS	112	0	92.9	.9	6.2	0	0	0	0	
FIJIANS	110	0	89.1	1.8	9.1	0	0	0	0	
NEW CALEDONIANS	243	0	77.4	2.1	20.5	0	0	0	0	
LOYALTY ISLANDERS	103	0	77.7	2.9	19.4	0	0	0	D	
SIAMESE (Bangkok)	213	0	74.7	3.3	21.1	0.5	0	0	0	3.3

SEVERAL Rh GENES are tabulated with respect to frequency. The terminology differs from that in text: rh in chart is r in text and Rh_0 is R^0.

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THE RARE EARTHS

They are neither earths nor especially rare. Their abundance as fission products of uranium has stimulated a new interest in their possible usefulness for the laboratory and industry

by Frank H. Spedding

IN THE table of the elements, the catalogue of the primary substances from which all things in nature are made, there is a cryptic chapter that has mystified generations of schoolboys, to say nothing of professional chemists. It is a group of elements about which so little has been known that they are customarily dismissed as a footnote to the periodic table, apologetically labeled "the rare earths." This more or less anonymous group, usually designated simply as elements number 57 to 71, accounts for nearly one fifth of all the known elements, yet until recently it has been largely ignored. Since 1945 the rare earths have received increasing notice, and the names of some of them now even appear occasionally in the newspapers. These long-neglected elements not only have played a significant part in the atomic energy project but they are beginning to be appreciated as materials that can be put to unique and valuable uses.

The name "rare earths" is quite inaccurate as a description of these substances. They are metals, not earths; they were given that name because they were first known in the form of their oxides, which resembled the materials then known as earths, such as lime, magnesia and the like. Nor are they particularly rare. One of the rare earths, cerium, is more abundant in the earth than tin, silver, gold, cadmium, mercury, antimony, tungsten or platinum. As a group the rare earths make up about five thousandths of one per cent of the earth's crust. There are rich pockets of them in many parts of the world. The chief source from which they are obtained at the present time is the mineral monazite. This mineral is found in sands deposited by rivers in our own state of Idaho and in India, Brazil and other places. Several other minerals also are good sources of the rare earths; they occur in Texas, North Carolina and Colorado and abroad in Scandinavia, Greenland, Brazil, Australia and the Urals.

The reason why the rare-earth metals were believed to be rare, and why they remained for so long a little-explored chapter in the list of elements, is the great difficulty of separating them from one another. The rare earths are all very much alike chemically, and it takes an enormous amount of work to separate them in pure form by chemical methods. It can be done by means of fractional crystallization and other chemical reactions that take advantage of slight differences in their properties, but the task is laborious indeed. In the case of some of the rarer rare earths it requires as many as 40,000 operations to get them really pure.

THE remarkable chemical brotherhood of the rare earths is due to a peculiarity of their atomic structure. To understand this peculiarity we must look in some detail at the structural arrangement of an atom. The chemical properties of any substance are determined, as everyone knows, by the swarm of electrons that surrounds the atom's nucleus. The electrons are arranged in a series of shells, and the shells are filled in a regular sequence from the innermost one outward. Each shell can hold up to a certain maximum number of electrons; thus the innermost shell is filled when it has two electrons, the next can hold two, the next six, and so forth. In the shorthand used by atomic scientists the shells are named 1s, 2s, 2p, 3s, 3p, 3d, and so on. The element hydrogen has but one electron, and it revolves around the nucleus in the 1s shell, or orbit. Oxygen, with eight electrons, has two in the 1s shell, two in the 2s and four in the 2p. What distinguishes one element from another is the difference in the total number of electrons in the neutral atom.

The chemical activity of an atom depends on the energy states of its electrons and the manner in which these energy states are perturbed by electric and magnetic fields, including those that arise from neighboring atoms with which it may be combined. Now the energies ordinarily available in the laboratory—from heat, chemical reactions or moderate voltages of electricity—are sufficient only to disturb an atom's outermost electrons; those in the shielded inner shells are not affected. It is the outermost electrons, therefore, that mainly determine the atom's chemical behavior. They establish its valence (the number of bonds it can form with other atoms), its ability to form ions (lose or gain electrons) and almost all its other chemical properties, as well as many of its physical ones.

The chemical kinship of the rare earths depends in part on the fact that they all have three outer electrons which they can lose to other atoms, so that

THE PERIODIC TABLE at the bottom of the opposite page lists the elements in horizontal rows so that those with similar chemical properties may be connected by vertical or diagonal lines. Above the symbol for each element is its atomic number, or number of electrons in each atom. At the top of the page are diagrams showing the electron structure of two rare-earth atoms. The electrons are arranged in shells which in one terminology are labeled K, L, M, N, O and P and in another terminology are labeled 1, 2, 3, 4, 5 and 6. In the latter terminology the shells are divided into subshells labeled s, p, d and f. The maximum number of electrons in each s shell is 2; in each p shell, 6; in each d shell, 10; and in each f shell, 14. The number of electrons in each of these shells is indicated by the superscript number; for example, the notation $4f^2$ in the diagram of praseodymium indicates that it has two electrons in the f subshell of its fourth shell. The configuration of the electrons in all the rare earths is the same except for the 4f shell, which is shown in red. Lanthanum (La) has no electrons in the 4f shell, cerium (Ce) has one, praseodymium (Pr) has two and so on up to lutetium (Lu), which has 14. On the periodic table each of the rare earths is indicated by a solid red rectangle. The open red rectangles indicate elements that are usually grouped with the rare earths. The brackets beneath some of the symbols on the periodic table indicate the element in which the successive shells of electrons are filled.

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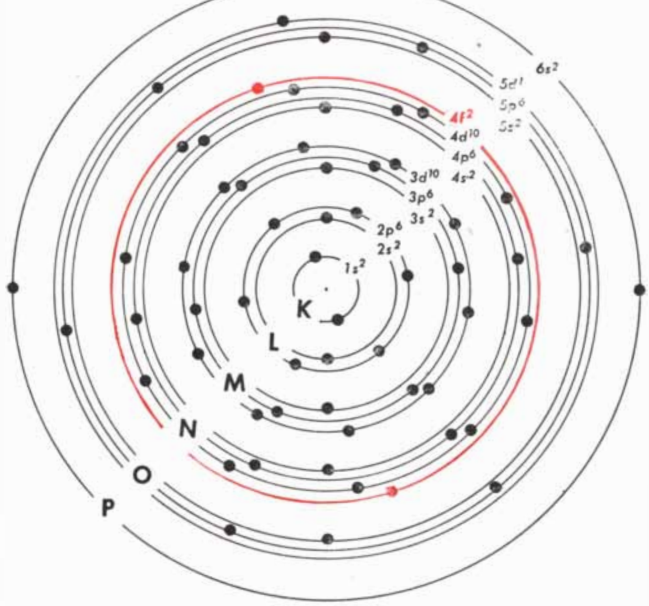
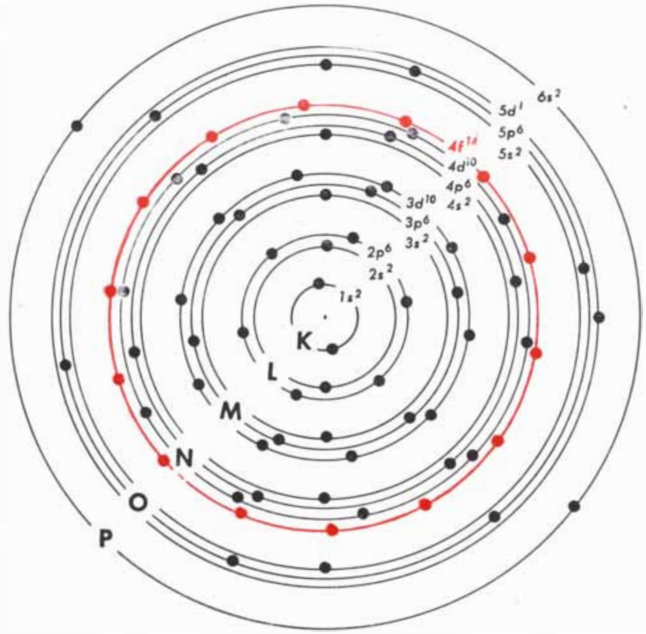
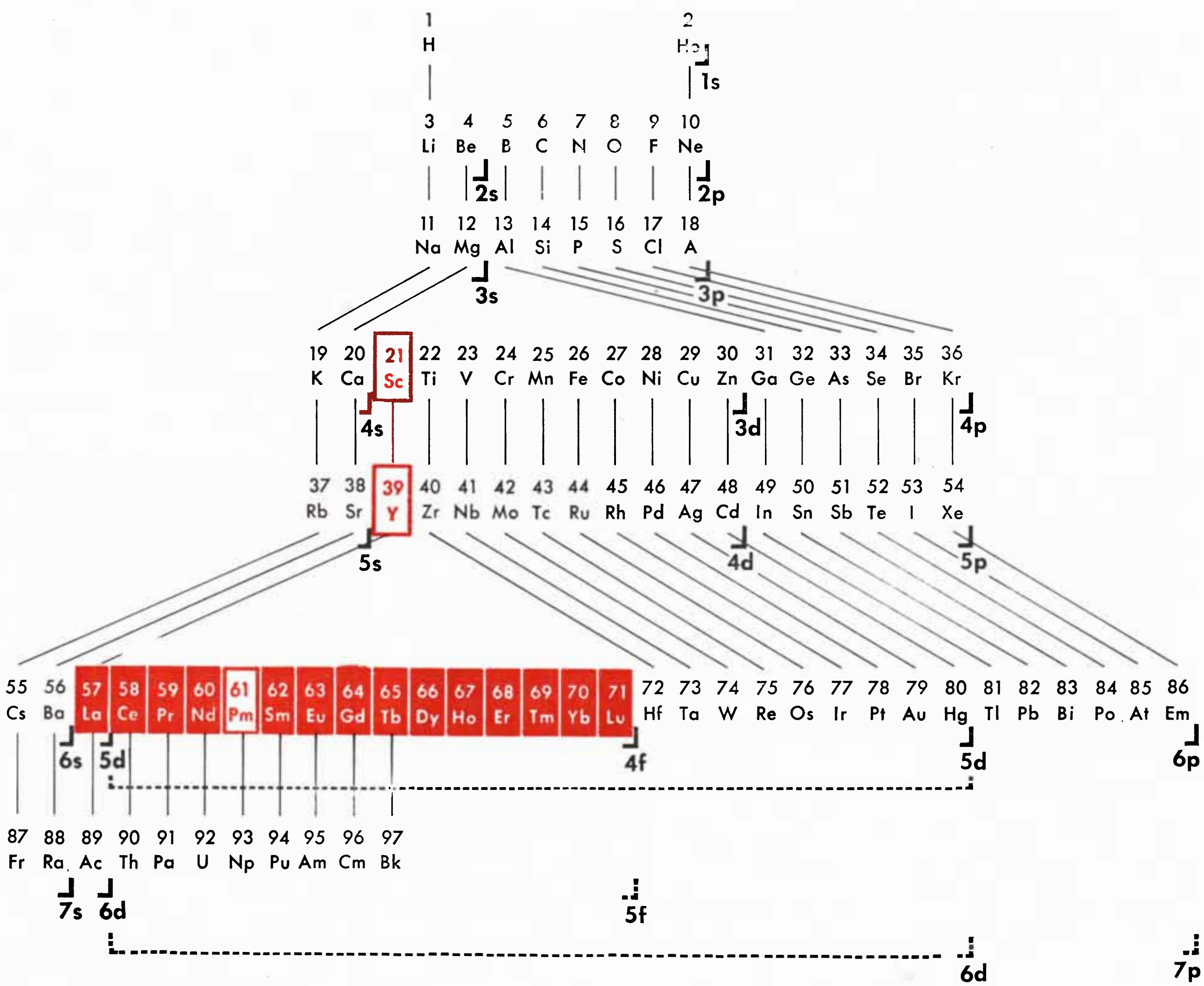


PRASEODYMIUM



LUTETIUM



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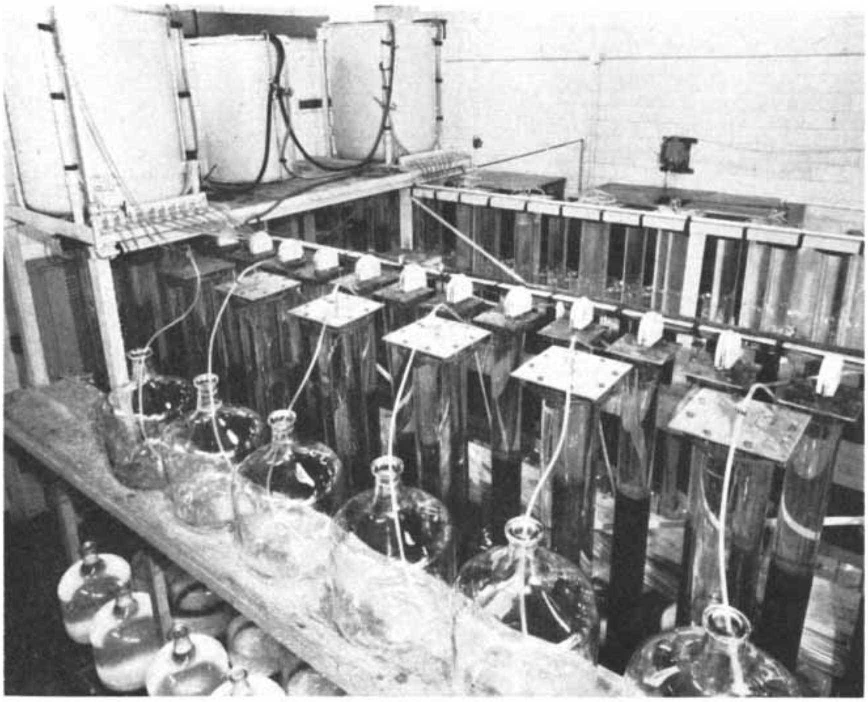
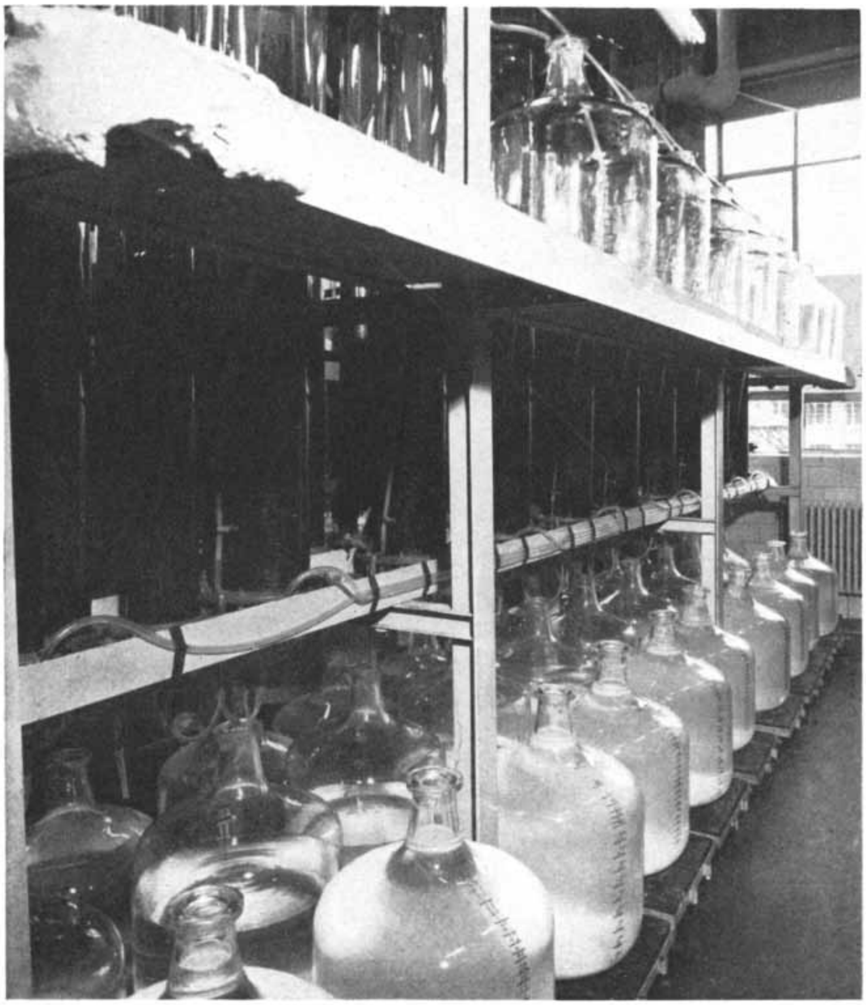


PILOT PLANT for the separation of rare earths by ion exchange has been set up at the Ames Laboratory of the U. S. Atomic Energy Commission.



SAME PLANT is shown from the bottom. At left are the ion-exchange columns. Bottles contain rare-earth solutions in various stages of purification.

all have a valence of three. But this in itself is not unusual; many other atoms have the same valence. What is remarkable about the rare earths is that in every one these outermost electrons occupy exactly the same shells. While the rare earths differ from one another in total number of electrons, the variation occurs not in the outermost shells, as is generally the case, but in one of the inner shells—the 4f shell. All the other shells up to and including 5s and 5p, which are outside the 4f shell, are completely filled, but this one is left open. The various rare earths are identified by the number of electrons they have in the 4f shell. Thus the rare earth cerium has one electron in this orbit, praseodymium two, and so on. The 4f shell has room for 14 electrons, and there are 14 rare earths. (Lanthanum, element 57, has no electrons at all in the 4f shell and hence is not a true rare earth, but it is grouped with these substances because it has very similar properties.)

It is easy to see now why the rare earths are so remarkably alike in chemical behavior. The electrons in the 4f shell are shielded from any ordinary outside influence by the closed shells that surround them; hence they play little part in the element's chemical activity. The rare earths' behavior therefore depends almost entirely on the configuration of their three outermost electrons, which is the same for all of them. Those slight differences that do exist among them derive from a certain slight physical effect due to the variation in size of the nucleus. The heavier the nucleus, the greater is its positive charge. An increase in the charge on the nucleus results in a stronger attraction of the electrons, and this causes the shells to shrink inward. Hence the heavier rare earths have smaller radii, and consequently are denser, than the lighter ones.

AS LONG AS workers had to use laborious and time-consuming chemical methods, such as fractional crystallization, to separate the rare earths, research on these elements was exceedingly difficult. But since 1945 a much more efficient and rapid method has been developed in connection with the atomic bomb project. The Atomic Energy Commission's interest in these elements stems from the fact that the rare earths are an important by-product of its atomic piles. When uranium or plutonium fissions, a fair percentage of the atoms into which it splits are rare earths. Some of these fission products, the so-called ashes of the atomic furnace, have a very high affinity for the neutrons that spark the furnace, and they can put out the atomic fires.

The new method used for separating the rare earths is the ion-exchange column (see "Ion Exchange," by Harold F. Walton; SCIENTIFIC AMERICAN, Novem-

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ber, 1950). This method depends on the ionic properties of materials and is very effective for separating closely similar substances that cannot easily be isolated by ordinary chemical reactions. In the rare-earth process a solution of the mixed rare earths is washed down a metal or glass column with a solution of citric acid. The bed of material in the column through which it flows is a synthetic resin, such as Amberlite, Nalcite or Dowex. These resins have active points to which positive ions are attached. The ionized rare-earth atoms can exchange with these ions and take their places on the resin. As the rare-earth ions progress down the column they undergo literally thousands of exchanges. The various rare earths differ slightly in their rate of progress, and one gets ahead of the other. As a result the ingredients come out separately at the bottom of the column in a fairly pure state—first citric acid, then the heaviest rare earth, then the next heaviest, and so on.

At the Ames Laboratory of the Atomic Energy Commission is a small pilot plant which can produce two to three kilograms (about four to seven pounds) of pure neodymium per month or smaller amounts of the other rare earths, depending on their rarity. The more common rare earths, such as cerium and lanthanum, are still produced by the chemical method of fractional crystallization, and probably will continue to be for some time to come. A number of firms are now producing rare earths commercially, both by chemical and ion-exchange methods.

THE rare earths, by reason of their peculiar structure, offer a golden opportunity to study the magnetic properties of materials and to test various theories of physical chemistry and physics, including the theories of solution and of metals. The fact that the rare earths are so alike in everything except their atomic radius and the properties that depend on the radius, such as density and crystal structure, makes them an ideal group for such tests. Just as the finding of the key word across the center of a crossword puzzle greatly simplifies the solution of the puzzle, so the rare earths, as a remarkably convenient group in which all the variables are constant except the atomic radius, offer a powerful key to study the laws of nature.

Their properties also suggest a rich variety of practical uses for these materials. The best way to indicate them is to run down the list of individual rare earths.

LANTHANUM, atomic number 57, was discovered by Karl Gustav Mosander of Sweden in 1839. Its name came from a Greek word which aptly describes the rare earths in general—*lanthanein*, meaning to be hidden or concealed. Lanthanum is always mixed with other rare earths in its ores. It is also a fission product of the splitting of uranium, thorium and plutonium. The pure metal is soft, ductile and, like most of the rare-earth metals, has a fairly low melting point—about 1,600 degrees Fahrenheit. It oxidizes in air (like calcium) and is attacked slowly by cold water and rapidly by hot water. Its reaction with water produces a hydroxide. It reacts with acids to give colorless salts. The salts are useful in chemistry because lanthanum forms one of the strongest bases. The impure metal is frequently used in alloys such as misch metal. The oxide (La_2O_3) has found considerable application in the optical industry, because it yields a special optical glass of high refractive index for cameras and other instruments. At a few degrees absolute, lanthanum metal becomes superconducting; that is, its resistance to electric current drops to practically zero. It has an intensely radioactive isotope, prepared in the atomic furnaces, which serves as a very strong source of gamma radiation and can be used in industry in place of hard X-ray machines.

Cerium, number 58, the commonest element of the rare-earth group, was discovered in 1803 by the German chemist Martin Klaproth and independently by the Swedish scientists Jöns Berzelius and Wilhelm Hisinger. Berzelius named the element after the newly discovered asteroid Ceres. Pure cerium, an iron-gray metal, is soft and ductile, melts between 1,418 and 1,472 degrees F. and burns brilliantly when heated in the form of a wire. Because it ignites easily, it is used as the active ingredient in cigarette-lighter flints. Cerium is the only rare earth that can form compounds other than oxides with a higher valence than three; it is therefore the most easily purified member of the group. Its trivalent compounds are called the cerous series and its tetravalent ones the ceric series. Ceric oxide (CeO_2), commonly formed when the cerium salts of the volatile acids are heated in the presence of oxygen, is a nearly white powder which is insoluble in nitric and hydrochloric acids but is soluble in sulfuric acid. The ceric salts are a brilliant orange or orange-red. The cerous salts, such as $Ce_2(SO_4)_3$, are colorless and more stable. Cerium oxide is used as an opacifier in porcelain coatings for signs and as an abrasive in polishing lenses and mirrors; it is a better polishing agent than rouge. The ceric salts are employed as oxidizing salts in chemistry and as drugs. Cerium nitrate finds application in the manufacture of Welsbach gas mantles and in the ceramic and textile industries. Cerium metal, a powerful reducing agent, is frequently employed as an active deoxidizer or "getter" in the iron industry and is well known as a scavenger or purifier in various types of foundry melts. The metal is also effective in alloys. Mixed in small amounts with aluminum, metallic cerium and its alloy misch metal make it possible to form sound aluminum castings. It has been reported that alloys of magnesium containing small amounts of cerium or neodymium show better properties than pure magnesium at high temperatures and are more resistant to sea water. Cerium metal can exist in several forms; one of these forms, which occurs at low temperatures or high pressure, is of considerable interest because in this state the metal shrinks in volume by 18 per cent—one of the largest changes in density of any of the metallic elements.

PRASEODYMIUM, number 59, was discovered by the Austrian chemist Carl Auer von Welsbach in 1885. The first part of its name comes from the Latin word for green, indicating the green color of its salts. The salts have found application in the ceramic industry for coloring glass and glazes.

Neodymium, number 60, also was discovered by von Welsbach in 1885, when he separated salts of a supposed element called didymium into two fractions, one of which was praseodymium and the other neodymium. The oxide, Nd_2O_3, is usually obtained as a light blue powder; in solution it is pink. Its salts, like those of praseodymium, are used for coloring glass and glazes. Neodymium is particularly useful in goggles employed in glass blowing, since it filters out the bright yellow light of sodium.

Promethium, number 61, is often referred to as the missing member of the rare-earth series, because it has never been conclusively proved to exist in nature. Element 61 was first definitely identified without doubt when it was discovered in the atomic piles as a fission product. Some of this synthetic element has been isolated and examined by atomic energy workers, but the amount is so small that not much is known about its properties (see "The Synthetic Elements," by I. Perlman and G. T. Seaborg; SCIENTIFIC AMERICAN, April, 1950).

Samarium, number 62, gets its name from the fact that it was first found in the ore samarskite, named for the Russian engineer Samarski. The element was discovered in 1879 by Lecoq de Boisbaudran of France and was obtained in the form of very pure compounds by another Frenchman, E. Demarçay, in 1901. Samarium forms both divalent and trivalent compounds. Its trivalent oxide, Sm_2O_3, has a cream color and is rapidly soluble in many acids, giving topaz-yellow salts such as $Sm_2(SO_4)_3 \cdot 8H_2O$. Samarium metal itself is extremely difficult to isolate in pure form.

Europium, number 63, was first identified in 1889 by the famous English physicist Sir William Crookes, inventor of the Crookes tube. He detected it as a

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NAME	SYMBOL	ATOMIC NUMBER	DENSITY	MELTING POINT (DEGREES C)	AMOUNT IN EARTH'S CRUST (PER CENT)
LANTHANUM	La	57	(α) 6.194 (β) 6.18	860	.00035
CERIUM	Ce	58	(α) 6.78 (β) 6.81	770 - 800	.00155
PRASEODYMIUM	Pr	59	(α) 6.776 (β) 6.805	940 - 960	.00025
NEODYMIUM	Nd	60	(α) 7.004	800 - 900	.00090
SAMARIUM	Sm	62	6.93	1350	.00035
EUROPIUM	Eu	63	5.244	1100 - 1200	.00001
GADOLINIUM	Gd	64	7.948	–	.00035
TERBIUM	Tb	65	8.332	–	.00005
DYSPROSIUM	Dy	66	8.562	–	.00035
HOLMIUM	Ho	67	8.764	–	.00005
ERBIUM	Er	68	9.164	1250 (?)	.00030
THULIUM	Tm	69	9.346	–	.00005
YTTERBIUM	Yb	70	7.01	1800 (?)	.00035
LUTETIUM	Lu	71	9.74	–	.00007

LIST OF THE RARE EARTHS also gives their known properties. Greek letters under the heading of density indicate two forms of those elements.

new absorption band in the spectra obtained from a fractionation of mixed rare earths. Later Demarçay isolated some compounds of the element. Europium, like samarium, has a divalent series of compounds as well as the more common trivalent ones. H. N. McCoy, chief chemist of the Lindsay Light and Chemical Company of West Chicago, published a series of papers in the late 1930s giving methods for preparing divalent europium salts and for separating europium and other rare-earth elements in the divalent state. He succeeded in separating several hundred grams of europium salts and was extremely generous with this material, giving or lending it to a large number of research workers for scientific purposes. Thus while europium is an extremely rare element, its properties are better known than those of any other rare earth except the three most common of the series—lanthanum, cerium and neodymium.

Gadolinium, atomic number 64, was named in honor of the Finnish chemist J. Gadolin. Its discovery is usually credited to the Swiss chemist J. C. G. Marignac, who obtained an impure form of it in 1880. The salts are strongly magnetic, and it was a salt of this element that W. F. Giauque first used to obtain temperatures below a few tenths of a degree absolute by the magnetic cooling method. The chilled metal has the unique property of being ferromagnetic, like iron. It loses its strong magnetic properties, however, at about room temperature.

Terbium, number 65, was discovered in 1843 by Mosander. He found another rare earth, erbium (element 68), at the same time, and at first the two were often confused. Mosander himself named the oxide of element 65 erbia and that of element 68 terbia, but by 1877 the prevailing usage among chemists had switched the names of the two elements. Terbium is one of the rarer rare earths.

Dysprosium, number 66, derives its name from the Greek word *dysprositos*, meaning hard to get at. It forms a white oxide (Dy_2O_3) which dissolves in many acids to form a yellow solution with a green tinge. Its salts are strongly magnetic, and it has been reported that the metal is ferromagnetic at very low temperatures.

Holmium, number 67, is one of the rarest of the rare earths. Its name is derived from *Holmia*, a Latinized form of Stockholm. It was discovered by J. L. Soret of Switzerland in 1878 and independently by P. T. Cleve of Sweden in 1879. Holmium oxide, Ho_2O_3, is yellowish in color and forms orange-yellow salts.

Erbium, number 68, is the confusingly named twin of terbium, as we noted above. Both were named for the town of Ytterby in Sweden, as were also ytterbium (element 70) and yttrium (element 39). Erbium forms a rose-pink oxide, Er_2O_3, which dissolves slowly in many acids, giving rose-colored solutions.

Thulium, number 69, is a very rare metallic element discovered by Cleve in 1878. Its name is derived from *Thule*, the title the Romans gave to the northernmost region of the inhabitable world; the phrase "Ultima Thule," used as the title of a famous novel by the Australian novelist Henrietta Richardson, means a remote goal or end. The oxide of thulium, Tm_2O_3, is white and its salts are a very pale green.

Ytterbium, number 70, was discovered by Marignac in 1878. In 1907, G. Urbain of France found that what Marignac had called ytterbium was actually composed of two elements, which he named lutetium and neoytterbium; the latter was eventually listed as ytterbium. Its common oxide Yb_2O_3, is colorless and when dissolved in acid forms colorless solutions. Ytterbium also forms a series of divalent compounds; their solutions are a yellowish green.

Lutetium, number 71, derives its name from Lutetia, a town in Gaul now known as Paris. Lutetium, an extremely rare element, was discovered in 1906 by Urbain and independently by von Welsbach. It forms a white oxide, Lu_2O_3. The salts of lutetium in solution are colorless.

Yttrium, number 39, a metallic element in the third column of the periodic table, is commonly classed as a rare earth, though it is not one actually. It is always found associated with the rare earths in ores and so closely resembles them in properties that it can be separated from them only with great difficulty. It was discovered by Gadolin in 1794 and obtained in a purer form by Mosander in 1843. Yttrium oxide, which is white, has found some use as a ceramic, particularly in electric resistance furnaces.

Scandium, number 21, is another metallic element usually classed with the rare earths because of its very similar properties. Its discovery by the Swedish physicist L. F. Nilson in 1879 was a dramatic event, for its existence and properties had been predicted 10 years earlier by the Russian author of the periodic table, Dmitri Mendeleyev. Nilson discovered the oxide, scandia, and found that its properties corresponded to those Mendeleyev had predicted for the compounds of a hypothetical element he had named ekaboron. Scandium, of course, means Scandinavia. Spectrographic observations show that scandium is rather abundant in some of the stars.

THE rare earths should soon become generally available for scientific research, and a great deal of work will be done on them. It is the author's opinion that many industrial uses for these materials also will develop in the next few decades as ways are found to produce them more cheaply.

Frank H. Spedding is director of the Ames Laboratory of the U. S. Atomic Energy Commission.

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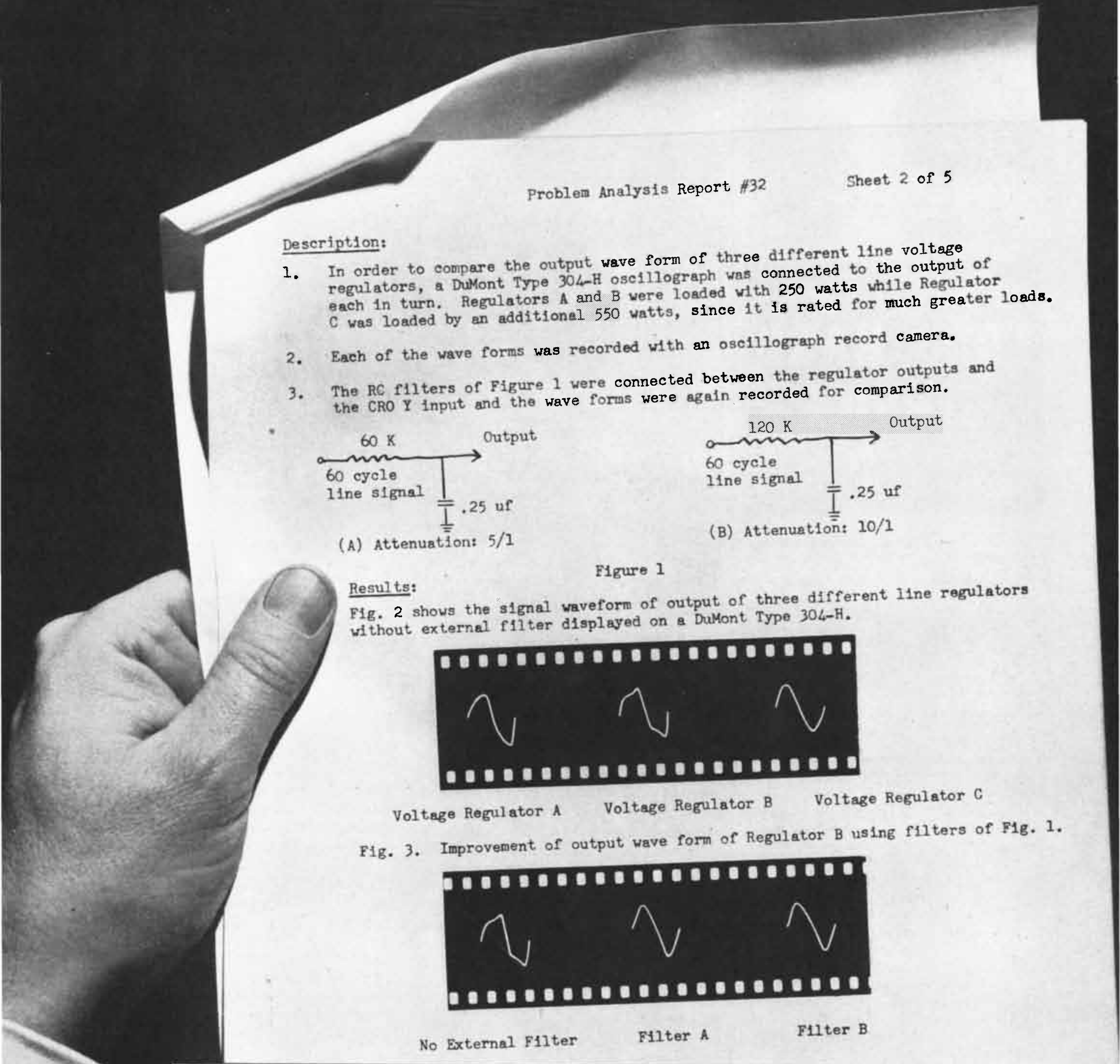
Problem Analysis Report #32 Sheet 2 of 5

Description:

1. In order to compare the output wave form of three different line voltage regulators, a DuMont Type 304-H oscillograph was connected to the output of each in turn. Regulators A and B were loaded with 250 watts while Regulator C was loaded by an additional 550 watts, since it is rated for much greater loads.

2. Each of the wave forms was recorded with an oscillograph record camera.

3. The RC filters of Figure 1 were connected between the regulator outputs and the CRO Y input and the wave forms were again recorded for comparison.

Figure 1

Results:

Fig. 2 shows the signal waveform of output of three different line regulators without external filter displayed on a DuMont Type 304-H.

Voltage Regulator A Voltage Regulator B Voltage Regulator C

Fig. 3. Improvement of output wave form of Regulator B using filters of Fig. 1.

No External Filter Filter A Filter B

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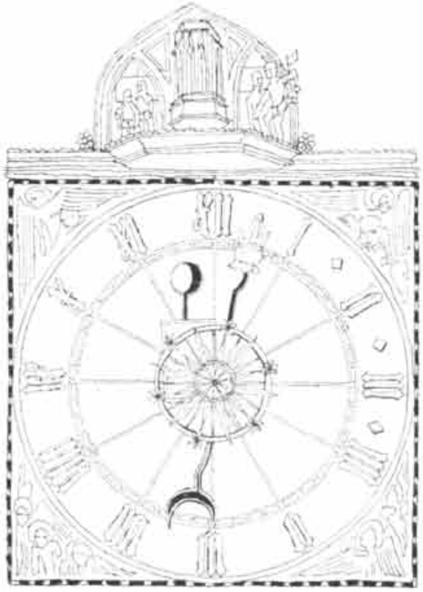

Varieties of Atom Bombs

BOTH in Washington and in Moscow there was more official news on atomic-weapons developments last month than at any time since Hiroshima. In Moscow Premier Joseph Stalin, following an announcement by President Truman that the Russians had exploded a second atomic bomb, publicly confirmed for the first time that the U.S.S.R. was producing atomic weapons. And in the U.S. Gordon Dean, chairman of the Atomic Energy Commission, disclosed that the Commission was well along in the development of new types of atomic weapons which amounted to a "revolution" in atomic warfare. He said that atomic weapons which could be employed against troops in battle were already available and that "serious consideration" should be given to their use.

The second Soviet atomic explosion, like the first one in 1949, presumably was detected by U. S. observers by means of radiation monitoring devices. Stalin's confirmation, presented through the medium of an interview in *Pravda*, said that the U.S.S.R. had tested "a type of atom bomb," and he added that further "tests of atomic bombs of various calibers will be made in the future."

Dean's disclosures, made in a speech at the University of Southern California and through the publication of parts of his testimony before a House Appropriations subcommittee, were the most circumstantial account yet to come from the Commission on its weapons work. He said:

"We think of the great mushroom-shaped clouds and the devastation that lay below them. We think of them as weapons to be used against cities or large areas, and we don't think of them for use in a battle zone against troops. But all this is changing.

"What we are working toward here is a situation where we will have atomic weapons in almost as complete a variety as conventional ones, and a situation where we can use them in the same way. This would include artillery shells, guided missiles, torpedoes, rockets and bombs for ground-support aircraft among others, and it would include big ones for big situations and little ones for little situations. . . . Given the right situation, and a target of opportunity, we could use an atomic bomb today in a tactical way against enemy troops in the field, against military concentrations near battle areas and against other vital military targets without risk to our own troops. We are steadily increasing, through our technological and production progress, the number of situations in which atomic weapons can be effectively employed in battle areas."

Dean added a prediction that the U. S. would develop atomic-powered airplanes within a decade.

Senator Brien McMahon, chairman of the Joint Congressional Committee on Atomic Energy, has presented to Congress a proposal for an increase in the atomic-weapons appropriation to $6 billion a year, about six times the appropriation the AEC received last year. His proposal was supported by Secretary of Defense Robert A. Lovett and the Joint Chiefs of Staff. McMahon argued that both on military and economic grounds atomic arms should replace conventional arms in U. S. defense plans.

"At the rate we are moving," he said, "I can see ahead only two ultimate destinations: military safety at the price of economic disaster or economic safety at the price of military disaster." The solution he proposed was "an atomic army, an atomic navy and an atomic air force in place of the conventional defenses we now maintain to the tune of 50 or 60 billion dollars a year."

Jeep

ANOTHER nuclear reactor, the second built independently in a small nation, has just been completed in Norway. (The other is in France.) Located at Kjeller, near Oslo, it was designed by Norwegian and Dutch scientists and is jointly owned by the two governments and Norsk Hydro, a Norwegian electric-power company. The Dutch contributed uranium they had hidden away from the Germans during the war; Norwegian electric power yielded the heavy water that serves as moderator. The reactor, a small, 300-kilowatt plant, is nicknamed Jeep by analogy with the British Gleep and the Canadian Zeep.

The builders of Jeep, led by physicists

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Gunnar Randers and Odd Dahl, had never seen a pile. They worked entirely from nonsecret data and took five years to complete their project. When the U. S. released information on some of its early reactors last winter, Randers and Dahl found that they had virtually duplicated the uranium heavy-water tank built at Argonne National Laboratory in 1944. The Kjeller reactor generates the same power as the one at Argonne, but it cost the equivalent of only $500,000, far less than any other reactor of comparable output. It will be used for the production of isotopes and the development of atomic power for ships, in which both Norway and the Netherlands, as maritime nations, are especially interested. The Dutch and Norwegian workers have promised to keep in touch with the U. S. Atomic Energy Commission and to "try not to publish details they don't want published."

Randers and Dahl consider their success proof that a small nation can build a reactor at reasonable cost with knowledge generally available. Among the other nations that have announced plans for reactors are India and Brazil, both of which possess large deposits of thorium.

Lawrence's Color Tube

A COLOR-TELEVISION tube that can receive color programs transmitted by either the CBS or the RCA system, or in black-and-white, has been developed by Ernest O. Lawrence, inventor of the cyclotron. The University of California physicist worked up the tube in his hobby shop in his spare time. He said that he started working on it in response to his children's questions about television.

The most important advantage of the tube is the simplicity of producing it. Paramount Pictures Corporation, who will manufacture the tube, claim that any manufacturer of standard tubes can turn it out at a cost no greater than that of black-and-white tubes. The color is produced by phosphors printed in alternate lines of blue, green and red on a glass plate just behind the viewing screen. A wire grid between the electron source and the phosphor-coated plate alternately guides the electrons to the proper phosphor, switching colors at the same rate as the transmitter that is broadcasting the signals. This switching rate is adjustable to conform to the dot-sequential or the field-sequential system.

Among the scientists who cooperated with Lawrence on the tube were his physicist colleagues Luis Alvarez and

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Long Life

HOW long can a germ cell stay alive? Botanists have been skeptical of the stories about plants grown from seeds that have been entombed for thousands of years; there has been no definite proof of seeds remaining viable for more than 150 years. But the new carbon-14 dating method has just shown that seeds can live much longer than that.

Last spring some ancient lotus seeds from a Manchurian peat deposit were planted in a greenhouse of the National Capital Parks in Washington. The seeds were covered with shells so thick they had to be filed off or removed by soaking for hours in concentrated sulfuric acid. Two of the seeds sprouted into plants. Some of the seed samples were then sent to Willard Libby of the University of Chicago for an estimate of their age by measurement of their radioactive carbon 14. Libby found that the seeds were at least 800 years old.

Aspirin and the Hormones

SOME Belgian and British physicians have been looking into the matter of how aspirin acts on the system, and their finding is that the drug produces its effects by a complicated chain of hormonal reactions.

Aspirin, or acetylsalicylic acid, has long been known as a painkiller and a useful medicine for rheumatic fever, where it often overcomes pain and fever as effectively as cortisone. Recently it was found that the drug increases the amount of some steroids in the urine. These effects indicated that the drug acted on the adrenal glands. But how? There were three possibilities: 1) it might stimulate the adrenals directly, as the pituitary hormone ACTH does; 2) it might stimulate the pituitary gland to secrete more ACTH; 3) it might work by some entirely different mechanism to produce results similar to those of ACTH. H. Van Cauwenberge of the University of Liége, Belgium, performed some experiments that seem to answer the question. He found that rats whose pituitaries had been removed showed no response to salicylate injections, though they responded normally to injections of ACTH. "It must be concluded," he reported in *The Lancet,* "that salicylates exert their effects indirectly through the pituitary." In other words, aspirin makes the pituitary make the adrenals work harder.

Children's Humor

A CHILD'S sense of humor is not so mysterious as many parents think. Martha Wolfenstein, a psychologist of

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the Jewish Board of Guardians in New York, studied 80 children between the ages of 5 and 12 and found that the sense of humor develops in a perfectly orderly fashion, with different types of jokes favored at different age levels.

Children under six have no ready-made jokes; they make up their own as a form of play. At six they start learning riddles, such as "Why do firemen wear red suspenders?" As they grow older they start telling more anecdotes and fewer riddles; by the age of 11 only a third of their jokes are riddles. Up to 10, girls tell more jokes than boys; after 10 it is the other way around.

Miss Wolfenstein believes that the great popularity of riddles between the ages of 6 and 10 is an expression of repressed sexual curiosity. As an example she takes one of the popular "moron" riddles: "Why did the moron tiptoe past the medicine cabinet? Because he didn't want to wake the sleeping pills." She comments: "The tiptoeing and reference to sleeping suggest that this has something to do with nocturnal investigations. The children give us a clue by their associations. They say: 'Sleeping pills put you to sleep, they don't sleep themselves.' The same thing could be said about parents at night. Thus there is here what we might call a latent riddle: 'Why are the parents at night like sleeping pills?' The moron in the joke is a fool because he doesn't know that they put you to sleep but don't sleep themselves. But is he such a fool? Why is he tiptoeing? Perhaps he knows after all that they don't sleep and is tiptoeing around to find out what really happens. The moron represents the child both in not knowing something and also, insofar as he does know something, playing dumb."

Poor Baby, Rich Baby

In Great Britain a Child Health Survey directed by J. W. B. Douglas of Oxford University recently investigated the question of why infant mortality is highest in low-income families. It found that the high mortality was traceable to three chief afflictions of the poor: higher rates of premature birth, pneumonia and gastroenteritis.

The survey was based on a follow-up of 5,380 children—one out of four of all those born in Britain during a week in March, 1946. The mortality for children of professional and salaried men was 23.7 per 1,000 live births; for children of "black-coated" (*i.e.*, white-collar) workers, 30.5; for children of agricultural workers, 41.6, and for children of urban manual workers, 44.9. Thus the death rate for children of manual workers was nearly double that for children of professionals. Moreover, though all groups have shown appreciable decreases in infant mortality since 1939, the improvement has been greatest in the first two categories, so that the medical advances

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of the last decade have actually widened the gap.

Among all groups the greatest cause of death in the first month is premature birth. The rate of premature birth is 50 per cent higher in the families of wage-earners than in the families of professional and salaried workers. Douglas suggests that this excess is due to early childbearing, closely spaced births, poor prenatal care and excessive work (either inside or outside the home) during the last months of pregnancy.

From the second to the twelfth month of life pneumonia and gastroenteritis are the greatest killers—and the most class-conscious. Elimination of these infections would wipe out the class differences in mortality during that period. Death from bronchitis and pneumonia in the first six months is four times as likely among the children of manual workers as among the children of professionals. Crowded, poorly ventilated homes and greater exposure to infection are at least partly responsible, Douglas believes.

After the first year, the class differences in mortality become much smaller. But Douglas concludes his report in *The Lancet* by noting that "if all the social classes had had the same mortality rates as the well-to-do," the lives of about 10,000 infants would have been saved in Britain in 1946.

Sociology and Dance Musicians

DANCE musicians are one of the queerest human breeds, as everybody knows. A University of Chicago graduate student named Howard S. Becker decided to study their peculiarities, and he reports his findings in the *American Journal of Sociology.*

To get his material he passed himself off as a piano player for 18 months among the dance musicians of Chicago. He soon found that dance musicians live in a psychological world apart from their listeners, whom they call "squares." Becker writes: "[They] feel that the only music worth playing is what they call 'jazz,' a term which can be defined only as that music which is produced without reference to the demands of outsiders. Yet they must endure unceasing interference with their playing by employer and audience. The musician views himself and his colleagues as people with a special gift that makes them different from nonmusicians and not subject to their control, either in musical performance or in ordinary social behavior. The square, on the other hand, is thought of as an ignorant, intolerant person who is to be feared, since he produces the pressures forcing the musicians to play inartistically. The square seems to do everything wrong and is laughable and ludicrous. The 'jazz fan' is respected no more than other squares. His liking for jazz is without understanding and he acts just like the other squares; he will

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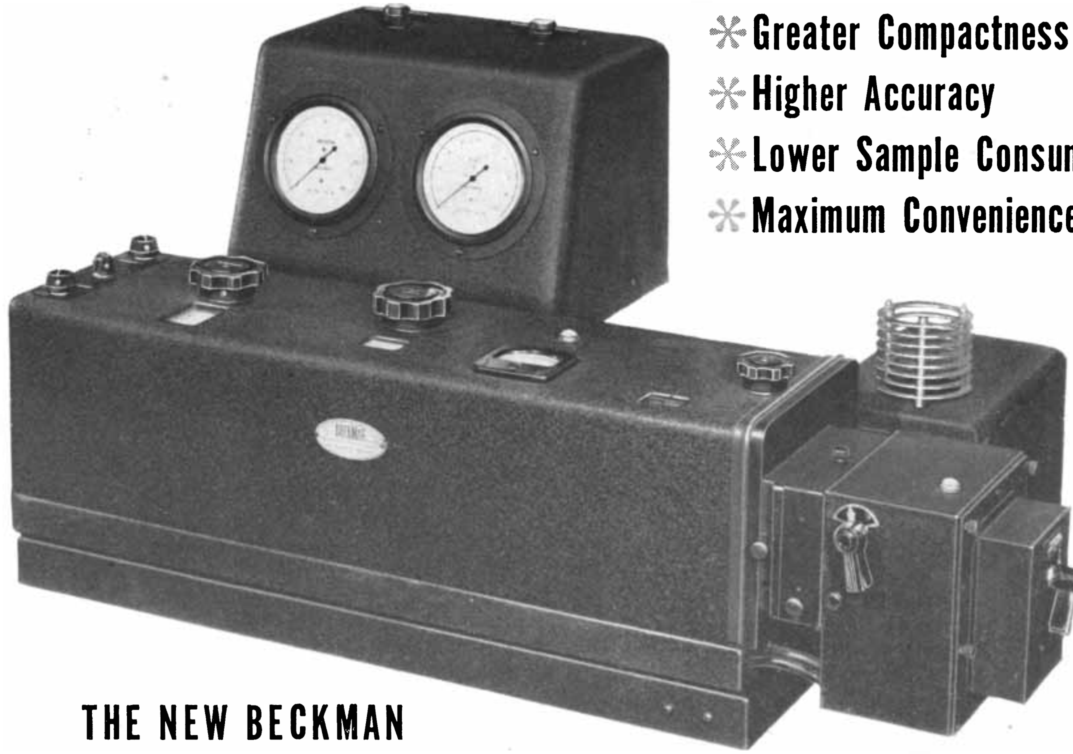

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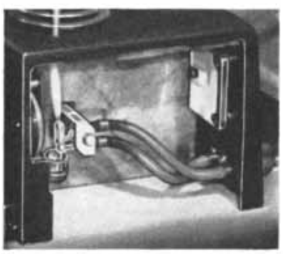

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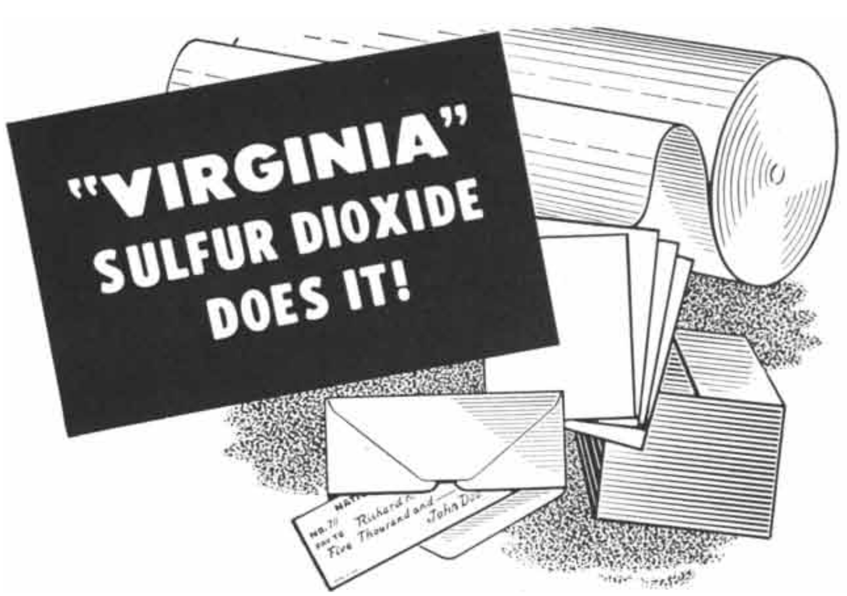

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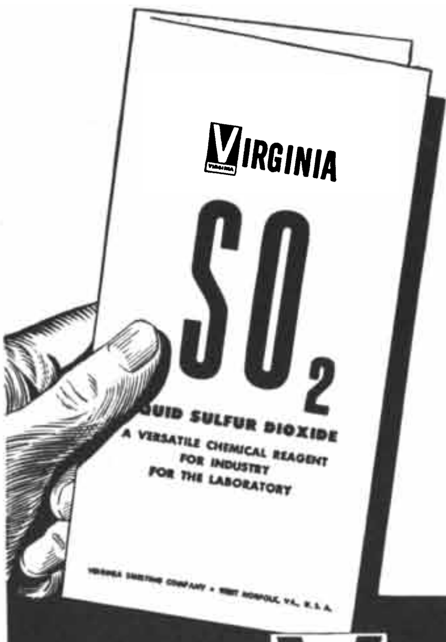

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request songs and try to influence the musician's playing."

But, as one "commercial" musician told Becker, "if you want to make any money you gotta please the squares." As a result, musicians become antisocial. They prefer to play on a platform away from the crowd and hate to play at weddings. They dress in a special way, talk an argot of their own, associate only with other musicians.

Becker concludes that their feelings are characteristic not of the artistic temper as such but rather of the service occupation, where the professional comes in direct contact with the consumer. The consumer knows and cares much less about the work than the professional, yet he can dictate how the work shall be done. "Conflict arises," says Becker, "from the professional's feeling that outsiders neither are capable nor possess the right to judge their performance." He suggests that people in other service occupations may have similar conflicts.

The Physiology of Emotions

When a person is excited, his pulse rate and blood pressure are likely to go up, his muscles to tense and he is likely to break out in a cold sweat. Subjectively we recognize various kinds of emotional excitement—fear, anger, disgust, and so on. But does the physiological mechanism make a distinction among them; does the body react differently, say, to fear and anger? Psychologists have generally assumed that it does not. A recent study shows, however, that fear and anger are not quite the same thing physiologically.

Albert F. Ax of the University of Washington chose these two emotions for study because they "have been most often described as having identical physiological reactions and because they can both be stimulated in the laboratory without too much difficulty." Thirty-two human subjects were thoroughly wired up to provide a continuous record of 10 different physiological reactions. The stimulus used to produce fear was a slight electric shock, followed by an alarming statement by the experimenter that something had gone wrong and the subject had nearly been electrocuted. The stimulus to anger was rude, abusive behavior by Ax's assistant. Ax found that fear produced more sweating, a higher pulse rate and a greater rise in blood pressure during the contracting part of the heartbeat. Anger produced more of a drop in palm temperature and a greater rise in blood pressure during the expanding phase of the heartbeat.

These differences in reaction patterns, says Ax, parallel differences in the effects of injecting two forms of adrenalin. The fear reaction is similar to that produced by epinephrine, anger to that produced by nor-epinephrine.

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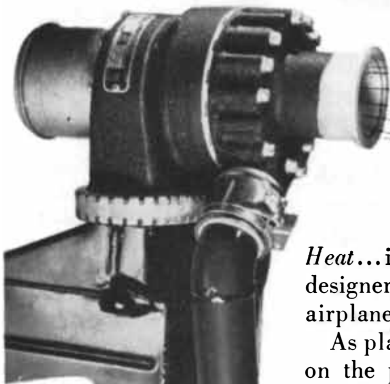

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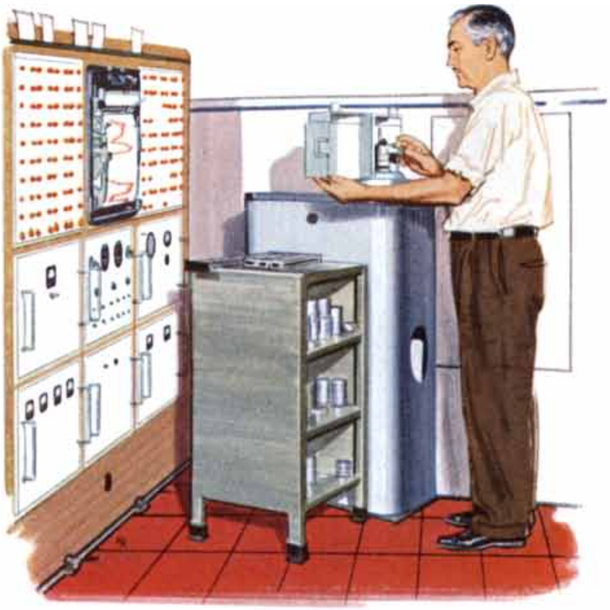

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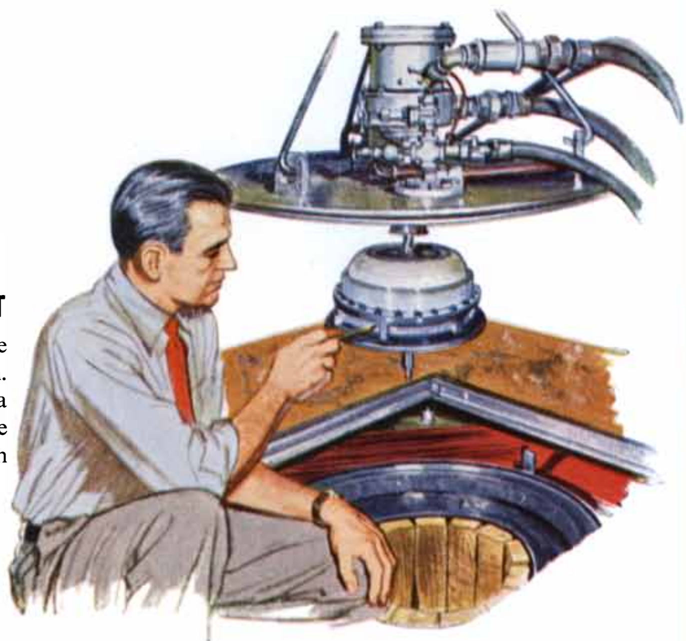

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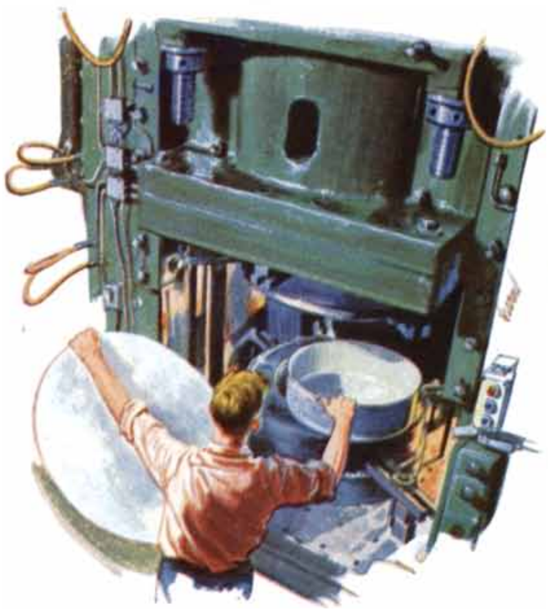

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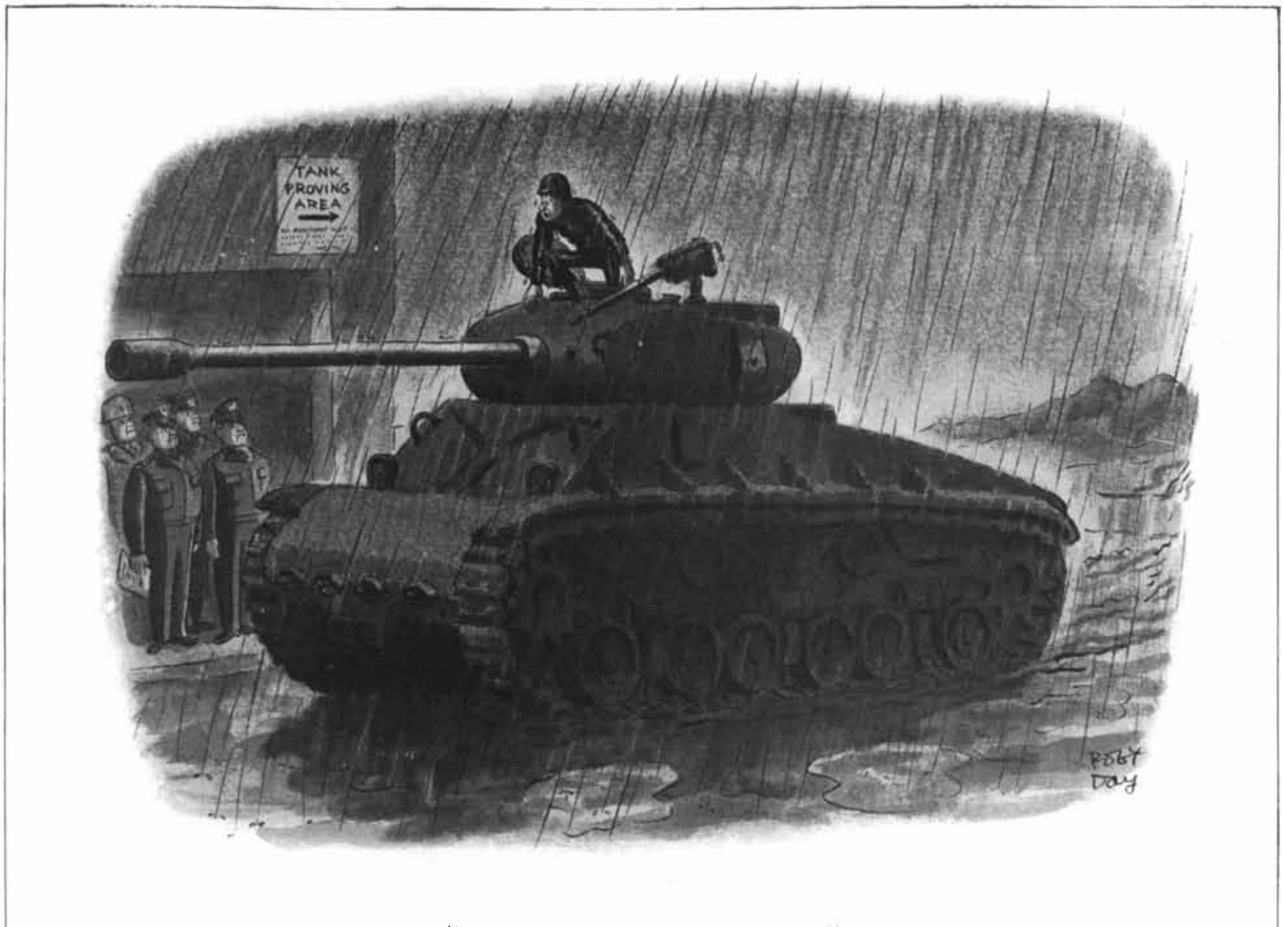

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VOLCANOES

The awe-inspiring mountains of melted rock reflect the dynamic activity of the earth's crust. Although they have caused much death and destruction, they are also useful and could be more so

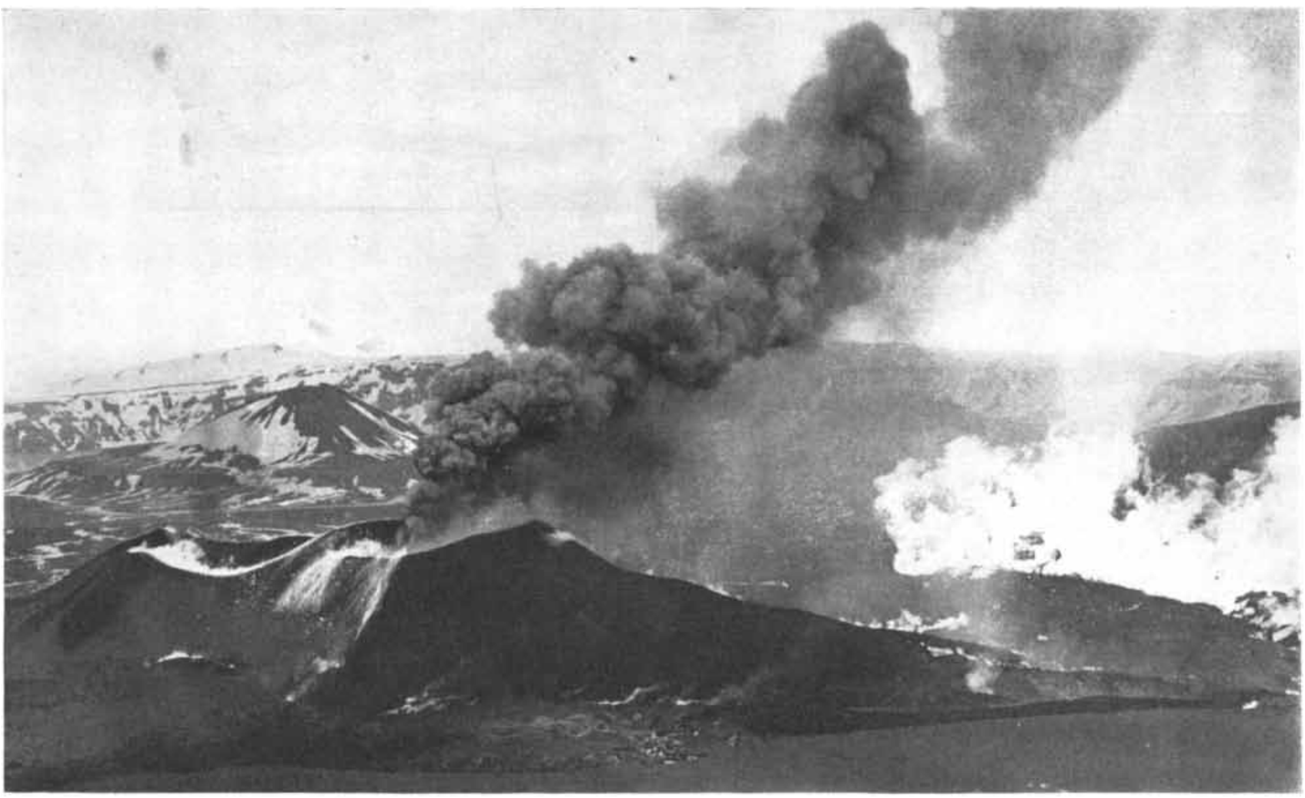
by Howel Williams

DURING the past 400 years some 500 volcanoes have erupted from the depths of our planet. They have killed 190,000 people; the most destructive eruption, that of Tamboro in the East Indies in 1815, wiped out 56,000 in one gigantic explosion. Volcanoes understandably have always terrified mankind. Yet it should not be forgotten that they also play a constructive role for our benefit. It is not merely that volcanic eruptions have provided some of the world's richest soils—and some of our most magnificent scenery. Throughout geologic time volcanoes and their attendant hot springs and gas vents have been supplying the oceans with water and the atmosphere with carbon dioxide. But for these emanations there would be no plant life on earth, and therefore no animal life. In very truth, but for them we would not be here!

What exactly are volcanoes, and how are they formed? Obviously they are symptoms of some kind of internal disorder in the earth. The eruptions we see at the surface are only small manifestations of great events going on below, events about which we can only speculate. We do, however, have some clues to what may be happening—a few tantalizing points of light that make volcanoes a most fascinating field of study.

The first clue lies in the location of the volcanic regions on the world map. We know that the active volcanoes are concentrated in parts of the world where earthquakes are most common, particularly in those areas where the earthquakes have a tendency to originate at a level about 60 miles down in the earth's crust. This suggests that volcanoes are connected with disturbances in the earth at that depth. Secondly, we know that most of the world's volcanoes are in young mountain belts, that is, where the face of the earth has recently been wrinkled and cracked.

Tens of miles below the surface of the earth there is an extremely hot shell of glassy or crystalline material. This solid



SMALL VOLCANO ERUPTS from the caldera of the larger Okmok volcano on Umnak Island in the Aleutians. A caldera is a large crater that is formed when a volcano ejects so much material that its cone collapses.

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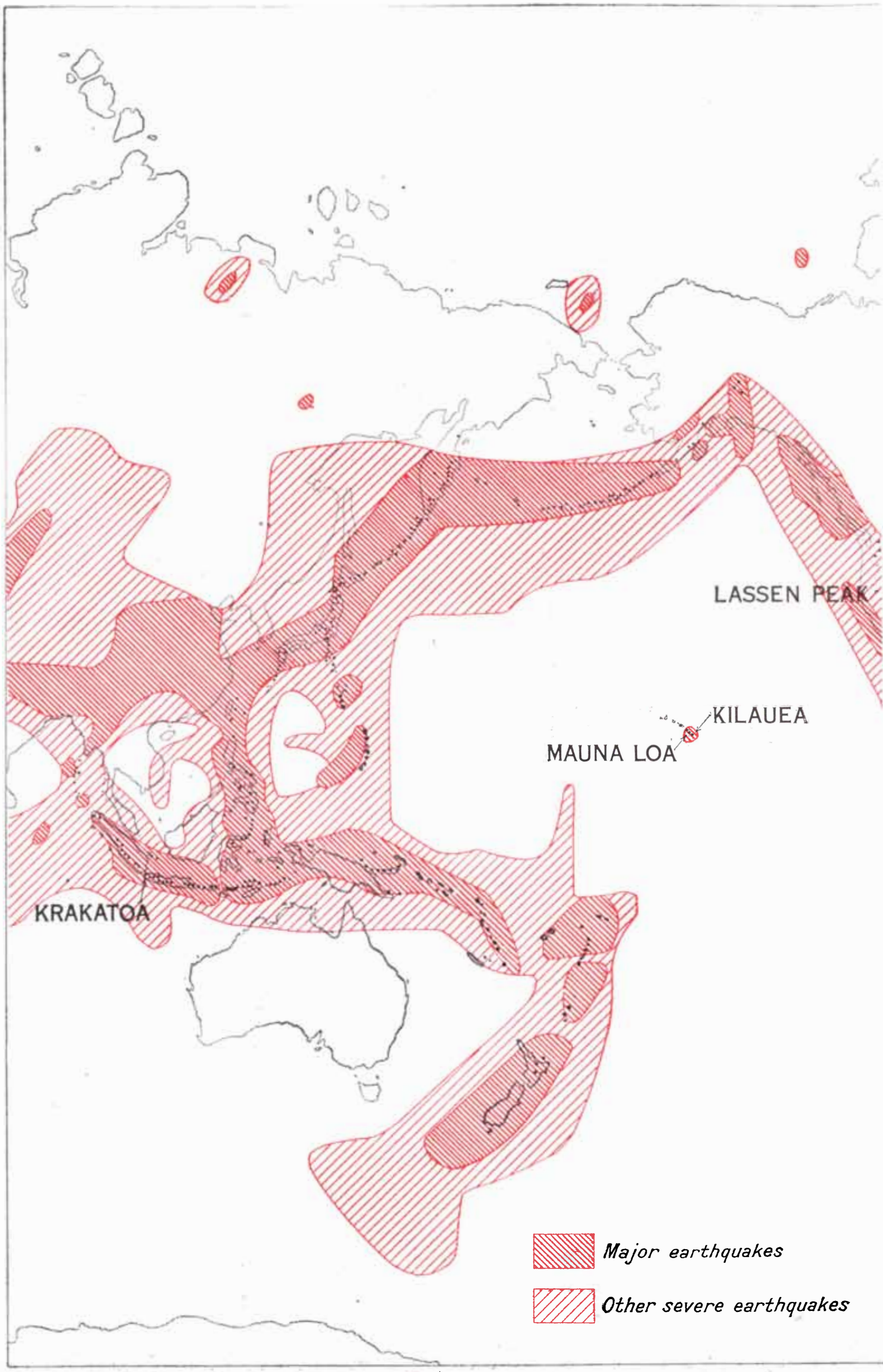
material becomes liquefied if the pressure on it is reduced or the temperature rises. The pressure may be reduced by the bending or cracking of the rocks lying above it; the temperature may be increased by radioactive heating. In either case, the liquefied material forms a fluid mass, called magma, that is lighter than the overlying rocks, and it tends to rise wherever it finds an opening. If there are fractures in the rock that let it rise directly to the surface of the earth, it comes out quietly as a flood of fluid lava. Sometimes it reaches a roof of solid rock a few miles below the earth surface; in that case it may spread sideways and form a reservoir of hot magma that erupts into one or more vigorous volcanoes where it finds cracks in the roof.

Disturbances of the earth in regions of mountain-building produce conditions favorable to formation of molten magma and its escape to the surface. To be sure, not all young mountains have volcanoes; there is none in the Alps or the Himalayas. These mountains have an unusual structure that suppresses eruptions. They were formed by low-angle thrusting and overfolding of the earth's skin; one layer is piled on another, making a thick cover of rock through which magma does not escape. In the mountain belts where volcanoes do occur there is less overlapping of the rock layers; these mountains have steep fractures that go deep into the earth.

The geological record shows that volcanic activity is most widespread during the period of adjustment that follows the formation of mountain ranges. After the great spasms of folding and uplifting that create the mountains have subsided, the earth's crust tends to settle down to a condition of stability, and it is during this stage of adjustment that the eruption of continental volcanoes reaches a maximum.

Types of Volcanoes

A volcano is usually pictured as a cone with a crater at the top which from time to time blasts forth streams and glowing bombs of lava and shattered rock. Actually there are almost as many types of volcanoes as there are landscapes. They range from the explosive kind to the sluggish and gentle, and they come in a great variety of shapes and sizes. The form a volcano takes depends not only on the structure of the earth below it but also on the physical nature of the erupting magma, or lava. One of the most important factors determining the shape and activity of a volcano is the magma's viscosity. This varies greatly; some lavas are so fluid that they flow over the ground at more than 20 miles an hour; others are so viscous that they move at little more than a snail's pace, and even the strong blow of a pick scarcely dents their incandescent surfaces.



VOLCANOES AND EARTHQUAKES tend to occur in the same parts of the world. On this map the outlines of the land are shown in gray. The regions in

Usually the more fluid the magma, the more extensive is the flow of lava, the flatter the resultant edifice and the fewer and weaker the explosive eruptions. A volcano formed mainly by quiet effusions of liquid lava generally has the shape of an inverted saucer. The volcanoes of Hawaii are of this kind, and they illustrate various stages in its growth. During the early stages of formation of such a volcano copious streams of extremely hot and fluid basalt are discharged from two or three intersecting rifts in the rock at the earth's surface. Where the rifts intersect a small summit-crater forms. As the volcano

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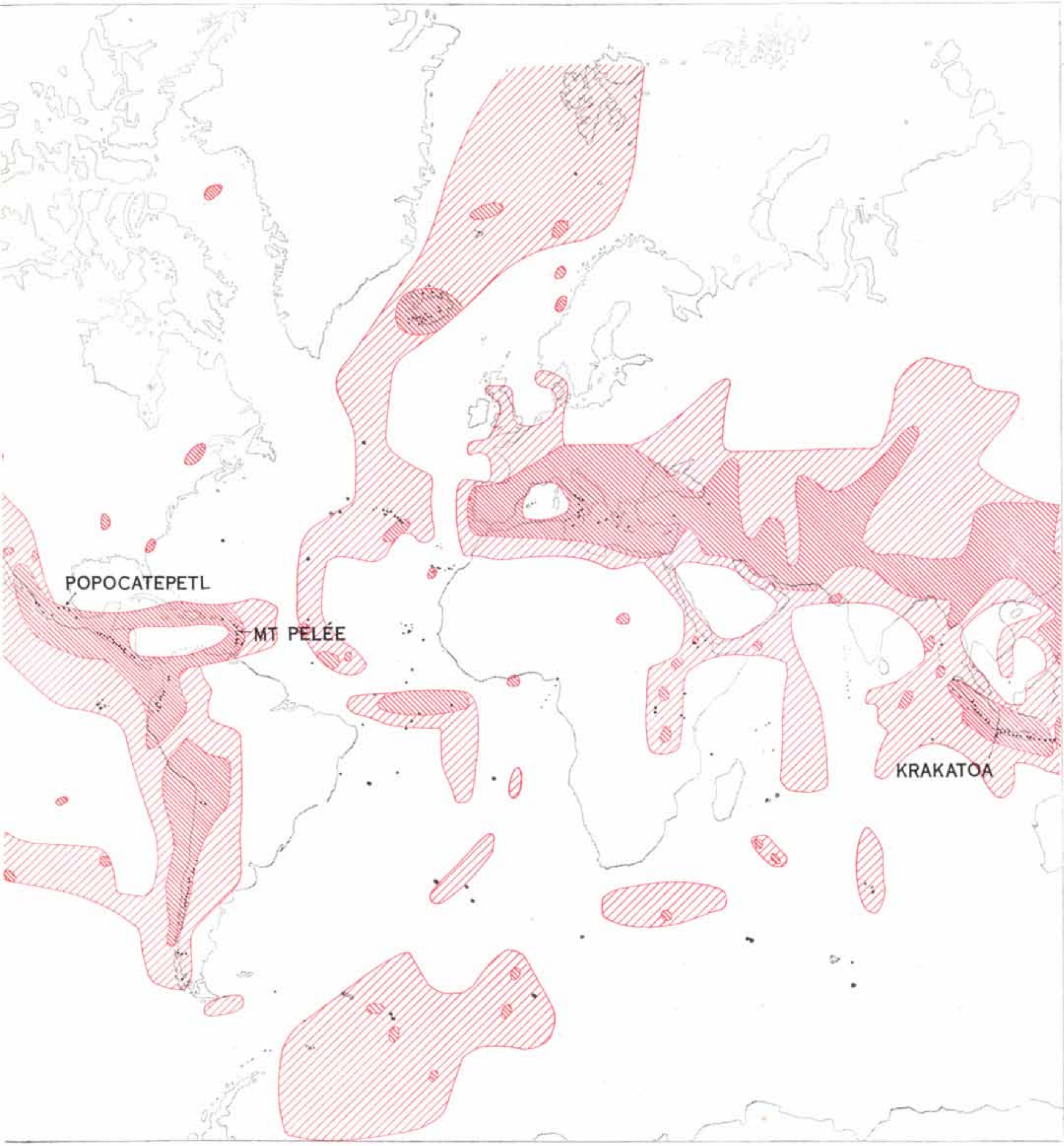

which major or severe earthquakes have taken place are depicted in red. The volcanoes are shown as black dots. Six discussed in the text are labeled. The map was prepared by the American Geographical Society.

grows to maturity, the summit crater is much enlarged by gradual collapse of its surrounding walls, and lines of pit-craters develop along the rift-zones cutting the flanks of the volcano. The Hawaiian volcanoes Kilauea and Mauna Loa are now in this stage of evolution. Later, in the volcano's old age, new lava flows fill up and obliterate the summit- and pit-craters. Eruptions take place at longer intervals; the lavas become more varied in composition, and, because most of them are more viscous than the earlier flows and therefore stick on the sides of the mountain near the top, the upper part of the volcano becomes increasingly steep. At the same time, because the longer intervals of rest permit development of greater gas-pressure in the viscous magma, explosive activity becomes more frequent and violent. Cones of ash grow in clusters on the higher flanks of the mountain. Mauna Kea and Kohala on Hawaii are now in this stage of old age, and Hualalai has lately entered it.

At the opposite extreme there are vol-

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MAUNA LOA in Hawaii is shaped like an inverted saucer. This type of volcano results from successive outpourings of relatively liquid lava. In foreground are cinder cones on the flank of the older volcano Mauna Kea.

canoes formed by lava squeezed out of the earth in an exceedingly viscous condition, somewhat like toothpaste from a tube. This produces a very steep-sided mountain. Indeed, the lava may be so nearly solid when it is thrust up through its "feeding pipe" in the earth that it rises as a slender obelisk, like the one that was pushed up to a height of 1,000 feet on top of the dome of the celebrated Mount Pelée in the West Indies in 1902. Lassen Peak in California is another good example of a viscous protrusion.

Other volcanoes, such as Mount Shasta and Mount Rainier in this country, Mount Mayon in the Philippines, Orizaba and Popocatepetl in Mexico and Fujiyama in Japan, are built in part by outpouring of lava and in part by the explosive discharge of fragments of rock. These so-called composite volcanoes have concave slopes that steepen to the summit. Their graceful profile rises from a wide base to a tall, slender peak. Still other volcanoes are composed wholly of explosion debris. This type of volcano is likely to grow very rapidly, and it usually builds a cone with even slopes.

It may take a million years or more to build a giant volcano of the Hawaiian type, such as Mauna Loa, or one of the composite variety such as Mount Shasta. The viscous kind grows much faster; the steep dome at the top of Mount Pelée, for instance, mushroomed to a height of 1,300 feet within 18 months. But the speed of growth of explosive volcanoes is even more spectacular. The young Mexican volcano of Parícutin was 1,200 feet high on its first anniversary. Monte Nuovo, which grew on the edge of the Bay of Naples in 1538, rose to a height of 440 feet in one day. The record goes to a volcano that sprang up suddenly from Blanche Bay on the island of New Britain in 1937. It attained a height of no less than 600 feet within the first 24 hours; when it stopped growing several days later, it was 742 feet high.

Plateaus

Volcanoes of the kinds we have been considering so far are all made by the discharge of material through a more or less cylindrical conduit in the earth's crust. Such a discharge generally produces a cone, a dome or a sharp, slender spine. But there are also volcanoes in which the magma issues from long fissures in the crust. In that case the flood of lava or ash usually produces a plateau, the nature of which depends on the composition of the escaping magma. There are two general kinds of magma, as every geology student knows. One is the type represented by basalt—a dark, heavy material, poor in silica and rich in lime, iron and magnesia. Basalt is believed to form a deep-seated, world-wide layer under the oceans and continents. The other is a lighter material, rich in silica and alkalies; its most typical variety is rhyolite. A basaltic magma is usually hotter and more viscous than a rhyolitic one.

Between 10 and 20 million years ago colossal eruptions of basaltic lava poured out of a region of fissures in the Pacific Northwest. There was a series of eruptions, sometimes separated by long quiet intervals, so that soils and even forests grew on one flow before being buried by the next. All together some 100,000 cubic miles of fluid lava erupted from the earth and spread over the surface; flow piled on flow until what had been a mountainous terrain was completely buried by a plateau of lava more than 5,000 feet thick and about 200,000 square miles in extent.

The rhyolitic type of fissure eruption, on the other hand, is exemplified by one that took place in 1912 in the Valley of Ten Thousand Smokes in Alaska. In that year swarms of cracks suddenly opened on the valley floor, and a gas-charged, effervescent magma foamed to the surface. It was loaded with droplets and clots of incandescent liquid, which cooled to fragments of cellular glass and lumps of white pumice. So mobile was the mixture that it poured for long distances down the valley in the form of glowing avalanches. Since then many other examples of such deposits have been discovered in this country, notably in Nevada and Utah, on the Yellowstone Plateau, in the Globe district of Arizona,

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LASSEN PEAK in California has much steeper sides than Mauna Loa. This type of volcano results from eruptions of more viscous material. Lassen Peak was last active in 1917; the cinder cone in foreground, in 1851.

and in the Sierra Nevada and Owens Valley of California. Fissure eruptions of this kind often cause a sinking and downbending of the earth's crust; they account for some of the largest volcanic basins in the world, including those that hold the beautiful lakes of Taupo in New Zealand, of Toba in Sumatra and of Ilopango in El Salvador.

Calderas

One of the most impressive volcanic structures is the type known as a caldera. Calderas are huge pits, shaped like a crater but much larger, usually several miles across. They are also made in a very different way. A crater is the opening through which a volcano discharges its products; it is built during the construction of the cone. A caldera, on the other hand, is a product not of construction but of collapse, for it is created by the cave-in of a crater's sides. In other words, few large volcanoes blow their heads off; usually they are decapitated by engulfment of their tops.

What brings about such a collapse? In composite volcanoes—those built partly of flows and partly of exploded fragments—tremendous explosions of pumice and ash may disembowel the cone and remove support for the volcano's top. The walls of the crater at the summit then founder into the depths. The majestic Crater Lake of Oregon was formed in this way. A 12,000-foot peak which we now call Mount Mazama once stood there. Some 6,500 years ago volcanic eruptions blew 10 cubic miles of pumice out of its subterranean feeding chamber, leaving a caldera six miles wide and 4,000 feet deep. In the gigantic explosion of Krakatoa in 1883, which expelled some four and a half cubic miles of pumice, the tops of the old volcanoes foundered into the ocean. This produced a caldera five miles wide and propelled a catastrophic tidal wave that drowned 36,000 people on the adjacent coasts of Java and Sumatra.

On the present site of Vesuvius there once stood a much higher volcano. It had lain dormant for so long that vineyards extended to the summit. During this long interval of rest gas pressure accumulated in the underlying magma-chamber. In A.D. 79 it suddenly found release in a succession of terrific explosions. First the lighter, gas-rich head of the magma-column was expelled as showers of white pumice. These buried the town of Pompeii. Then came the debris of a heavier and darker magma from lower levels of the feeding chamber. This clinkerlike material, water-soaked from heavy rains, swept down the mountainsides as mudflows and demolished the town of Herculaneum. During these violent but short-lived eruptions so much magma was emptied from the volcano's reservoir that the top of the mountain collapsed, leaving a huge, semicircular amphitheatre. Today the wrecked volcano is called Monte Somma; Vesuvius is the younger cone that has risen from the floor of its caldera.

Travelers through the Southwest have seen the giant stone towers that beautify the landscape of the Navajo Reservation, and many have wondered how they were formed. They are actually "embryonic" volcanoes that resulted from short-lived, powerful eruptions. Sometimes gas pressure generated by a body of magma thousands of feet underground blasts cylindrical passages to the surface and hurls out pulverized rock. Such eruptions form explosion pits surrounded by low rims of debris. Erosion may gradually destroy the cones and reveal the cylinders, or pipes, through which the material was fed to the surface. If the explosion material within the pipe offers more resistance to erosion than does the enclosing rock, a time comes when the pipe is left standing alone as a more or less cylindrical tower. Alternatively, if the filling in the pipe is less resistant than the walls, a circular basin persists at the surface. In the Swabian Alps of Southern Germany no fewer than 125 of these embryonic volcanoes occur within an area of about 200 square miles. The same phenomenon is responsible for the famous diamond pipes of South Africa.

Occasionally strong gas explosions

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CRATER LAKE in Oregon is a classic volcanic caldera. On this site once stood a 12,000-foot volcano. About 6,500 years ago eruptions expelled 10 cubic miles of pumice from beneath the volcano, which then collapsed into its own feeding chamber (*see opposite page*). Wizard Island, the small body of land that appears in this photograph on the far side of Crater Lake, is a cinder cone that was built up later on the floor of the caldera.

take place at such great depth that the pressure is not strong enough to drill a passage to the surface. Though these muffled "cryptovolcanic" explosions expel no lava or ash, they do deform the earth surface, generally producing a circular depression from two to four miles wide with a central body of uplifted rocks. Walter H. Bucher of Columbia University, our chief authority on cryptovolcanoes, has investigated these peculiar structures in several localities in the U. S., notably at Jeptha Knob, Ky., the Serpent Mound, Ohio, and the Wells Creek Basin of Tennessee.

Steam Explosions

In many volcanic eruptions ground water plays an important part, for the sudden contact of ground water with rising magma produces steam and a violent explosion. This was the cause of a series of strong blasts from the Kilauea volcano in Hawaii in May, 1924. Lava drained from the feed pipes through fissures that opened far down on the sides of the volcano. Many avalanches then tumbled into the pit from the walls and ground water rushed into the empty conduits. The conversion of the water to steam generated enough pressure to blow out the plug of avalanche debris in a series of violent blasts. In 1888 the Japanese volcano of Bandai, which had long been quiescent, erupted with alarming violence. Almost half of the mountain was destroyed and 27 square miles of land was devastated by avalanches resulting from steam blasts that lasted only a few minutes. Presumably ground water had found sudden entry to the hot interior of the dormant volcano.

How much energy is released in a volcanic explosion? Many calculations have been made to determine this, in terms of gas pressures, on the basis of the heights to which eruption clouds ascend and the initial velocities at which bombs are erupted. During explosions of particular violence, such as that of Krakatoa in 1883, fine ash may be blown as high as 30 miles, and even in lesser eruptions it is common to see columns of ash rising 5 to 10 miles into the upper air. In most eruptions the gas pressures range from 50 to 400 atmospheres. In the violent volcano Asama in Japan, which sometimes hurls out large bombs with a muzzle velocity of more than 800 feet per second, the gas pressures may approximate 600 atmospheres.

We have noted that the nature of an eruption depends largely on the viscosity of the magma. The viscosity in turn depends on the magma's composition, its temperature and the amount of gas it holds. The most important factor in producing eruptions probably is the gas. Without gas a magma becomes inert; it can neither flow nor explode. Once the magma, impelled by its relative lightness, has risen from the depths, it reaches a level not far below the surface where the major role in its further advance is played by the effervescence and expansion of bubbles of gas.

The Powerful Charge

What is this gas, this "eruptive element *par excellence*"? In order of importance the gases originally present in the magma seem to be hydrogen, carbon monoxide and nitrogen, with lesser amounts of sulfur, fluorine, chlorine and other vapors. But in the cloud of gas that emerges from a volcano well over 90 per cent is water vapor, with carbon dioxide next in abundance. How much of this

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water vapor is due to oxidation of hydrogen in the magma, how much is ground water and how much is derived from water-bearing rocks surrounding the magma reservoirs at depth is unknown. Some idea of the prodigious quantities of gas given off from some volcanoes may be gained from the fact that long after the glowing avalanches covered the Valley of Ten Thousand Smokes in 1912, the deposits of pumice continued to give off steam at the rate of six million gallons per second and discharged into the atmosphere some one and a quarter million tons of hydrochloric acid and 200,000 tons of hydrofluoric acid per year.

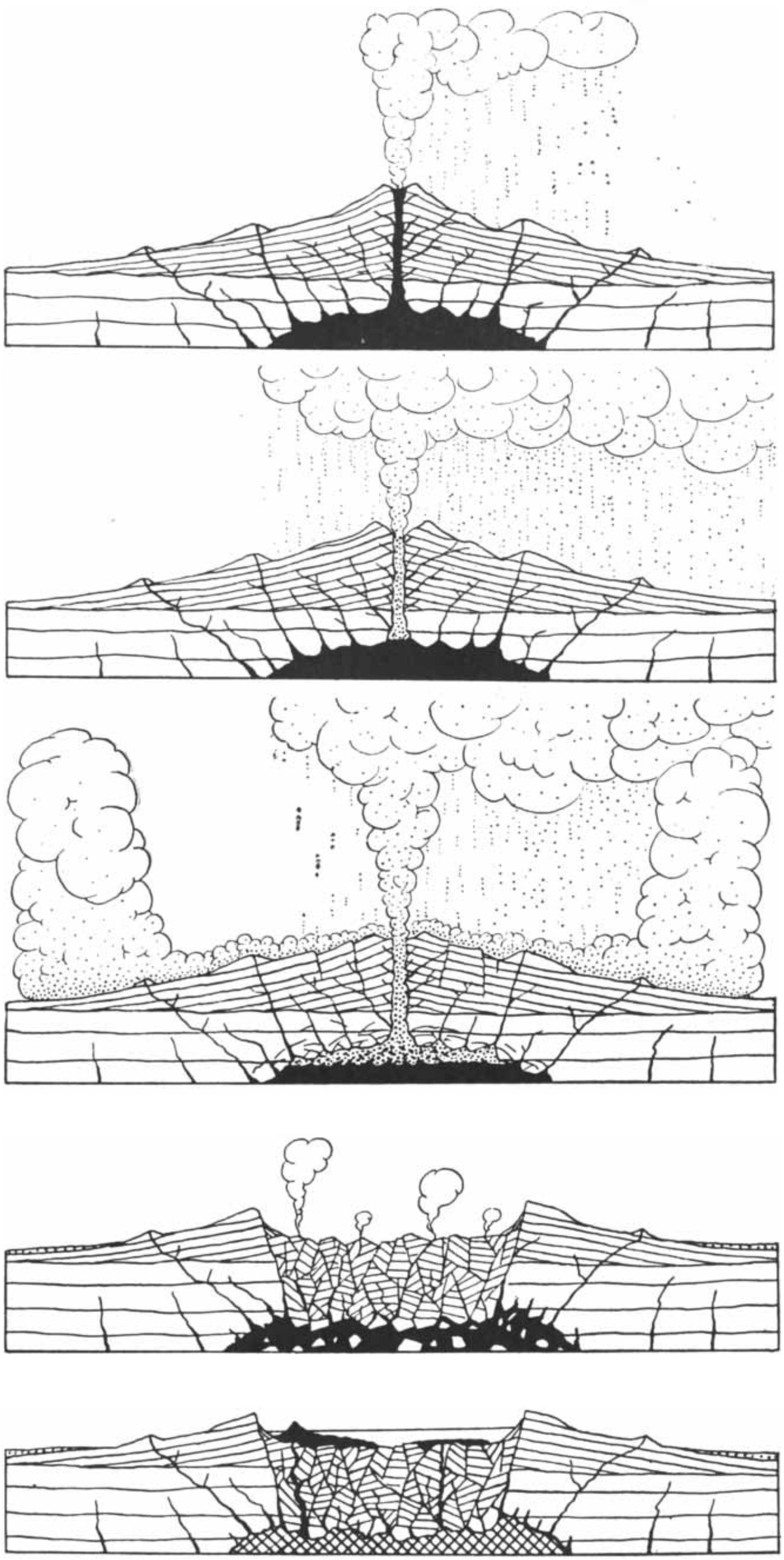
Apparently gases are important in maintaining high temperatures in magma, in keeping volcanoes alive and in awakening those that are dormant. But this is a speculative matter on which we have little information. The volcano-furnace may be kept hot by the burning of combustible gases; it may also be fueled by other heat-yielding reactions.

At all events, it is the sudden release of gas that accounts for the violent eruptions of long-dormant volcanoes. The gas may be held in solution in viscous magma until heat-yielding reactions near the surface make it boil at an accelerating and finally at a cataclysmic rate; this was the way Mount Pelée discharged the glowing avalanches that destroyed the town of St. Pierre and its 30,000 inhabitants in 1902. Sometimes gases may rise slowly to the top of a magma-column during long intervals of quiet until they either melt or blast an opening to the surface. The spectacular fountains of fiery lava that gush for hundreds of feet into the air during the opening phases of most eruptions of Mauna Loa bear vivid testimony to this upward concentration of gas in a magma-column.

The activity of Vesuvius alternates between periods of relative quiet, when it erupts sluggish flows of lava or rhythmically tosses out glowing bombs, and explosions that burst forth with tremendous strength. Vesuvius produced catastrophic eruptions in 1872, 1906, and 1944. During the intervals between these explosions minor eruptions gradually increased the height of the central conelet and therewith the height of the central column of magma. Then the sudden opening of fissures far down the sides of the mountain allowed lava to escape quickly from the lower part of the column. The draining of the column greatly reduced the pressure on the underlying magma, allowed a large amount of dissolved gas to escape suddenly from solution and thereby produced colossal explosions.

Predicting Eruptions

One object of any science, perhaps the chief, is to improve our powers of



EVOLUTION OF CRATER LAKE presumably proceeded along the lines shown in these drawings. At first magma stood high in the volcano; later it sank as eruptions of pumice increased. Then the volcano collapsed into its chamber. Finally the caldera filled with water and Wizard Island arose.

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prediction. Is it possible to say where and when volcanoes may erupt? To some extent, yes. As to where, we know that they are likely to erupt only in regions of recent mountain-building and fracturing, in or close to belts of marked earthquake activity and almost surely only in regions still or lately marked by volcanism. When? That is a more difficult question.

We can get some warning from the seismograph. An increase in the number and intensity of local quakes in a volcanic region is fairly sure to herald an eruption. For 16 years prior to the great eruption of Vesuvius in A.D. 79 the neighboring region was repeatedly shaken. For 20 days before Parícutin was born in Mexico in 1943 the surrounding country trembled from increasingly numerous and vigorous shocks. T. A. Jaggar and R. H. Finch of the Hawaiian Volcano Observatory have foretold when Kilauea and Mauna Loa would erupt, by study of the distribution of quakes caused by fissuring of the ground as magma surged toward the surface. In many volcanic regions such preliminary quakes are accompanied by subterranean rumblings and by avalanches from the walls of craters.

Next to seismic evidence, tilting of the ground around dormant volcanoes is perhaps the most reliable clue to impending activity. The underground movement of magma often causes rapidly changing tilts on the surface. Indeed, active volcanoes almost seem to breathe; they are forever swelling and subsiding as the subterranean magma fluctuates in level. By combining strategically placed tiltmeters and seismographs, it has been found possible to say approximately where, as well as when, an eruption of Mauna Loa will take place. Accurate measurement of the cracks along the rim of the Kilauea crater also serves as a guide, for these cracks are not just superficial openings caused by slippage but mark fundamental planes of weakness that go deep, and when they widen rapidly it usually means that magma is rising beneath the crater floor.

Another hint of imminent eruption may be given by strong local disturbances of the earth's magnetism. These are produced by the rise of hot, nonmagnetic magma in the volcanic pipes and by heating of the adjacent wall-rocks. Along with the magnetic changes there are commonly changes in electrical currents in the earth; these are detected, for instance, several hours before every violent explosion of the Japanese volcano Asama. Other indications of impending eruptions, though rather unreliable, are a sudden rise in the temperature of hot springs and gas vents around a dormant volcano, a pronounced increase in the volume and acidity of escaping gases, or a sharp increase in the temperature of near-surface rocks.

Some volcanoes behave in a roughly cyclic fashion, so that the likely sequence of events may be foretold. For instance, when the central conduit of Vesuvius has grown to unusual height, the danger of a flank outburst of lava followed by catastrophic explosions from the summit is at a maximum. And once an eruption has begun, it may be possible to predict fairly well what is likely to follow. Thus the late Frank Perret of the Carnegie Institution of Washington, by a careful analysis of the early phases of an eruption of Mount Pelée in 1928, was able to reassure the frightened inhabitants of St. Pierre that there would be no repetition of the awful calamity of 1902.

Volcano Control

Given sufficient warning, it is sometimes possible to minimize the damage caused by a volcano's eruption. The first recorded effort of this kind was undertaken during an eruption of Mount Etna in Sicily in 1669. The inhabitants of Catania, a town in the path of the lava pouring down the mountain, made a brave attempt to save their city by digging a channel to divert some of the lava. Unfortunately the new stream moved toward a neighboring town, the angry citizens of which soon put a stop to the efforts of the Catanians.

In recent years the U. S. Air Force has tried the experiment of checking lava flows by bombing them from the air. These tests were made on the Mauna Loa volcano in Hawaii. There are three ways in which a flow may be checked. The method of attack depends on the stage or circumstances of the eruption. Where the lava flows as an open stream between levees of partly crusted material, bombs are dropped on the levees to break them down. Some of the lava is diverted through the breaks, the pressure on the main stream is relieved and the flow may then come to a halt. Where the lava has become completely crusted over, so that the liquid portion pours through internal tubes, bombing may not only produce breaks permitting it to escape but may clog the tubes with solid debris and cause enough stirring and effervescence of gas so the liquid becomes more viscous or even congeals. Thirdly, bombardment may break down the walls of the cinder cone at the source of the flow itself, thus dissipating the energy of the eruption in many minor flows.

In Java dams have been built to divert volcanic mudflows away from villages and agricultural lands, and for some of the more active volcanoes there are danger maps indicating areas particularly liable to devastation. Installed on the walls of a canyon on the side of the volcano Merapi are thermoelectric devices which cause an alarm to ring in the volcano observatory when the air in the canyon is heated by passing lava or hot avalanches; villages in the danger zones can then be warned. In addition there are artificial hillocks in some of the villages which serve as islands of refuge from volcanic mudflows.

Harnessing the Energy

Naturally a good deal of thought has been given to how the immense energy of volcanoes might be harnessed for man's use. It has been done on a relatively minor scale in several countries, notably Italy and Iceland. In Iceland many buildings are heated by volcanic steam, and by warming fields with steam pipes the country is able to raise crops that normally grow only in more temperate climates. In Italy natural steam has been used to generate electricity since 1904. There is a region in Tuscany where steam from a deeply buried body of magma comes out of the ground through rifts and is also tapped artificially by means of wells. A typical well develops a pressure of about 63 pounds per square inch, and it yields 485,000 pounds of steam per hour at a temperature of about 400 degrees Fahrenheit. In 1941 Tuscany's harnessed volcanic steam generated 100,000 kilowatts of electric power. In addition, a large amount of boric acid, borax, ammonium carbonate, carbon dioxide and other chemicals was recovered from the vapors.

The energy available from the gas vents and hot spring waters of volcanic regions is of fantastic proportions. The hot springs and geysers of Yellowstone National Park, for instance, are calculated to give off 220,000 kilogram-calories of heat—enough to melt three tons of ice—every second. A well drilled to 264 feet in the Norris Basin there developed a steam pressure of more than 300 pounds per square inch. At "The Geysers," 35 miles north of San Francisco, there are wells which, it is estimated, could provide an average of more than 1,300 horsepower each.

Thus far little use has been made of this available energy. There are many technical difficulties, of course, in the way of large-scale utilization of volcanic power, not least among them being the acidity of many of the vapors. But one can expect with confidence that these difficulties will be largely overcome, and that more widespread use will be made of the stores of energy now running to waste.

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ATITLÁN AND TOLIMAN VOLCANOES in Guatemala are examples of composite cones formed both by the outpouring of lava and the explosive discharge of rock. On the sides of the cones are flows from fissures.

MONO CRATERS in California are plugs of solidified lava surrounded by pumice. In the southwestern U. S. the erosion about volcanic plugs has proceeded to such an extent that they are left standing as stone towers.

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Sumerian "Farmer's Almanac"

The recent discovery of an inscribed clay tablet at the site of an ancient city near modern Baghdad has made possible the translation of a 3,500-year-old agricultural handbook

by Samuel Noah Kramer

A SMALL clay tablet recently discovered by an American expedition in Iraq has made possible the restoration of a 3,500-year-old document which is of prime importance to the history of agriculture. Sponsored jointly by the Oriental Institute of the University of Chicago and the University Museum of the University of Pennsylvania, the expedition found the cuneiform inscription at the ancient Sumerian site of Nippur, not far from modern Baghdad, during its last excavating season in 1949 and 1950.

Upon its arrival in the laboratory of the University Museum the tablet, a tiny clay slab three inches by four and a half inches, was in very poor condition. After it was baked, cleaned and mended, however, practically its entire text became legible. It was found to contain 35 lines from the middle of an agricultural handbook, of which eight other fragments and tablets had previously been discovered. The new piece made possible a trustworthy restoration of the text as a whole.

The restored document, 108 lines in length, consists of a series of instructions addressed by a farmer to his son. It constitutes a complete guidebook for the year's agricultural activities, beginning with the inundation of the fields in May and June and ending with the cleaning and winnowing of the freshly harvested crops in the following April and May. Hitherto only two similar farmer's "almanacs" have been known from ancient days: Virgil's famous and poetic *Georgics* and Hesiod's *Works and Days*. The latter, by far the earlier of the two, was probably written in the eighth century B.C. The newly restored Sumerian clay document was inscribed about 1700 B.C., and thus antedates Hesiod's work by approximately a millennium.

THE SUMERIAN farmer's almanac begins with the line: "In days of yore a farmer gave [these] instructions to his son." The directions that follow concern all the important labors a farmer must perform to insure a successful crop. Since water was a prime essential for the tilling of Sumer's parched soil, our ancient mentor started with a passage concerning irrigation. Care was to be taken that the water did not rise too high over the field; when the water subsided, the wet ground was to be carefully guarded from trampling oxen and other transgressors. The field had then to be cleared of weeds and stubble and fenced in.

The farmer was now counseled to have his household and hired help prepare the necessary tools and containers. He had to have an extra ox for the plow. Before beginning to plow he had the ground broken up twice by the mattock and once by the hoe. Where necessary the hammer was used to pulverize the clods. The farmer was further admonished to stand over his laborers and see to it that they did not shirk their work.

The actual plowing and sowing could now begin. These tasks were carried on simultaneously by means of a seeder; that is, a plow with an attachment which carries the seed from a container through a narrow funnel down to the furrow. The farmer was instructed to plow eight furrows to each strip of approximately 20 feet. He had to see that the seed was placed at an even depth, or, as the almanac puts it: "Keep an eye on the man who puts in the barley seed that he make the seed fall two fingers uniformly." If the seed failed to penetrate the earth properly, he had to change the share, "the tongue of the plow." According to our ancient expert there were several kinds of furrows. He advised in particular: "Where you have plowed straight furrows plow [now] diagonal furrows; where you have plowed diagonal furrows plow [now] straight furrows." Following the sowing the furrows had to be cleared of clods so that the sprouting of the barley would not be impeded.

"On the day when the seed breaks through the ground," says the Sumerian handbook, the farmer should say a prayer to Ninkilim, the goddess of field mice and vermin, lest these harm the growing grain; he should also scare away the birds. When the barley had grown sufficiently to fill the narrow bottoms of the furrows it was time to water it; and when it was dense enough to cover the field like the "mat in the middle of a boat," it was time to water it a second time. A third time he is to water its "royal" grain. Should he then notice a reddening of the wet grain, it was the dread *samanu* disease. If the crop showed improvement, he was to water it a fourth time, and thus get an extra yield of about 10 per cent.

The time had now come for harvesting. The farmer was cautioned not to wait until the barley had bent under its own weight but to cut it "in the day of its strength," that is, at just the right moment. Three men worked as a team on the standing grain: a reaper, a binder and a third whose duties are not clear.

The farmer then threshed the grain by driving an oxcart back and forth over the heaped-up grain stalks for a period of five days. Following an appropriate prayer the grain was winnowed with pitchforks, laid on sticks and freed of dirt and dust. The document closes with the statement that the agricultural rules it lays down are not the farmer's own, but those of the god Ninurta, the son and "true farmer" of the leading Sumerian deity, Enlil.

SO MUCH for a sketch of the contents of what is probably the first farmer's handbook in man's recorded history. In order that the reader may taste the real flavor of the document, however, I append the following literal translation of its more intelligible passages. The reader is asked to bear in mind that the renderings are in some cases highly tentative, since the text is full of obscure and perplexing technical terminology. The translation has been worked out provisionally by Benno Landsberger and Thorkild Jacobsen, leading cuneiformists of the Oriental Institute of the University of

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Chicago, and the present writer; it will no doubt be considerably improved over the years as our knowledge of Sumerian language and culture deepens:

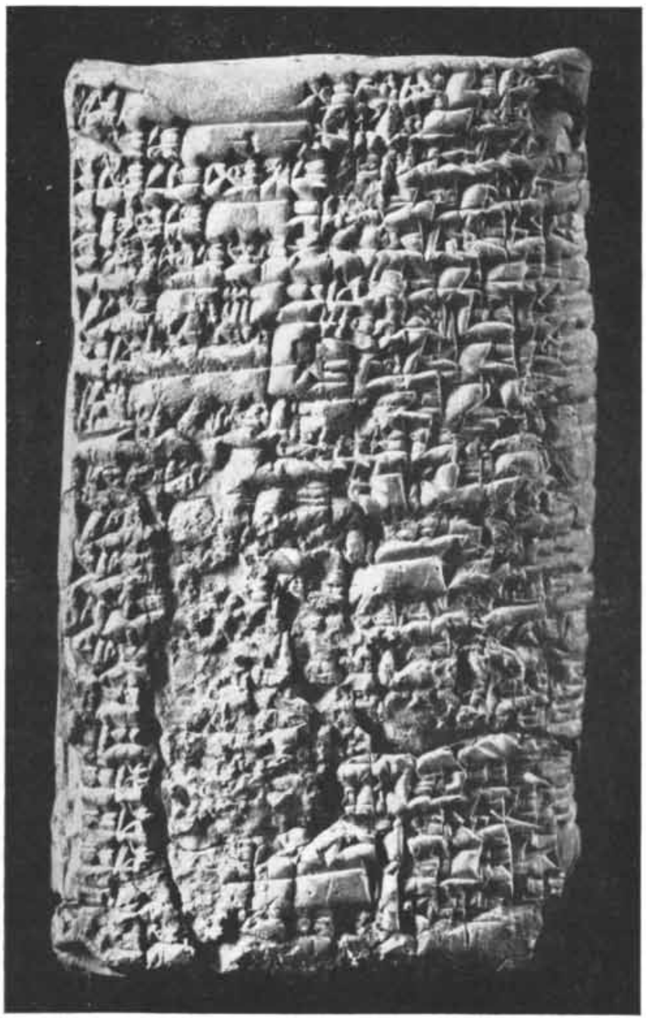
"In days of yore a farmer gave [these] instructions to his son: When you are about to cultivate your field, take care to open the irrigation works [so that] their water does not rise too high in it [the field]. When you have emptied it of water, watch the field's wet ground that it stays even; let no wandering ox trample it. Chase the prowlers and have it treated as settled land. Clear it with ten narrow axes [weighing no more than] two thirds of a pound each. Its stubble [?] should be torn up by hand and tied in bundles; its narrow holes shall be gone over with a drag; and the four sides of the field shall be fenced about. While the field is burning [in the summer sun] let it be divided up into equal parts. Let your tools hum with activity [?]. The yoke-bar should be made fast, your new whip should be fastened with nails, and the handle to which your old whip was fastened should be mended by the workers' children. . . .

"When you are about to plow the field, keep your eye on the man who puts in the seed that he let him drop the grain uniformly two fingers deep, and use up one shekel-weight [a sixteenth of a pound] for each strip of nineteen and a half feet. If the seed does not sink in properly change your knife, 'the tongue of the plow'. . . . Plow diagonally where you have plowed straight, and plow straight where you have plowed diagonally. . . . All the clods must be carried off . . . and everything should be made favorable for the sprouting grain. When the sprouting grain has broken through the earth, say a prayer to Ninkilim [the goddess of insects and rodents]. Also shoo away the birds. When the grain has filled the narrow bottom of the furrow, pour water over the top seed. When the grain stands as high as [the straw in a] mat covering the middle of a boat, pour water over it. Pour water on its [the field's] 'royal' grain. If the moistened grain turns red, it is sick with the *samanu* disease. When it produces [once again] healthy [?] grain, water it [a fourth time]; it will then produce for you one extra measure in ten of pure grain. When you are about to harvest the grain, let not the grain bend over [of its own weight]; harvest it in the moment of its ripeness. One man reaps, one bundles the grain, and one piles it up before him; let three harvest [as a team]. . . .

"Guide your [threshing] wagon; make the oxen of your threshing wagon go up over the grain mounds. Your threshing lasts five days. . . . When the grain is heaped up on the ground say a prayer for the soiled grain. When you winnow the grain with pitchforks, pay attention to the man who lifts the grain from the ground; there should be two men who lift the grain. If the grain has become soiled, lay it on sticks. Say a prayer against the harshness of the evening and night. Free the grain of impurities like the clear day.

"[These are] *the instructions of* [the god] *Ninurta, the son of Enlil.*
O Ninurta, farmer of the gods, your praise is good."

Samuel Noah Kramer is professor of Assyriology at the University Museum of the University of Pennsylvania.



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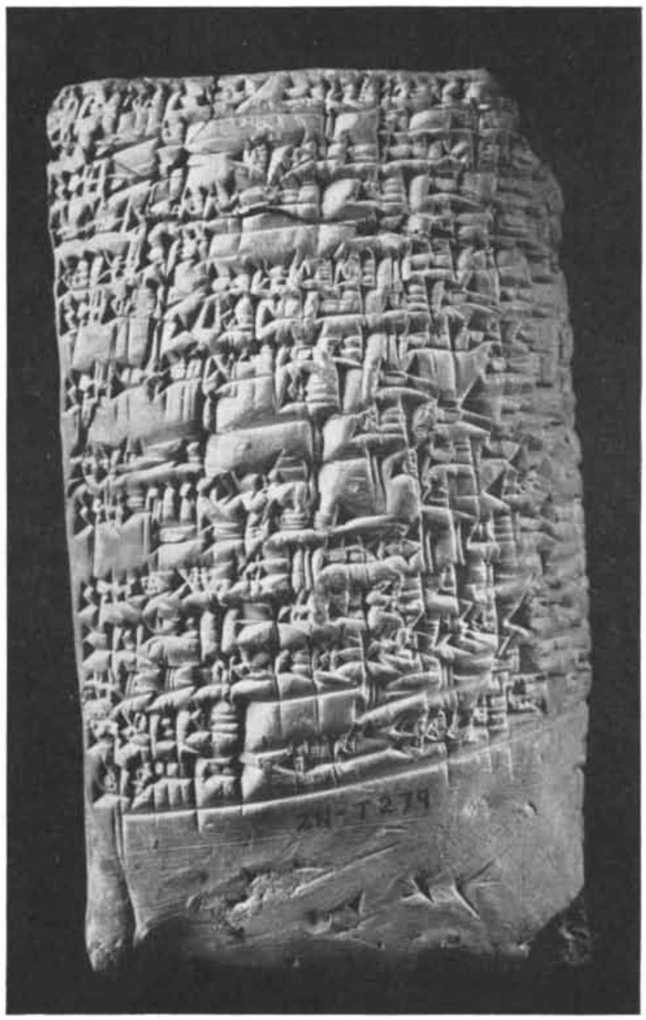

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INSECTS IN AMBER

In which the insect species that were trapped in the gum of pine trees 30 to 90 million years ago are compared with those caught in flypaper under similar conditions today

by Charles T. Brues

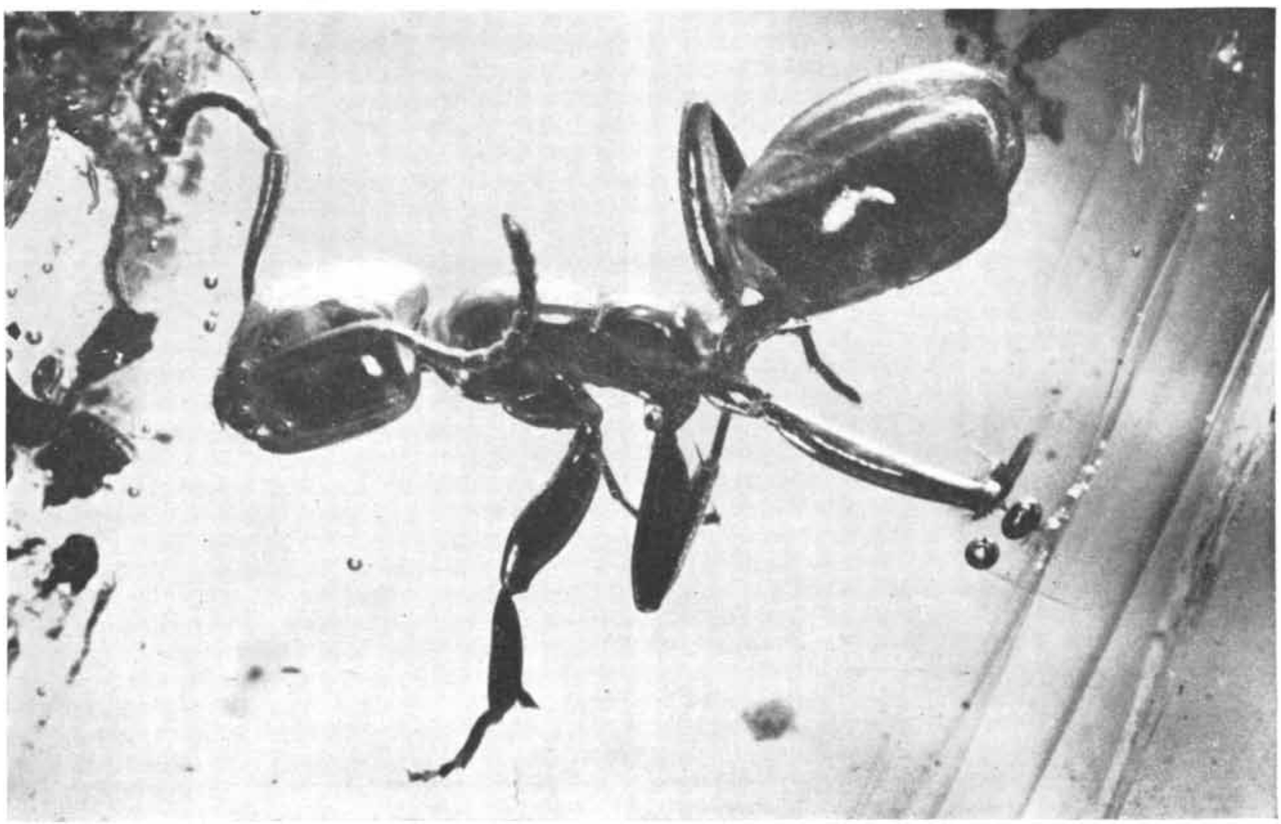
AMONG all the living creatures on earth the most abundant, the most varied and the most highly specialized are the insects. Many people think our era should be called the Age of Insects rather than the Age of Man. There are those who argue that the insects will some day dominate the living world. Is there any evidence to support this prediction?

We need not pay too much attention to the naïve fear that the insects may kill off the human species by their activities in destroying crops and spreading disease; man himself, by his prodigious consumption of natural resources and multiplication of population, is contributing to the downfall of his species on a far larger scale than the insects could. But what of the insects themselves? Are they still on the ascendancy—an ever-increasing horde destined to take over the earth? Or have they begun to go downhill toward extinction, like the giant dinosaurs and other vanished groups that once ruled the planet?

The only place where we can look for an answer to this question is in the fossil history; perhaps by tracing the record of the rise and evolution of insects through the long geological ages we may get some hints as to their trend. Unfortunately the record is woefully incomplete. Most of the vast parade of life that has passed across our planet is lost forever in decay. All we have left to read are the remains of an occasional organism that was accidentally trapped and turned to stone before it could disintegrate. In the case of the insects the rock record is particularly barren, because these delicate creatures have no hard, bony skeleton and are not readily fossilized.

Yet there is one deposit vault where we *can* find ancient insects, more beautifully preserved than any fossil ever disinterred from the rocks. This reservoir is amber: an ancient tree-sap which trapped insects like flypaper and then hardened to preserve the insects intact for millions of years. Found in several parts of the world, these pieces of amber provide us with collections of insects

A GALLERY of insects in amber is shown in the photographs on these six pages. The specimens are from the collection of the Museum of Comparative Zoology at Harvard.



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from 30 to 90 million years old, so well preserved that they can be examined in almost as great detail as modern species that have been caught alive and mounted by careful laboratory methods.

THE richest tomb of ancient insects yet discovered is Baltic amber found in Germany. Most of us are acquainted with Baltic amber; it is commonly cut into small ornaments and beads, which used to be worn as necklaces by superstitious Victorian ladies to ward off the discomforts of hay fever, asthma and other allergic afflictions. Such beads often contain small insects. Baltic amber is the fossilized resin of an extinct species of pine that grew in the Baltic region during the geological period known as the Oligocene, some 70 million years ago. When first exuded from the living trees, the resin trapped many small insects on its sticky surface. Engulfed in this viscous substance, the insects were preserved without damage just as they were. As the resin solidified into amber they remained like delicate trinkets imbedded in transparent plastic. After the trees had died and rotted away, the amber, unaffected by the wood-destroying fungi and bacteria, was left in small chunks in the soil. Eventually erosion washed it with the soil into the sea. Since amber is only slightly heavier than sea water, the waves carried it about and cast it up on the shores of the Baltic. The pieces of crude amber now found vary greatly in size; some weigh a pound or more, but most are very much smaller. Fortunately the pieces are often accumulated in pockets in the earth, where they may be dug out or mined.

The insects preserved in amber of course are not entirely whole, for there is nothing to prevent the decay of their internal organs. But all their external details, even to the most minute bristles and hairs, are faithfully preserved; due to the fact that their outer covering is made of a tough, horny material called chitin (from the Greek word for coat of mail). When we examine one of these specimens, what we really see is its mold in the amber, lined with a pigment composed of metamorphosed and carbonized material from the chitinous skeleton. Any attempt to free the fossil insect by dissolving away the amber is doomed to failure, for once the supporting amber has been removed, the specimen crumbles into dustlike fragments. Hence we must study it just as it lies in its amber tomb.

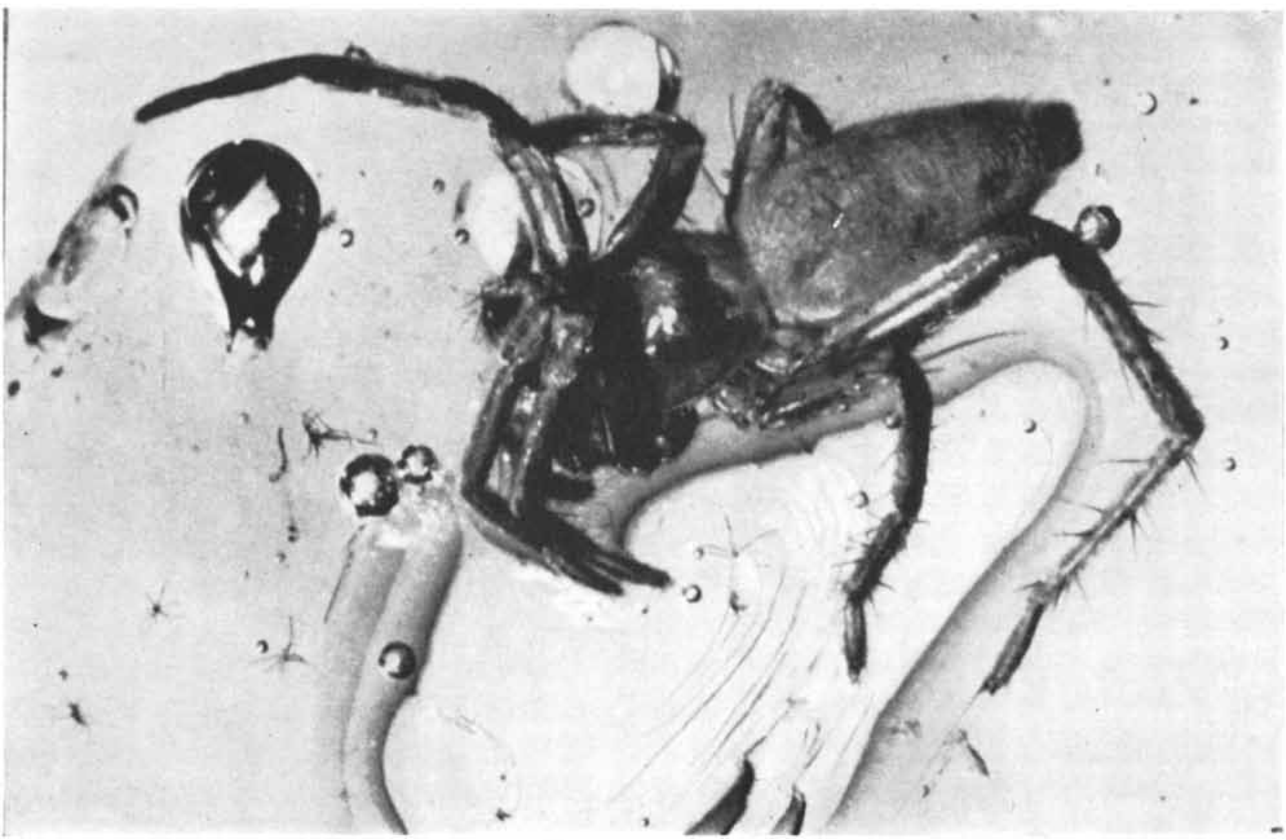
Clear amber is a transparent material of a yellowish or brownish color. Usually, however, the amber is clouded with trapped mold, vegetable matter, tiny air globules and bubbles of water vapor exuded from the insects. This may obscure the insects, but the specimens can often be salvaged for examination by careful cutting and polishing of the amber into small blocks or slabs.

Many thousands of insects in amber, ranging from a partial to a nearly perfect condition of preservation, have been collected. A number of entomologists, including the writer, have made technical studies of these insects and have been able to classify them with such exactitude that it is now possible to compare the insect life of 70 million years ago with that of today.

TO THE best of our knowledge insects first came into existence on this planet about 250 million years ago. Their rise and evolution roughly coincides with that of the air-breathing vertebrates. Among the earliest insects were some winged forms very different from any now living, and some hardy types, such as the cockroaches, that still exist in much the same form in the warmer parts of the globe. The evolution of insects progressed rapidly toward great variation and specialization. By the dawn of the Age of Mammals, some 70 million years ago, they were present in numbers and variety closely comparable to the picture that they present today.

The insects of that period, as preserved in the Baltic amber, were very similar to those that now inhabit the temperate regions of Europe and North America. To be sure, very few of the species that lived then exist in exactly the same form today. But most of the genera and almost all of the families of that time still survive in the form of modern variants of the ancient types.

Most remarkable among the Baltic amber insects are the ants. These greatly specialized social insects, today a dom-



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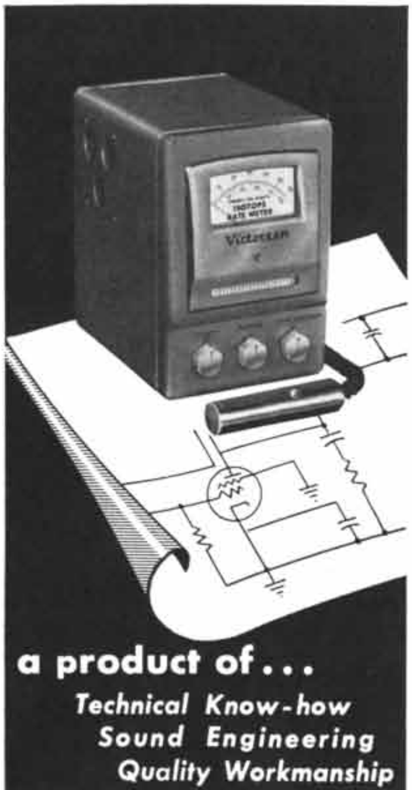

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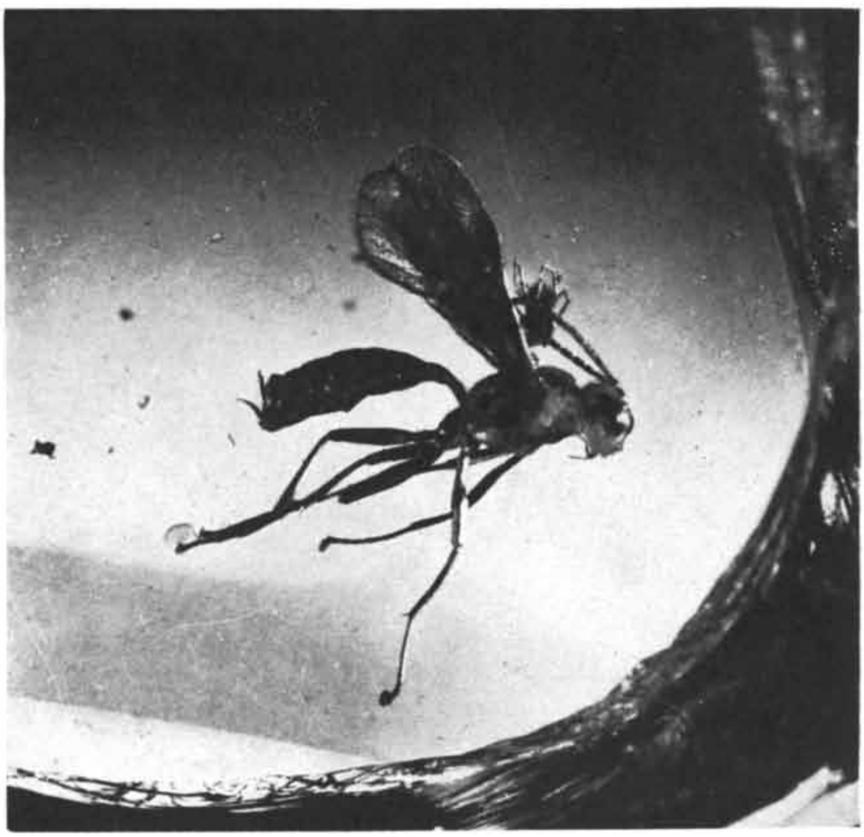
inant group, especially in the tropics, were even more abundant 70 million years ago than they are at present. Moreover, they included a wide variety of types. Some of those types are now extinct or have disappeared from the Baltic and live only in other parts of the world. For example, one genus of ants that was first discovered in Baltic amber was later found to have modern descendants living in Malaya. There is a family of parasitic wasps in the Baltic amber which now survives only in Australia and South Africa. (Wasps are members of the same order of insects as the ants.) On the other hand, the most abundant ant in Baltic amber is hardly distinguishable from the mound-building black ant (*Formica fusca*) that now ranks among the commonest of ants in Europe and North America. It is clear that the speed of evolutionary change has varied greatly among different kinds of insects. Some have evolved rapidly into new types; others have undergone no visible change at all. On the whole, however, considering the ants, beetles, flies, wasps, bugs and other types of insects that are found in amber, it looks as if the insect fauna existing at that time was not too unlike that of the present day.

Yet we cannot be sure that the insects preserved in amber are really representative of the insect population of that era. Obviously there are many kinds of insects in a forest that will not be trapped in resin on pine trees. Some are too large and powerful to be caught; many, large and small, are not in the habit of visiting pine trees. Consequently any statistical comparison of the modern insect population with that in the amber is necessarily open to gross error.

SOME years ago we took a census of insects in a present-day forest by a method simulating that of the Baltic amber, in order to get a statistically comparable population. The method we used was to tack sheets of sticky "tanglefoot" flypaper on the trunks of large pine trees. Insects flying about or crawling on the tree trunks were caught in the tanglefoot just as they had been in the exuding resin of the pines in ages past. The numerous insects and other tiny fauna trapped on the paper were soaked off in alcohol and were recovered in good condition for examination. Our collections were made in primeval sections of the Harvard Forest in Massachusetts, where the tree types and other conditions are very similar to those that existed in the Oligocene forest. We obtained a statistically valid sample of more than 21,000 insects.

Just as we expected, we found that most of our captives were of the smaller varieties of insects in the forest, proving that the scarcity of large species in the Baltic amber does not mean such species were absent from the ancient forests. In our count of the trapped insects we encountered a surprise. While working in the moist, shaded forest, we were constantly annoyed by mosquitoes, black flies and deer flies, which appeared in swarms and bit us unmercifully. We also



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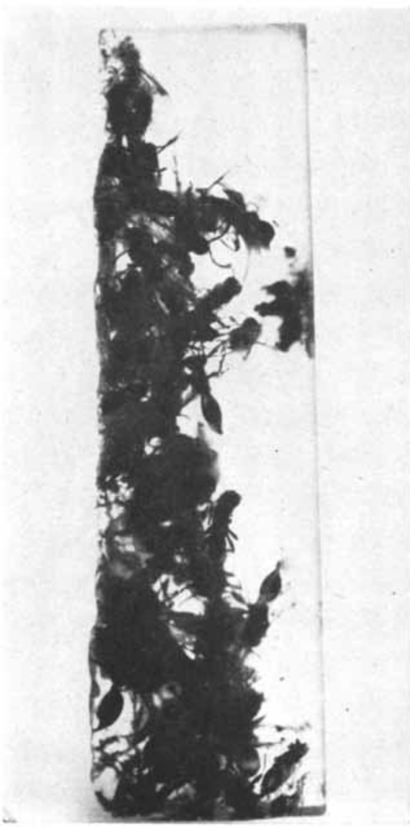
saw several mosquitoes caught while the papers were being put on the trees. Yet in our final tally of the collections we found we had captured only 26 mosquitoes, 18 black flies and 3 deer flies. Evidently such insects constitute only a very minor proportion of a forest's total insect population. The reason we are so impressed with their numbers is that they seek out the company of warm-blooded animals, and we notice them more than other insects. I must admit that the comparatively low density of the mosquito population was an eye opener for me as an entomologist.

INSECTS are classified into three major groups. The first group are primitive, wingless types that mature into adults without much change. (This group does not include fleas or lice, which are descended from ancestors that once had wings but lost them as they evolved into parasites.) The second group undergo a partial metamorphosis as they mature and acquire wings. The third group go through three distinct stages of growth—the larva, the pupa and finally the winged adult. These three major groups represent the evolutionary path of the insects, proceeding from the most primitive to the most highly developed. In the early ages, 200 million years ago, the first group was dominant; today the third group is by far the most abundant.

What does the comparison of the population on our flypaper with that in the Baltic amber show as to the trends



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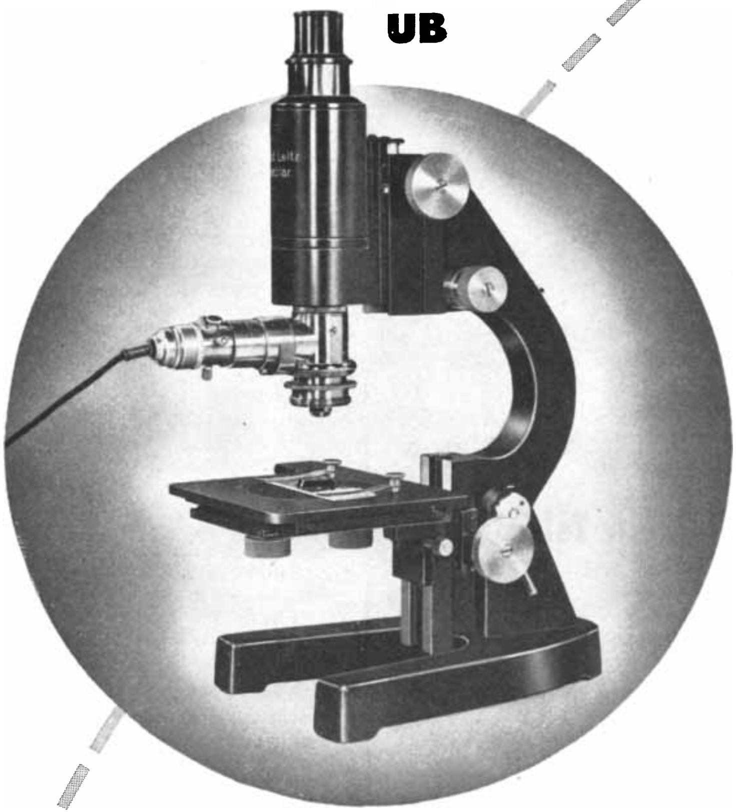

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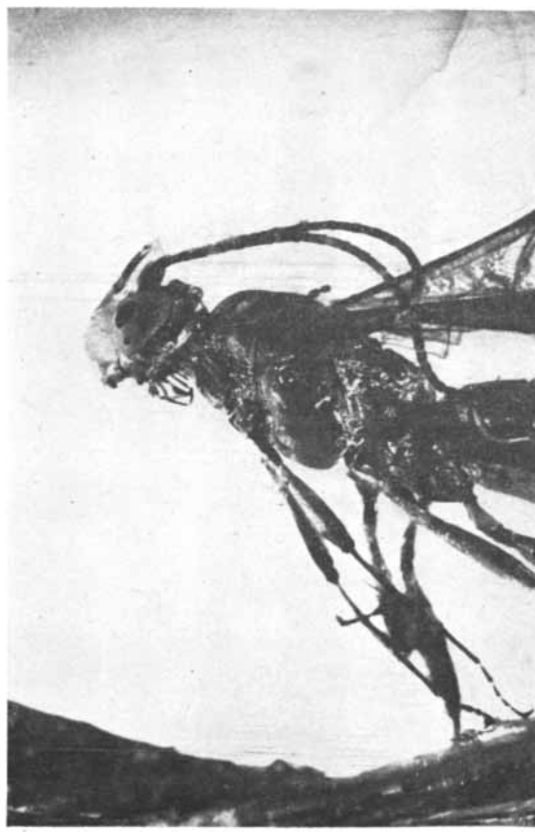
during the past 70 million years? One thing it shows is that so far as numbers go, the more specialized types of insects continue to gain at the expense of the more primitive. Consider, for instance, the largest and most specialized order of insects: the flies. Flies account for a considerably larger proportion of the total insect population now than they did then. In the amber they made up 54 per cent of all the insects trapped; in our flypaper census their proportion has risen to 72 per cent. In particular the group known as *Muscoidea,* which includes the common house-fly, fruit flies and their allies shows a great relative increase. Yet on the whole the flies, notwithstanding their rise in numbers, cannot be said to have exhibited any great surge of evolutionary enterprise or invention during these recent millions of years. Some of the insects in amber were just as specialized and peculiar as any found today.

Moreover, not all of the highly developed types of insects have grown in numbers. A striking example are the ants: according to our flypaper census they are only about one ninth as abundant today as they were in the ancient forests.

In general the picture we get from these two comparable censuses, spanning the past 70 million years, is that of a decline in primitive types of insects, a gain in the relative abundance of the specialized orders and some substantial changes in the ratio of certain groups to the total population. But by and large



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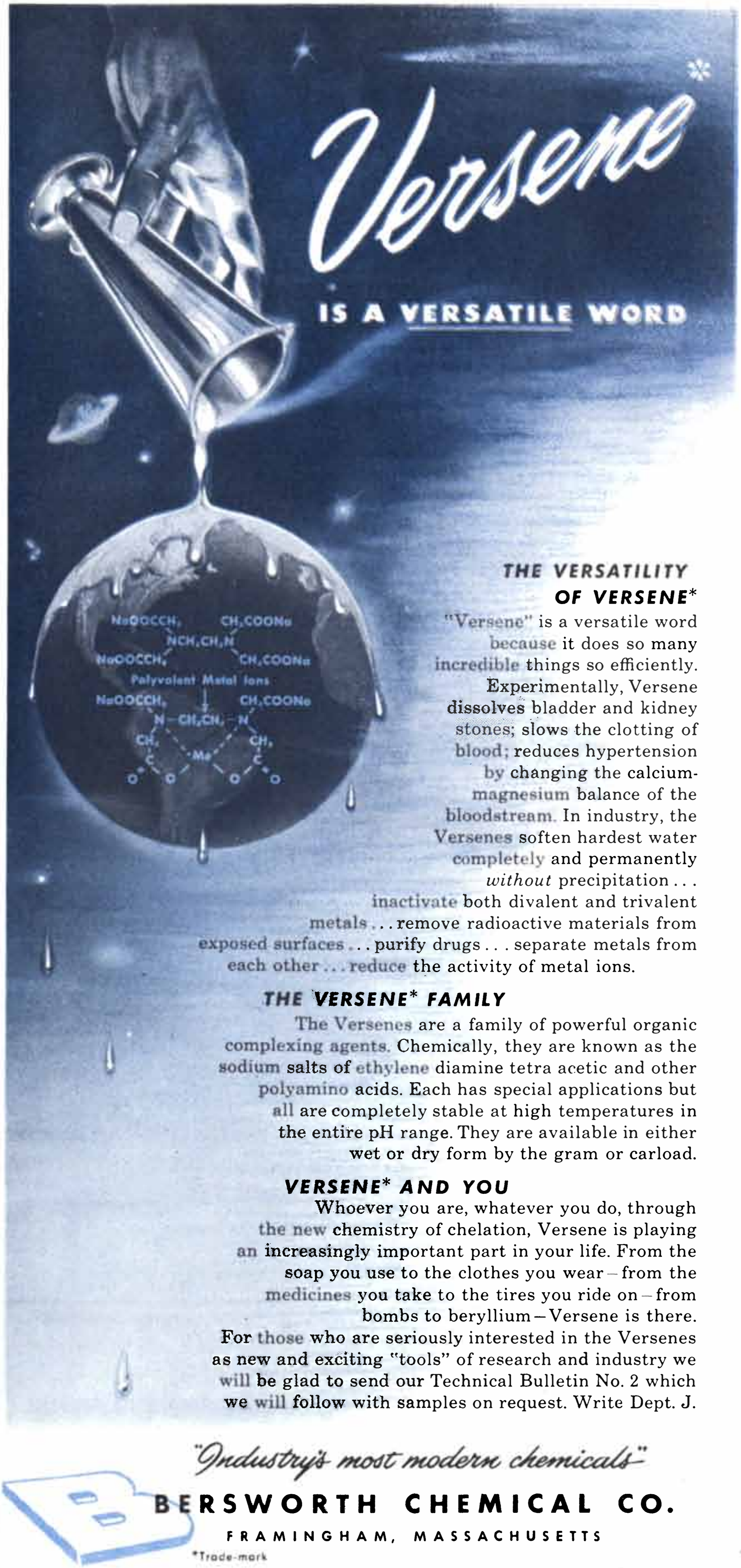
the insect population of today remains remarkably similar to that of the earlier age. All the major orders of insects now living were represented in the ancient Oligocene forest. Some of the specific types have persisted throughout the 70 million years since then with little or no change, indicating a pronounced fixity that gives little promise of adaptive change in the future. Furthermore, the insects of that age already showed great varietv; indeed, in some groups that we have been able to compare in detail we find a greater diversity in the Oligocene insect fauna than in the present one.

CAN we still be sure, then, that this is the Age of Insects? Are insects still increasing in abundance and variety, or have they passed their heyday? We have no way of comparing their total numbers then and now, but our sample censuses suggest at least that many abundant groups of insects have passed their prime. Although we may still be in the Age of Insects, it seems safe to say that they are not now coming into bloom.

What path they may follow in the future it is impossible to predict, because man is rapidly breaking down their environment. The march of civilization, with its attendant mechanical monstrosities, is remaking the whole face of animate nature—for better or for worse.

Charles T. Brues is professor emeritus of entomology at Harvard University.



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Surgical Cutting

Like the cutting of other craftsmen, it requires such tools as knives, scissors, chisels and saws. But the surgeon works under trying conditions, and nature always finishes his job

by Sir Heneage Ogilvie

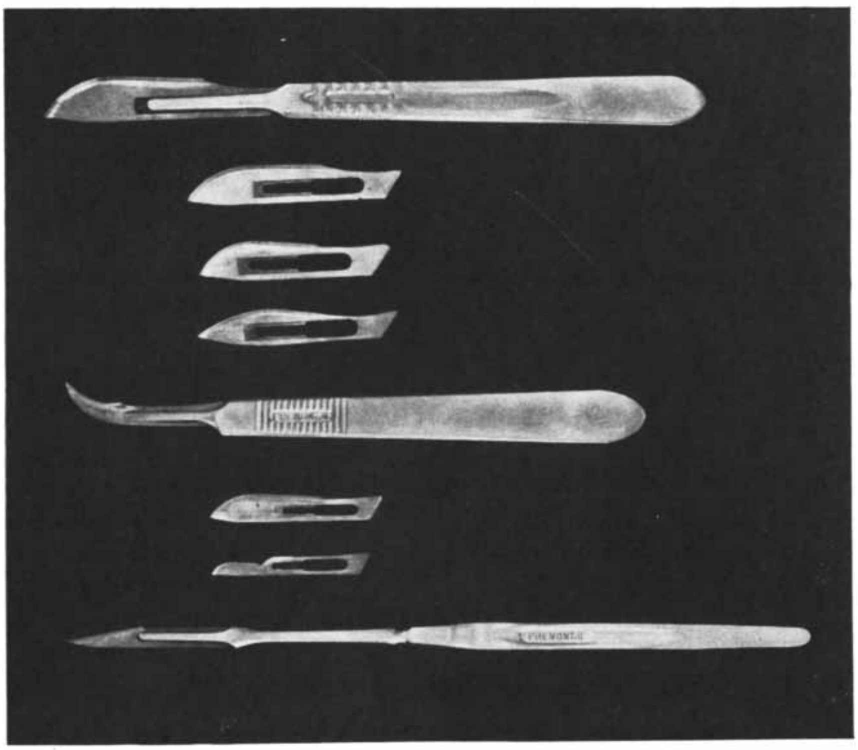
THE SURGEON is a craftsman rather than an artist. His customers come to him for honest, careful, delicate work, not for flashes of genius or operations suddenly devised in a moment of inspiration, and they hope, above all, to be spared the artistic temperament.

Craftsmen have been pushed out of many trades by mass production, but they survive wherever men wish for something made to their personal requirements, as in cabinetmaking, bootmaking, tailoring, jewelry, boatbuilding and the manufacture of surgical instruments. The brotherhood of craftsmen have certain characteristics in common. They are rugged individualists, calling no man their master and none their servant. They take pride in their work, and accept complete responsibility for it, provided they are allowed to go ahead at their own pace and to exact their own standards of excellence. They select their tools with critical solicitude and, having acquired a set suited to their requirements, take them from job to job and refuse to lend them or part with them.

All this applies to the surgeon. His tools are very like those of other craftsmen—knives, saws, scissors and so on, each adapted to the particular needs of his job. But in performing his work the surgical craftsman is subject to certain unique conditions. First, he cannot bring his work where he wants it: he cannot put it in a vise or, if its toughness worries him, lay it on a board to cut it. He must cut, shape and stitch an organ where it lies, or within the small range of movement allowed by the blood vessels that keep it alive. Secondly, he cannot choose the finest material to work on but must take what he finds; in fact, the material with which he works is usually inferior of its kind, or he would not be asked to work on it. Thirdly, every manipulation is final and irrevocable: he cannot throw away a job that is not going to his liking and start again. Lastly, his work is not a process complete in itself but the blueprint of one that will be finished by the tissues.

These tissues, being alive, are vulnerable to injuries that may nullify his work. They may be injured by violence, by heat or by chemicals. When the continuous rampart of skin and epithelial membrane that protects them is breached at any point, they are exposed to the attacks of bacteria. They have their own methods, perfected over millions of years of evolution, of repelling attacks and repairing damage, but such repair may leave a permanent trace in the way of scar tissue or limited movement.

The surgeon, then, must insure that he himself contributes in no way to the damage. He must plan his incisions to avoid the arteries and nerves on which depend the survival and the function of the tissues with which he is dealing. He must guard against clumsy cutting that might injure, forcible retraction that might crush or strong chemicals that might sear. When working on bone with high-speed cutting or drilling instruments he must take care to dissipate the heat they generate. He must suture with sufficient tension to obliterate any spaces in which fluids might accumulate and bacteria might thrive, yet not tightly enough to obstruct the blood supply. He must use nothing but sterile instruments, and he must leave nothing in the



KNIVES are the basic tools of the surgeon. These knives have specialized handles and detachable blades for various purposes. In general the larger blades are used for major surgery and the smaller blades are used for minor surgery. The knives were furnished by the Crescent Surgical Sales Co., Inc.

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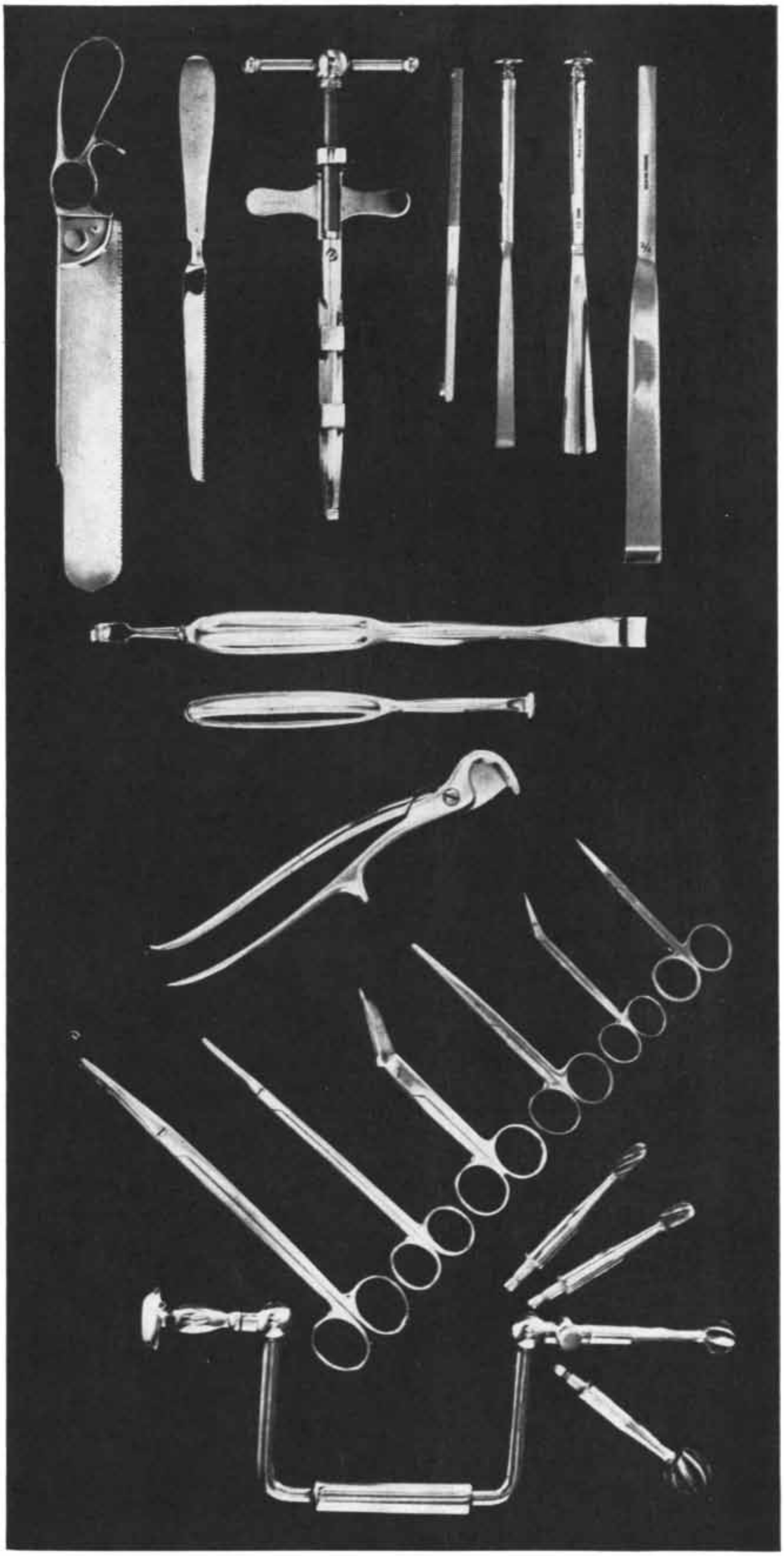
body that is not sterile. Hence his fastenings must either be absorbable, like catgut, or innocuous, like fine silk or thread or a wire of an inert metal.

The only satisfactory method of sterilization is by heat. Antiseptics can kill any bacteria to which they have access, and they play a useful part in the sterilization of water or clothing, but they cannot reach bacteria embedded in dirt in the joint or screw of an instrument. Scrubbing and cleaning are not enough, either: the glistening surface of a metal instrument after a good scrub and polishing would look, if magnified to the size at which bacteria are visible, like the shell-pocked surface of a battlefield. A bit of dried serum lodged in a depression only one thousandth of an inch across is large enough to shelter a whole family of cocci. Surgical instruments, then, must be sterilized by heat, and must be made of material that will withstand the 266 degrees Fahrenheit to which they are submitted in a pressure sterilizer.

LET us get on with the operation and see what kinds of tools the surgeon uses and how he uses them. Cutting, of course, is usually the first step. The surgeon cuts to get access to the site where the trouble lies; he cuts to drain or remove stones; he cuts away tumors or unhealthy tissues; he cuts to remodel, and he cuts to transplant tissues from one site to another. The way he cuts and the tools he cuts with vary according to the material and the site.

Skin is the first layer to be cut, and the most difficult. Skin is tough, because its purpose is to protect the deeper tissues from every kind of injury. Tanned, it becomes leather; untanned, it is nearly as tough as leather but more resilient and flexible and therefore much harder to cut, for leather can be laid on a firm block, but skin is bedded on yielding subcutaneous fat. Skin, too, is always under tension, for it must conform to all the movements of the body and the changing size of the parts it covers. When we fill our lungs, the skin expands with the chest; when we empty them, it does not wrinkle but adapts itself to the smaller circumference. When, therefore, the skin is cut, the wound gapes, and when a circle is cut out, the hole that remains is a good deal larger than the bit taken out. In addition to all this there is always a shearing strain on the skin in any part of the body that is not in a position of rest, that is, roughly the position assumed by a sleeping man. The skin under strain has a tendency to spring back to the rest position. Hence when an incision is made, the edges of the cut move sideways (*i.e.,* in a parallel direction) with respect to each other.

The surgeon who takes pride in his craft wishes to rejoin the skin at the



OTHER TOOLS are saws (*top left*), a rib guillotine (*top center*), chisels (*top right*), tools for removing the outer membrane of bone (*above center*), a rib shears (*center*), scissors (*below center*) and a brace with four burs. These instruments were furnished by the J. Sklar Manufacturing Co.

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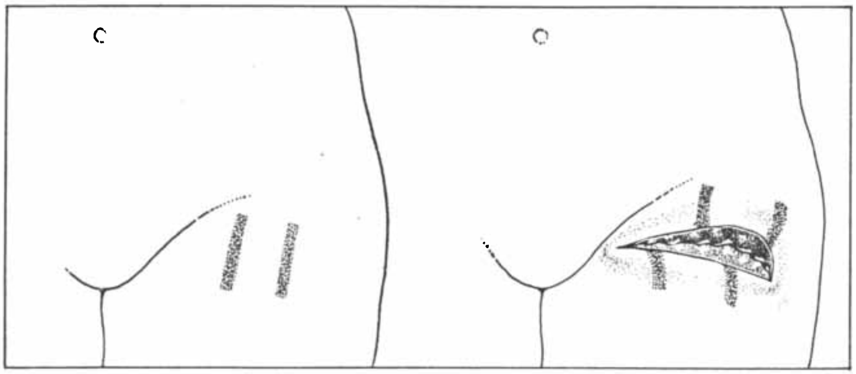
site of his cut exactly as it was before he divided it. But unless he has gone through the tattooed mermaid on a sailor's chest, he cannot, once continuity has been broken, tell which bit matches which. He therefore marks the skin before he cuts it by a series of strokes across the line of the proposed incision, made with some lasting dye such as gentian violet. Then, when he comes to sew up, he matches the purple lines to get the edges of skin in the original position.

TO CUT cleanly a leathery sheet floating on a layer of subcutaneous fat is a subtle problem. The beginner tends to handle a knife as if he were trimming a photographic print, using the point and pressing hard. As a result he goes too deep and exposes some structure that is not on the schedule, or he makes a jagged cut, or he does both. A pointed knife can be used only when there is some firm structure behind. The surgeon's cutting knife is rounded—indeed, in some of the latest patterns there is no point at all—and he uses only the belly for cutting. Most surgeons stretch the skin across the line of the proposed incision with the thumb and the index finger of the left hand and hold the knife lightly between the thumb and first two fingers of the right hand. They draw the belly of the blade along with light even pressure in a sweep similar to that with which the fiddler draws his bow across the strings. In this way the depth of the cut can be judged with great exactitude, provided the knife is sharp. A blunt knife requires firmer pressure, and when force is applied, depth judgment is lost; the blade, once through the resisting skin, plunges into the soft underlying fat.

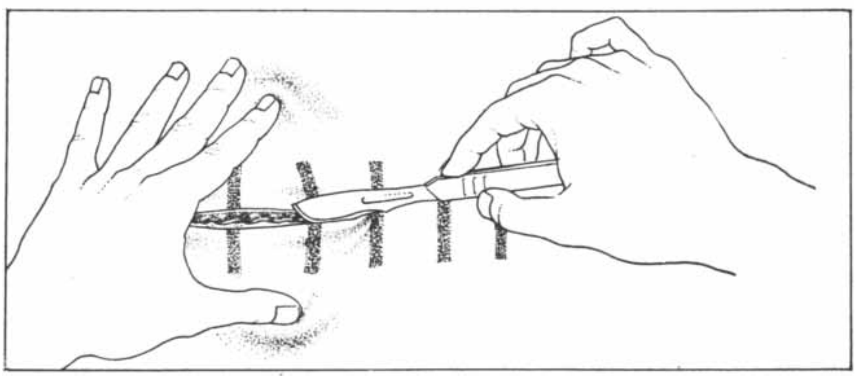
The length and direction of the cut the surgeon makes in the skin is determined first of all by the job that he has to do inside. But wherever possible, and particularly in parts of the body that show, he tries to cut along a natural skin crease. A skin crease is a place where the skin is constantly being bent and straightened out by the movements of the underlying parts, just as a shoe crease lies where the foot comes up on the toes in walking. The underlying elastic fibers lie at right angles to these creases, so that a cut along the crease divides these fibers at right angles. The inelastic scar that forms after healing merely interrupts the fibers at one place along their length and is hardly noticeable. On the other hand, a cut at right angles to the crease would interpose an inelastic band between and parallel to the elastic fibers, hampering movement and leaving an unsightly ridge when the part was stretched.

A cut that follows a crease is usually curved, and one that outlines an area of diseased tissue to be removed is almost necessarily so. A curved cut in an elastic sheet bedded on a soft underlay tends to slope inward on the curves. The surgeon must therefore slope his blade outward as he sweeps around in order to make his cut at right angles to the surface—a necessary proviso if the edges of the cut are to be fitted together accurately afterward.

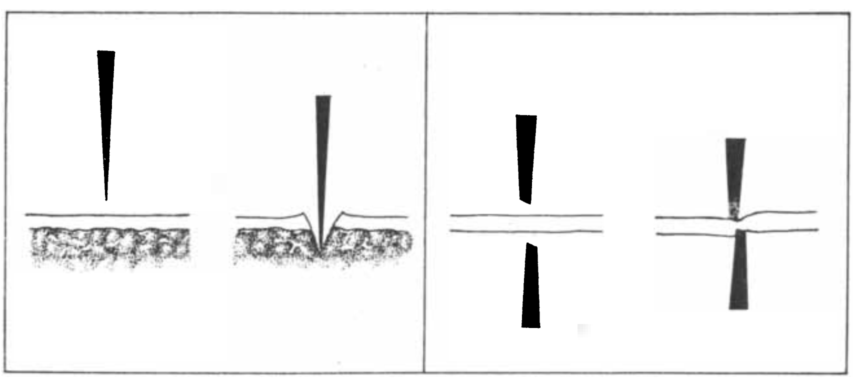
THE KNIFE is the surgeon's symbol. It cleaves by the sharpness of its edge, and, however deep the cut, it goes on dividing cleanly, damaging nothing except the structures lying exactly in its path. Often, however, the surgeon finds it necessary to lay aside his scalpel and resort to scissors. The advantage of scissors is that they cut only what lies between their blades, whereas a knife may penetrate beyond the layer of immediate attack. Scissors are not cutting but shearing instruments; they tear apart rather than cut apart, and therefore damage some tissues at the line of cleavage. But when the tissues to be divided are soft or in thin sheets, this damage is negligible. Scissors are seldom used to cut skin, but they are the instrument of choice for dividing sheets like the fibrous layers of the abdominal wall or the peritoneum that lines the cavity. Most scissors used in surgery are blunt-pointed; the plunging of a point into a



SKIN IS MARKED before cutting to enable the surgeon to join the skin in its original position. This incision is for the surgery of varicose veins.



SKIN IS CUT by lightly drawing the curve of the knife along the surface. Most surgeons stretch the line of the incision between thumb and forefinger.



KNIFE AND SCISSORS part a membrane in somewhat different ways. The knife (*left*) cuts; the scissors shear. The latter are the easier to control.

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surface to make a hole is not a surgical procedure.

The extent to which a surgeon uses scissors in his work once the skin is passed is a matter of individual preference and skill with the instrument. Scissors can be, and very often are, used as two-purpose tools. Opened, the points separate tissues; closed, they cut them. Scissors-dissection is always associated with the name of the Mayo brothers, after whom the most popular pattern of dissecting scissors is named. Mayo scissors, which may be curved or straight, have blades with narrow rounded ends. The end of the instrument, with its blunt points together in the closed position, is thrust like a probe between adjacent tissue structures; the scissors are then opened, and the diverging blades push the structures apart, stretching and revealing the bonds that link them or the capsule that covers them. These bonds are cut by the scissors to the extent that they have been revealed. The instrument is then thrust in again, and the process is repeated. In this way the whole of a block dissection for removal of glands in the neck can be done with scissors, the only other instruments required being hemostats to pick up blood vessels before they are cut.

THE SURGEON does not do all his cutting with cold steel; for some operations he finds it convenient to use a machine that cuts by means of electricity. The actual cutting agent in this case is heat. The principle is as follows: When an alternating current of very high frequency is applied to tissue, no current flows into the tissue. The tissue's resistance to the current, however, produces heat in the region of contact with the electrode. If the area of contact is broad, the heat generated is small. But when it is narrow, the current generates a very high temperature. The surgeon's electric cutting machine applies two electrodes to the body—one broad and one narrow. The first makes wide contact with some indifferent part of the body, usually the patient's thigh; it consists of a metal plate over a pad soaked in salt solution. The other electrode is a steel needle with an insulated handle; this is the cutting tool. The surgeon switches on the current with a foot pedal. The current reaching the thigh through the moist pad is diffused over a wide area, but that coming in through the operative needle instantly coagulates the tissue at the needle's point. As the surgeon strokes the needle along the tissue, it falls apart as if it had been cut with a knife. The cut made through tissues with the stroke of this electrocoagulating needle, as it is called, is indeed much like that of a knife, but its surfaces are killed by heat. Hence they do not bleed. On the other hand, they cannot heal. In these properties lie the value and the disadvantage of the method.

Electrocoagulation is used particularly for cutting structures that bleed freely from many small vessels and in which the bleeding is difficult to control, either because there is little fibrous tissue to hold sutures or ligatures or because the site is inaccessible. It is commonly used in operations on the brain, the liver and the kidneys; for cutting through large sheets of fat, as in the radical removal of the breast for cancer; in operations on the tongue and throat, and in those on the bladder and prostate. Because the heat sterilizes as it cuts, the electric needle is convenient for cutting infected structures. It is used widely in cancer surgery, particularly for the removal of portions of tissue for microscopic examination; its advantage is that it avoids disseminating malignant cells from the cut surface. It is used by some surgeons to remove hemorrhoids, because the coagulated surface is less painful afterward than a knife cut carrying living nerve endings.

The fact that electrocoagulation leaves a layer of dead cells on the cut surfaces means that these surfaces cannot heal until the dead layer has been cast off. Electric cutting is therefore used for destruction rather than for access, for making wounds that will be allowed to repair themselves rather than for those that will be sutured afterward. It is never used for cutting skin, never for undertakings in which a beautiful scar is desired.

THE surgeon operating on soft tissues is using the craft of the leather worker, the butcher and the tailor, working perhaps more slowly and more meticulously, but with tools and movements that are essentially similar. When he operates on bone, he allies himself to the hard-material artificers—the carpenter, the engineer, the stonemason. If he is a habitual bone-artificer he calls himself an orthopedist and joins a trade union as exclusive as that representing any subdivision of the building trade.

The mention of bone calls up a mental image of a hard and indestructible skeleton which persists for tens of thousands of years after the brain that animated it and the muscles that moved it have returned to their elements to take their part in the endless cycle of living matter. Yet bone is very much alive; it can grow, it can repair injury, it can be killed. Indeed, it is killed more easily than a soft tissue, because it cannot undergo those changes of swelling and increased blood supply that underlie the resistance of living tissues to injury and infection.

Bone has the physical properties of a hard wood such as oak. Like oak, it can bend, split and break. Young bones contain more animal matter, bend further without breaking and cut more easily

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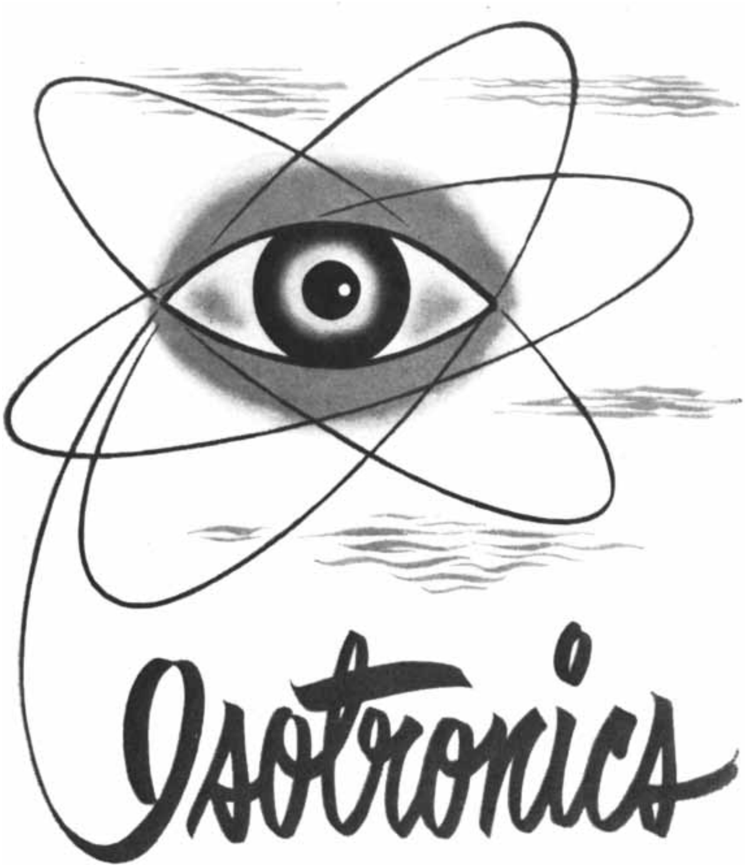

The astronomer uses Sorensen isotronic equipment in operating a giant telescope; the nuclear physicist uses it to regulate cyclotrons and the successors to cyclotrons. Batteries for guided missiles are precisely charged by isotronics. Isotronics, the technique of regulating and controlling voltage, current, power and frequency by electronic means, has many varied uses. It helps test airplane propeller pitch controls, and enters into calibration and inspection setups of countless manufacturing processes. X-ray equipment, television and radio transmitters are protected against premature failure of expensive tubes when isotronics holds filament voltages within close limits.

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than adult bones. The basic tool for cutting bone, as for cutting wood, is the saw. The type of saw that is selected will depend on the size of the bone to be cut, on its fixity and on the room available. To cut across a large bone in amputating a limb, the best tool is a stiff, fine-toothed saw such as that used by butchers and cabinetmakers. To cut across a slender bone too mobile to be sawed, such as a rib or a bone in the hand or foot, the surgeon usually chooses strong shears. To fashion a bone graft, and to prepare a bed for it in the recipient bone, he uses a tiny circular saw driven by electric or pneumatic power. For cutting the skull, where his chief concern is to avoid damage to the brain and its membranes, he has a very special technique. First he bores a series of holes in the skull with a bur. He inserts a flexible wire saw into one hole and passes it between the skull and the membrane lining it to the next opening. Then he seizes both ends of the wire saw and cuts the bridge of skull between the holes by sawing from within outward. In this way, step by step, he lays open a large enough section of skull to operate on the part of the brain he wants to reach.

For cutting away diseased bone or reaching diseased tissue beneath bone, he employs chisels or gouges. Because chronically infected bone is as hard as concrete, the orthopedic surgeon's chisels are more like those of the stonemason than those of the carpenter. To trim a bone surface, as in the operation for reconstructing the hip joint, where he needs to shape a rounded head and a cup socket that fit each other, he has still other special cutting tools.

A LAYMAN watching a surgical operation for the first time is struck by its relative bloodlessness. He has vivid memories of the copious bleeding, staunched only with difficulty, that always issues from a cut in everyday experience—a battle wound, say, or even the slicing of a finger with a bread knife. He does not realize that the arteries and veins from which this bleeding comes can readily be controlled by the surgeon, who knows exactly where they are and takes precautions to prevent bleeding before he cuts them. The surgeon requires a bloodless field, because at every stage he must see clearly what he is cutting, down to the smallest filament. He cuts meticulously and deliberately, having regard to the vital as well as the physical properties of the tissues, for each cut is irrevocable, and the finished job must last a lifetime.

Sir Heneage Ogilvie is surgeon to Guy's Hospital in London and a Fellow of the Royal College of Surgeons.

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		New alkali resistant glass	21.0	0.012	3.0
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PURPLE BACTERIA

The behavior of these colored microorganisms in the presence or absence of light is a simple means of studying the basic mechanism by which living things react to their environment

by Roderick K. Clayton and Max Delbrück

ONE of the prime mysteries of biology is the means by which an organism perceives and responds to a change in its environment. If we try to explain such a response in the basic terms of chemistry and physics, we find it an exceedingly complicated process. To gain some insight into the problem, therefore, we should start with the simplest possible systems. By studying the responses of single cells to very simple stimuli we may throw some light on the behavior of more complex organisms.

The fundamental property involved here (*i.e.*, response to a change in the environment) is known by the name of irritability. It means the ability to be excited by some external stimulus. Physiologists used to consider irritability to be a highly specific property of living matter—a fundamental characteristic of life. But that was before the day of neon tubes and Geiger counters. The fact that these lifeless physical systems—and many others now commonplace in atomic physics—also exhibit the property of irritability has naturally suggested that the excitability of living tissues may be explained on a physical basis. This is a fairly new idea, and the search for physical mechanisms of irritability in cells is only just beginning. This article will describe a recent approach to the problem through study of the responses to light of the single-cell organisms known as purple bacteria.

IRRITABILITY has of course been investigated exhaustively from the biological point of view. The favorite method has been to study the stimulation of nerve fibers by electricity. Next to electricity, the environmental factor that can most easily be controlled and measured is light. It should be expected, then, that single cells which respond strikingly to changes in illumination would be as useful as nerve fibers in the study of irritability.

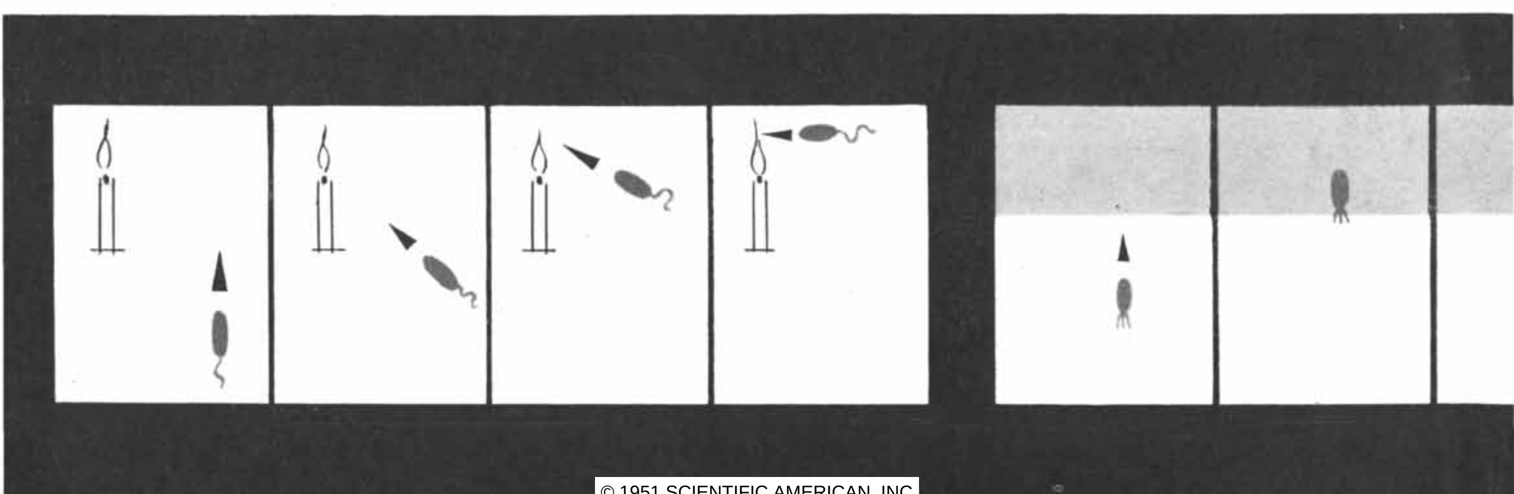
There are many simple organisms—notably certain bacteria and some of the single-celled plants known as algae—that show such reactions. Usually the reaction is an abrupt movement of some kind in response to darkening of a sensitive part of the organism. For example, when the green alga *Euglena* is exposed to a source of light, it changes its direction of swimming in abrupt steps until it points directly toward the light. *Euglena* swims in a rotating fashion with the motion of a screw. Its abrupt shifts of direction occur when a certain light-sensitive spot on the alga swings around to the shaded side, away from the light, during its rotation.

The oval-shaped purple bacterium *Chromatium* illustrates another kind of response. This organism derives its calories from light. When it is in a region of uniform illumination, it swims in a straight line. If the light is dimmed suddenly, the bacterium recoils, pauses briefly and then swims on again. Its direction, however, is usually changed. The reason is that the pause that follows the recoil is just long enough to permit the bacterium to be knocked off its course by Brownian motion of the molecules in the water. As a result of this wonderfully simple routine, these bacteria manage to accumulate in strongly illuminated regions, recoiling whenever they begin to enter a darker region.

An even more effective response to light is exhibited by the purple bacterium *Rhodospirillum*. This corkscrew-shaped creature can swim forward and backward with equal ease. When it encounters a decrease in illumination, it simply reverses its direction of swimming. Hence a spot of light acts as a trap for these bacteria; whenever they start to swim out of the light, the darkness causes them to reverse direction and swim back. The trapping effect of light

EUGLENA, a green alga, is one of many microorganisms that are sensitive to light. When the alga is exposed to light (*symbolized by candle*), it changes the direction in which it swims. Then by abrupt steps it turns toward the light.

CHROMATIUM, a purple bacterium, also reacts to light. When the bacterium is in a region of uniform



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on *Rhodospirillum* is illustrated in the drawing on the next page. These bacteria can be made to write the initial of their own name by the projection of a pattern of light in this form on the slide. A suspension of bacteria placed at random on the slide collects in the light pattern within a few minutes.

We shall examine in detail some of the ways in which the movement of these bacteria in response to light (called phototaxis) can be exploited in the study of irritability. Let us start by reviewing some of the main features and activities of this organism.

THE FIRST important studies of purple bacteria were made by the German botanist T. W. Engelmann in 1883. Examining a culture of these bacteria under light that had been split into the colors of its spectrum, he found that the bacteria congregated in certain parts of the spectrum, principally the blue and the infrared. Apparently these colors looked "brighter" to the bacteria than other wavelengths. Engelmann surmised that light was essential for the growth of these bacteria, and that they contained a pigment, analogous to the chlorophyll of green plants, which absorbed the life-supporting light. He guessed further that this vital pigment absorbed blue and infrared light most strongly. In 1907 another investigator, Hans Molisch, performed experiments which supported Engelmann's speculation.

By that time it was known that the pigment in question consisted of two fractions, one pale green and the other red. Molisch surmised correctly that the pale green fraction was a single pigment similar to the chlorophyll of plants and that the red fraction was related to the red and yellow coloring matter of many plants (carotene and similar pigments). It is known now that the chemical structure of the green pigment in purple bacteria is very similar to that of chlorophyll, and that the red fraction is indeed a mixture of carotene-like pigments.

Engelmann's studies had suggested that purple bacteria live by a form of photosynthesis—the process which uses the energy of light to convert nutrients into the living stuff of the cell. In recent years biologists have begun to study the purple bacteria's photosynthetic metabolism in detail, and this work has turned out to be far more rewarding than the analysis of the pigments. In particular, C. B. van Niel, at the Hopkins Marine Station in California, has carried out investigations comparing the photosynthesis of purple bacteria with that of plants; these studies have shed a great deal of light on the chemistry of the photosynthetic process.

Green plants take in carbon dioxide and water and, with the help of light, convert these to cell materials and free oxygen. Purple bacteria also convert carbon dioxide to cell substances, but instead of water (H_2O) they use some oxidizable substance such as hydrogen sulfide (H_2S). As a result they release sulfur instead of oxygen. This finding led van Niel to the very significant conclusion, recently confirmed, that the oxygen given off by plants comes not from carbon dioxide, as was once thought, but from water.

Purple bacteria can grow in the dark, but in that case they need oxygen, the energy of combustion taking the place of energy from light. Under these circumstances the bacteria are attracted to oxygen exactly as they are attracted to a light. They accumulate in regions of high oxygen concentration; as soon as they start to leave such a region they reverse their direction of swimming and move back to it. On the other hand, in the light, where oxygen inhibits their growth, they avoid regions of high oxygen concentration.

This clear suggestion that a direct connection exists between photosynthesis and phototaxis is supported when we examine the various kinds of responses of purple bacteria to specific colors, or wavelengths, of light. Several workers have performed experiments to determine what wavelengths are absorbed most strongly by the bacteria's pigments, what wavelengths are most effective in promoting photosynthesis and what wavelengths have the strongest attraction for the swimming organisms. They find that in general the same wavelengths favor all three processes. The chlorophyll of purple bacteria absorbs light most strongly at the wavelengths of 8,750 and 5,900 Angstrom units. These very wavelengths, the experiments show, are also active in promoting photosynthesis and phototaxis.

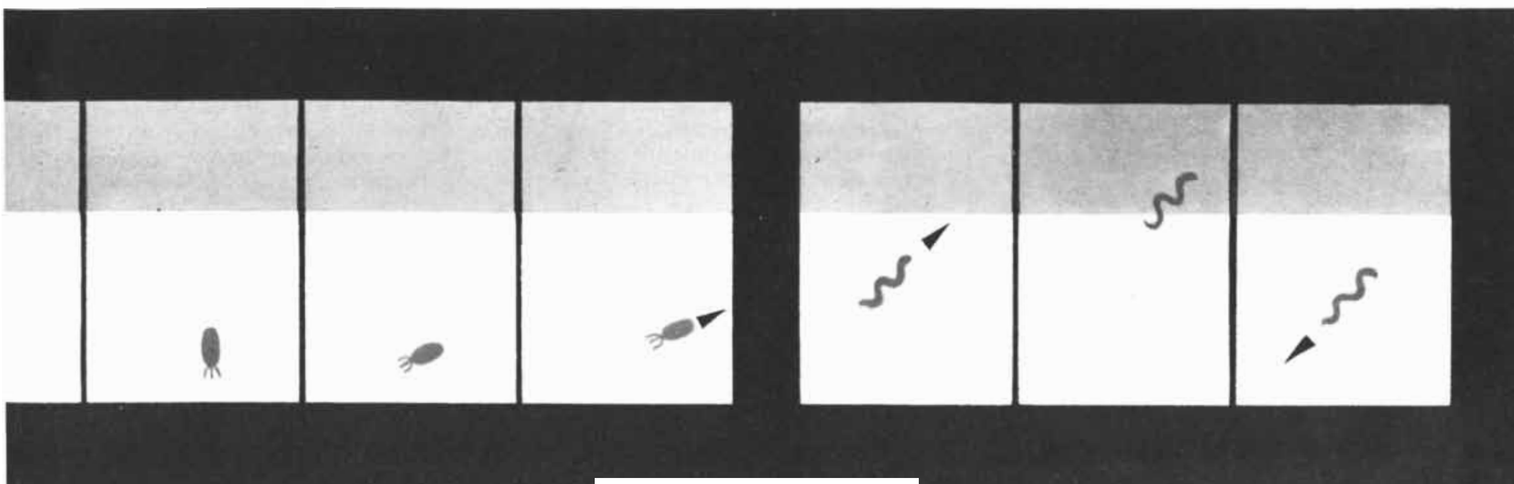
All this seems to indicate that phototaxis is intimately associated with photosynthesis; it has been suggested that the sudden decrease in photosynthetic activity which follows a sudden decrease in illumination is responsible for the bacterium's reversal of its swimming direction and movement back to the light. The experimental evidence is not unanimous on this point, and the discrepancies have not yet been explained, but the hypothesis provides a working basis for further experiments.

WE have seen that the purple bacteria have been most useful in the study of photosynthesis, and that this process is closely connected with their phototactic mechanism. Now let us return to the purple bacteria's response to a change in light as a simple case of biological irritability. Compare it with the irritability of nerve fibers, as measured by their response to an electric current. The first thing we notice is that in both cases the change must be abrupt to produce its maximum effect. A gradual decrease of illumination is much less effective in causing bacteria to reverse their swimming direction than is a sudden decrease. Similarly a current that is introduced gradually and stepped up slowly has much less effect in exciting a nerve fiber than one which is turned on abruptly.

In the second place, this stimulus, or

illumination, it swims in a straight line. When the light is suddenly dimmed, the bacterium recoils and pauses. When it starts, it tends to swim in another direction.

RHODOSPIRILLUM, another purple bacterium, has a more efficient response than *Chromatium*. When the light is dimmed, the bacterium reverses its direction.



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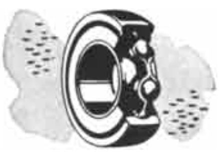

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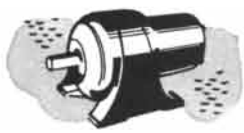

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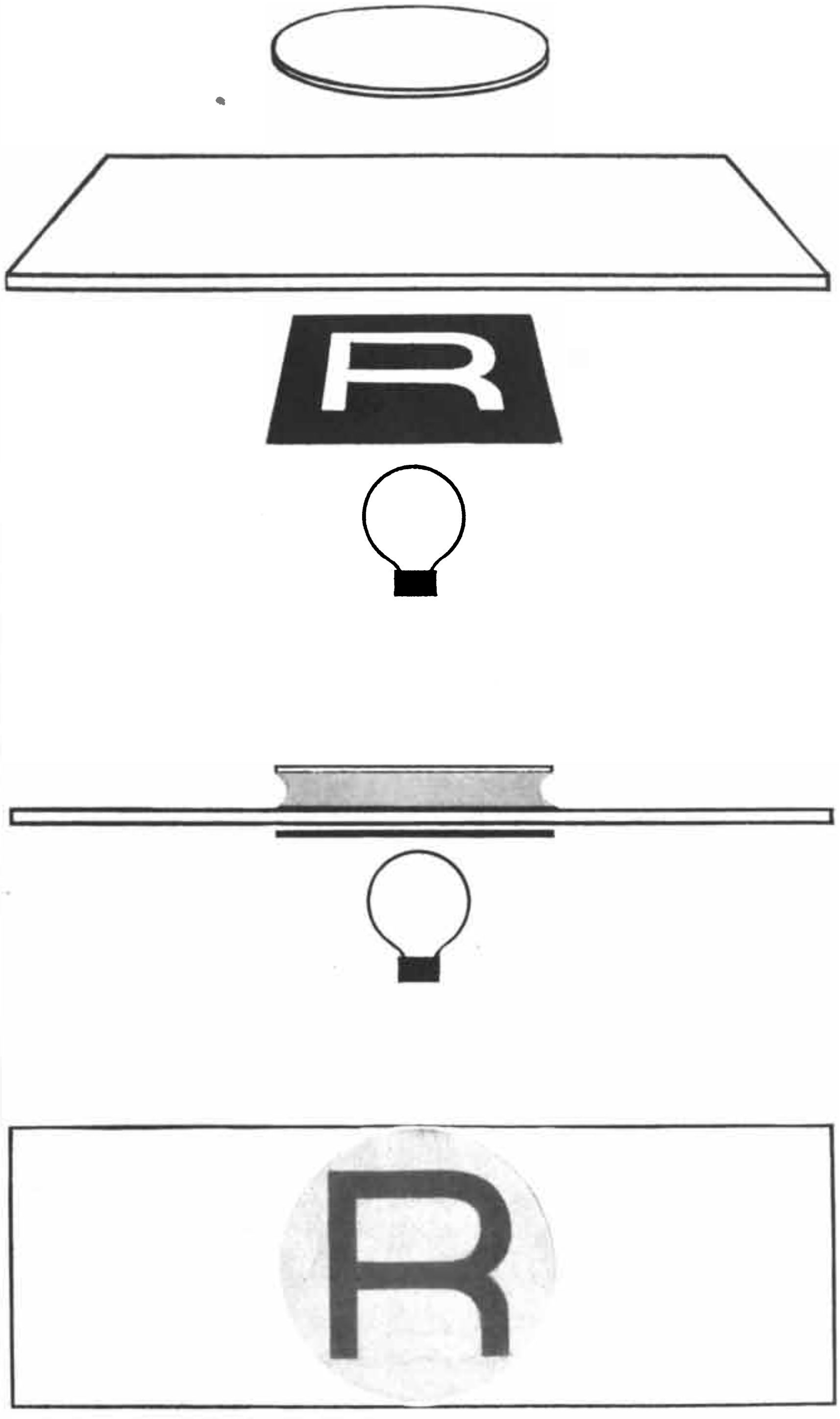

TENDENCY OF PURPLE BACTERIA to congregate in lighter regions is demonstrated by the experiment shown in this illustration. At the top of the illustration are a cover glass, a microscope slide, an opaque mask in which an R-shaped hole has been cut, and a light source. In the middle of the illustration a colony of purple bacteria growing between the cover glass and the slide is exposed to light through the mask. The bacteria then tend to assemble in a region on the slide which has the same shape as the hole in the mask.

change in environment, must be above a certain threshold in magnitude to produce any effect. Furthermore, the effect, if it appears at all, is always of the same magnitude regardless of the magnitude of the stimulus. In other words, both the bacterium and the nerve fiber exhibit an "all-or-none" response to their respective stimuli. In the case of the purple bacterium's reaction to light, the threshold stimulus is a five per cent decrease in illumination. A reduction of five per

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cent or more in the intensity of the light excites most of the bacteria in the affected region; a reduction of less than this amount excites only a few of them. A remarkable feature of this situation is that a five per cent change is effective regardless of whether the light intensity is 100 foot-candles or only a hundredth of one foot-candle. This fact may reflect an important feature of the mechanism of irritability.

In the case of the nerve fiber the "all-or-none" effect is a familiar, thoroughly studied phenomenon: To excite a fiber at all an electric current must be of a certain minimum strength and duration. If it is sufficient, it causes the fiber to propagate a self-sustaining electrical disturbance down its length. But the vigor of this response does not depend on the size of the stimulus; the electrical disturbance is the same no matter how much current is applied, provided it is sufficient to excite the fiber.

There are still other ways in which the responses of bacteria to light and of nerve fibers to electricity parallel each other. Both types of irritable cells show a summation effect; that is, they add the effects of two weak stimuli repeated in quick succession and are able to respond to the combined stimulus. Both have a refractory period—a short interval immediately after a response during which they cannot respond to a new stimulus. Both respond with a rhythmic series of regularly repeated responses under certain conditions of stimulation. In the case of the purple bacteria this occurs when the light is suddenly dimmed and kept at the lowered level of intensity. For about a minute the bacterium keeps reversing its swimming direction; one might say that when its first reversal fails to restore it to its brightly illuminated condition, it keeps on trying again and again.

THESE peculiar phenomena are known to biologists as accommodation, summation, refractoriness and rhythmicity. What is the explanation of them? The German physical chemist K. F. Bonhoeffer has suggested a possible answer on the basis of some experiments with an artificially created "excitable" system. This system, known as Lillie's model, is an iron wire immersed in nitric acid. It shows some striking points of similarity to a nerve fiber. When stimulated electrically, it goes into a self-sustaining chemical reaction and then returns to a passive state. Its activity exhibits the characteristic "living" properties of accommodation, summation, refractoriness and rhythmicity. One can account for these effects by considering the behavior of the wire in terms of two variables. One, the degree of activation, measures the extent of processes in the wire which culminate in its activation. The other, the degree of refractoriness, measures the resistance of the wire to activation.

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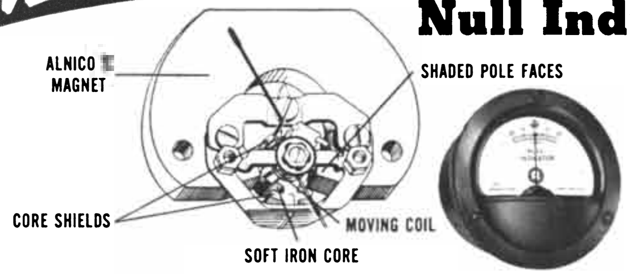

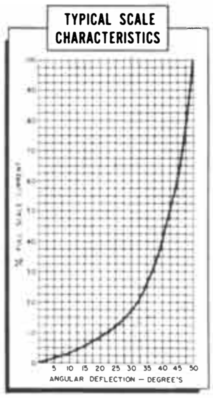

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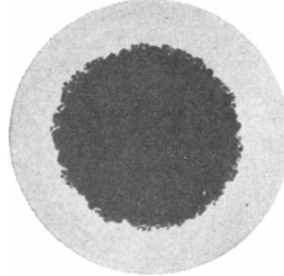

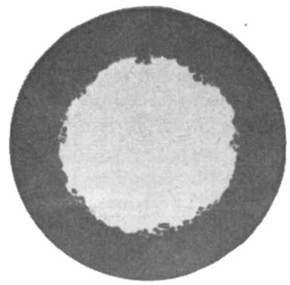

LIGHT AND DARK responses of purple bacteria are shown by these two drawings. The drawing at the top shows a colony of bacteria grown under a cover glass in light; the bacteria (*dark area*) avoid the air at the edges of the glass. The drawing at the bottom shows a colony of bacteria grown in the dark; the bacteria congregate near the air at the edges.

If such variables could be applied to a nerve fiber, defined concretely and measured throughout the course of excitation and recovery, and if their interplay were then found to account precisely for the various phenomena of nerve excitation, our understanding of the physical mechanism underlying that particular case of irritability would be enhanced enormously.

If all excitable living systems have a common physical mechanism for irritability, then the essential relations between stimulus and response should be the same in every case. Thus it should be of great interest to see whether the accommodation and other effects in purple bacteria are quantitatively similar to those in nerve fibers. This could be investigated by using light pulses in a manner analogous to the use of electric-current pulses in nerve studies. By investigations such as these it is hoped that the purple bacteria will be as useful in the study of irritability as they have been in the elucidation of photosynthesis.

Roderick K. Clayton is a Merck post-doctoral Fellow at the Hopkins Marine Station of Stanford University. Max Delbrück is professor of biology at the California Institute of Technology.

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by I. Bernard Cohen

JOSIAH WILLARD GIBBS, by Lynde Phelps Wheeler. Yale University Press ($4.00).

THE name of Josiah Willard Gibbs is known to all scientists and to everyone interested in science, and his place as one of the great masters in the rise of modern science is assured by the constant application of his work. Some know Gibbs best for his vector analysis, others for his phase rule or his statistical mechanics. Yet Gibbs the man has remained a shadowy figure behind these great ideas, and the myths and legends about him—many at direct variance with established fact—are as numerous as those about any hero. The distinction of revealing the true figure of Gibbs, in full stature and many dimensions, has been reserved for Lynde Phelps Wheeler, a former student of Gibbs whose career has included being an associate professor of physics at Yale, a director of radio research at the Naval Research Laboratory and a staff member of the Federal Communications Commission. A few years ago Wheeler contributed to a volume that dealt with the work of Gibbs in applied mechanics; the subsequent news that he was preparing a full-length biography of Gibbs aroused hopes that at last a biography by one who knew Gibbs and understood the principles and practice of science would illuminate the life and achievement of one of the greatest American scientists. This new biography deserves warm praise, both for the extent and quality of its new material concerning Gibbs' life and for its adroit exposition of Gibbs' scientific work. There emerges from these pages for the first time a human Gibbs rather than a wax figure, and many of the treasured myths about Gibbs may now be relegated to the realm of fancy to which they belong.

It is often said that Gibbs took little interest in the dissemination of his ideas, that this was why he was willing to publish his contributions in such obscure places as the *Transactions of the Connecticut Academy of Sciences.* The practicing scientist, however, knows that what is important in the spread of scientific discoveries is not so much the journal of publication as the fact of getting

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BOOKS

A new biography of Willard Gibbs by a physicist who was one of his students

knowledge of the new contribution into the hands of fellow scientists who will most appreciate it. This is done in two ways: by having the article, book or monograph reviewed, announced or noticed in journals of wide circulation; and by obtaining reprints of articles to be sent out "with the compliments of the writer." Gibbs was careful to follow both procedures. His list of those to whom he sent reprints was kept with care and is reproduced in an appendix to Wheeler's biography. Gibbs sent out a total of 2,008 reprints to individuals and 77 to institutions and journals. The list of men who received these reprints is a veritable "Who's Who" in the 19th-century world of mathematics and the physical sciences. It includes such figures as Simon Newcomb, E. C. Pickering, S. P. Langley, A. A. Michelson, Felix Klein, Wilhelm Ostwald, Heinrich Hertz, Max Planck, Henri Poincaré, Lord Rayleigh, Lord Kelvin, Rudolph Clausius, Gustav Kirchhoff, Ludwig Boltzmann, Hermann von Helmholtz, R. W. Bunsen, J. J. Sylvester, J. J. Thomson, Oliver Heaviside and Oliver Lodge. The principal list comprises the names of 160 individuals in the U. S. and Canada, 119 in Great Britain, 104 in Germany, 57 in France, 11 in Italy, 10 in Holland and Belgium, 10 in Austria, 8 each in Russia and Switzerland, 5 in Poland, 3 in Denmark, 2 in India and 1 each in Spain, Brazil, China and Japan. Furthermore, in the case of his famous "Equilibrium of Heterogeneous Substances," Gibbs sent out portions of the galley proof in advance of publication to James Clerk Maxwell, William Thomson (later Lord Kelvin) and Clausius. Like any other author seriously interested in getting a good audience for his work, he compiled a list of scientific journals that he wished to receive review copies of his book *Statistical Mechanics.*

Gibbs sent some of his proofs to eminent men of science while he was still a young and unknown scientist; we may accept this as evidence that he desired to make his work known and had confidence in its importance. It is true that he did not attempt to popularize his work. He never had a general audience, and even the great scientists of Gibbs' time found his writings difficult. Yet the difficulty did not reside in the obscurity of Gibbs' prose so much as in his ideas. Gibbs' contributions became accessible to a large group of scientists only in the 20th century, after new discoveries in atomic physics had made clearer the relation between physics and chemistry. In this sense Gibbs' work was ahead of his time. Its effect was at first restricted to such giants as Hertz, Helmholtz and Maxwell.

Wheeler has delineated the growth of young Gibbs with many interesting documents. His character was apparently set early in youth, and he was described in his precollegiate days at the Hopkins Grammar School as follows:

. . . Gibbs with visage grave
Sits in the seat our Rector to him gave.
A student he—and one who seldom looks
With playful countenance from off his books.

When this verse was written, Gibbs was 15. At the same period of his life a letter from one "who was a possible rival" for a young lady's favors tells us that Gibbs brought her "a most beautiful bunch of pond lillies . . . but Fanny does not like him at all, and we teaze her about him, but she likes his flowers much better than she likes him." Wheeler comments that this is the only instance he has "been able to find of Gibbs having more than a friendly interest in anyone of the other sex, outside of his family." Yet Gibbs was not a recluse, as many have said. Wheeler notes his trips with friends, excursions and picnics in which he delighted in the company of children, and, above all, his kindness toward students. As for the fact that Gibbs never married, Wheeler says: "The assumption of . . . inherited family responsibilities early in life, coupled with the uncertainty of his health throughout the period when most young men have thoughts of founding a family of their own, may well have been the predisposing causes of his bachelorhood." While very likely true, this is not wholly convincing. The psychological reasons for Gibbs' bachelorhood, and for his shyness, must have been closely related to his intense creative gift. Boltzmann compared Gibbs with another shy bachelor: Newton. It must be confessed that we are as far from understanding the inner personality of Gibbs and Newton as we are from explaining the peculiar quality of mind that resulted in their great works.

Wheeler brings out the generally overlooked fact that Gibbs began his career as a practical engineer rather than a theoretical scientist. After his graduation from Yale he obtained a doctorate in engineering at the Scientific School (which, by the way, appears to have

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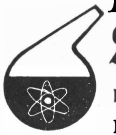

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been the first engineering doctorate granted in this country). Gibbs' doctoral thesis, dealing with the design of gears, bore the title "On the form of the teeth of wheels in spur gearing." He devoted much time to the invention of a "center vent" hydraulic turbine which he had intended to patent but never did, and to a railway car brake based on the idea of utilizing "the application of brakes on the engine pulling the train to actuate the setting of the car brakes by virtue of the train's inertia." The latter idea was not novel, but the patent granted to Gibbs was based on new devices that allowed the brakes to operate whether the train were moving forward or backward or whether the engine were in front of the cars or at the rear, and on the structural means he suggested to increase the pressure of the brakes against the wheels. Wheeler comments that "the merits of Gibbs' invention lie in a keen appreciation of the nature of the operative requirements for a brake and in the ingenuity of the mechanical means he provided to implement them."

When Gibbs went to Paris to study, he apparently decided "that the principal object of his studies was to strengthen his theoretical rather than his practical knowledge." He continued his studies in Berlin, and in 1871 returned to New Haven, where the Corporation at Yale voted that he be "appointed Professor of Mathematical Physics, without salary, in the Department of Philosophy and the Arts." Two years later he was offered a professorship at Bowdoin at a salary of some $2,000 a year, which he declined.

Why did Gibbs prefer to stay on at Yale without salary? Obviously he was attracted to his home town and college. But it was perhaps more important that he had a private income more than adequate to his needs, and that his duties at Yale were light. He could teach whatever he wished and as much or as little as he wished; he had few students and little academic responsibility. In other words, Yale offered him the best possible environment for creative research. To give up this situation for a post that possibly involved a heavy load of elementary teaching would have been unwise as well as uncongenial. In 1879 Gibbs received a more tempting offer: Daniel Coit Gilman invited him to join the faculty of the new Johns Hopkins University at a salary of $3,000. But Yale finally offered him a salary of $2,000 with promise of an increase, and he stayed on.

Among the best chapters in the Wheeler book are those that summarize Gibbs' scientific contributions. One is devoted to thermodynamics, another to mathematics, one to optics and one to statistical mechanics. Here the reader will find an admirable summary in relatively nontechnical language of Gibbs' achievements with reference to later developments in which they have played an important part.

In addition to presenting a fully rounded picture of the life and work of Gibbs, Wheeler has enriched the volume by his personal reminiscences of Gibbs as a teacher. Gibbs emerges from these pages as a contented, almost joyous, man; in fact, he was described by the daughter of one of his best friends as "the happiest man" she ever knew. Although he never had many students or achieved popular fame, he was secure in the knowledge that his works were being read and appreciated by his peers, and that his influence was constantly growing. Nor were professional honors lacking: he received degrees and medals and was elected to the National Academy of Sciences and other scientific societies at home and abroad. Wheeler mentions another honor that must have pleased him even more: The great Maxwell made a plaster representation of Gibbs' famous thermodynamic model of water and sent it to him as a gift.

The only fault that one can find with this excellent and revealing biography is that the author does not quote the many interesting letters to which he refers. Some, such as one by Maxwell's student Freeman telling how Maxwell made the model for Gibbs, are surely of great interest; the reader's curiosity about the contents is not much satisfied by the sentence: "The letter is dated February 18, 1875, and is preserved in a bound volume of the Gibbs scientific correspondence assembled by Addison Van Name and now deposited in the Yale Library."

I. Bernard Cohen is assistant professor of general education and of the history of science at Harvard University.

GENESIS AND GEOLOGY, by Charles Coulston Gillispie. Harvard University Press ($4.50). A historian's account of a phase of the 18th- and 19th-century warfare between science and theology, when advances in geology began to shake the foundations of the Mosaic interpretation of the evolution of the earth. The controversy described here took place mainly in England, where for some reason scientists exerted themselves heroically to reconcile the revelations of religion and research. Despite a formidable baggage of footnotes and other impedimenta of academic learning, Mr. Gillispie, who writes with a nice wit and has dug out a set of agreeable anecdotes from an appalling stack of dusty writing, makes a much better than average contribution to the history of thought.

NOBEL: THE MAN AND HIS PRIZES, by H. Schück, R. Sohlman, A. Österling, G. Liljestrand, A. Westgren, M.

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Siegbahn, A. Schou, N. K. Ståhle: edited by the Nobel Foundation. University of Oklahoma Press ($6.00). On its 50th anniversary the Nobel Foundation issued this book containing a biographical memoir of Alfred Nobel, an account of the establishment of his Foundation, and brief histories of each of the fields—medicine, chemistry, physics, literature and work for peace—in which the Nobel prizes have been awarded. A handsome and valuable reference work. It is also of interest to the general reader for its well-written surveys of scientific progress and its disclosures of the frequent disagreements and jockeying within the Nobel organization and among advisory committees, especially in connection with the literary and peace awards.

HISTORY OF RUSSIAN PHILOSOPHY, by N. O. Lossky. International Universities Press, Inc. ($10.00). An examination of the development of Russian philosophical thought from about the middle of the 19th century to the present by a former professor of philosophy at the University of St. Petersburg. The special tendency of the work, whose author now teaches at the Russian Orthodox Seminary of New York, is reflected in its emphasis on literature and systems of thought "useful for arousing a sympathetic interest in Christianity in the minds of highly cultured people who have grown indifferent to religion under the influence of the general character of modern civilization." Why this book of 400 pages should cost $10.00 is almost as difficult to comprehend as some of the features of Russian philosophy.

THE CHINESE IN SOUTHEAST ASIA, by Victor Purcell. Oxford University Press ($11.50). A substantial study of the Chinese population in the various regions of Southeast Asia: Burma, Thailand, Indochina, Malaya, Borneo, Indonesia and the Philippines. Mr. Purcell's historical and analytical account treats of problems of demography, social life, economic structure, education, political status, and the like; he makes it clear that the eight to ten million Chinese who have overflowed into these areas from the "southern lip" of China are, though the fact has not been recognized, of "the greatest political, economic and social significance to the region, and indirectly to the world as a whole." This was a survey beset with difficulties, yet Purcell has made a valuable beginning from which later studies may take sound departure.

SOME FAMOUS STARS, by W. M. Smart. Longmans, Green and Company ($2.50). In these essays, based on lectures delivered at the Royal Technical College in Glasgow, Professor Smart exhibits certain major problems of astronomy as they have arisen in the course of measuring the distance of various stars

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GEOGRAPHY OF THE PACIFIC, edited by Otis W. Freeman. John Wiley & Sons, Inc. ($10.00). Thirteen specialists contributed to this useful handbook. It brings together a mass of scattered and often scarce information on the geographic setting of the Pacific; on the people, resources and industries of Australia, New Zealand, the Philippines, Indonesia and the various archipelagoes and smaller islands; on major anthropological, economic and political aspects of the many lands of this immense region.

THE MAIN STREAM OF MATHEMATICS, by Edna E. Kramer. Oxford University Press ($5.00). A popular survey of mathematical thought palatably presented and easily digested. Miss Kramer deals with the usual run of subjects from arithmetic and geometry through probability, transfinite numbers and the theory of relativity. She has borrowed freely from other books in the field, but her treatment of certain topics such as statistics and the design of experiments is novel. The volume as a whole is one of the better examples of its kind.

THE VEDIC AGE, edited by R. C. Majumdar and A. D. Pusalker. The Macmillan Company ($8.00). The first volume of a projected 10-volume cooperative work on the history and culture of the Indian people. The period covered

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CORRECTION

on accuracy of the automatic TELEPLOTTER

You may have noted, as did other keen-eyed readers, a misplaced decimal point in this company's advertisement in the September issue of this magazine. The Teleplotter, which plots 40 points per minute, was listed as having an accuracy of ± 25 mm.

Of course the Teleplotter is a hundred times better than this —its accuracy is actually ± .25 mm!

Additional information on the Teleplotter can be found in our advertisement on page 59 of this issue.

TELECOMPUTING
Corporation, Burbank, California
"Turn hours into minutes with Automatic Data Analysis"

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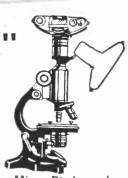

Micro-Photography

"Nature Photography With Miniature Cameras"
by Alfred M. Bailey, Director of the Denver Museum of Natural History
This eminent explorer and scientist displays his finest Exakta photographs and others along with explanatory material.
64 pp., 50c

in this installment is from the prehistoric beginning to about 600 b.c., the principal subject matter being various aspects of the Aryan conquest of India. The introductory chapters treat the sources of Indian history, its geological and geographical background, Indian flora and fauna and kindred scientific topics. The preface to the work points out the shortcomings of existing histories, their foreign bias and failure to give adequate expression to the intellectual, cultural, political and religious forces that have shaped the course of Indian history. The scholars enlisted for this monumental survey aim to restore the balance. Judging by the first volume, this promises to be an enterprise of rare quality. For scholars it will be indispensable, and anyone concerned with Indian history will find many of the separate contributions of the greatest interest.

THE DINOSAUR BOOK, by Edwin H. Colbert. McGraw-Hill Book Company, Inc. ($4.00). The second edition of a popular book on the majestic reptiles that for more than 100 million years, in the Mesozoic Era, dominated the earth. Sixty million years ago they became extinct, and 59 million years later man appeared; it is doubtful he will reign as long. Dr. Colbert, Curator of Fossil Reptiles and Amphibians at the American Museum of Natural History, writes simply and unassumingly, conveying an immense amount of fascinating information. The charts, diagrams and glossary are nicely executed; the photographs and other illustrations are vivid.

POWELL OF THE COLORADO, by William Culp Darrah. Princeton University Press ($6.00). The subject of this biography, Major John Wesley Powell, was a wonderfully energetic, restless, curious, courageous and able man whose colorful career was spent in a variety of endeavors. A stray bullet cost him an arm at the battle of Shiloh, where he commanded a battery of artillery; this neither ended his service in the war nor kept him, over the next 40 years, from pursuing vigorously his vocation as a teacher, engineer, geologist, ethnologist, explorer and civil servant. His most famous and hair-raising exploit was the first journey down the dangerous Colorado River, from Green River, Wyo., through the Grand Canyon to Callville, Nev., a Mormon town now submerged under the waters backed up by Boulder Dam. Among Major Powell's less spectacular but perhaps more important achievements were his labors as a founder of the U. S. Geological Survey, as the first director of the Bureau of Ethnology and as a tireless advocate of more enlightened policies toward the Indians. Mr. Darrah's biography is an exhaustive piece of scholarship, and its readability survives a somewhat prosaic narrative style.

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What GENERAL ELECTRIC People Are Saying

C. E. EGELER
R. F. VANDEN BOOM
Lamp Division

ILLUMINATION MAINTENANCE: Illuminating engineers, and to a lesser extent, consumers of light in industry, have long realized the gradual but serious cumulative loss in illumination resulting from dirt on lamps and reflectors. Most manufacturers simply are not aware that where there is no regular cleaning, the light loss may be as much as 50 per cent. This is no doubt due in part to the paucity of actual test data regarding the rate of depreciation in lighting levels which occurs under various service conditions.

The operating cost of a lighting system always involves energy, lamp and lamp replacement (labor) costs. In a typical medium-sized plant using two-lamp 40-watt fluorescent industrial units, with energy at 1½¢ per kw-hr, 85¢ net lamp cost for a 40-watt fluorescent lamp, a 50¢ cost of random lamp replacement and 4500 burning hours per year, the over-all annual operating cost excluding investment amortization is $8.10 per 2-lamp luminaire. Two cleanings per year will provide a 42 per cent increase in illumination, or $3.40 worth of light. For a given average illumination the required investment will likewise be substantially reduced. Even though this investment factor be ignored, any cleaning cost up to $1.70 per fixture pays a real dividend. With systematic maintenance, a two-lamp 40-watt fluorescent unit usually can be cleaned for about 35 cents.

Defense mobilization imposes on industry an imperative responsibility for the most effective use of production facilities and manpower. Good lighting becomes more vital than ever, particularly when it is remembered that in the increment of needed workers there will be a greater proportion of older people who need the higher illumination levels to compensate for impairment of vision and age.

National Technical Conference of the Illuminating Engineering Society
August 27–30, 1951

C. G. SUITS
Research Laboratory

METALLURGICAL RESEARCH: The gas turbine, most modern powerplant for aircraft, locomotives, and other machinery, could be made appreciably more powerful with the same fuel consumption by relatively small improvements in certain metals.

Present gas turbines operate at a turbine inlet temperature of 1400 to 1500 degrees Fahrenheit. When this temperature can be increased a mere 100 degrees (by developing metals able to withstand such increase in temperature), the fuel required for a given output may be decreased five to seven per cent, and, equally important, the net power output from a plant of given size may be increased 15 to 20 per cent.

The future of many products of industry rests squarely upon future improvements in the metallic materials of which they are made. That is the simple reason for the extensive activity here directed toward the understanding, improving, developing, designing, engineering and manufacturing of alloys.

Although the type of fundamental and exploratory research performed in the G-E Research Laboratory is more commonly found in a university environment, the experience of 50 years has shown the great value of this approach in an industrial laboratory. Such research has added materially to the standard of living of the American public.

Metallurgy Conference
Schenectady, New York
August 22, 1951

★

L. L. GERMAN
Knolls Atomic Power Laboratory

RADIATION MONITORING: To illustrate the radiological aspects of civil defense according to air and surface types of atomic explosion, I would like to present a system of radiation monitoring which has been worked out by a group in Schenectady for use principally within the first hour after the explosion. Undoubtedly, many effective systems of this nature have been developed throughout the country.

For both types of explosion, it will be necessary to determine the location of the center of the explosion. This task can be accomplished by the use of simple units called "lampshades"—so named because of the shape. The metal lampshade functions on the effect of shadows created by the generated heat and light at the time of the explosion. Mounted at various locations around the target area, so that there will be at least four units within five to ten thousand feet from a burst any place within the target area, a shadow will be cast on the inside painted surface of the lampshade at the time of explosion. Wardens will be assigned to read these units, and should two or more wardens report direction and altitude angle, the headquarters unit can then determine ground zero and the height of the explosion. Since the position of the bomb explosion can be fairly well defined by a minimum of these units, considerable information is supplied quickly by available and simple facilities.

The radiation measurements required for both types of explosions are determined by simple ionization chambers strategically placed throughout the city so as to surround the potential target area. The ideal system would consist of a placement of these chambers on a grid system separated by approximately 1500 feet.

Civil Defense Communications Conference
Syracuse, New York
September 13, 1951

You can put your confidence in—

GENERAL ELECTRIC

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THE AMATEUR ASTRONOMER

Conducted by Albert G. Ingalls

A CLOCK-DRIVEN telescope that can be taken down in two minutes for transportation in the trunk of an automobile is shown at the right and in the upper half of the drawing on the next page. The instrument, designed and built by Lloyd W. Sharp of 229 Newell St., Walla Walla, Wash., weighs only 39 pounds. It approaches the richest-field type, designed to show at one view the greatest possible number of Milky Way stars, and has a mirror 6 inches in diameter and 30 inches in focal length. The driving mechanism by which the telescope follows the motions of the stars is an old ship's clock movement, but a common spring-driven alarm-clock movement would serve.

Most of the description of this telescope is in Roger Hayward's drawings. Other details are given by Sharp.

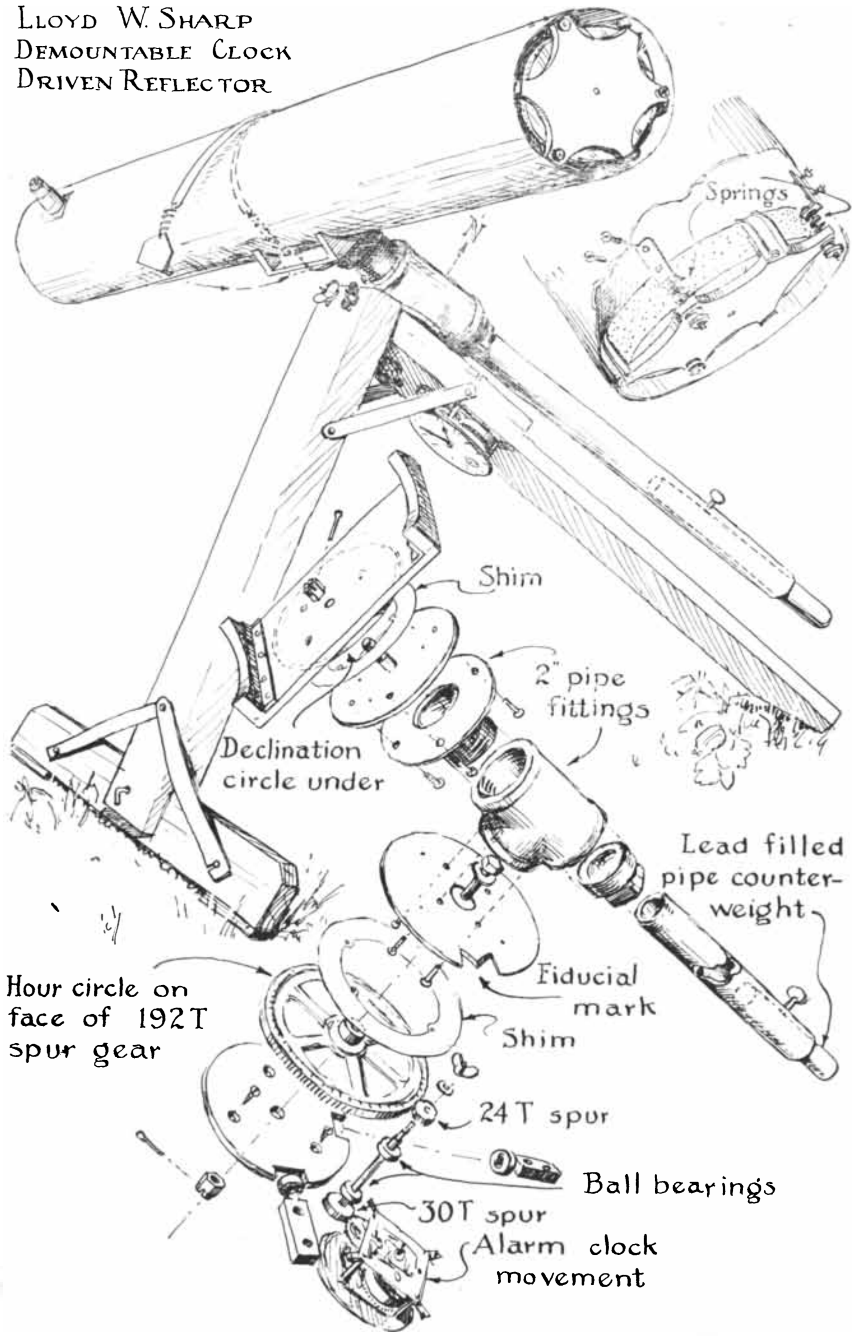
The main supporting leg is a lightweight box of 24-gauge sheet steel. "Practically everything that comes apart on this instrument comes out of a slot," Sharp says, referring to the braces attached to the leg which have "slightly angled, snugging-up slots that drop over studs and are held in place by gravity." He adds that "although my telescope, which I call 'Portable Pete,' smacks of baling wire in spots, it performs beyond my fondest hopes." This is a telescope that could be made by a beginner, yet it contains luxuries.

The driving-gear train between the clock and the telescope is simple. The wheel that drives the minute hand of the clock, turning at the rate of 10 teeth an hour, meshes with a 30-tooth spur gear on the ball-bearing jackshaft, which is thus driven at the rate of one revolution every three hours. A 24-tooth gear on the upper end of the shaft then drives a six-inch, 192-tooth gear on the right ascension axis at the rate of once every 24 hours, a solar day. Corrected speed for the sidereal day of 23 hours, 56 minutes, 4.09 seconds is obtained, or rather approximated, by adjusting the speed of the clock. The gears are numbers G174, 171 and 189, obtained from the Boston Gear Works of Quincy (not Boston), Mass., and their cost was $4.30.

The pipe fittings used on the declination axis—floor flange, T, and reducing bushing—are a full two-inch size.

"This is clearly a poor man's telescope," Sharp writes, "though not 'cheap.' Slight imperfections of the gear teeth will cause slight hour-angle variations, producing oblong star images if celestial photography is attempted. Even in this respect the drive will serve for all except ultra-microscopic results, but its main purpose is as a luxury during ordinary visual observation, to keep the heavenly bodies from crawling out of the field of view because of the earth's rotation as soon as they are located. If the telescope is used as a camera, precise alignment of the polar axis with the earth's axis will be as important as correct clock rate, and this cannot be accomplished in a hurried assembly.

"Ball bearings on the jackshaft and ball-bearing rollers under the right as-



A portable telescope that can be driven by an alarm clock

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OPTICS

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54m/m (2 1/8")	600m/m (23 1/2")	$12.50
78m/m (3 1/16")	381m/m (15")	$21.00
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83m/m (3 1/4")	660m/m (26")	$28.00
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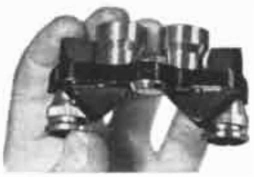

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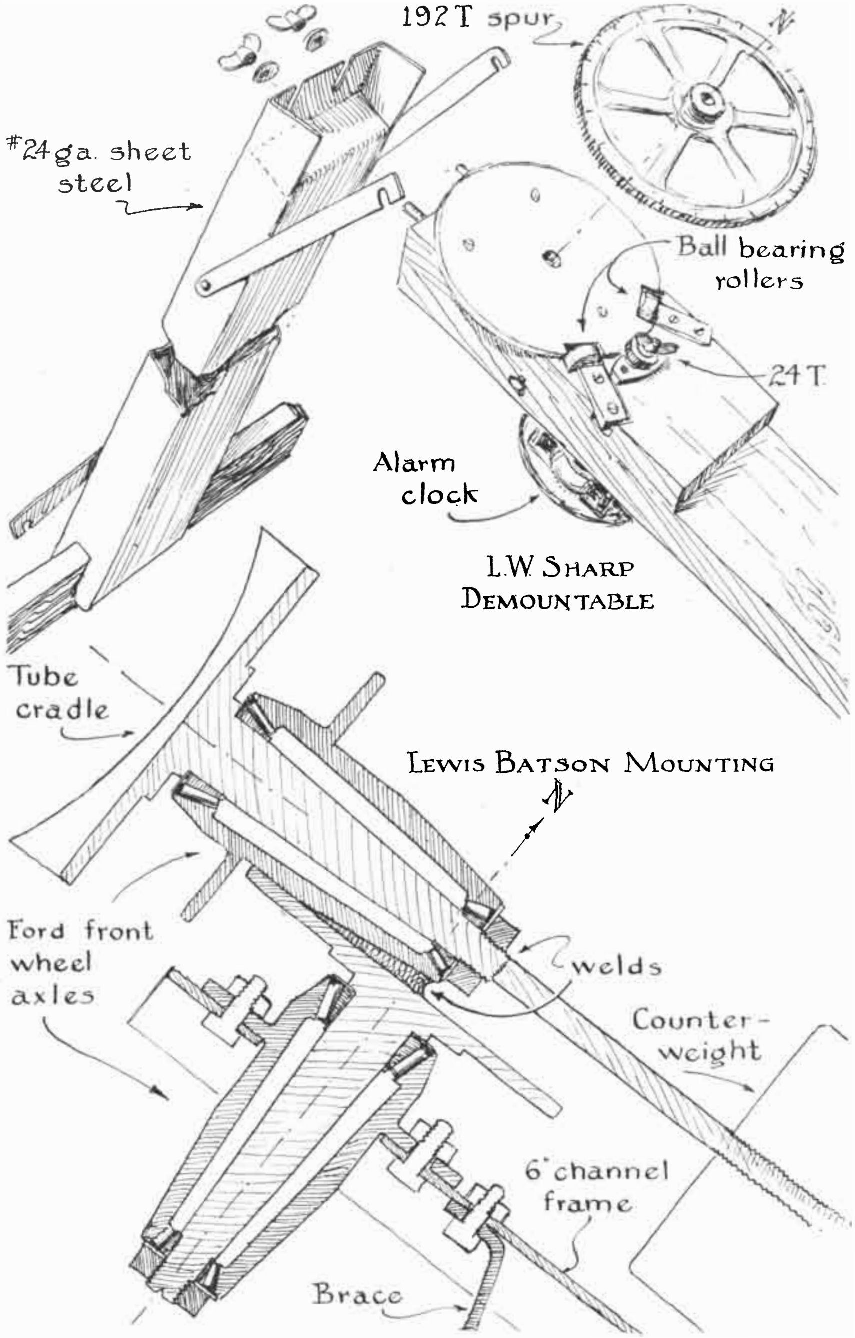

A mounting made from automobile front-wheel spindles

cension base plate reduce the friction so that the clock is strong enough to drive the telescope. If the clock used is not strong enough, the addition of a spring-loaded sector that can be cocked will supply enough torque for an entire evening, the clock then serving largely as a time control.

"While the hour circle may be inscribed on the 192-tooth gear, this is perhaps superfluous, since the gear has 8 teeth per hour as a sufficient guide.

"Both right ascension and declination bearings are of the disk type with annular contact and shims of 0.01-inch sheet metal. The disk-type bearing is unequaled for ease of fabrication and smoothness of operation. It combines maximum steadiness with minimum frictional overshoot, an annoying characteristic of hand-powered telescopes resulting from spring in the mounting combined with high static friction. When the object is not centered well enough in the field of view of such a telescope, the observer pulls the telescope to center it. On the first pull nothing happens, so he pulls harder. Suddenly static friction is overcome and the telescope moves too far. Well-lubricated bearings of large radius and area greatly reduce this overshoot."

By loosening and reclamping the wing nut on the jackshaft, the user of the Sharp telescope can employ the convenient slip-ring principle described by Russell Porter in his chapter on the de-

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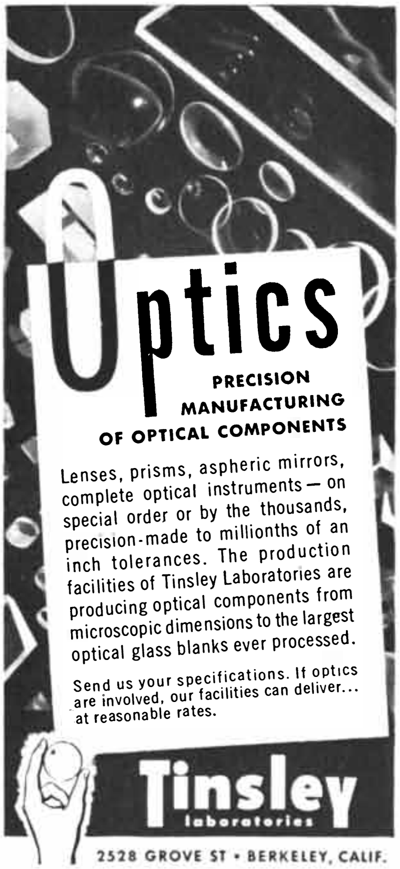

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sign of mountings in *Amateur Telescope Making*. This method enables the observer to "bring any bright known star into the center of the telescope field and set the circle to that star's right ascension, taken from the ephemeris," thus freeing himself from unnecessary drudgery for the entire evening of use.

The six-inch mirror is mounted in a generous seven-inch tube. The cell, made of aluminum, has no rear-end protuberances. Its little central hole assists in lining up the prism.

When Sharp was invited, as other workers are, to criticize his own telescope by pointing out spots he might improve if he were building it again, he listed the tube-clamping strap with spring catch, which permits the tube to rotate for the most convenient eye positions in only one direction, but snubs it in reverse; a tendency of the jackshaft wing nut to work loose; and the absence of a declination lock.

Such self-criticisms are useful to other builders. They underscore the often-given advice that the beginner, instead of attempting to make the final large and perfect telescope on his maiden effort, should approach it by building a series of instruments, perhaps one a year, in the course of which many of the things that "would be done another way another time" are certain to be found.

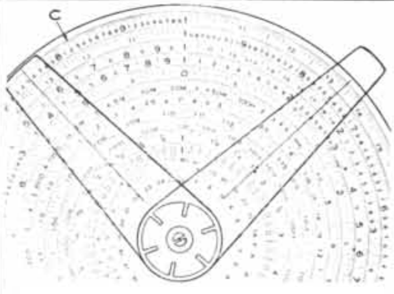
FRONT-WHEEL spindles from an old Ford, tapered roller bearings, hubs, and hub flanges with their axle and steering connections burned off provided the main parts of a mechanically and esthetically excellent mounting built by Lewis Batson of Wiggins, Miss. The mounting, suitable for any ordinary telescope, is shown in the lower part of the drawing on the opposite page. The right angle between the axes was set by first making light welds at the edge of the parts and then bending these welds slightly to allow the spindle flanges to conform to a square held against them.

"I have used this mounting for my 10-inch $f/3.4$ reflector and it is very satisfactory," Batson states. "I am particularly pleased because the construction did not require much modification of the original parts nor any creation of parts out of the whole cloth at all."

The mounting is bolted to a six-inch channel iron with a brace, and is set in a concrete base. The drawing shows the mounting ready to receive a telescope.

Batson puts a self-accusing finger on one detail that would be done another way another time. While the axes have excellent rigidity, the counterweight, a length of ⅝-inch steel carrying a 50-pound lead weight, "is a source of vibration, the only one of serious moment."

The telescope has a stubby tube for which the Ford spindles are sufficiently rugged, but Batson agrees with the suggestion that truck spindles would perhaps be better with longer tubes.



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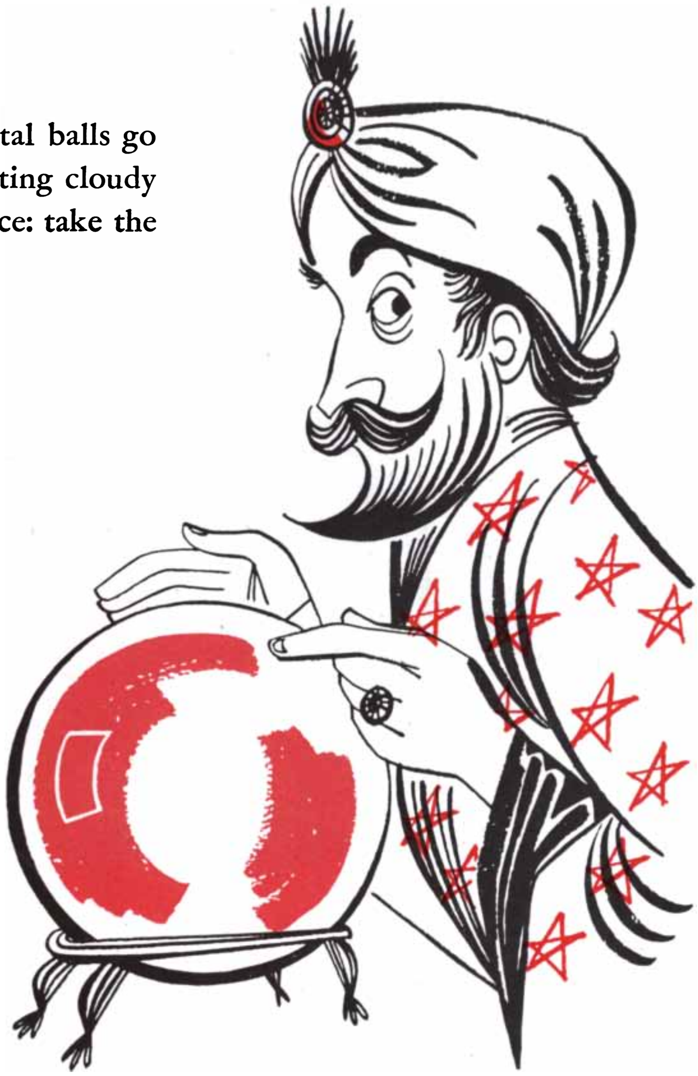

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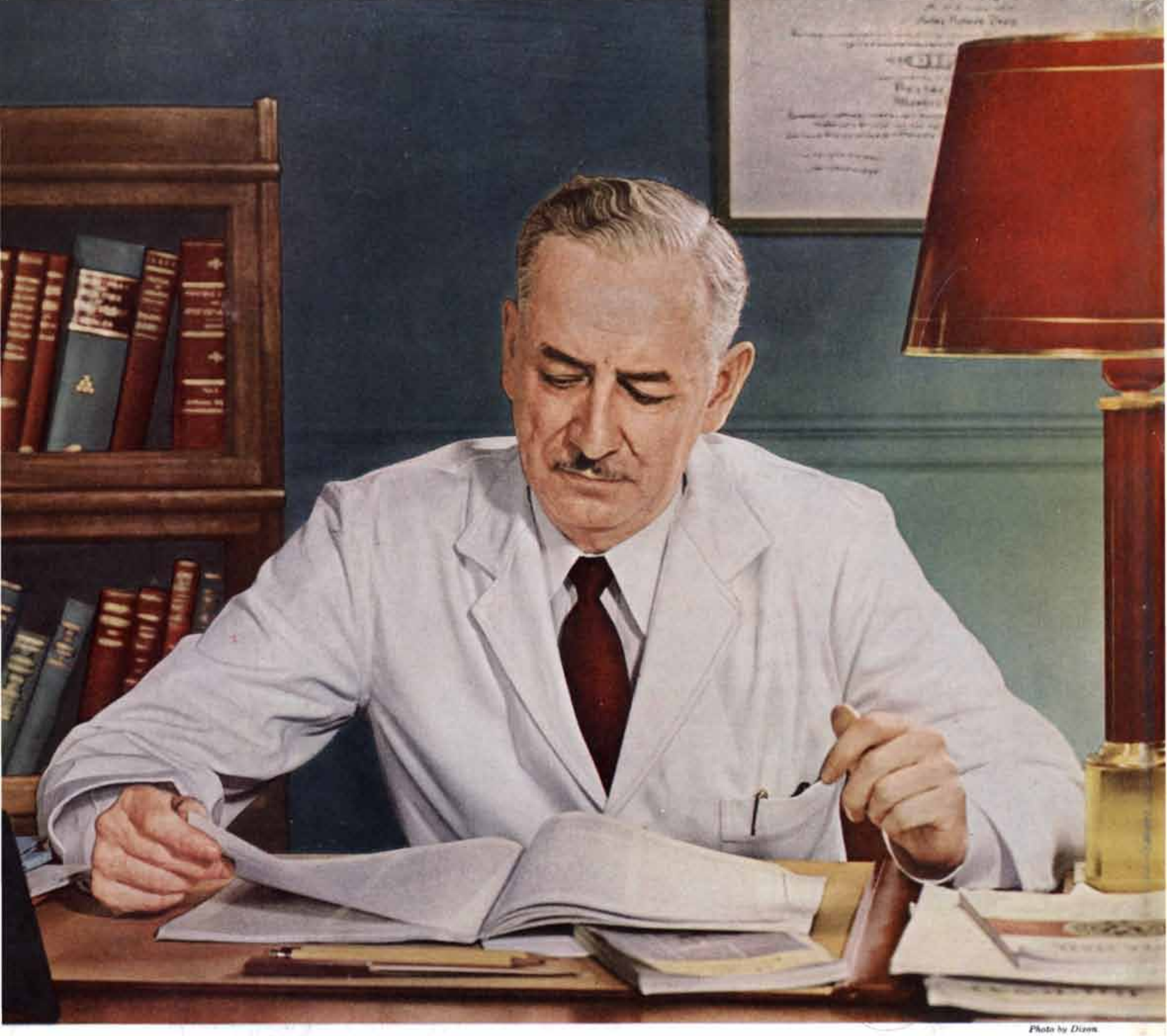

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