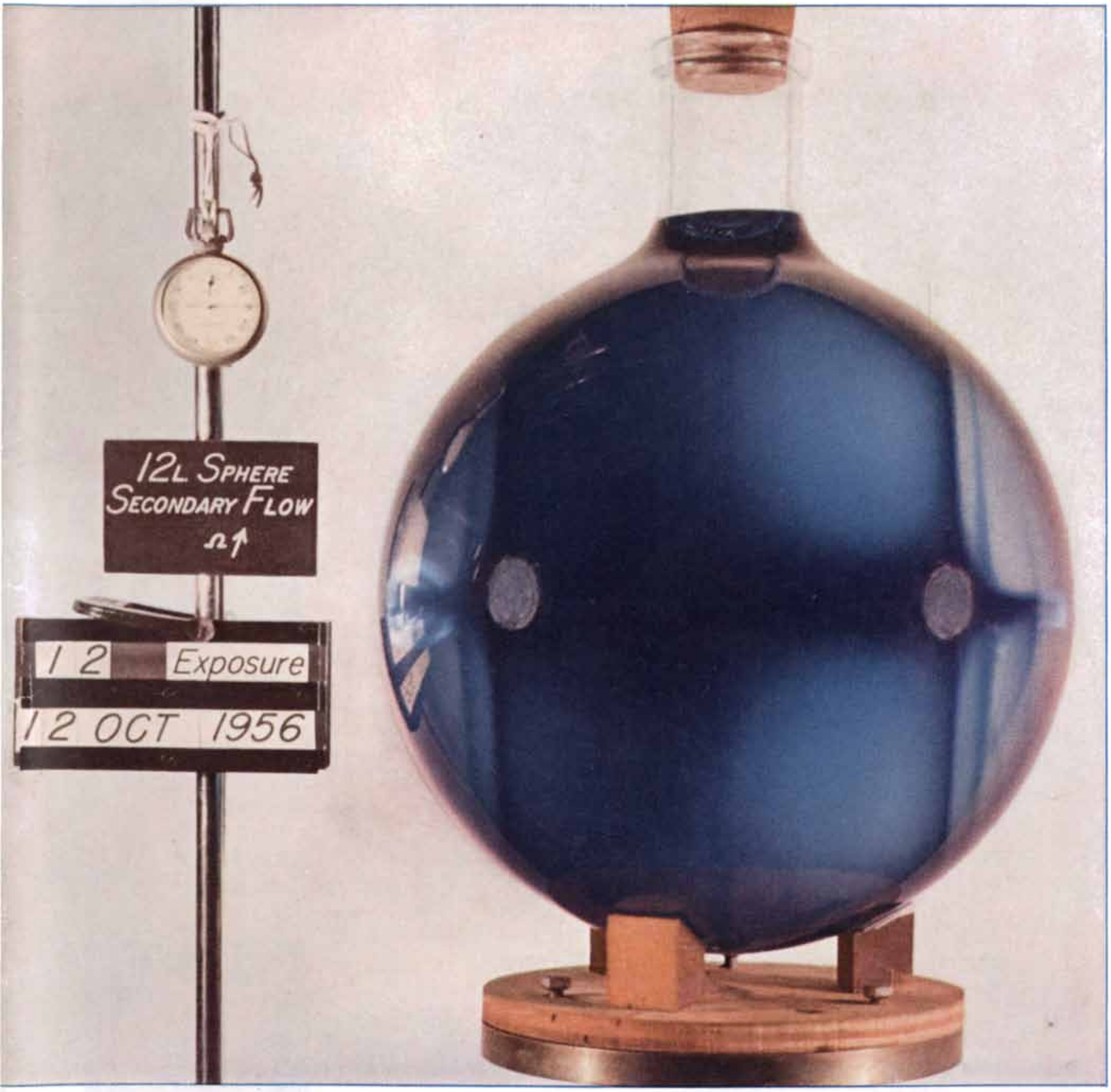
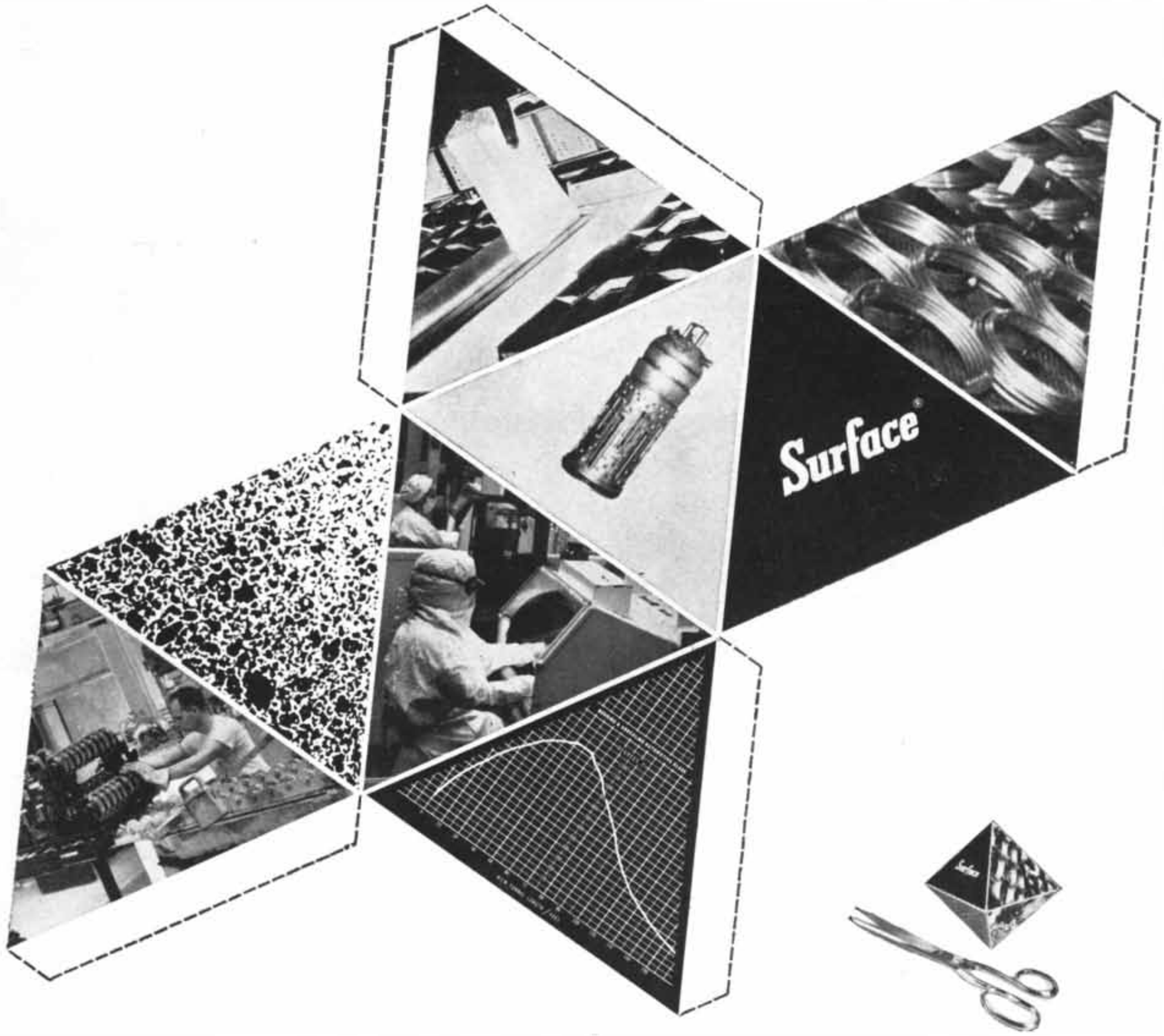
SCIENTIFIC AMERICAN



ATMOSPHERIC MODEL

FIFTY CENTS

December 1956



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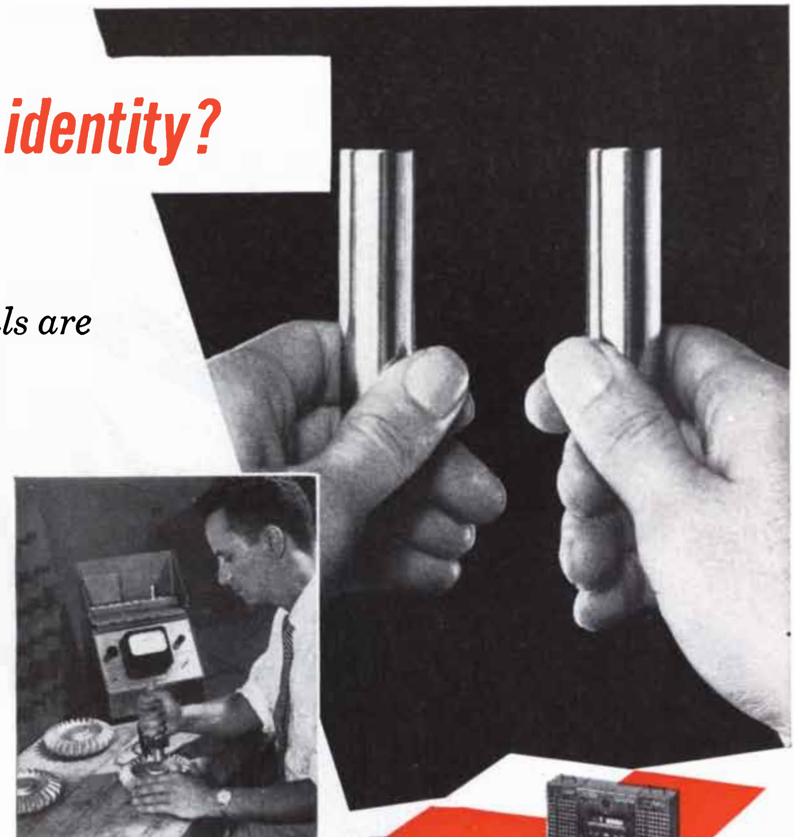

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Established 1845 **SCIENTIFIC AMERICAN** December, 1956 Volume 195 Number 6

ARTICLES

DEPARTMENTS

THE COVER

The photograph on the cover shows a water-filled flask on a rotating turntable. Dye introduced into the flask at the horizontal midplane spreads upward and downward in cylindrical sheets. The effect is a general property of rotating fluids like the atmosphere (*see page 40*).

THE ILLUSTRATIONS

Cover photograph by Dave Fultz

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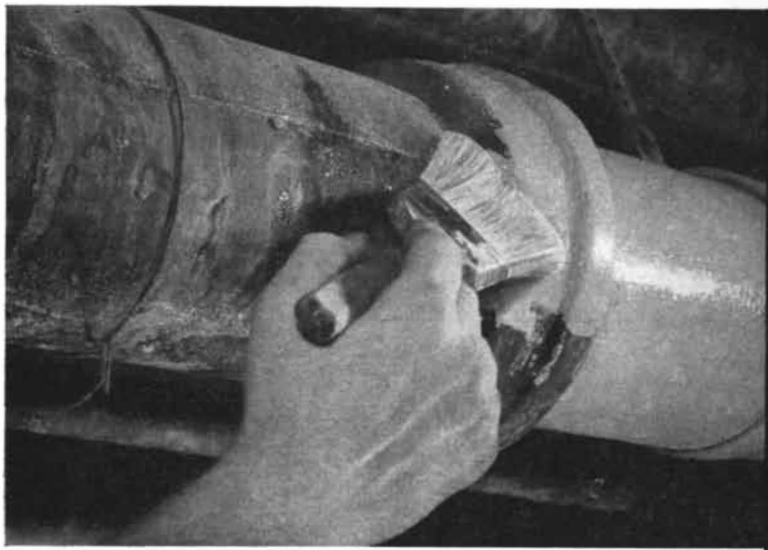

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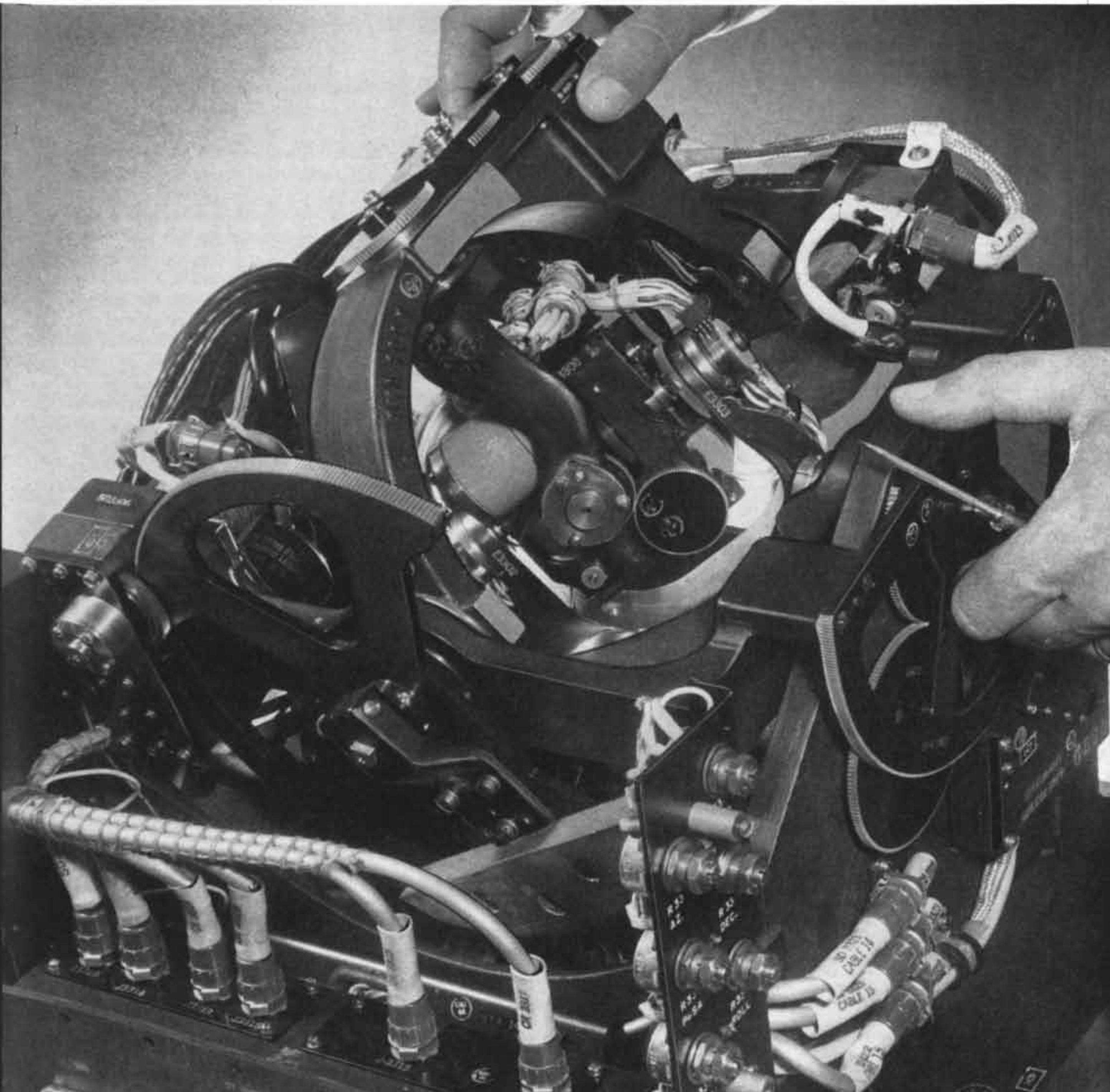

LETTERS

Sirs:

The recent article by Martin Ryle on "Radio Galaxies" [Scientific American, September] could perhaps be misleading to your readers where it refers to the discordance between the Cambridge and Australian observations of radio sources. In fact, the Australian observations are quite consistent with a steady-state universe and, if correct, the Ryle cosmology is invalid.

Working in collaboration with O. B. Slee and using our "cross" radio telescope, I obtained some preliminary results more than a year ago which were described at the International Astronomical Union Symposium on radio astronomy held in England. These were simple counts of the kind mentioned by Ryle in which more than 1,000 radio sources were counted in an area of slightly more than two steradians in the southern sky. The divergence between these and the Cambridge counts was very marked. Now Ryle's cosmology requires that the increase in the space density of radio sources with increasing distance should be roughly constant in every direction and, while we did not attach great weight to the accuracy of our preliminary work, it was clear that the Cambridge and Australian results could not be reconciled by any reasonable adjustment of parameters. It is true that we found a small surplus of faint sources and this is what Ryle probably meant when he said that our results ". . . indicate that radio sources are not distributed uniformly with distance." However it was stressed that the counts were uncorrected for expected instrumental effects and that the apparent divergences from uniformity were within the experimental uncertainty.

Obviously a common study of the sky in an area accessible to both instruments was required, and Ryle kindly sent us in advance of publication a list of Cambridge radio sources near the celestial equator; meanwhile we proceeded with the preparation of a catalogue in this area. A detailed comparison of results has now been made in an area of one steradian stretching from Cetus to Monoceros. Except for the stronger sources the catalogues disagree grossly. There are 227 Cambridge and 383 of our sources in this area, but only 60 coincidences in position within the limits of error and, of these coincidences, about 40 would be expected by chance. It is obvious that at least one of the catalogues is hopelessly wrong.

Now difficulties might be expected to arise when two or more radio sources are sufficiently close together for a radio telescope to respond to each simultaneously. The Cambridge instrument responds to signals in an area of sky 50 times greater than does ours and, although a quantitative comparison is complicated by the fact that the former is an interferometer with multiple responses whilst the latter is a pencil-beam instrument with a single response, it is clear that there is a great disparity in the ability of the two instruments to resolve individual sources. The Cambridge catalogue lists about two sources per beam-width on the average, compared with 17 beam-widths per source in our catalogue. We have analyzed the behavior of different types of radio telescopes in the presence of confusion caused by many interfering sources and find that the agreement between the two catalogues breaks down just about at the intensity level where the confusion factor should begin to limit the reliability of the Cambridge survey; the corresponding intensity level in our survey is an order of magnitude lower. About 95 per cent of the sources listed in the Cambridge catalogue have intensities below the appropriate level of reliability and the number in our catalogue below the level is about 2 per cent.

Further evidence for the relative reliability of the surveys is afforded by the coincidence of radio sources with bright nebulae, which are expected to be radio emitters. In our catalogue radio sources of about the expected intensity and an-

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gular size are listed close to the positions of the six brightest nebulae in the area, including the Orion nebula and the Rosette nebula; none of these sources is included in the Cambridge catalogue.

After correction has been made for the effect of finite resolution and some other instrumental effects, we find that our source counts are not significantly different from those expected with a random distribution in a Euclidean universe. A very small residual excess of faint sources could be explained either by a clustering of distant sources, for which there is evidence, or by random fluctuations in space density; there is no need to invoke any special cosmology.

A full account of this work has been prepared for publication in the *Australian Journal of Physics.*

B. Y. Mills

Commonwealth Scientific
and Industrial Research
Organization
Sydney, Australia

Sirs:

I am very glad of the opportunity of replying to Mr. Mills's letter. In a subject which is advancing as rapidly as radio astronomy it is natural that there should be differences of opinion from time to time; in some cases these differences may be finally resolved only by more detailed observations. It is possible that in the present case a definite conclusion may have to await the completion of the new survey of greater resolving power which is now in progress at Cambridge on a frequency of 160 megacycles per second.

We feel, however, that Mills has not fully appreciated the arguments put forward in our earlier papers; from the evidence we have available to us we do not feel that his criticisms constitute a serious case against our conclusions.

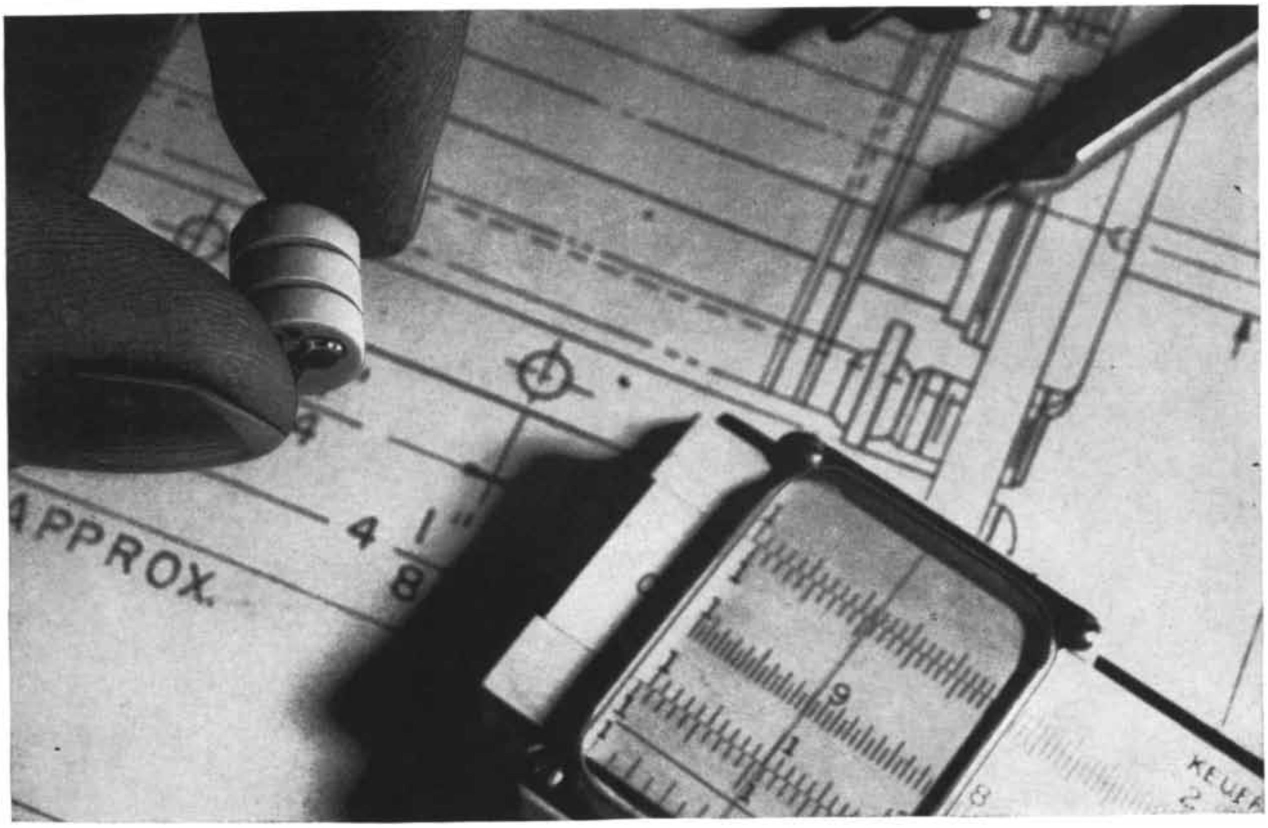
We agree entirely with him that the number of coincidences of individual sources in the small area for which a comparison of the surveys has been made was disappointing; independent evidence for the reliability of the individual sources in the original Cambridge survey can be obtained from the new survey, on 160 megacycles, which provides a fourfold increase in resolving power. Although several months' work is required before the reduction of an appreciable area of sky is complete, we have, for the purpose of this letter, made a comparison of a small area of sky. This area included 14 sources of the original survey, all having a flux density less than 37.10^{-26} m.k.s. units—an intensity range for which Mills would regard our results as of negligible value. The comparison revealed eight sources whose positions and intensities were both in agreement with those in the new survey. For sources in this range of intensity 50 per cent were marked as unreliable in the 81.5-megacycle survey paper [J. R. Shakeshaft, M. Ryle, J. E. Baldwin, B. Elsmore and J. H. Thomson; *Memoirs of the Royal Astronomical Society*, 67, 106 (1955)]. This figure is confirmed by the present results.

Errors in the positions of individual sources have no effect on the estimated number of sources falling within a given intensity range. Near the limit of a survey errors in the intensity will also arise; we cannot however understand the estimate which Mills has made concerning the "level of reliability" in our survey. One contributory cause of his error may be the fact that he has misread the constants of our antenna system as described in our paper [M. Ryle and A. Hewish; *Memoirs of the Royal Astronomical Society*, 67, 97 (1955)]. He states that our beam-width was 2 degrees by 20 degrees and that we are therefore claiming to observe two sources per beam-width.

The measured beam-width of one of our aerials is 2 degrees by 15 degrees but *four* such aerials are used in the instrument. Even if one were to disregard the advantages of using an East-West interferometer in determining the effective "base-level" amongst adjacent sources, the *envelope* pattern—that of each half of the interferometer—has an effective beam-width of 2 degrees by 7.5 degrees.

It is also possible to test the effect of confusion in modifying the number-intensity relationship by restricting the analysis to the more intense sources; if this is done for sources of intensity greater than 40.10^{-26} m.k.s., where there are approximately seven beam-widths per source, it is still possible to give a slope for the curve of log N against log I (where N represents the number of sources having an intensity greater than I), of -2.6 ± 0.4 as compared with the slope of -1.5 which would be expected for a uniform distribution of sources.

Although such arguments have some weight in discounting the criticism which Mills has made, we prefer an alternative approach. We have for some years been aware of the importance of determining the number-intensity relationship by a method which does not depend on the subjective interpretation of records near the limit of detection. It was for this reason that P. A. G. Scheuer and



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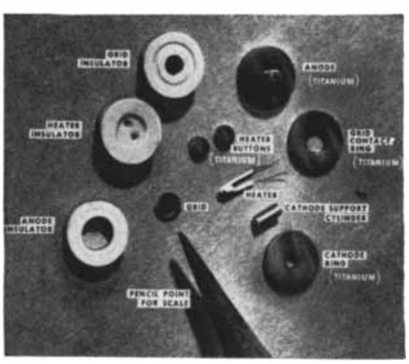

These are the essential components of the initial micro-miniature tube General Electric developed for UHF-VHF television receivers. The metal parts are titanium.

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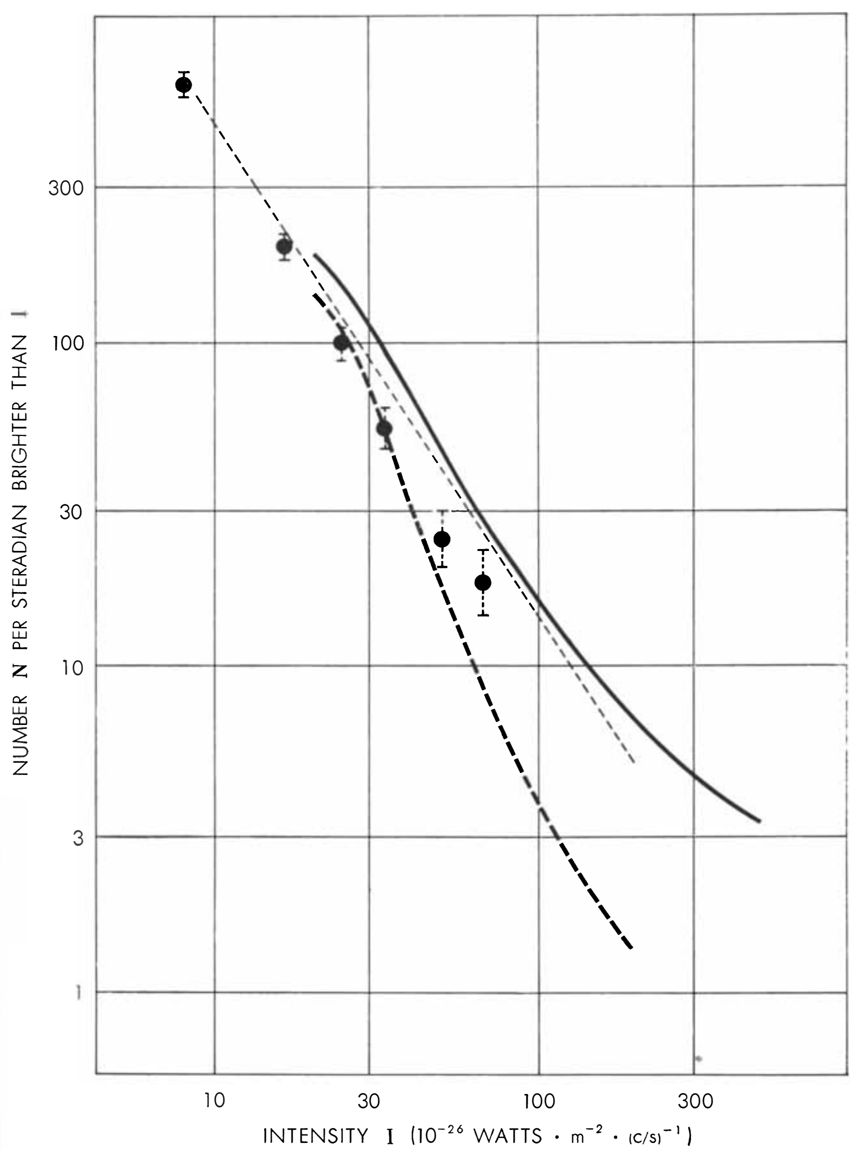
I developed a method which is entirely independent of the interpretation of the records in terms of individual sources [M. Ryle and P. A. G. Scheuer; *Proceedings of the Royal Society*, Series A, *230*, 448 (1955)]. This method, which is based on a statistical study of the record amplitude, enables various possible models of the source distribution to be tested directly from periodic sampling of the record size (which in our case can be carried out with considerable accuracy, the noise being small compared with the signal).

The method, and the results of applying it to the 81.5-megacycle survey, were described in our original paper [Ryle and Scheuer, cited above], where it was shown that the observations were inconsistent with a uniform distribution of sources.

It is now worth seeing just how far our estimate of the number-intensity relationship differs from Mills's. We are here hampered by the lack of any extensive data; the only information available from Sydney being that presented at the 1955 meeting of the I.A.U.

The Cambridge 81.5-megacycle survey revealed two classes of source: those of very small angular diameter and large "surface brightness" which showed an apparent increase of density with distance; and extended sources of much lower "brightness," which did not. The latter class includes galactic nebulosities and normal extragalactic nebulae.

Curves of log N — log I for each class



RYLE PLOTS the results of the Cambridge and Australian surveys. The solid curve represents the Cambridge radio sources near the Milky Way; the heavy broken curve, the Cambridge sources remote from the Milky Way. The dots represent the Australian survey and its limits of error. The light broken curve represents a uniform distribution of the radio sources.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of source were published as Figure 6 in our survey paper [Shakeshaft *et al.*, cited above]. The possibility that the increased slope obtained for the sources of small angular diameter was caused by partial resolution of sources of intermediate angular size was discounted in the paper concerning the interpretation of the results [Ryle and Scheuer]; the absence of any sources of intermediate size was also noted in the survey paper [Shakeshaft *et al.*].

Mills's antenna system does not distinguish extended sources from sources of small diameter unless they exceed 50 minutes of arc; the number of sources observed by Mills should therefore be compared with the sum of the numbers of Cambridge sources of both kinds, the extended sources being taken together with those of small diameter.

Owing to the concentration of the extended sources towards the Milky Way, it is necessary to plot two separate curves: one represents the addition of all Cambridge sources for areas near the Milky Way ($b<12$ degrees); the other represents areas remote from the Milky Way.

The points given by Mills for 1,030 sources in an area which we understand was mainly remote from the Milky Way but included some areas near it, are also included; the scales of intensity have been adjusted according to the quoted intensities of eight bright sources whose positions were in good agreement in the two surveys.

It can be seen that Mills's points, which fit a line of slope -1.8, fall between our two curves; the absolute number of sources per unit solid angle at a given intensity is also nearly the same.

The agreement between these two series of observations, made with entirely different techniques and suffering from different experimental limitations, seems to us to be reasonable: it was for this reason that I implied in my article that I believed that the Australian observations were not inconsistent with the Cambridge number-intensity relationship.

We look forward to seeing further details of Mills's survey, but in the meantime we feel that our conclusions concerning the spatial distribution of sources of small angular size are substantially correct.

Martin Ryle

Cavendish Laboratory
University of Cambridge
Cambridge, England

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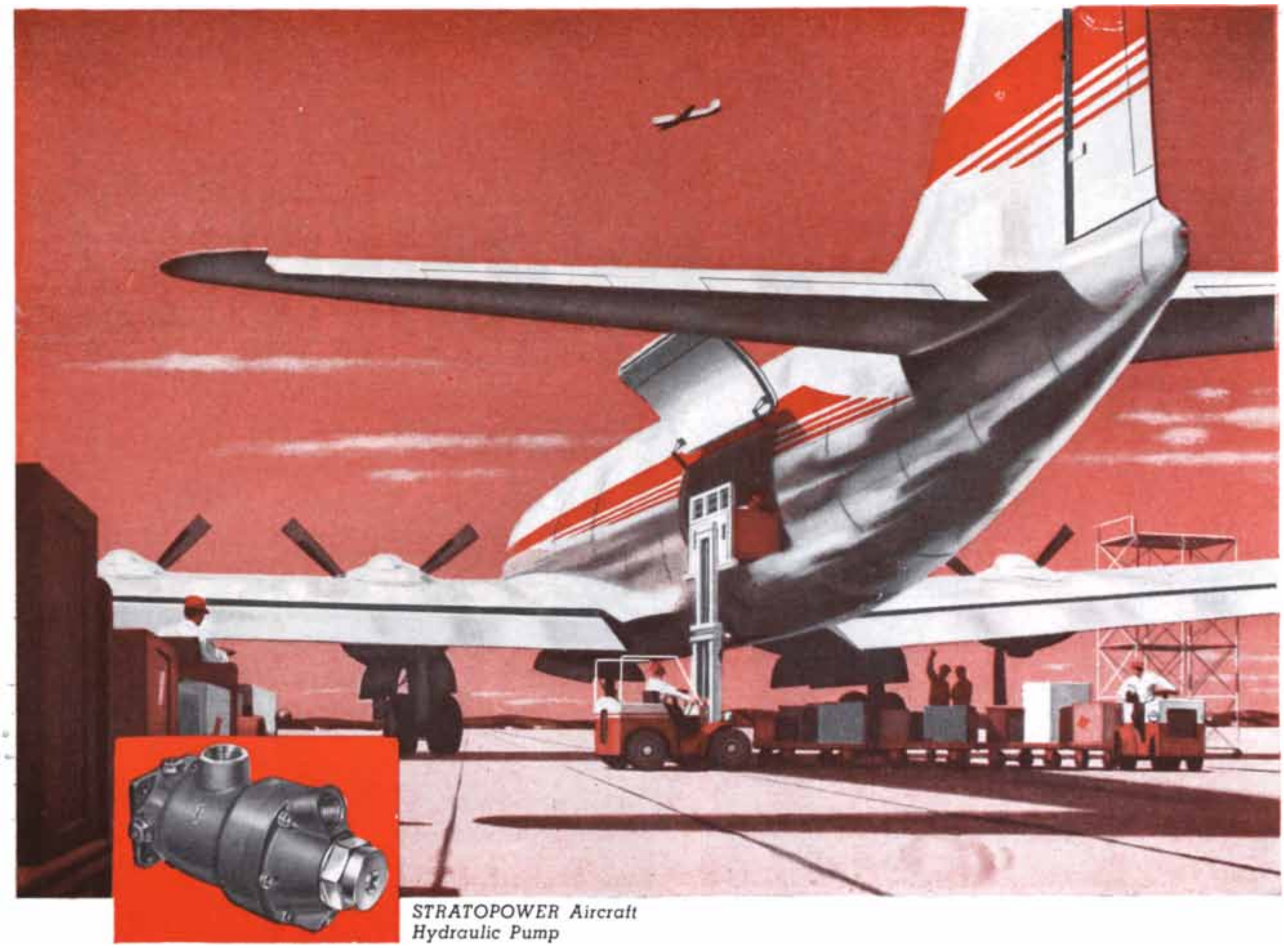

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DECEMBER, 1906: "The recent meeting of the National Academy of Sciences at Boston was notable in several respects. Dr. George E. Hale exhibited photographs of the sun and discussed solar spectra. Prof. Bailey Willis discussed heterogeneous elements of the North American continent, indicating that this continent has had five elevations and four submergences. Dr. Charles S. Minot discoursed on the nature and causes of old age. The alpha and omega of the programme was Alexander Graham Bell on aerodromics. The discouraging factor of aerodromics is the well-known mathematical formula that the sustaining surface of a machine increases only as the square of its dimension, whereas its weight increases as the cube. If, then, you build your large machine in the same form as a small and successful model, it soon becomes too heavy to rise at all. To meet this difficulty, Dr. Bell decided to fasten together many small supporting surfaces so that he could increase the supporting surface at just the same rate as the weight. He found that he could build up large masses of these units compactly, giving great supporting power. These structures can fly at as low a rate as 10 miles an hour instead of the 37 miles per hour at which the Wright brothers operated their machine in Dayton, Ohio."

"Concurrently with the completion of the trials of the *Dreadnought* comes news of the launching by the Japanese of a battleship, the *Satsuma*, which not only exceeds the British ship in size and power, but seems to have made, like that vessel, an enviable record in speed of construction. Most remarkable of all is the fact that this, the world's greatest battleship, has been built entirely by the Japanese themselves. Moreover, a sister ship is under construction. The most striking fact about this truly enormous vessel is her armament, which is to consist of four 12-inch guns carried in two turrets forward and aft on the center line, and no less than twelve 45-caliber 10-inch guns mounted in pairs

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The new silicon is being used to develop still better transistors and rectifiers for telephony. It is another example of how Bell Laboratories metallurgists help open the way to improved telephony.

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Metallurgist Henry C. Theuerer, M.A. in Chemistry, Columbia, watches a molten zone in a silicon rod under purification. Mr. Theuerer's most recent achievement was development of water-vapor treatment for removal of boron.

in turrets on the broadside. The Japanese, as a result of their experience in the war, have concluded that nothing less than the 4.7-inch rapid-fire gun is sufficient to stop large torpedo boats and destroyers. Consequently, the *Satsuma* will also carry a battery of a dozen of these pieces. It is noteworthy that this nation has four 16,000-ton 22-knot armored cruisers afloat or on the stocks, which will carry four 12-inch and eight 8-inch guns as their main battery. This gives them the same offensive power as our own battleships of the *Georgia* class, and practically places them in the battleship class. Evidently this youngest of the naval powers is determined to become master of the Pacific."

"The London *Daily Mail* has offered a prize of £10,000 ($50,000) to anyone who travels by aeroplane from London to Manchester (165 miles) in one day, two stoppages being allowed for the taking in of gasoline. Spurred on by the *Daily Mail*, the London *Daily Graphic* offers £1,000 ($5,000) to the inventor who first produces a machine which, heavier than air, shall fly, with one or more human passengers, between two points not less than one mile apart."

DECEMBER, 1856: "The latest news from England brings the gratifying intelligence that arrangements have been made to construct the Ocean Telegraph Line from Newfoundland to Ireland. Contracts for the whole extent of the Atlantic cable were signed in London. It is all to be completed and placed on board two steamers, ready for sea, on or before the 31st of May next; and by the 4th of July next it is confidently expected that Great Britain and the U. S. will be in telegraphic communication."

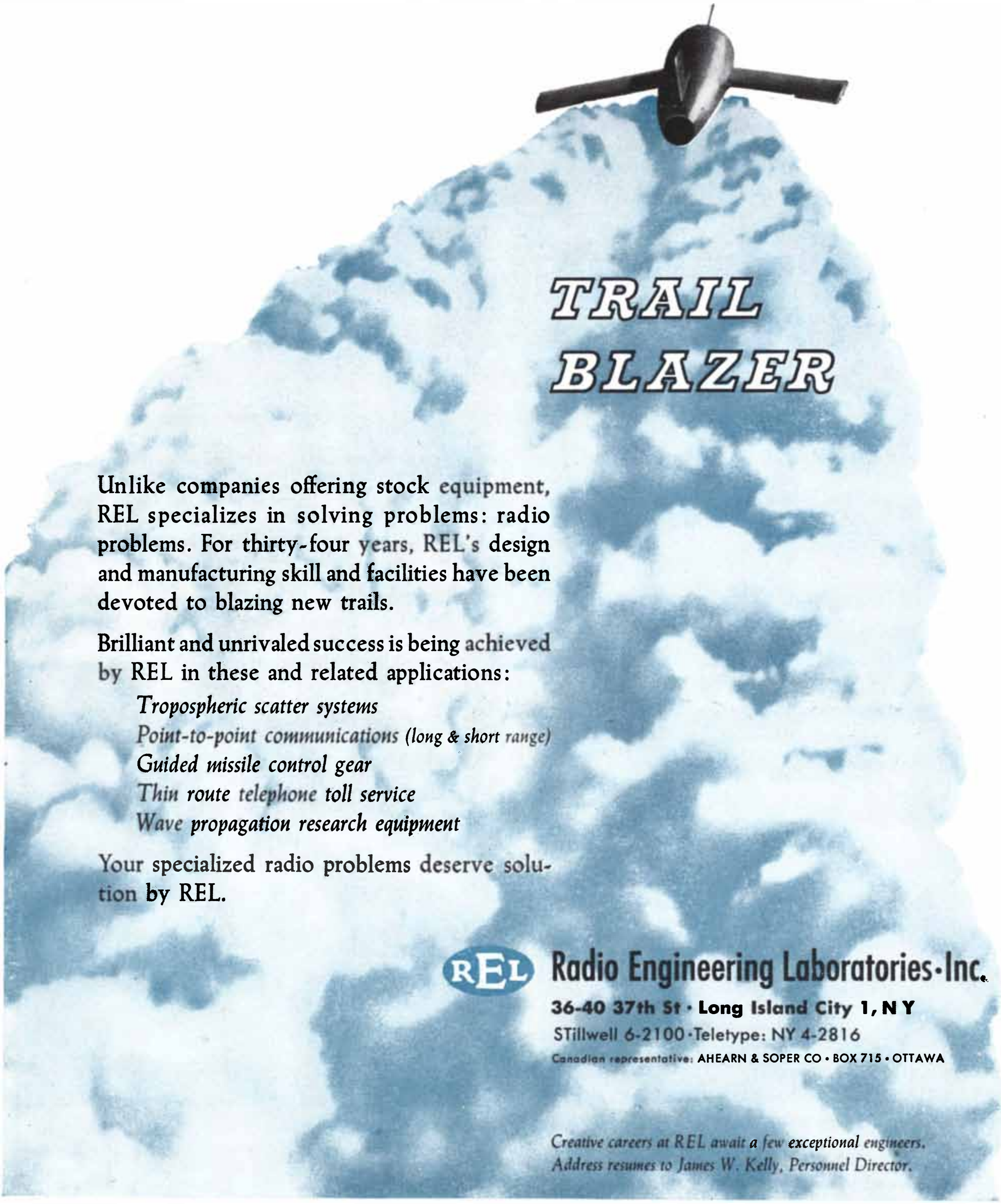
"The subject of a bridge over the East River, to unite the cities of New York and Brooklyn, has oftentimes been talked of, and various plans have been proposed to effect this object. A suspension bridge has been the only apparently feasible plan proposed, and yet it has been considered impracticable, because, on the New York side of the river, a tower about 200 feet high would have to be erected to allow the curve of the bridge to clear the tallest masts of ships sailing under it. This would require a grade of roadway up to it, starting from Broadway (the

highest street), gradually rising above the tops of the highest stores. To overcome this difficulty, it is now designed that a bridge should start with its first high piers from the foot of Fulton Street, New York, and stretch over the river on successive arches to Brooklyn Heights—requiring no grading on that side. It is intended to be an arched bridge, having iron pillars resting on double stone piers laid on submarine foundations. The lineal arches are to be 300 feet in length. Such a bridge would no doubt cost a great sum, but it is the most ingenious plan yet proposed for such a structure over the East River."

"A most remarkable new invention, which we have recently examined, is a small and neat hand-machine for printing. Its object is to print letter after letter, as a substitute for writing with pen and ink. The devices combined to execute the printing continuously in lines are ingenious. The letters of the alphabet, numbers, punctuation marks and spaces are so arranged that when a lever is pressed down, the letter is forced upwards and impressed on a sheet of paper. The paper is fed into the machine on a roller. When one line is printed, the roller is turned forward one notch, then pushed back to its starting position, and the machine is ready to print another continuous line. A band of paper of any length may be used in the machine, and the printed portion can be read as it is fed out. This machine is well adapted to meet the wants of the community for various purposes. It can be brought into service in villages, in getting out handbills, notices or labels of any kind, and it forms a very instructive mode of teaching young persons to spell, punctuate, compose, &c., because they can reproduce at pleasure, in printed form, essays in prose or verse."

"The city of Paris alone contains 110 establishments exclusively occupied in the manufacture of materials used by photographers, and one of them employs 130 workmen. There are 700 photographers in Paris, some of whom execute 80 to 100 portraits a day by each photographer, costing 15 cents each and sold at an average of $6. The stereoscope is also a branch of photography, in which one Parisian firm has accumulated $120,000."

"The race among the clippers from China to England, with the first cargoes of tea for the present season, has been won by the American clipper *Maury*. She carried a cargo of 600 tuns of tea."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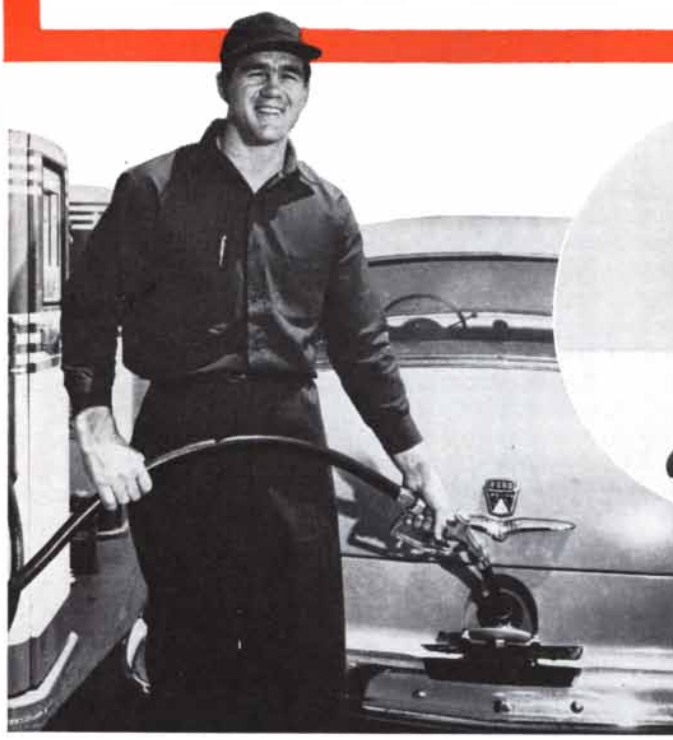
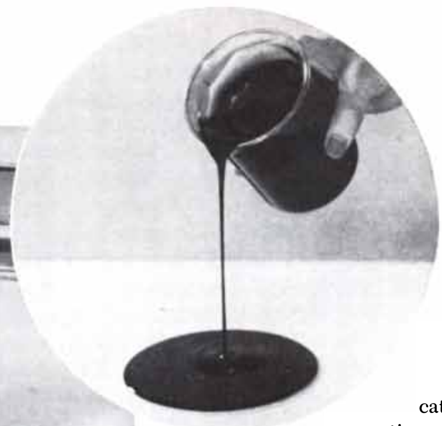
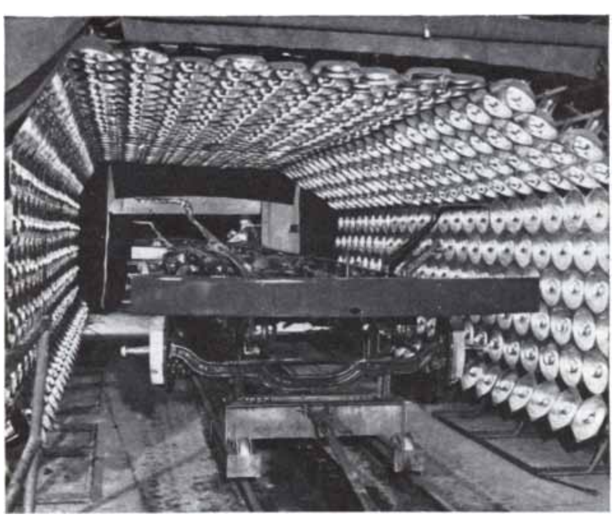
Life ...on the Chemical Newsfront





RESIDUAL OILS BECOME GASOLINE in the rapidly expanding refinery process of catalytic hydrogen desulfurization. With the aid of Cyanamid's HDS Catalysts, refinery by-product hydrogen removes as H_2S the high sulfur content of still residues. In addition, hydrocracking produces gasoline-range products and gas oils suitable for conventional cracking. Cyanamid's HDS Catalysts are a cobalt-molybdena type designed to combine maximum catalytic efficiency with physical characteristics that provide maximum catalyst life and throughput. **(Refinery Chemicals Department)**

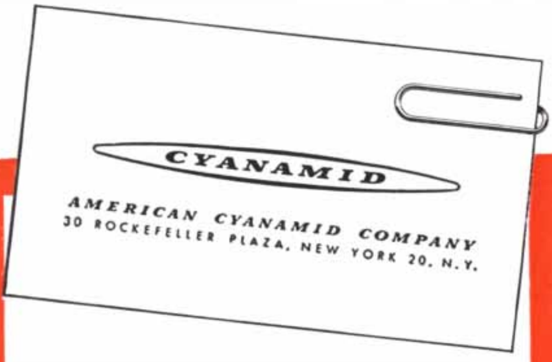


FASTEST DRYING PAINTS EVER MADE are formulated from styrenated alkyd resins modified with Cyanamid's Acrylonitrile. Baking enamels can be dried in five minutes at 300° F. Typical air-dry paints are dust-free in 5-10 minutes, tack-free in 10-15 minutes, and hard-dry in less than half an hour. These fast-drying films are harder and tougher, more resistant to chemicals and solvents, and display remarkable resistance to bronzing and chalking. The use of Acrylonitrile as a co-monomer has similarly improved physical and chemical properties in a wide range of products. **(Organic Chemicals Division)**

THE MEDITERRANEAN FRUIT FLY seriously threatened the Florida citrus industry this summer. It is being controlled with area-wide aerial and ground spraying with Malathion, Cyanamid's recently developed broad-spectrum insecticide. View above shows spraying in the Miami Beach area. When the "Medfly" last invaded Florida in 1929, 75% of the state's citrus crop had to be destroyed in a two-year drive to effect control of the infestation. Malathion-bait spray is expected to control the infestation efficiently without such drastic loss to Florida's agriculture. **(Agricultural Chemicals Division)**

NEW HEIGHTS IN SAFETY AND STRENGTH: Putnam Rolling Ladder Company utilizes sandwich construction of glass fiber and LAMINAC® Polyester Resin to create lightweight ladders with nonconducting properties that make them ideal for power and electrical work. Non-corrosive properties and superior strength recommend these ladders for chemical plants—in fact, they're excellent for any kind of plant under any kind of condition. LAMINAC Resin and glass fiber are also combined in the fabrication of boats, chemical processing tanks, structural building panels and automotive equipment.
(Plastics and Resins Division)

ADD SPARKLING WHITE GIFT WRAPPERS to the applications for "whiter-than-white" papers made possible with Cyanamid's CALCOFLUOR* PHS Concentrate optical brightener. Where eye-appeal counts, papers treated with CALCOFLUOR stand out because the ultraviolet portion of light is converted into a visible blue-white, adding whiteness and brightness to the paper. CALCOFLUOR optical brighteners are well established as textile and detergent aids. Their use is also rapidly increasing in paper because of the unequalled contrast given to typography and illustration by these brilliant white papers.
(Organic Chemicals Division) *Trademark



Additional information may be obtained by writing on your letterhead to the Division of American Cyanamid Company indicated in the captions.

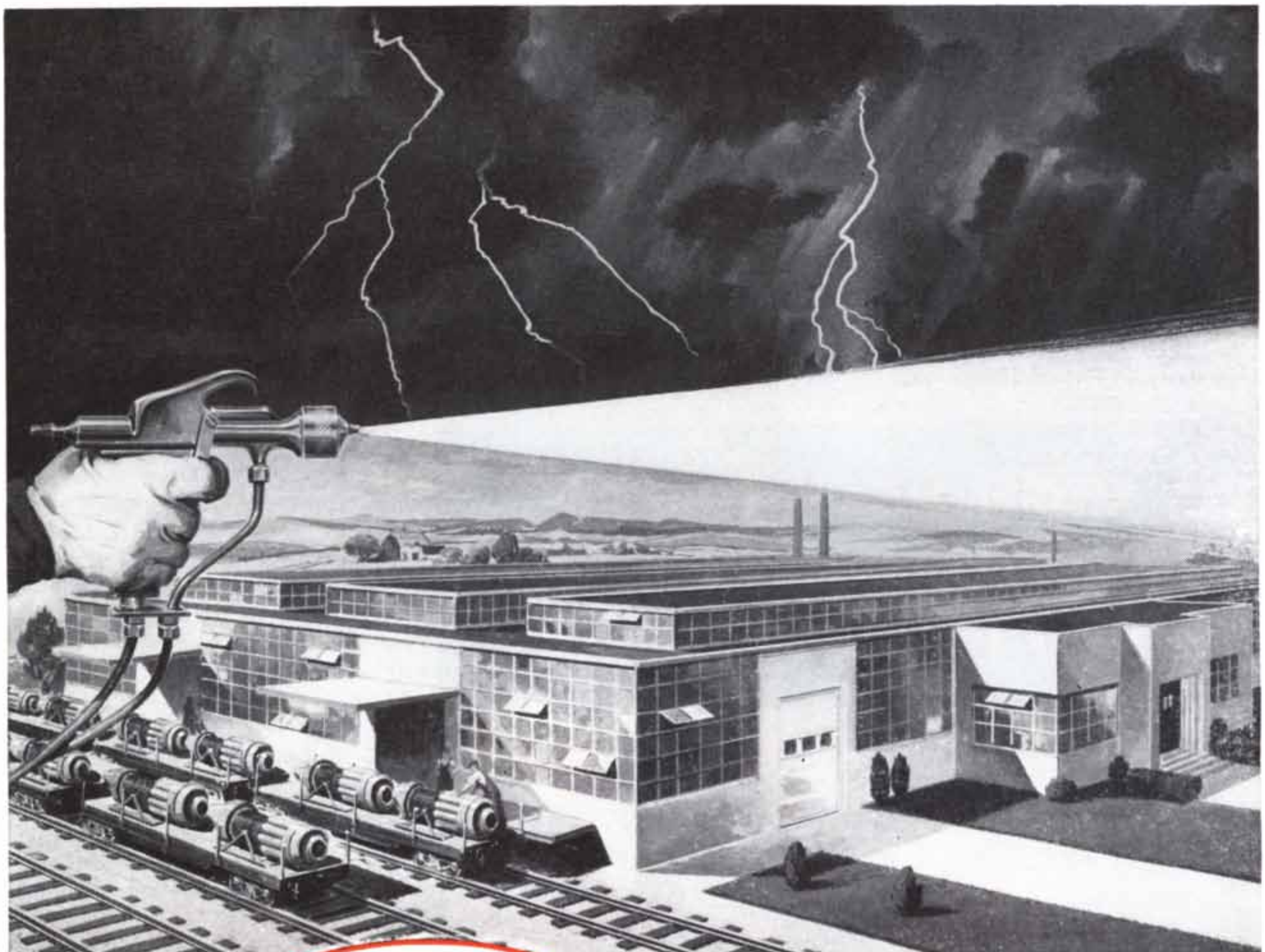
Building for the Future Through Chemistry

THE AUTHORS

HERBERT H. HYMAN and PAUL B. SHEATSLEY ("Attitudes toward Desegregation") are public opinion experts who have collaborated for many years. One of their many joint efforts is the survey described in their article, which they designed and carried out for the National Opinion Research Center of the University of Chicago. Hyman is a professor of sociology at Columbia University, where he received his Ph.D. 15 years ago. He made public opinion and morale surveys for the Government in the U. S., Germany and Japan. This year he received the Julian H. Woodward memorial award of the American Association for Public Opinion Research. Sheatsley has directed the Eastern office of NORC since 1942. At present he is carrying out a major investigation of the public's attitudes toward health and medical care. He was once a newspaperman and a Gallup pollster, and has served on the executive councils of both the World and the American Associations for Public Opinion Research.

VICTOR P. STARR ("The General Circulation of the Atmosphere") is a professor of meteorology at the Massachusetts Institute of Technology. A graduate of M.I.T. and the University of Chicago, he has been a professional meteorologist for 25 years, many of them with the U. S. Weather Bureau. During World War II he taught meteorology to military personnel at the University of Chicago. Starr is the author of a book called *Basic Principles of Weather Forecasting* and of many research papers on his chief interest, the general circulation of the atmosphere.

JOHAN T. RUUD ("The Blue Whale") is professor of marine biology at the University of Oslo. He has served as dean of the science faculty of his university and as chairman of the Norwegian Research Council for Science and the Humanities. Born in the old sailing-ship port of Kragerö, on the south coast of Norway, Ruud went to sea in a merchant steamer before he took up studies at Oslo. Johan Hjort, his teacher at the University, interested him in the scientific problems of Norway's whaling industry, and after graduation Ruud spent many seasons with the whaling and sealing fleets. In 1938 he was appointed director of the State Institute for Whale Research. The achievement



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To wipe out corrosion by weather, rust and rot, industry looks to the performance and versatility of the 6 specifically-engineered Firestone Exon solution resins.

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Ruud considers most interesting has nothing to do with whales: he was the discoverer of a genus of Antarctic fishes (the *Chaenichthyidae*), which are considered to be the only vertebrates without red blood cells.

ALBERT GHIORSO and GLENN T. SEABORG ("The Newest Synthetic Elements") are leading workers in the University of California's Radiation Laboratory at Berkeley. One or both of them have participated in the discovery of all of the transuranium elements. Seaborg, a Nobel prize winner, is director of chemical research at the Radiation Laboratory. He received his Ph.D. from the University of California in 1937 and has been there ever since except for his work at the Metallurgical Laboratory of the University of Chicago during World War II: he was primarily responsible for the development of the chemical separation procedures used in the manufacture of plutonium. Besides the Nobel prize, he has received many honors: on January 11 he will be awarded the Perkin medal in industrial chemistry for 1957 at a dinner in his honor at the Waldorf-Astoria Hotel in New York. Ghiorso, an electrical engineer, has made major contributions in the instrumentation of nuclear chemistry and physics.

GEORGE W. GRAY ("The Lamont Geological Observatory"), a member of the staff of the Rockefeller Foundation, has written articles for SCIENTIFIC AMERICAN on many subjects, ranging from microbiology to the size of the universe. His most recent article was "Life at High Altitudes," in the December, 1955, issue. Gray is the author of a number of books on science, and he has won the George Westinghouse–A.A.A.S. prize for science writing.

A. M. GAUDIN ("Sorting Solids with Bubbles") is Richards Professor of Mineral Engineering at the Massachusetts Institute of Technology. He was born in 1900 in Smyrna, Turkey, where his father managed a French-owned railroad and had mining interests; his grandfather, Marc-Antoine Gaudin, made contributions to atomic theory and was the first to synthesize corundum, ruby, sapphire and rock crystal. Young Gaudin's first love was entomology, but after receiving his B.S. in France he went to Columbia University to study mining engineering and stayed in the U. S. to teach at Columbia, the University of Utah, the Montana School of Mines and then M.I.T. He has writ-

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These ears of corn might have been gobbled by the corn earworm — estimated to be our second most destructive farm insect—if it had not been for a new insecticide development that will save millions of ears of eating corn annually for food consumption!

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ten two textbooks and more than 100 articles. As a mineral consultant he has visited every state in the Union and all the provinces of Canada, as well as South America, Africa and Europe. Among the engineering processes he has developed are several currently in use for the extraction of uranium.

LORUS J. and MARGERY J. MILNE ("Electrical Events in Vision") are, respectively, professor and assistant professor of zoology at the University of New Hampshire. Lorus Milne, a Canadian, became a U. S. citizen in 1942. He and his wife both hold Ph.D.s from Harvard University and are well known for their work in invertebrate vision, which owes its present direction to research they did during World War II with H. K. Hartline at the Johnson Foundation of the University of Pennsylvania. The Milnes conducted an expedition to the jungles of Central America in 1953-54. They are now engaged in another expedition in the West Indies, and will return in the spring of next year to lecture and to continue their research at the Scripps Institution of Oceanography of the University of California. They have contributed several articles to SCIENTIFIC AMERICAN.

A. G. BEARN ("The Chemistry of Hereditary Disease") is an associate of the Rockefeller Institute for Medical Research in New York City. He was born in England in 1923, and comes from a family in which the scientific and administrative sides of medicine were both well represented. After earning his M.D. at Guy's Hospital in London, Bearn served in the medical branch of the Royal Air Force. Later he studied for two years at the Postgraduate Medical School in London. He has been with the Rockefeller Institute since 1951.

MARTIN GARDNER ("Flexagons") is a free-lance writer with a mathematical bent. After graduating from the University of Chicago in 1936, he went into newspaper and public-relations work. After service in the Navy during World War II he began to write humorous short stories for magazines and serious articles for such journals as *Scripta Mathematica, Philosophy of Science* and *The Journal of Philosophy and Phenomenological Research*. His books include *In the Name of Science*, a survey of pseudo science, and *Math, Magic and Mystery*, which is to be published this month. Gardner wrote an article on logic machines for the March, 1952, issue of SCIENTIFIC AMERICAN.

Getting specific about gravity!

Falling apples fascinated Sir Isaac Newton. No doubt he enjoyed a few of them while devising his famous gravitational formulas. Newton's concern was with what came down, whereas aviation engineers today are primarily concerned with what goes up. Even so, the gravitational challenge is the same.

A jet plane, intercontinental missile—or anything that moves — usually leaves the design stage too heavy for optimum performance. To be specific — the specific gravity of the material of construction is too high.

Now, with Titanium, the design engineer can capture the strength of alloy steel at barely more than half the weight. What's more, Titanium is unaffected by most corrosives . . . and is impervious to the deadly attack of sea water and marine atmospheres. Its coefficient of expansion is low . . . and it can withstand long-time operating temperatures as high as 1000°F.

All types of Titanium mill products, from foil to seamless tubing, are made by TMCA. With production going up and prices going down, now is a good time to design with Titanium. Technical literatuıe on Titanium is available just by asking.

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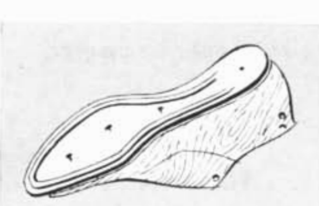
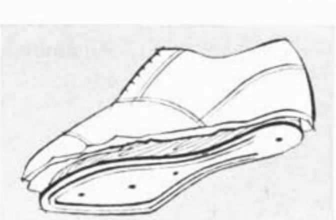
Here's

"Bottom filling" Here, cold-process cork filler is being spread into the irregularly shaped cavity created by the welt process. The cork forms a springy inner cushion that will stay flexible and comfortable for the life of the shoe.



In the Goodyear welt process, a die-cut leather insole—with a lip raised around its edge—is tacked temporarily onto a shaped wooden form called a last.



The parts of the upper are stitched together and the heel counter and the box toe of the shoe fitted into place. The assembled upper is then pulled down over the last.

how men's shoes are made

The construction of welt shoes is pretty standard but its development makes a fascinating story

Until about 100 years ago, a man couldn't tell his left shoe from his right. They were both the same. Then some unknown hero changed all this by shaping the two shoes differently. Since that time, there has been only one major development in the art of making men's shoes: the Goodyear welt process, named after the son of the famous rubber pioneer.

Today, practically all men's shoes are made by Goodyear's welt process. In this construction, a narrow strip of leather—the "welt"—runs around the outside of the shoe and is lock-stitched to both the shoe upper and the insole. Then, as the drawings below show, the outsole is in turn stitched to the welt.

Shoes made this way are strong and keep their shape well. But this welt construction also raised a problem for the manufacturers. The combined thicknesses of welt, upper, and insole lip created an irregular cavity between the insole and the outsole, and this cavity had to be filled.

In the early days, the cavity was filled with sheet leather, patiently trimmed by hand to fit. But since the cavity varied in depth, the leather never really filled it. Neither was the leather soft enough to provide a comfortable cushion for the foot. Obviously a filler was needed that would not only fill the cavity completely but also be easier to use and more resilient.

In their search for a more practical filler, shoe manufacturers turned to a plastic material that could be "buttered" into the cavity where it would harden. This filler was made of cork particles and wax. It was heated and then spread into the cavity. As it cooled, the wax hardened to hold the cork in place.

This filled the cavity all right. But since heat softened this material in the first place, heat from the foot or from a long summer's walk would soften it again. When this happened, the softened filler would squeeze out from under the foot wherever foot pressure was greatest. The result was a lumpy, uncomfortable shoe. Winter brought its problems, too, for then these "hot" fillers became stiff and brittle.

Armstrong research chemists, at work on the problem, realized that cork, because of its lightness and resilience, was the ideal base material for a shoe filler. The question was how to develop a binder that would resist both heat and foot pressure.

After years of experimental work, they found the answer in a unique combination of resins and drying oils. There remained, however, the problem of formulating a solvent to make the new binder plastic and workable. It had to be a special solvent . . . one that struck a delicate balance of qualities. It couldn't be too active, for example, or it would make the binder watery. And if it was not active enough the filler would be too thick to spread.

The first solvents tested took too long to evaporate (no good from a production standpoint). Finally, Armstrong chemists found a way to blend certain solvents to get what they wanted . . . a filler that was plastic enough to apply easily, yet that set up fast enough to satisfy the most cost-conscious production man.

The new Armstrong "cold process" filler provided a complete solution. It conformed subtly to the natural shape of the foot. And it stayed that way, flexible and comfortable, for the life of the shoe.

Armstrong makes a full range of shoe cushioning materials: cork composition, cork-and-rubber, and cork-and-fiber. Basic materials similar to these are being used also for such things as gaskets and friction materials. Perhaps one of them can lower costs or improve performance in your product. For details, write to Armstrong Cork Company, Industrial Division, 8212 Inland Road, Lancaster, Penna.

Armstrong Industrial Products

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ADHESIVES
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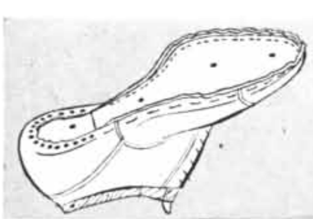
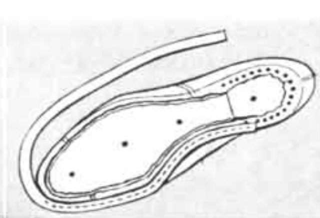
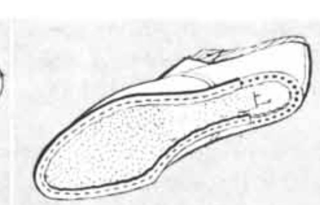


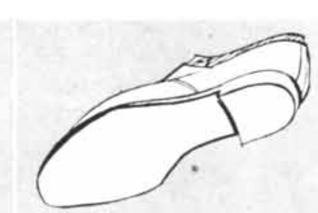
Lower edges of the upper are then pulled down over the insole and tacked temporarily to the last. Tacks are removed when the welt is sewn in place.



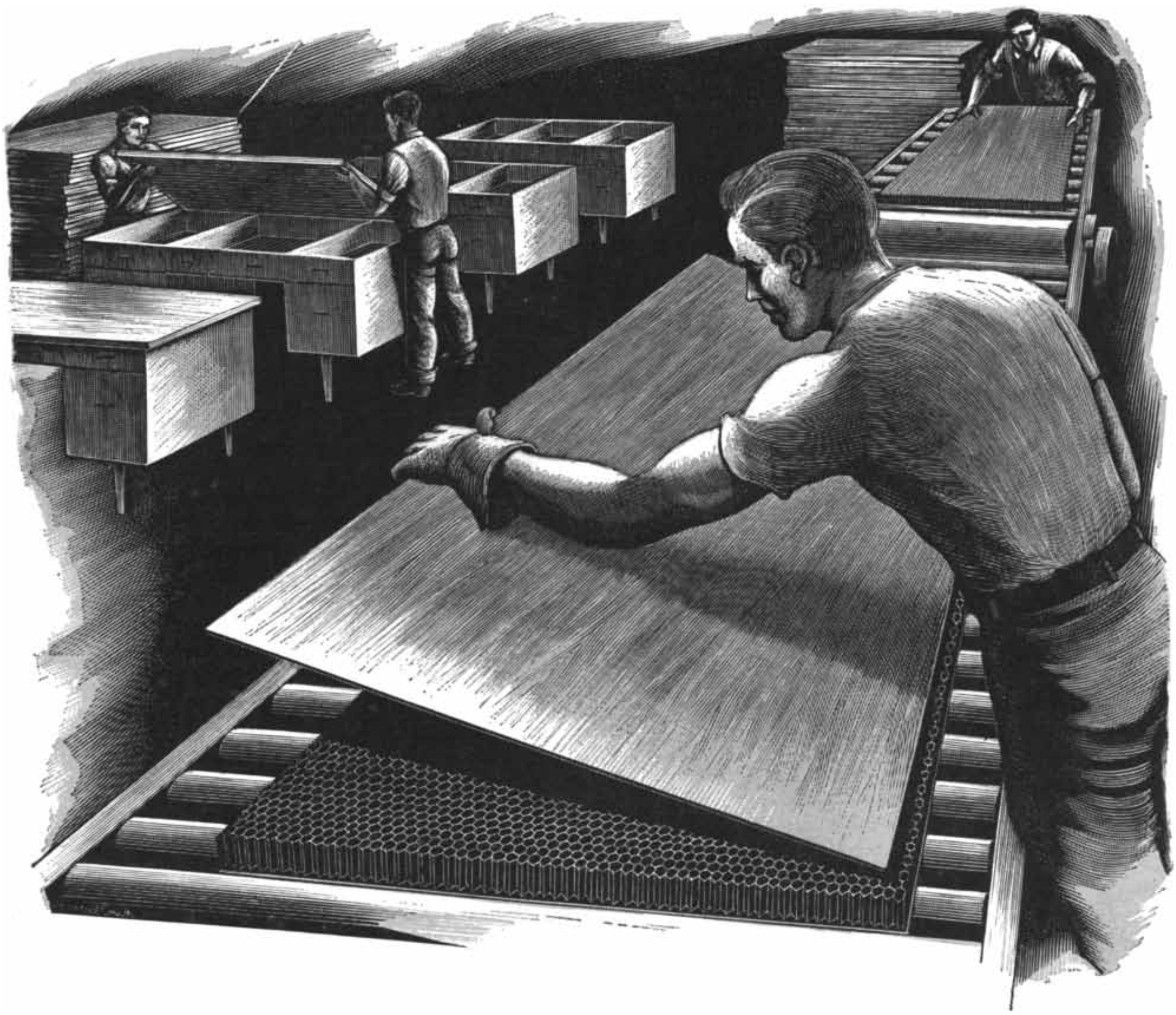
A narrow strip of leather — the welt—is sewn to the upper and insole lip. Excess material around the welt is trimmed away by machine.



The welt is pounded flat and a metal or fiber shank is put in position. The cork filler is "buttered" into the cavity created by the welt process.



Finally, the outsole is sewn on with lock-stitches passing through the welt. The heel is attached, the shoe is polished and pulled from the last.



Turn out sandwich panels fast—with this easy-to-use adhesive

The adhesive is Armstrong D-253—and it's made to order for positive high-speed bonding of sandwich panels on fast assembly lines.

D-253 is very easy to use. You can spray it on core and skin sheets, force dry it for one or two minutes, then assemble your sandwich. One pass through a pinch roll—and you've got a completed panel, ready for processing into such things as desk and table tops, flush doors, or office partitions.

Although D-253 is a thermoplastic adhesive, it has exceptionally high dead-load strength. It bonds sandwich panels firmly, permanently—and instantly. There's no time-consuming curing. The tough, flexible D-253 bond also has high shear strength, excellent resistance to moisture, and good resistance to heat.

Armstrong D-253 is versatile, too. With it, you can bond honeycomb or other cores to many different skins, including plywood, stainless steel, aluminum, and plastic laminates.

For more information on D-253 and other Armstrong Industrial Adhesives, write to Armstrong Cork Company, Industrial Division, 8012 Inland Road, Lancaster, Pennsylvania. In Canada, 6911 Decarie Boulevard, Montreal. Armstrong Adhesives are available for export.

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Attitudes toward Desegregation

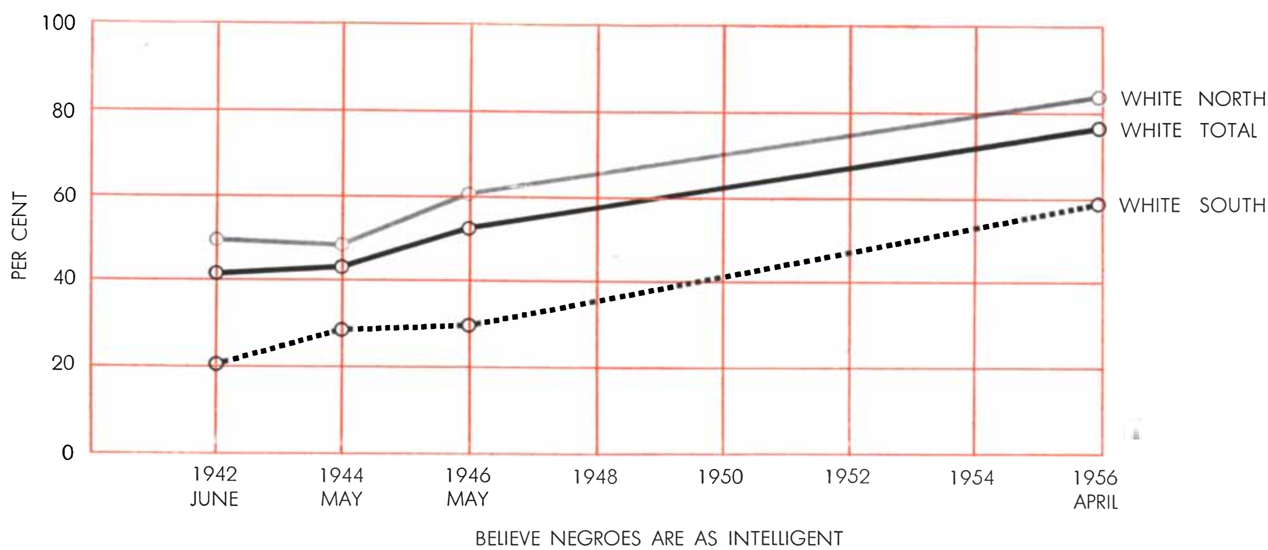
During the past 14 years the National Opinion Research Center has sampled the opinions of the entire U. S. on this troubled issue. Its findings do not agree with some common conceptions

by Herbert H. Hyman and Paul B. Sheatsley

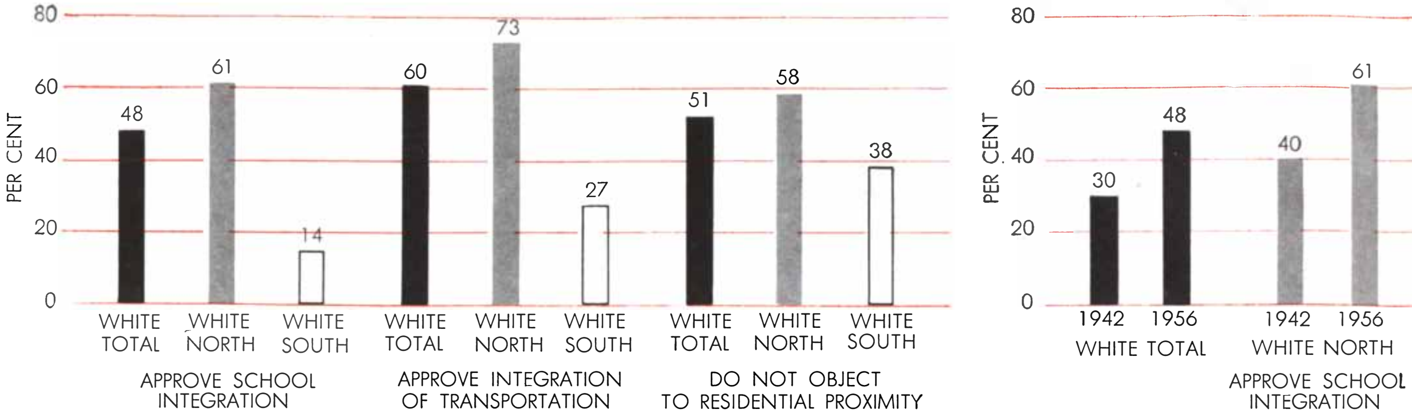
In early September the attention of millions of Americans was focused on two small towns in the border states of the South. In Clinton, Tenn., and Clay, Ky., the issue of racial segregation was being powerfully dramatized in terms which all could understand. Would Mrs. Gordon, the Negro mother in Clay, win her struggle to enter her two children in the local public school? Or would the powerful forces of segregation manage to postpone the day when white and colored children would sit in the same classroom? The drama in both towns was well covered by the nation's press and broadcasting facilities, and they gave a pretty clear picture of the state of public opinion in the two communities, and of the nature and strength of the forces on each side.

The larger picture is less clear. Clinton and Clay are but two of thousands of Southern school districts, each with its own problems and its own traditions. Some have managed to integrate their public schools, painfully, and are now evaluating and pondering their experience. Some have defied the Supreme Court desegregation decision. A third group are doubtful, reluctant, but moving slowly in the direction of integration. Millions of Southerners are searching their traditions and their souls, and millions of Northerners also are reacting to the situation created by the court order. No journalist can describe the hopes, fears, opinions and attitudes of these millions with the same clarity, intimacy and truthfulness that was possible in a small town like Clay, Ky. Yet it is imperative that these feelings be accurately described and understood. As was demonstrated in Clay—and in Louisville, where desegregation was peacefully achieved—the future of school integration depends ultimately not upon troops and law courts but upon the attitudes of the American people.

These attitudes can be determined accurately only through scientific sampling surveys. Such surveys have been con-



CHANGE OF ATTITUDE is reflected by curves of response over a period of 14 years to the question: "In general, do you think Negroes are as intelligent as white people—that is, can they learn things just as well if they are given the same education and training?" The points on the curves indicate the per cent of the respondents who believed that Negroes were as intelligent as whites.



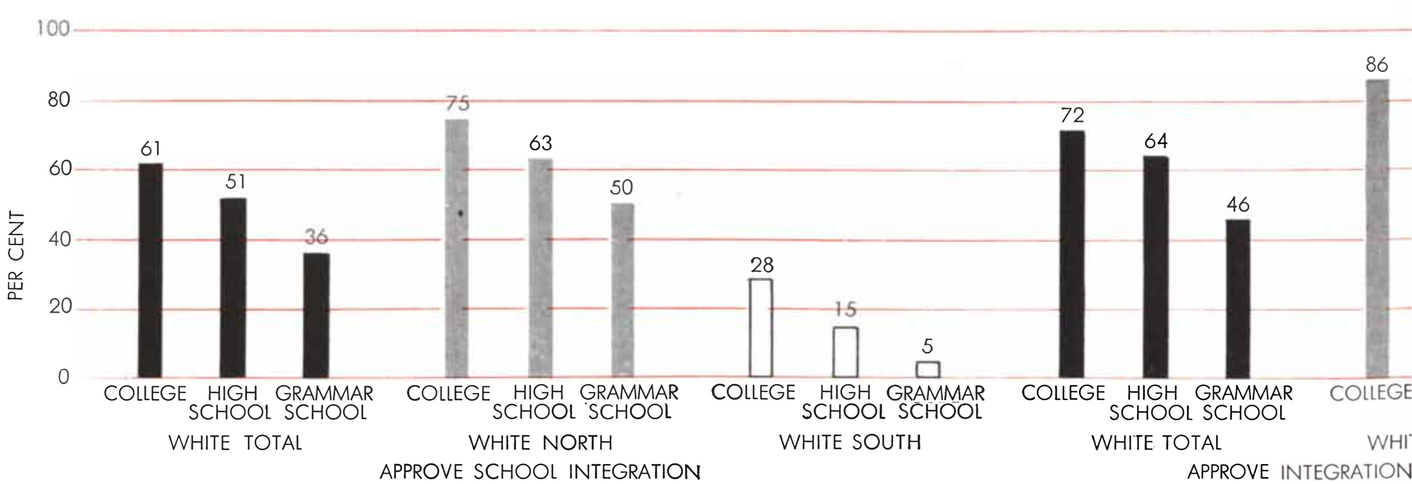
ATTITUDES ON THREE KINDS OF SEGREGATION were sought by the following three questions: (1) "Do you think white students and Negro students should go to the same schools or to separate schools?" (2) "Generally speaking, do you think there should

ducted by the National Opinion Research Center at the University of Chicago over the past 14 years, so that we have an accurate measure not only of present attitudes toward the Negro but also of how the attitudes have changed. The findings will be summarized in this article.

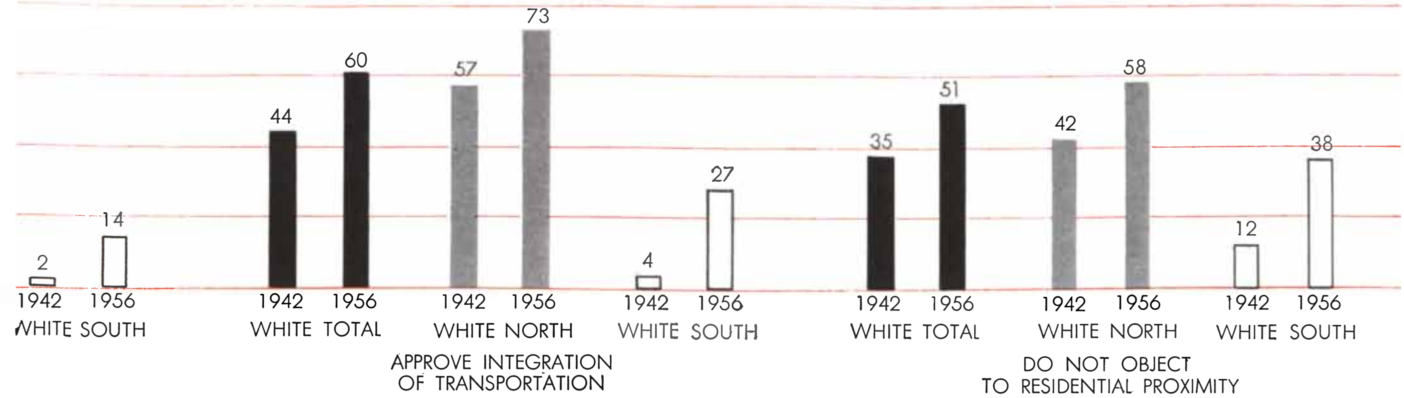
The National Opinion Research Center employs a trained staff of 200 or more resident interviewers in the cities and counties that comprise its master sample of the U. S. The interviewers question a scientifically chosen cross section of the population according to a standardized procedure. Each interview, together with information about the person interviewed—age, sex, education, occupation, place of residence and so on—is transcribed to a punched card, and elaborate analyses and comparisons can then be carried out with tabulating machines. The analyses show not only the over-all nationwide views of white people toward racial segregation but also the attitudes of various subgroups: North *v.* South, older people *v.* younger, integrated *v.* defiant areas in the South, and so on. And most important, they show the trends in these attitudes over a 14-year period. The first of these studies was conducted in June, 1942, on behalf of the Office of War Information, which was then concerned with the problem of racial attitudes as they affected the war effort. In 1944 and again in 1946 NORC repeated some of the same questions. Then, 10 years later, the same queries were put to equivalent cross sections of the public in a series of surveys between January and September, 1956. These surveys show only the attitude of the white population: they do not include the views of the 15 million Negroes in the U. S.

The problem of Negro-white relations in the U. S. involves, of course, not only school segregation but also many other areas of life; recent years have seen the issue posed acutely in public carriers and housing as well as in schools. In its surveys this year NORC inquired about all three areas, employing the following standardized questions: "Do you think white students and Negro students should go to the same schools or to separate schools?" "Generally speaking, do you think there should be separate sections for Negroes on streetcars and buses?" "If a Negro with the same income and education as you have moved into your block, would it make any difference to you?" The questions are simple and straightforward, easily understood by all population groups, and they were supplemented by further questions to clarify any ambiguity in the answers.

In the U. S. as a whole, 60 per cent of the whites interviewed favored integration on public transportation facilities, 51 per cent did not object to living near Negroes, but only a minority of 48 per cent supported school integration. Of course there were wide differences be-



INFLUENCE OF EDUCATION on attitudes toward desegregation is indicated by the chart at the bottom of these two pages. The questions were the same as those listed beneath the charts at the top of these pages; they were asked in 1956. The interviews were



be separate sections for Negroes in streetcars and buses?" (3) "If a Negro with the same income and education as you have moved into your block, would it make any difference to you?" At left is the response in 1956; at right, responses in 1942 and 1956 are compared.

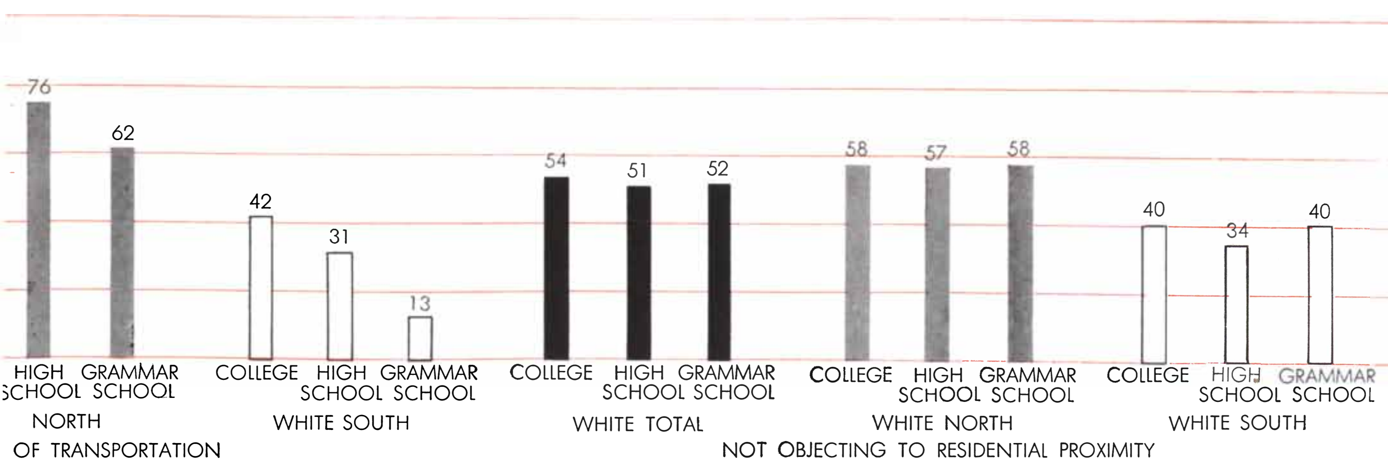
tween the North and South: in the North a majority favored integration in all three situations; in the South, a majority opposed it in all three.

Perhaps the most striking result here is the fact that among the three aspects of integration, the North is least tolerant toward residential proximity, while the South is more tolerant toward this than toward desegregation in schools or transportation. In most of the North, whites maintain a social distance from Negroes though allowing them the legal right to use public facilities. In the South, where public mixing is barred by law, many whites nevertheless do not object to informal social contacts with Negroes. A Charlotte, N.C., housewife said: "I can't see any harm in it. I don't mind living beside them but I don't want the children going to school with them. I just don't." On the other hand, a Brooklyn housewife said: "I approve of them. They should have the same rights. But I wouldn't want to live with them."

There can be little doubt that on racial segregation people honestly expressed their deeply felt opinions. They were not at all reluctant to talk about the subject to the interviewers, and they consistently showed a livelier interest in this topic than in almost any other public question on which people are polled. As one respondent said when the interviewer, after a series of questions about Russia, the Suez Canal crisis, the hydrogen bomb and similar problems, came to school segregation: "Now you're asking the right questions." In the overwhelming majority of cases, the answers, and emphatic comments, fairly burst forth: "We moved last year because some Negroes moved into our block." "I'll go to jail before I let my kids go to school with Negroes." "I don't have to think about *that* question, I'll tell you right now." In contrast to most issues, on which anywhere from 10 to 20 per cent of the public have no opinion or can't make up their minds, on questions about racial segregation the "Don't know" group is never higher than 4 per cent. Almost everyone knows exactly where he stands on the matter.

The picture as sketched thus far does not appear encouraging. The regional differences are sharp. Hardly anyone is undecided or lukewarm about his stand. And people who uphold segregation tend to be anti-integration right down the line, whatever specific aspect of the issue is raised. The rigid views of the segregationists are matched for consistency, strength and intensity by those who favor integration, and the gap would appear irreconcilable.

However, the statistics take on new meaning when viewed in historical perspective. They are very different today from what they were in 1942, when the same questions were asked in the first NORC survey on the subject. In 1942 fewer than one third of the respondents in the nation at large favored school in-



conducted by some 200 trained workers of the National Opinion Research Center. The interviewees were a representative sample of the U. S. white population. Responses are accompanied by age, sex, occupation, and other information about the respondent.

tegration; today almost half endorse the idea. In 1942 two thirds of the population objected to the idea of living in the same block with a Negro; today a majority would not object. Fifteen years ago a majority were for segregation on buses and street cars; today 60 per cent reject the idea. In the North, support for school integration has risen among whites from 40 per cent in 1942 to 61 per cent now. In the South only one white person in 50 spoke up for school integration then; today the figure is one in seven. The proportion of Southern whites who would allow Negroes equal facilities on buses has jumped from 4 to 27 per cent. The South of today has moved far from its earlier position [*see charts at the top of the two preceding pages*].

That these are real changes rather than accidental results reflecting unreliability of the method of ascertaining public opinion is attested by the fact that three separate surveys in 1956 yielded almost precisely the same results—on the school integration question, for instance, the three did not vary by more than one percentage point in the nation as a whole. Furthermore, there was no appreciable shift in a survey made just after the September violence in Clay and Clinton and in Sturgis, Tex. In short, the gains so slowly won over the last 15 years are solidly based—not easily accelerated nor easily reversed.

Though we have been referring to "the South" as if it were a single-minded region, this of course is far from the case. Kentucky differs from Mississippi, South Carolina from Texas, the city of Louisville from a small town in Georgia. In our analysis of the 1956 surveys we divided Southern communities into three groups: (1) those which had integrated their schools; (2) those which had taken at least some tentative steps in that direction, and (3) those which had announced their intention to resist the Supreme Court order. The analysis showed a consistent relationship between public opinion and the actual status of school integration in each area. Where integration has been achieved, 31 per cent of the white population endorse the idea of desegregation; where some steps have been taken toward the goal, 17 per cent of the white public favor integration; where officials have announced defiance of the Supreme Court order, only 4 per cent approve of integration.

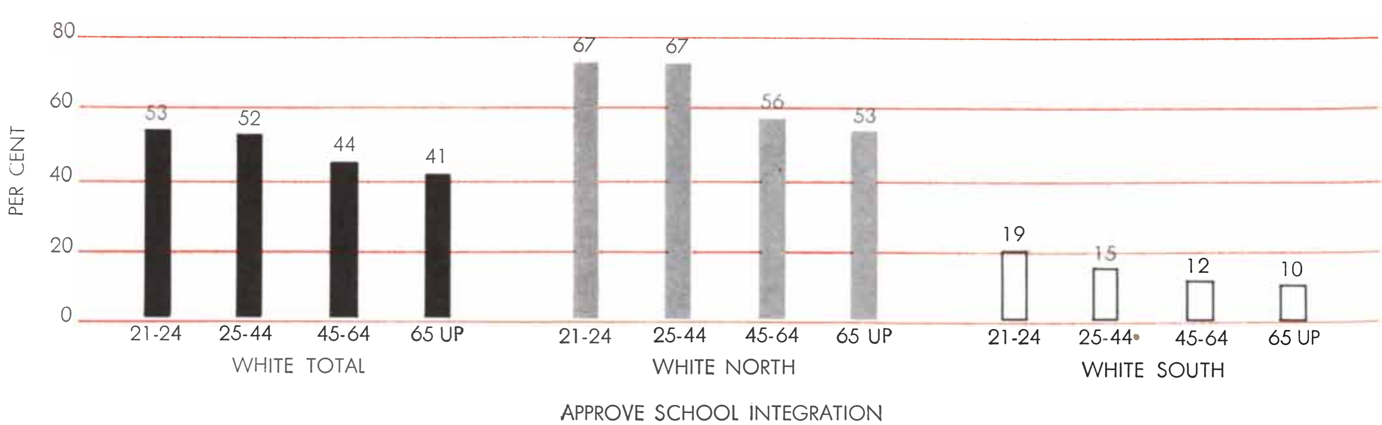
It is clear that those authorities who have integrated schools in the South have not had a majority mandate from the people. Rather, these leaders seem to have utilized their constituents' relative tolerance to push on ahead of public opinion. The problem in those parts of the South which are defying the trend toward integration is pointed up by these figures. Even assuming in those areas a local leadership which was desirous of implementing school integration, such officials would be confronted with the almost unanimous opposition of their constituents.

In the extremely segregationist areas and in those which have integrated their schools the news of the September outbreaks of violence in Clay and Clinton produced no significant change in people's attitudes. But in the "middle group"—the communities taking tentative steps or marking time—the violent incidents had an unfavorable effect on the cause of integration. In those communities support for integration, which had fluctuated between 17 and 24 per cent earlier in the year, dropped to 10 per cent in September. Whether this represents an important shift or merely a short-term reaction will have to be determined by future surveys.

As might be expected, age and education show a definite influence on an individual's attitude toward racial segregation. In both the North and the South it is the younger people who are most ready to accept integration. They account in part (but only in part) for the general shift in sentiment over the past 15 years. As the older, less tolerant generation passes on, it is being replaced by a new generation which is generally less hostile than its parents to the idea of integration. The differences are not very large, but they are significant and consistent [*see chart below*].

Education makes for tolerance, and the younger people are generally better educated. In the U. S. as a whole 61 per cent of the college-educated white persons endorse school integration, but only 36 per cent of those with a grammar school education. In the South 28 per cent of the college-educated favor school integration, but only 5 per cent of those with eight years or less of schooling. Strangely enough, education makes no difference when it comes to tolerance toward residential proximity to Negroes [*see chart on page 36*]. But social and financial status may enter here, for the better-educated tend to have higher incomes, and upper-income groups are generally the most intolerant of Negro residence in their neighborhoods.

What are the underlying reasons for the shift in attitude toward segregation over the last 15 years? Does it represent merely a grudging accommodation to outside pressure or does it mean a really fundamental change in people's beliefs about racial questions? Some evidence on the point is provided by the answers to a basic question that



INFLUENCE OF AGE on attitude toward desegregation in the schools is presented by this chart. The question, asked in interviews during 1956, was: "Do you think white students and Negro students should go to the same schools or to separate schools?"

was asked in all the NORC surveys: "In general, do you think Negroes are as intelligent as white people—that is, can they learn things just as well if they are given the same education and training?" On this issue there has been a dramatic change in people's beliefs, both in the North and the South. Fifteen years ago 50 per cent of Northerners answered "No" to the question, but today only one Northern white person in seven says that Negroes are inferior in intelligence. In the South a substantial majority today credit Negroes with equal intelligence, against only 21 per cent in 1942 [*see chart on page* 35]. This is a revolutionary change which goes far to explain the rise in acceptance of school integration. It has undermined one of the most stubborn arguments for segregation and provides a barrier to any future reversal of the trend. Among those who believe that Negroes are as educable as whites, 58 per cent favor integration of schools, while among those who deny their equal intelligence, only 19 per cent favor it.

But it is obvious that favorable beliefs about intelligence do not automatically produce integrationist attitudes. A full three quarters of the Southerners who concede the Negro's intelligence nevertheless still maintain a segregationist position. Plainly, however, their position is not as firmly based as it formerly was. Once the educability of the Negro has been granted, it becomes considerably more difficult to argue against integration in the schools.

One further question from the NORC survey files throws light on the moral dilemma of segregation. Gunnar Myrdal, in his book *An American Dilemma*, pointed out the conflict between the U. S. creed of "fairness" and "equality" and the practice of segregation. Yet the paradoxical fact is that Americans do not generally see a moral dilemma here. In the NORC surveys over a period of more than a decade, a majority of the U. S. people have not considered Negroes to be mistreated. To the question, "Do you think most Negroes in the U. S. are being treated fairly or unfairly?" about two thirds of the respondents have consistently answered, "Fairly." Southerners have been even more prone than Northerners to say that Negroes are treated fairly [*see chart below*].

It may be, of course, that the majority are either deliberately or unconsciously hiding their true feelings and thus concealing a moral dilemma which they do in fact experience. It would be difficult to prove the point, but certainly a study of the comments people make in answering the question reveals little soul-searching, hesitation or feeling of guilt. Many declare: "They're being treated too doggone good." Respondents remark: "Just look around you. They are being given every opportunity for progress that they never had before." "Look at all the Negro ballplayers and others." To most people any argument that Negroes are not being treated fairly appears to fly in the face of the evidence.

The absence of any marked long-term change in this attitude suggests that the public's standard of fair treatment depends largely upon the existing situation. If the standard for fair treatment were fixed, one would expect that as the lot of the Negro improved over the years, the proportion of people who felt he was being treated unfairly would decline. One might further expect that in the South, where Negroes face a greater amount of discrimination, a larger proportion of the public would grant that he was unfairly treated. But neither is the case. What these findings suggest is that the appeal to the American creed of fair play as an argument for integration is not a widely effective argument.

Nonetheless, the long-term trend is steadily in the direction of integration. It has moved far in 15 years, and it may be accelerating. Certainly there is no evidence that it will soon, if ever, reverse itself, for it is supported by revolutionary changes in ancient beliefs about Negroes and by the continued influx of better educated and more tolerant young people into the effective adult public. But while the long-term outlook is decidedly favorable, the prospects just ahead are not encouraging. In the defiant areas of the South, where 94 per cent of the people vigorously demand continued segregation, it is highly unlikely that either local leadership or outside pressure will change public opinion; indeed, outside force may intensify the sentiments of the local population.

Still, the surveys show that it is not necessary to wait until a majority of whites are ready to grant the Negro equal access to schools, buses and residential neighborhoods. In the Southern areas that have integrated their schools during the last two years, two thirds of the white public continue to mutter that Negro children really should go to "separate schools." But the fact of integration has been accepted, and one looks forward with interest to the results of future opinion surveys in those areas. Segregationists are themselves inclined to agree that theirs is a lost cause. When Gallup Poll interviewers recently asked Southerners, "Do you think the day will ever come in the South when whites and Negroes will be going to the same schools, eating in the same restaurants, and generally sharing the same public accommodations?", only one in three answered, "No, the day will never come."

LACK OF CHANGE IN ATTITUDE is reflected in responses over a period of 12 years to the question: "Do you think most Negroes in the U. S. are being treated fairly or unfairly?" The variation in North, South and the entire U. S. is not more than 3 per cent.

The General Circulation of the Atmosphere

Concerning a new and surprising answer to one of the central questions of meteorology: What forces give rise to the great westerly and easterly wind systems that prevail on the earth?

by Victor P. Starr

The key to our weather lies in the movement of air, and the key to that in turn lies in the power mechanism that drives the air circulation. Aristotle pointed out more than 2,000 years ago in his *Meteorologica* that the winds of the earth must derive their energy basically from heating of the air by the sun. Warm air rises and cooler air falls. Starting from these elementary facts, meteorologists from Aristotle's time to ours have tried to draw a picture of the general circulation of the atmosphere between the warm and cold regions of the earth. But these simple schemes do not work. Indeed, the flow of air in the atmosphere, as we are able to sound it today, turns out to be in many respects precisely the opposite of what the classical theories predict!

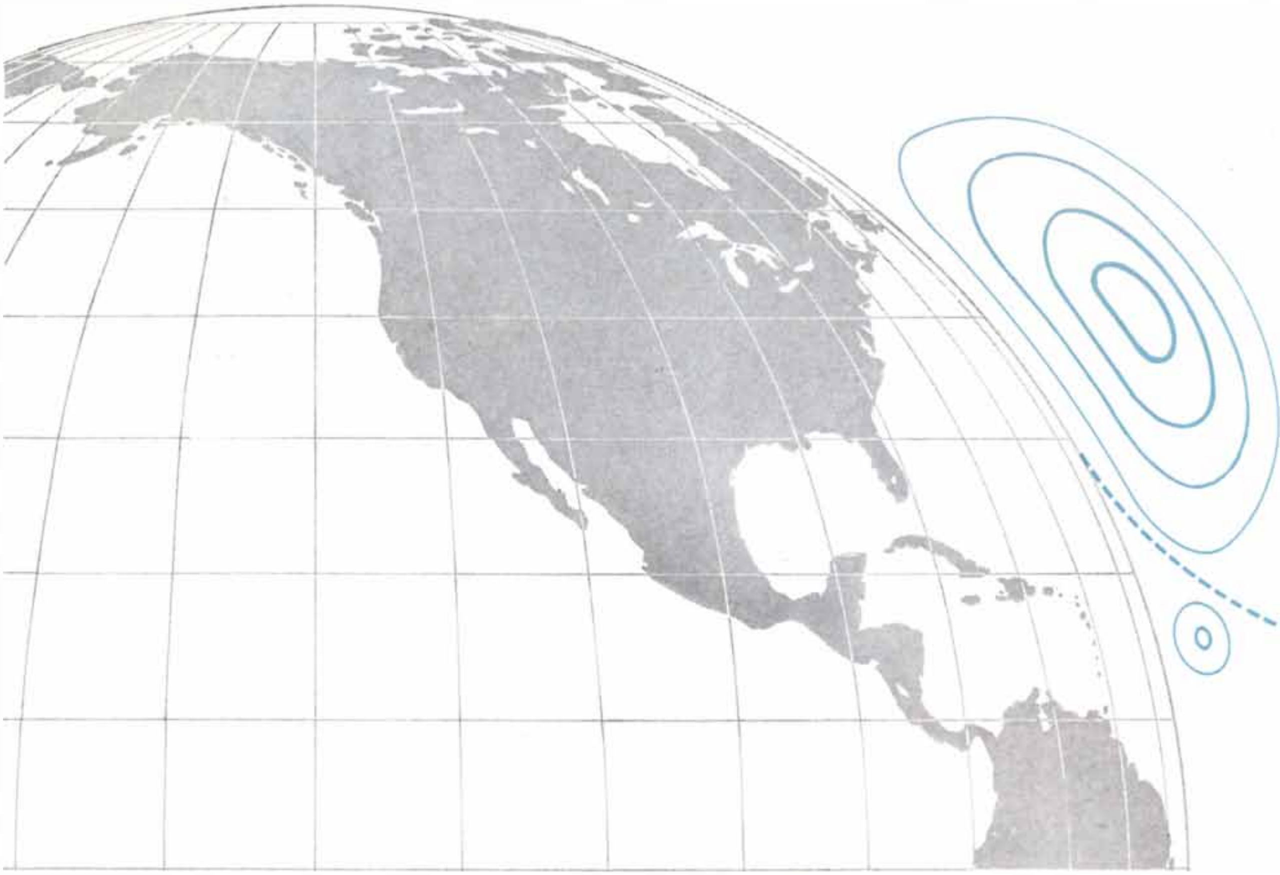
Within the last decade or two, meteorologists have begun to look at the atmosphere from a more sophisticated point of view. Three new lines of approach have brought the subject down out of the clouds, so to speak. First, new instruments and airborne observations are giving us more detailed and wider-ranging maps of the winds than man has ever had before. Secondly, we have more powerful tools in dynamics and mathematics with which to analyze the data and build theories. And thirdly, it has been found possible to test the theories with laboratory models.

Reflecting on the question of the large-scale circulation of air on our planet, it is natural to begin by thinking of an atmospheric hemisphere (say the Northern Hemisphere) as a large cell of air which is warmed near the Equator and cooled near the pole. We might think of a room with a radiator at one end. Air warmed by the radiator rises ceilingward and then moves toward the cool end of the room; as it does, the cool air there sinks and flows toward the radiator end. In this process, producing a layer of warm air at the top and a layer of cooler, denser air at the bottom, the original center of gravity of the air in the room has fallen. In energy terms, what has happened is that potential energy has been converted into energy of motion (kinetic energy). This process has long been supposed to provide the main force driving the general circulation of the atmosphere. In the classical picture, stemming mainly from the studies of the 18th-century Englishman George Hadley, air warmed in the tropics rises and flows poleward, then sinks as it cools and flows back toward the Equator over the ground. The easterly and westerly winds around the earth are the result of deflection of this motion by the rotation of the earth. According to the classical theory, the winds' energy is fed from the large-scale kinetic energy of the basic north-south overturning circulation.

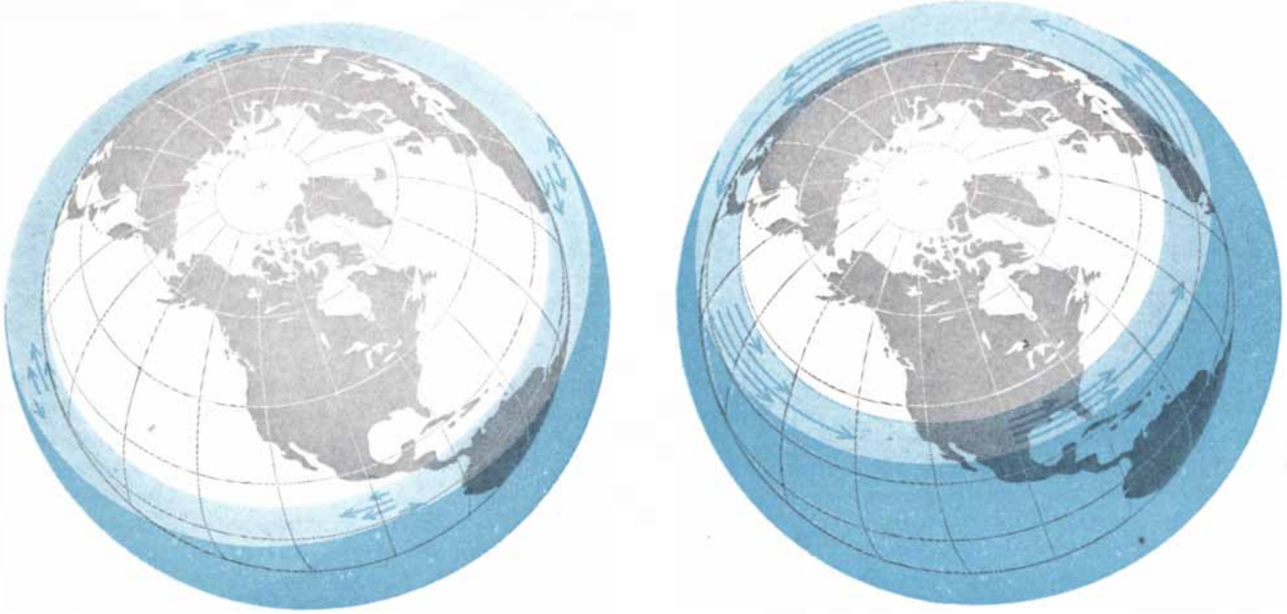
Studies of the general circulation since Hadley's day have been devoted largely to trying to find cell models which could account for the air movements that we observe at the surface of the earth [see "The Circulation of the Atmosphere," by Harry Wexler; Scientific American, September, 1955]. The outstanding phenomena to be explained are the great westerly and easterly wind systems. In the Northern Hemisphere the prevailing winds are easterly in the region from the Equator to about 30 degrees latitude, and westerly from 30 to about 60 degrees. The easterlies are strongest at about 15 degrees latitude; the westerlies, at about 35 degrees. Both wind systems also vary in strength with height above sea level. The atmosphere of the earth is so shallow, in proportion to the size of the solid part of the planet, that on the scale of a classroom globe it would correspond to no more than the thickness of a good coat of paint, but it is nonetheless separated into layers of very different wind speeds. The westerlies are strongest at a height of about seven miles; the easterlies, at an altitude of a mile or two.

The classical theories all supposed that the wind systems were powered essentially by a south-north overturning circulation—air rising in the hot latitudes and falling in the cold. About 10 years ago our group in the department of meteorology at the Massachusetts Institute of Technology set out to determine whether such a circulation actually existed. Before that time it had been impossible to do so. Any general north-south movement of air would be so slow (measured in feet, rather than miles, per hour) that it would be almost undetectable in the "noise" of day-to-day winds. The only hope of resolving it was to obtain wind readings over a period from a large and dense network of sensitive recording stations. Ten years ago there were enough stations spread over the Northern Hemisphere to begin such a survey. We proceeded to collect and analyze thousands of records.

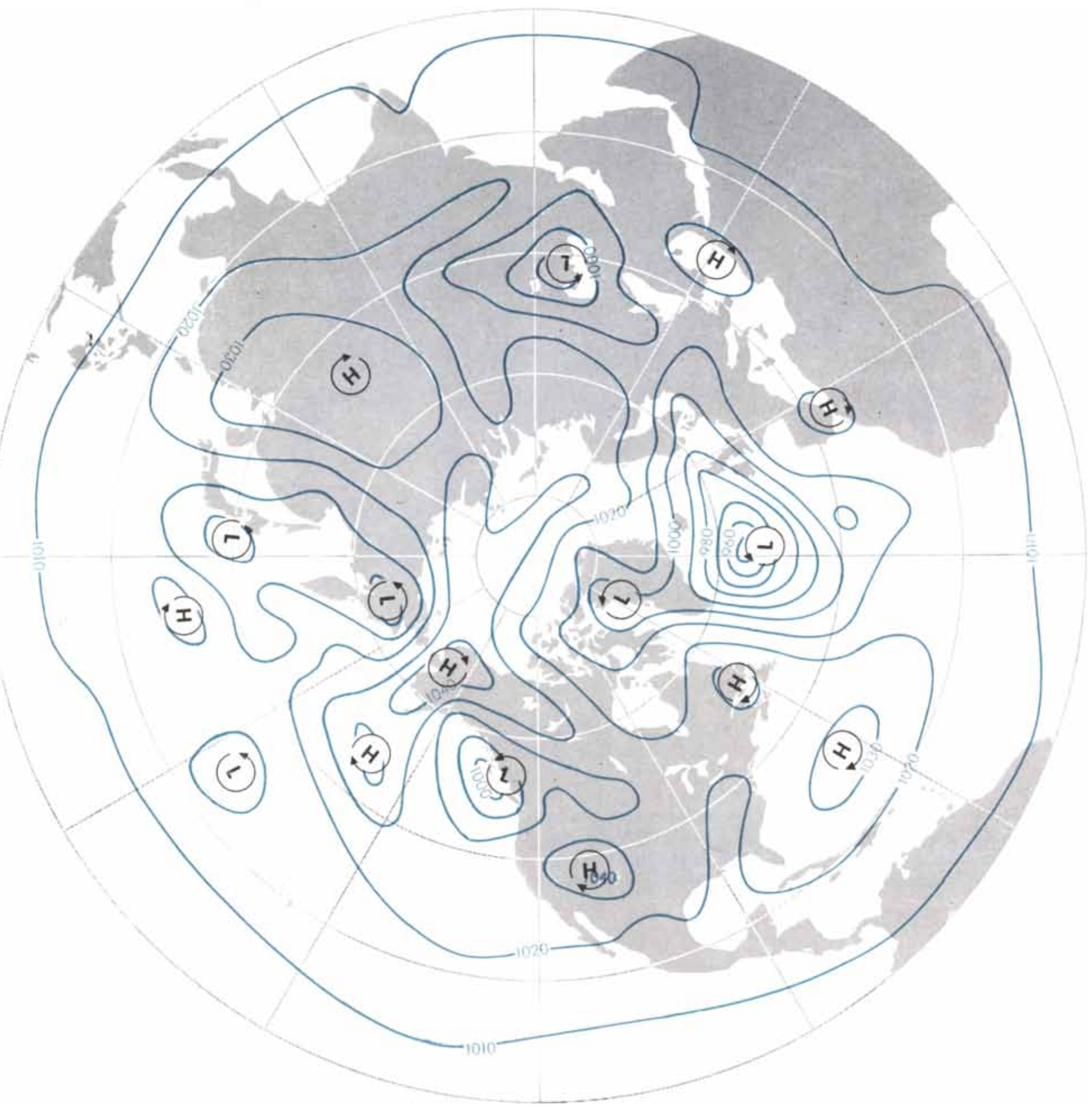
What did we find? The classical pattern turned out to exist only in textbooks. If there is any large-scale overturning of the atmosphere—and this is not yet certain—it goes the wrong way! Near the



PREVAILING WINDS in the Northern Hemisphere are shown in "cross section." Each colored contour line traces a region of constant average wind speed, westerly above the broken line and easterly below it. Weight of contour lines is roughly proportional to the average speed. The maximum westerly speed comes at about 35 degrees North latitude and an altitude of seven miles. Maximum easterly speed occurs at 15 degrees and a height of one to two miles. Contours cover a speed range of about 10 to 40 miles per hour.



EAST-WEST WIND PATTERNS are seen from another point of view by making imaginary slices through the atmosphere at different latitudes. The slice at left, made at 15 degrees North, shows the vertical pattern of the trade winds. Slice at right is at 35 degrees North and gives the vertical pattern of the westerly winds in the mid-latitudes. Average speeds are indicated by arrow lengths.



CYCLONES AND ANTICYCLONES are regions of low pressure (L) and high pressure (H) respectively. As this simplified weather map shows, they are distributed over a hemisphere in a random or turbulent fashion. Colored lines are isobars, or lines of constant atmospheric pressure (measured in millibars), which mark out the highs and lows. These air masses rotate in the directions indicated by the arrows around the labels. Cyclones are usually composed of warm air which is rising; anticyclones contain falling cold air.

Equator and the North Pole there are small cells of the expected type, turning over in the northward direction. But the great bulk of the hemisphere's air, from the subtropic to the subpolar regions, appears to circulate in the opposite direction [*see diagrams on next page*]. This means that warm, light air in the southerly part moves downward and cold, heavy air in the northerly part rises. In other words, the latter portion of the general circulation moves against the force of gravity. Such a circulation must use up kinetic energy in maintaining itself, and therefore it cannot be supplying energy to power the westerly or easterly winds.

Where, then, do these wind systems get their energy supply? We turned, as a working hypothesis, to the idea that it might come from the great rotating air masses known as cyclones and anticyclones. These are the familiar systems that appear on our weather maps as high-pressure and low-pressure areas. A high is most frequently a mass of cold air broken off from the polar air belt; as it moves southward, the earth's rotation sets it spinning in the clockwise, or anticyclonic, direction. A low usually represents a detached mass of warm air moving northward and spinning in the counterclockwise (cyclonic) direction.

Now it has always been thought that these eddies draw their energy of motion from the major circulations, rather than the other way around. It is well known that in a water pipe, eddies of turbulence drain energy from the main flow and slow it down. The general phenomenon is summed up in the ditty:

Big whirls have little whirls,
That feed on their velocity.
And little whirls have lesser whirls,
And so on to viscosity.

This being the usual case, how can the little whirls in the atmosphere feed energy into the big whirls?

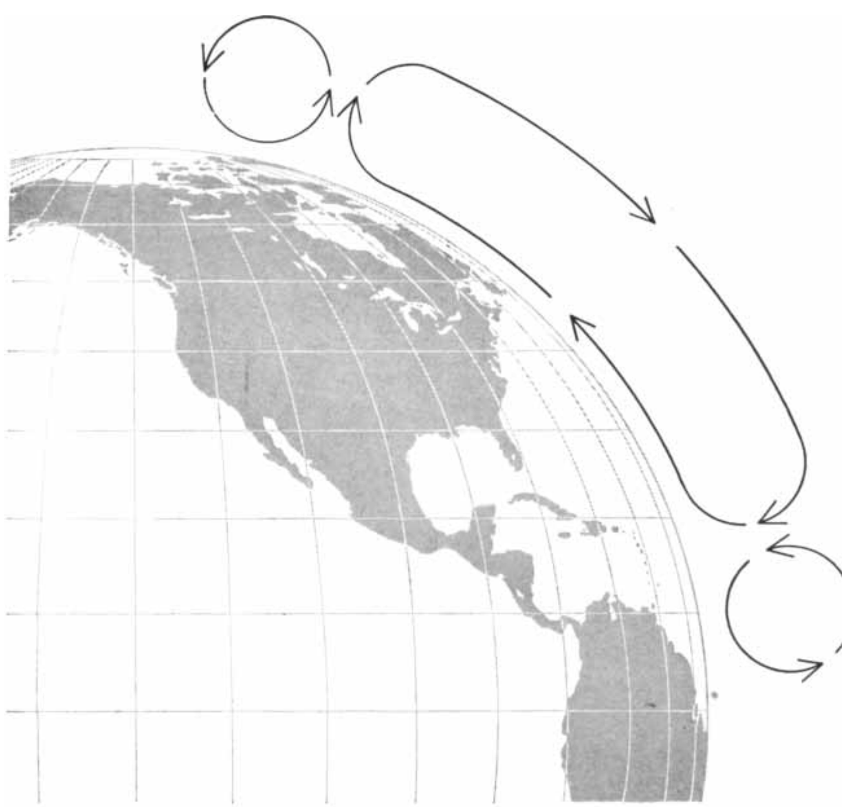
The answer is that the eddying masses of air in the atmosphere, unlike eddies generated by the flow of water in a pipe, carry their own, independent stores of energy. Warm air masses moving into a cooler zone rise, and cold masses moving into a warmer zone fall. In so doing they convert potential into kinetic energy. It is conceivable that the cold and warm air masses, coming into the mid-latitudes from the north and the south, could contribute energy of motion in such a way as to account for the prevailing westerly flow of air in this zone. In fact, calculations based on principles of fluid dynamics and the rotation of the earth have established a theoretical basis for this hypothesis.

The theory has also been checked by meteorological measurements. If the wandering air masses feed energy to the westerlies in the mid-latitude zone, this means that they must deliver more westerly momentum to this zone than they take out of it. To test the hypothesis, records of wind speeds measured at various latitudes by many observing stations were studied. The results confirmed that the air masses coming in from the north and south do in fact contribute a net westerly momentum to the mid-latitude zone of strongest westerly flow.

The tropical easterlies, on our hypothesis, arise from the same general process that produces the westerlies. We may say, roughly, that the cyclones carry so much westerly momentum into the mid-latitudes that they leave a deficit in the tropics—*i.e.*, an easterly flow.

As I have indicated, observational and mathematical tests of the hypothesis have gone hand in hand. To describe the complex dynamics of the atmosphere in mathematical terms is, of course, a formidable task. The equations involve many variables: *e.g.*, density, temperature, pressure, moisture content, air motions in three dimensions, and so on. A high-speed computer has been used for the calculations. It has been necessary to make some simplifying assumptions. But the gratifying fact is that the solutions of different workers agree. Among

"CLASSICAL" CIRCULATION, predicted by older theories, shows air rising in the tropics, flowing north aloft, falling near the poles and returning south along the surface.



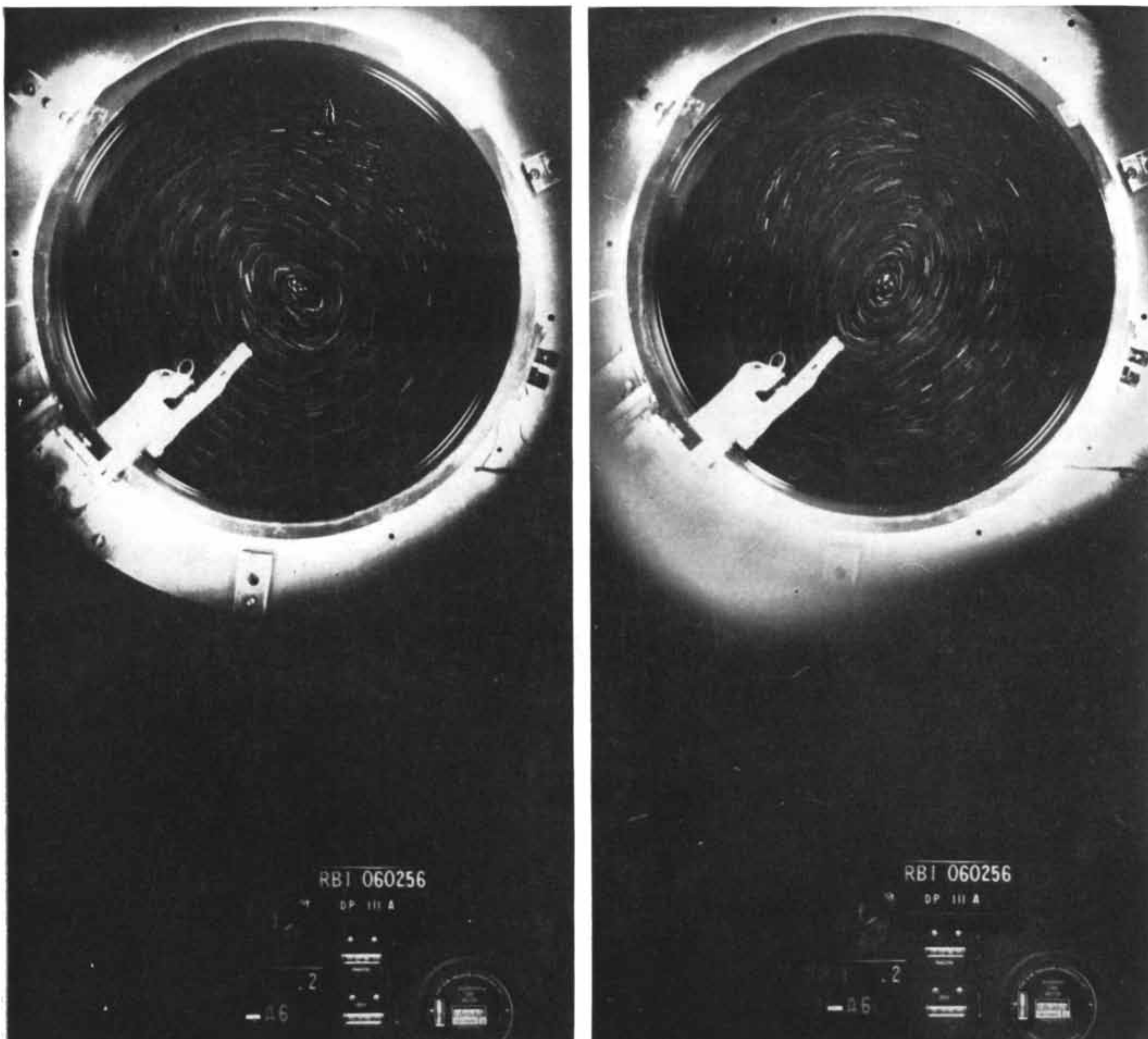
ACTUAL CIRCULATION is predominantly opposite to that in the classical picture. The main body of flow carries air downward in lower latitudes and upward in higher latitudes.

the leading investigators in this work are H.-L. Kuo, Jule G. Charney and Norman A. Phillips.

Kuo's calculations show that the rotation of the earth plays a double role in the large-scale shaping of our weather: it breaks up the primary north-south circulation into cyclones and anticyclones, and then it channels these turbulent motions into the prevailing east and west winds. In other words, our planet's heat source—the sun—sets the air of the earth in motion and the rotation of the planet manipulates the air into a complex pattern of little whirls and big whirls.

The picture outlined by the foregoing studies has lately been confirmed in remarkable fashion by small mechanical models. One of these was constructed by Dave Fultz of the University of Chicago. He uses a flat-bottomed pan containing about an inch of water to represent the atmosphere of one hemisphere. Patterns of flow in the water are made visible by putting a few drops of dye or other tracing material in it.

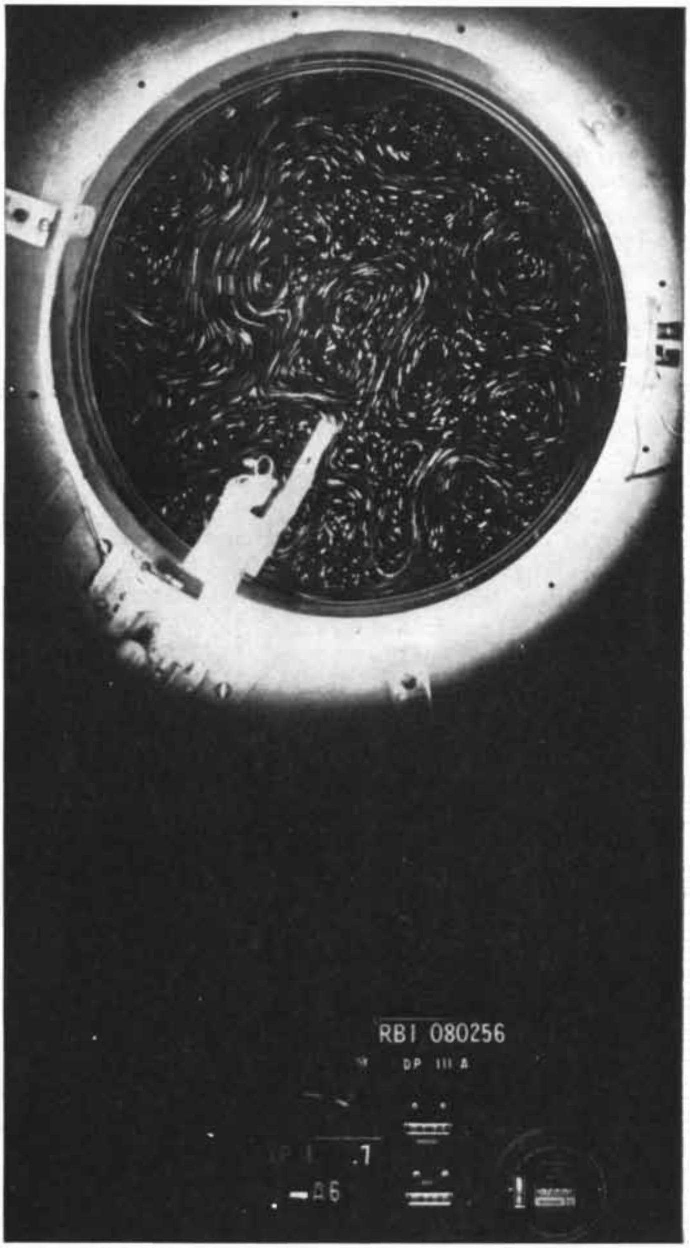
When the perimeter of the pan (the "equator") is heated and the center (the "pole") is cooled, the water begins to flow in the simple Hadley pattern of an overturning circulation. The current rises at the edge (the "equator") moves along the top of the water toward the center, then sinks and flows back toward the edge along the bottom of the pan. The pan is now set to rotating. When the speed of rotation reaches a certain value (which agrees with Kuo's theoretical calculations) the simple initial circulation breaks up dramatically into eddies like the cyclones and anticyclones of a weather map. From both the pe-



MODEL OF THE ATMOSPHERE consists of water in a rotating vessel. The pan is heated at the periphery and cooled in the center. When the rotation is slow (two revolutions per minute), a simple pattern of circulation results. Photographs at left show two views riphery and the center, eddies move toward the middle "latitudes" in the pan. "Westerly" currents promptly appear in this zone, and "easterlies" come into being near the edge (the "equator"). The water currents even reproduce the vertical variations in our atmosphere: at the bottom of the pan there are separated eddies, while at higher altitudes the water flows in fast undulating streamlines.

Thus observations, theoretical analysis and laboratory experiments all seem to bear out the new conception of our atmosphere as an air ocean set in motion by the sun's heat and broken up by the earth's rotation into big whirls fed by little whirls. The theory is not accepted by all meteorologists, however. The observations are still not conclusive; theoretical studies may go astray through use of unjustified assumptions; models often do not accurately represent the things they are supposed to represent. But this writer will be surprised if the general picture proves to be fundamentally wrong, though further research will undoubtedly modify its details.

Whether this new insight into the atmospheric machinery, assuming it is correct, will enable mankind to do anything about the weather is a moot question. Probably it will help eventually in long-range forecasting. But control of the weather and climate now looks even more difficult than had been thought. A complex of random, unmanageable processes seems to govern our weather patterns. To effect any general change would require nothing less than altering the Equator-Pole heat differential or the rate of the earth's rotation.



of this circulation one "day" (revolution) apart. When the rotation is made faster, the simple circulation breaks up into a pattern of eddies resembling a weather map. At right are two views, one revolution apart, of the pattern at six revolutions per minute.

THE BLUE WHALE

Although its commercial importance has dwindled, it is the largest animal that ever lived. Some specimens are 100 feet long and weigh 150 tons. A blue whale calf grows at a rate of 200 pounds per day!

by Johan T. Ruud

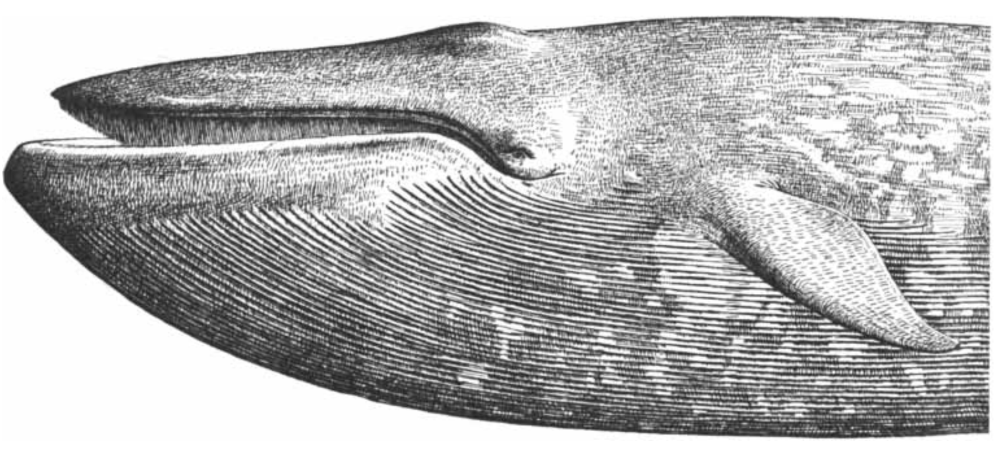
(Sulphur Bottom).—Another retiring gentleman, with a brimstone belly, doubtless got by scraping along the Tartarian tiles in some of his profounder divings. He is seldom seen; at least I have never seen him except in the remoter southern seas, and then always at too great a distance to study his countenance. He is never chased; he would run away with rope-walks of line. Prodigies are told of him. Adieu, Sulphur Bottom! I can say nothing more that is true of ye, nor can the oldest Nantucketer.

This quotation from Herman Melville's chapter on "Cetology" in *Moby Dick* illustrates how little was known 105 years ago about the king of whales. Melville elected the sperm whale as the leviathan of the seas, but the sperm was almost a runt compared to the sulfur-bottom, now better known as the blue whale. The blue whale is by far the biggest living creature that has ever inhabited the earth. At its fullest growth it is about three times more massive than were the extinct dinosaurs. Since Melville's day it has been chased as no whale ever was chased before, and for decades hunters of the sea have prized the blue whale as the mightiest game on our planet.

The species gets the yellowish color of its underside from a thin film of diatoms living on its bottom surface, but its back has a bluish color, which accounts for its present more common name. The blue whale belongs to the rorqual, or finback, group. It was first reported by Robert Sibbald, a Scottish scientist, who examined a specimen stranded in the Firth of Forth in 1692. Carl von Linné (Linnaeus) later named the species *Balaena musculus*. Either the description of the blue whale at the time was not sufficiently specific or later naturalists were led astray by an irresistible urge to discover new species, because in the following 150 years we find the blue whale acquiring a score of different Latin names. At the turn of the 20th century Frederick W. True of the U. S. National Museum brought order out of the confusion of Latin names. There is still a slight difference, however, between the European and American classifications: in Europe the blue whale is considered to be of the same genus as all the other finbacked whales and is called *Balaenoptera musculus*, while in the U. S. it is placed in another genus and called *Sibbaldus musculus*.

As Melville said, American open-boat whalers of his day never chased the blue whale: they considered it too fast and violent, and inferior in value to either the right or the sperm whale. However, toward the end of the mid-18th century whaling era, when right and sperm whales had become scarce, attempts were made to kill the blue whale from open boats with explosives shot from swivel guns. This proved fruitless, because blue whales, in contrast to right whales, usually sink when killed. The difficulty was mastered when Captain Svend Foyn of Norway, the founder of modern whaling, introduced the steam-powered catcher. This is a small steamer furnished with a cannon that fires a grenade-headed harpoon. With this efficient weapon Foyn was able to kill the giant whale and tow it to a shore base, where it could be stripped of blubber, dismembered and cooked.

In the course of 90 years of modern whaling, a total of about 350,000 blue



BLUE WHALE is depicted as it would appear if its vast bulk could be viewed as it floated in the water. Its back has a bluish color; its underside is yellowish and pleated. When the

whales have been killed in all waters of the world. Most of these (91.4 per cent) have been taken in the last 50 years in Antarctic waters, a large proportion of them by "floating factories" operating on a mass-production basis. From these immense catches cetologists have obtained a wealth of anatomical and statistical information about the blue whale.

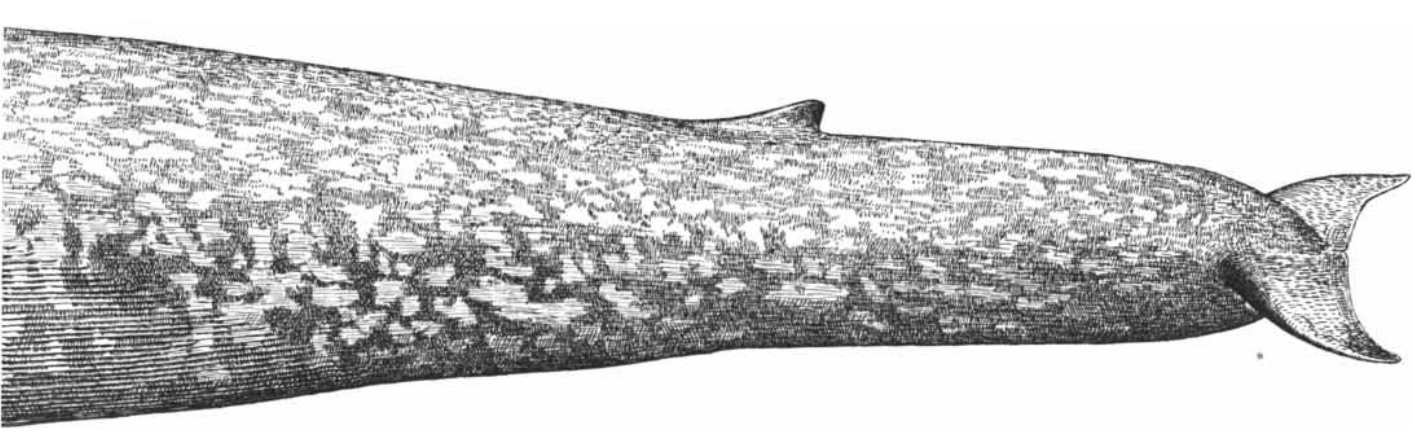
No photograph can do full justice to this huge animal. It cannot be properly photographed in the water; only a good draftsman can give a true impression of the blue whale's beautifully modeled body [*see drawing on these two pages*]. The skin is hairless and extremely smooth, the shape of the body completely streamlined. The foreflippers, which are stiff and comparatively short and narrow, act as rudders for steering and balancing. Propulsion is provided by the whale's powerful tail, whose broad, horizontal flukes, stroking up and down in the water, easily give the blue whale a sustained speed of five to 10 knots; in short spurts it can travel faster than that. Modern whaleboats of 16 or 18 knots often need considerable time to overtake it.

Blue whales are baleen whales, *i.e.,* they have no teeth in their jaws, but thin plates of whalebone (baleens) are attached to the upper palate. The baleens, fringed at the edges, form a grid or sieve with which the whale traps its food—tiny shrimplike crustaceans called "krill." It was the whalebone, used for a variety of purposes where today we use plastics or steel, that made the right whale so highly prized; the blue whale was considered less valuable because its baleens are not as flexible and are considerably shorter—three feet instead of 12 feet. The blue whale's collection of food is assisted by the peculiar construction of its brimstone belly, which is wrinkled, or pleated, from the chin to the navel [*see photograph on next page*]. This gives its underside a flexibility which allows its mouth to hang down as a huge bag for scooping up crustaceans in the sea water; when the whale brings its jaws together, closing the bag, contractions of its pleated belly squeeze the water out between the fringed baleen plates, while the bag retains the food.

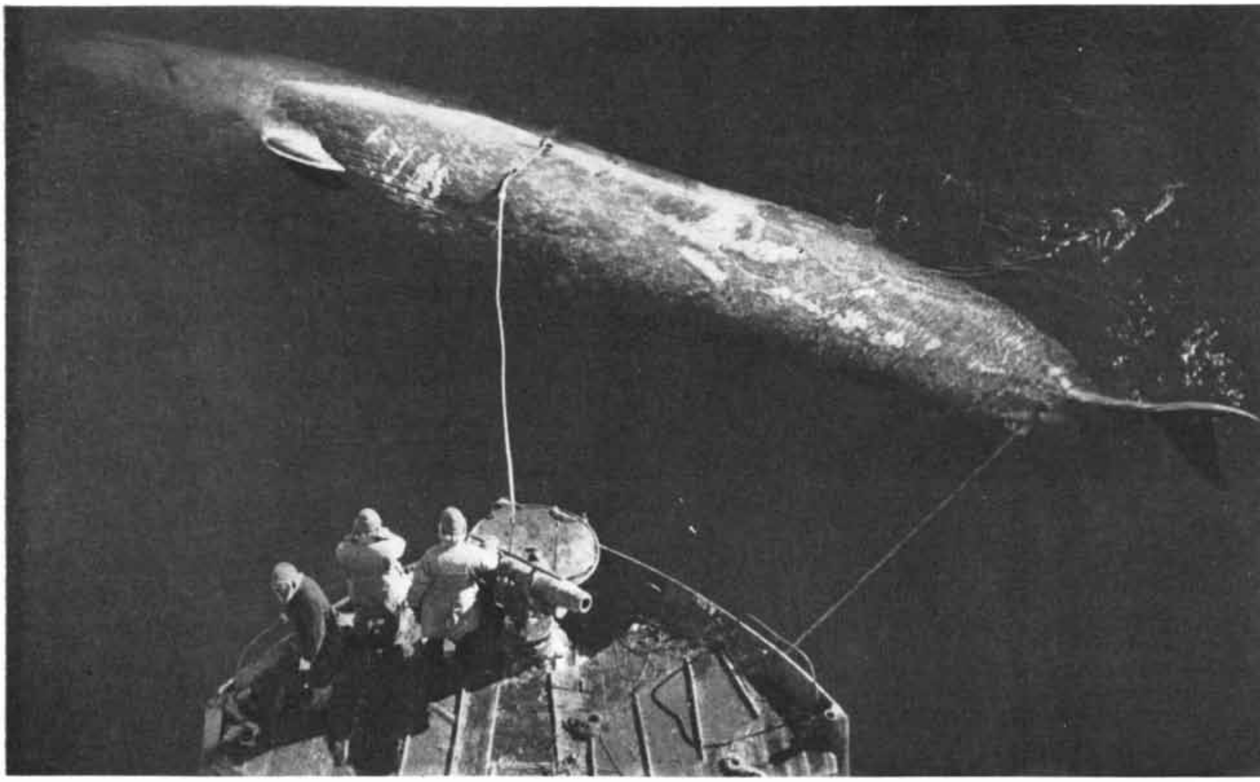
The whale is a lung-breathing mammal and must rise to the surface to take in air at more or less regular intervals. Through its blowholes, nostrils conveniently located on the top of its head, it forcefully expels air from its lungs and immediately takes a deep breath. The warm, moist expired air condenses as soon as it is discharged into the colder atmosphere, and the whale's expiration is visible for miles as a high, springing fountain. A blue whale traveling at ease will rise to the surface for a minute or two, blow three or four times and sound again for 10 to 15 minutes. It can feed under water without getting water into its lungs, because its windpipe passes through its throat as a separate tube.

Most of the blue whale's senses are rather weakly developed according to human standards. Its eyes cannot see very far, but this does not matter much, because of the short range of visibility under water. The whale's anatomy indicates that its sense of smell must be inferior. Whalers agree, however, that its sense of hearing is very good—some think too good. At the Marineland Studios in Florida, where porpoises are held in captivity in big ponds, investigators have discovered that these small, toothed whales are capable of echo-locating their prey. They emit squeaking signals and evidently can pick up echoes from other animals in the water and decide their direction. This is reminiscent of the supersonic echo-location used by bats, and a Dutch anatomist has demonstrated a correspondence between anatomical structures in the ears of bats and of whales. Quite recently specialists in underwater noise at the Woods Hole Oceanographic Institution have recorded sounds emitted by right whales swimming nearby. So it seems possible that baleen whales locate their tiny prey by tracking the echoes of sounds they themselves emit.

The biggest blue whales reported have been 100 feet long or more and weighed 150 tons. (For comparison, the giant extinct dinosaurs are estimated to have weighed 40 to 50 tons, and the largest present land mammal, the elephant, weighs three to four tons.) The average blue whale taken in the Antarctic today is 78 or 79 feet long and weighs 80 to 85 tons. This means that in the last 50 years 25 million tons of blue whales have been taken in Antarc-



whale feeds, it drops its lower jaw like a huge bag to collect small crustaceans. The lower jaw is then closed and its content of water is forced out through the fringed baleen plates suspended from the upper jaw. This process filters the crustaceans out of the water.



DEAD BLUE WHALE is hauled in by a Japanese catcher vessel. The whale is lying on its side; its tail is at the right. Part of its pleated bottom may be seen to the right of the flipper at the left. The harpoon, still attached to its line, is in the whale's back.

HEAD OF THE SAME WHALE is photographed from the catcher. In the noselike structure at upper right are its blowholes. A blue whale swimming without effort will sound for 10 to 15 minutes, surface, blow three or four times in a minute or two and sound again.

tic waters—a weight equal to the total annual catch of the world's fisheries.

Weighing a blue whale requires several hours' hard work, because the huge beast has to be weighed piecemeal. Until recent years only three weighings of blue whales had been reported. But since 1947 Japanese scientists have weighed more than 30 in the Antarctic, and accurate figures are therefore now available [*see chart below*]. Of the total weight of the average blue whale, blubber accounts for 27 per cent, meat for 30 per cent, bone for 18 per cent and internal organs for 12 per cent. The heart alone may weigh as much as 1,300 pounds, and the kidneys, 1,078 pounds.

A newborn blue whale calf is about 23 feet long and weighs two and a half to three tons. At weaning, which is assumed to take place seven months after birth, the calf weighs about 23 tons. Whale milk is extremely nourishing, containing as much as 38 per cent fat, which probably explains why the calf grows at the amazing rate of about 200 pounds per day. However, compared to the explosive growth of a baby elephant seal or harp seal, the daily gain of the blue whale suckling is moderate—3 to 4 per cent of the birth weight.

At the age of 19 months a young blue whale is about 66 feet long and weighs 45 to 50 tons. At puberty (about four years) its weight has reached some 70 or 75 tons. It has gained an average of about 88 pounds a day on its own, which is remarkable when we consider that its diet consists of tiny crustaceans.

Blue whales are most abundant in the biologically productive areas of the oceans where plankton and krill abound. In summer they migrate to the high Arctic and Antarctic latitudes as swarms of plankton grow in the wake of the retreating ice; blue whales are supposed to penetrate farther into the icy regions than any other species. In the autumn they go back to temperate waters, where mating and birth take place. The newborn calf has only a thin insulation of blubber and would probably freeze to death if born in the icy waters of Arctic or Antarctic areas.

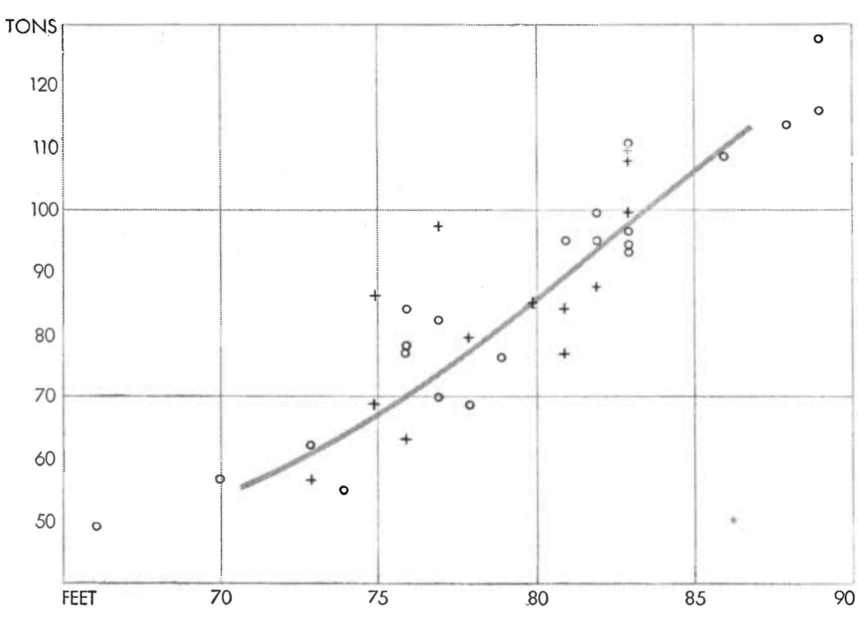
We know neither the migration routes of the blue whales nor their nursing grounds. In summer they are concentrated in rather narrow belts in the polar seas, but it is believed they disperse over wider fields when they leave these feeding grounds, because nowhere in lower latitudes have whalers encountered blue whales in numbers comparable to those seen in high latitudes. Blue whales are not gregarious: they are seldom seen in groups of more than two or three.

Our knowledge of the life history of the blue whale has gradually been pieced together by studies conducted at whaling stations in all waters, from the Arctic shores of northern Norway to the island of South Georgia in the Antarctic, from stations in the Far East to stations in British Columbia. By examination of pregnant females, which are unavoidably killed in considerable numbers every season, we can trace the growth history of the fetus. These studies show that pregnancy lasts 10 or 11 months. Mating takes place mostly in winter. In the southern seas most of the calves are born in April. Because the growth of blue whales after weaning varies greatly, it is not easy to judge their age. The ages of sexually mature females can be estimated from the number of *corpora albicantia* (scars left by burst follicles) in their ovaries. In 1940 Norwegian and Russian scientists independently found a more general index of age—annual growth zones in the baleen plates. However, there is a snag to this method, for the whales continually wear down the baleen plates from the edge. Nevertheless Japanese and Norwegian workers have learned by this index that blue whales usually attain sexual maturity at four or five years, rather than at two years as was formerly supposed. A more promising method of age determination has been developed recently by English scientists. The ear tube of baleen whales is completely filled by a waxlike plug, which may have something to do with conducting sound from the outer opening to the inner ear. The important point is that the plug grows with the skull and shows very distinct growth zones. This was discovered only a year ago, and the first extensive collection of plugs was made during the Antarctic season 1955-56.

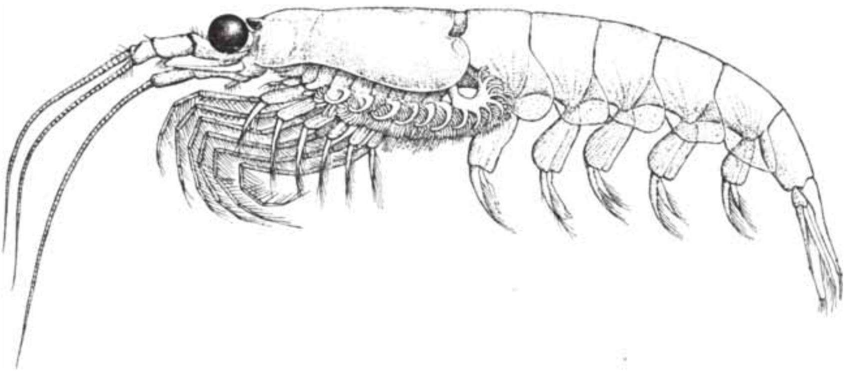
A blue whale seldom bears more than one calf at a birth. From the fact that about half of the sexually mature females taken by whalers in a season are pregnant, we can assume that most blue whale females bear a calf every other year. This is an important consideration in the effort to protect and regenerate the stocks of blue whales.

Blue whales are eagerly sought as the most valuable prey by modern whalers. Although they made up only 15 per cent of the whales sighted in the Antarctic in the seasons before the last war, they are so prized that they accounted for most of the catch. In the peak season of 1930-31 a fleet of 41 floating factories killed 28,325 blue whales, 8,601 fin whales and 510 humpbacks.

There is ample evidence that blue whales were greatly overfished in the 1930s. Fewer large whales were found as time went on, and the catches consisted more and more of small and immature ones. As blue whales became less



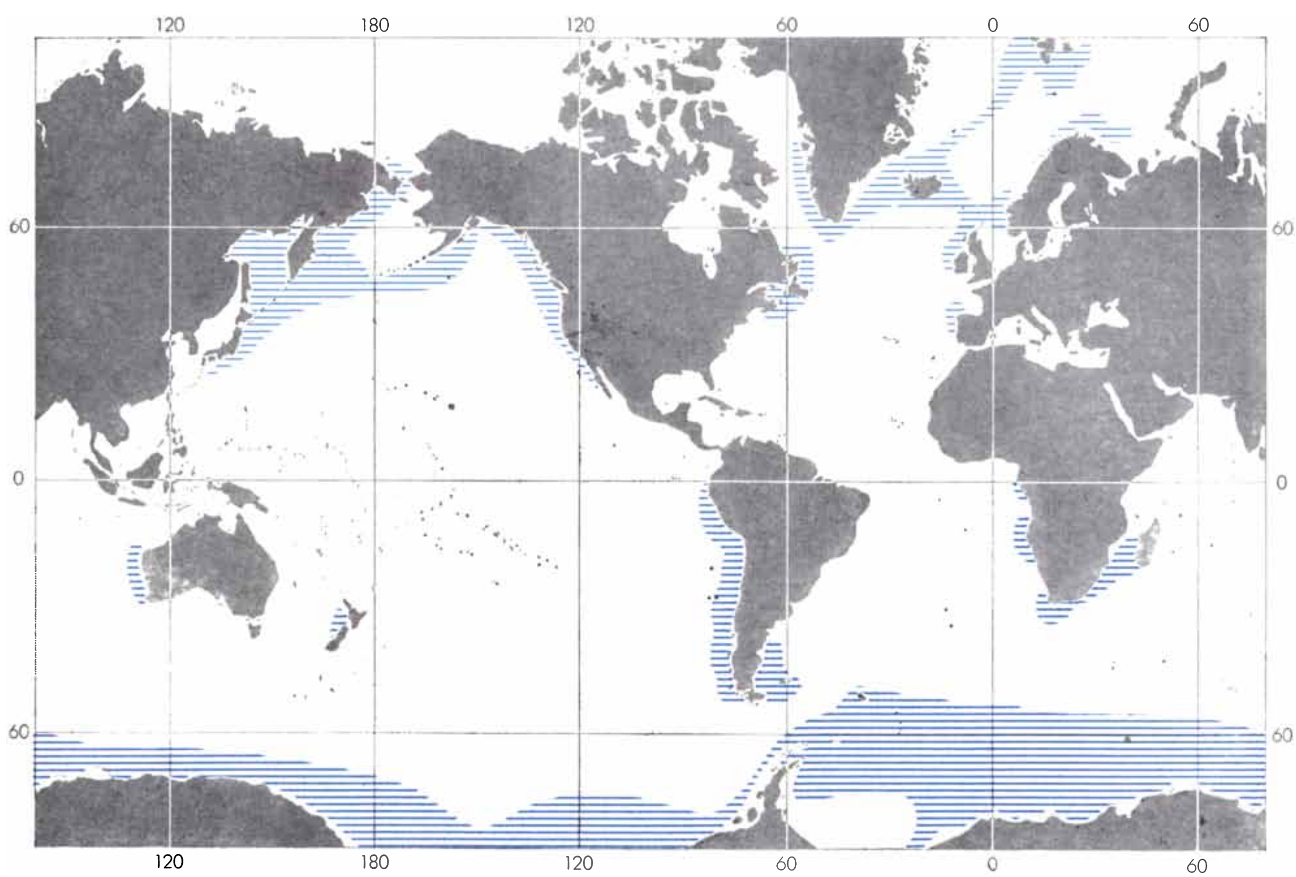
WEIGHT OF 36 ANTARCTIC BLUE WHALES is plotted against their length. The crosses indicate males; the circles, females. The whales were weighed piecemeal by investigators.



BLUE WHALE FEEDS on small shrimplike crustaceans which are called "krill." This drawing depicts a southern species of krill, *Euphausia superba,* enlarged about two times.

abundant, the whalers paid more attention to the second-best whale, the finback. The relative number of blue whales in Antarctic catches went down from about 76 per cent in 1930-31 to about 35 per cent in the last season before the war. After the war a degree of protection was given to blue whales by an international convention for the regulation of whaling, signed at Washington, D.C., in 1946. An over-all ceiling on the number of whales that could be taken per season by the Antarctic floating factories was established. The total catch was restricted to 16,000 units (later further reduced to 14,500 units). The unit is one blue whale. A blue whale gives about 20 tons of oil, a fin whale 10 tons and a humpback whale 8 tons. Thus one blue whale unit amounts to one blue whale or two fin whales or two and a half humpback whales. To encourage the taking of fin whales rather than blue whales, a later opening date has been set for the whaling season and a still later one for blue whales (which migrate to the Antarctic earlier than fin whales). Nevertheless the stock of blue whales has continued to decline.

History repeats itself, and whaling is no exception. Bowheads and right whales were depleted almost to extinction by the old open-boat whalers. Blue whales of the North Atlantic and Arctic have now been depleted so far that all the countries involved, except Iceland and the Faroe Islands, have agreed to protect them completely for a period of five years. In the Antarctic also the blue whale is following the right whale. Between 1914 and 1928 annual catches of 2,000 to 3,000 blue whales by whalers based at South Georgia were not unusual; last year only three blue whales were taken by 21 modern catchers in a six-months' season. Today the whaling economy depends on the catches of fin whales. The blue whale has become industrially unimportant. But its surviving members remain the greatest creatures that have ever lived on the earth.

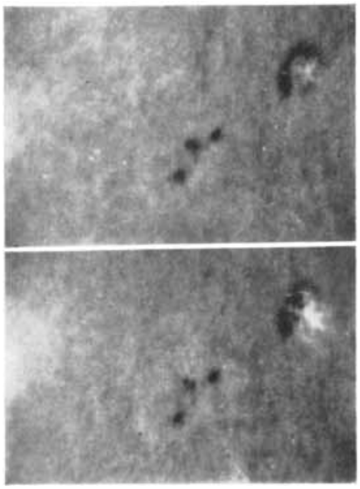


GEOGRAPHICAL DISTRIBUTION of the blue whale is outlined in color on this map. The colored areas are waters where blue whales have been caught in the operations of modern whaling. In some of them they are greatly depleted and even near extinction.

Kodak reports to laboratories on:

films for those engaged in advanced photographic exercises and those who are not . . . watching a tail-lash at leisure . . . what's available in microreproduction

Sun and grain

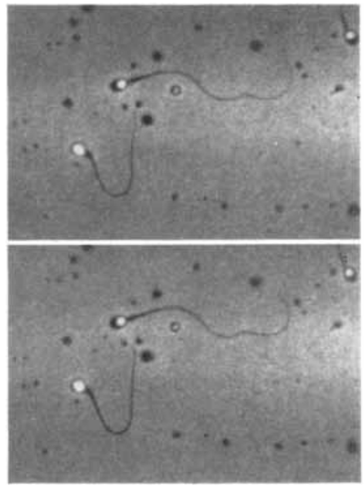


These two frames of movie film were taken ⅛ second apart. They are part of a cine record of a sunspot made on August 11, 1954, at the RCA Solar Observatory, Rocky Point, N. Y. When one computes how fast the "flare" has moved in the ⅛ second, one is inclined to attribute the apparent motion to excitation rather than to transport of actual material at a velocity of 50,000 kilometers per second.

Since Dr. William A. Miller was photographing the face of the sun itself, getting enough light on his film was the very least of his problems. He could therefore afford to choose *Kodak Spectroscopic Film, Type 548-GH*, in which the balance between light sensitivity and resolving power is weighted overwhelmingly in favor of the latter. (Only *Type 649* is slower and finer-grained than *Type 548*.)

Anyone else who can afford so prodigally to trade film sensitivity for fineness of grain can make arrangements for a supply of Kodak Spectroscopic Film, Type 548-GH (*or even* Type 649), *by writing to Eastman Kodak Company, Special Sensitized Products Sales, Rochester 4, N. Y. The same emulsion on glass can be ordered directly from Kodak dealers as* Kodak High Resolution Plates. *Frankly, though, if you are not making photographic reticles or engaging in other advanced exercises, and if you need practical camera speed along with the finest grain that can accompany it, your best bet is to pick up a few rolls of the new* Kodak Panatomic-X Film *at the nearest film counter.*

Time and light microscopes united



These two photomicrographs were taken 1/500 second apart through a phase microscope at 105× magnification of objects some 400 billion times smaller than the sunspots in the adjoining column. We made some 4,000 such photomicrographs in a recent 8-second span of time. By projecting the pictures at the usual 16 frames per second, it became possible for the first time to watch at leisure how spermatazoa whip their tails.

This was done by attaching to the light microscope a powerful time magnifier, the *Kodak High Speed Camera*. Also, it was the unprecedented sensitivity of *Cine-Kodak Tri-X Film* that permitted a light level that such heat-sensitive subjects could survive long enough to be photographed.

Now we wonder what else can be done with high speed movies through the microscope that would be worth the price of a *Kodak High Speed Camera* ($1713.50). Protozoology, perhaps. Crystal formation?

For guidance in working out a possible alliance between this camera and your microscope, write Eastman Kodak Company, Medical Division, Rochester 4, N. Y.

Fear not the paper mountain

How most efficiently to store and retrieve records of fact, feeling, fancy, or thought set down by one human being for another to read at a subsequent time—this core problem we employ dozens of men to ponder. (A few of their schemes are already in the hands of the fellows with the screwdrivers and square-wave generators.) For the present, those who fear the paper mountains must trust in microfilm and the microprint card (the latter for objectors against a return of literature to the scroll format).

Recordak Corporation, our subsidiary with offices at 415 Madison Avenue, New York 17, and branch offices in many other places, is the pioneer in working out routines for record-keeping through microfilm. Other organizations sell and service our Kodagraph apparatus for making or viewing microfilms in less specialized applications.

One such, University Microfilms, 313 North First Street, Ann Arbor, Mich., has set itself the task of microfilming a vast number of past and current periodicals from many fields and many nations. They couch their advertising argument in terms of a quadratic equation in t, the time during which a periodical file is stored, and then in 15 pages of close-set type list all the periodicals which they sell in microfilm form. Prices are comparable with the cost of merely binding paper editions. Of the Augean labors in law and librarianship that made the list possible they say little. Perhaps if you write them, they will send you a copy.

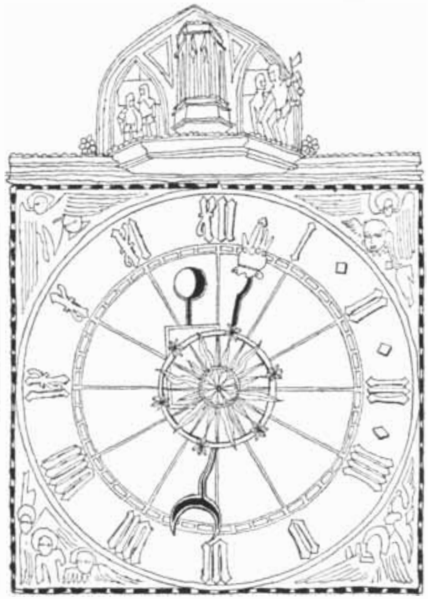
Another of our microfilming dealers, Micro Photo Inc., 4614 Prospect Avenue, Cleveland 3, Ohio, strives for eminence in the newspaper division of the microfilm domain. Their catalog, in addition to the New York *Herald Tribune*, the Las Vegas *Optic*, the Waukegan *Little Fort Porcupine* (March 12, 1845 through March 16, 1847), and some 800 other current and defunct titles, offers also the *Official Gazette of the U. S. Patent Office* in microfilm from 1930 to date.

For our own survey, "What's Available on Microprint Cards," write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

Price quoted is subject to change without notice.

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

Kodak
TRADE MARK



SCIENCE AND

Nobel Prizes

The Nobel science prizes, worth $38,633 each, were divided this year among eight scientists in four countries, including, for the first time, the U.S.S.R.

William Shockley, Walter H. Brattain and John Bardeen shared the physics prize for their invention of the transistor. The discovery was made at the Bell Telephone Laboratories, where the three physicists were working on semiconductors. They found that small electrical changes at the surface of these materials would cause large variations in their ability to conduct current. In other words, semiconductors could be made to amplify small electrical signals. This fundamental property has made possible a revolution in electronics, in which vacuum tube amplifiers are being replaced by tiny, reliable transistors which operate on very little power.

The chemistry award went to Sir Cyril Hinshelwood of Oxford University and Nikolai N. Semenov, director of the Institute of Physics in Moscow, for their pioneering studies in the kinetics of gaseous reactions. They showed that gases react through intermediate products known as free radicals, which are formed by successive molecular collisions in the now-familiar chain reaction. Semenov demonstrated that gaseous explosions consist of rapid, branching chain reactions, in which each radical forms two or more new ones. His theories were originally concerned chiefly with combustion processes in engines, but they have since been applied to controlled chain reactions used in the manufacture of plastics and other polymers. Hinshelwood is particularly noted for his analysis of the way in which energy is apportioned among various possible types of motion in complex molecules.

The medicine prize was given to Werner Forssmann, a German general practitioner, and Dickinson W. Richards and André Cournand of Columbia University for their development of heart catheterization. This technique, in which a flexible tube or catheter is pushed through a vein directly into the cavity of the heart, was first tried by Forssmann on himself. Unable to find a colleague willing to assist in the experiment, he stationed himself in front of a fluoroscope and pushed a catheter by way of a vein in his arm until he saw the tip enter the right side of his heart. His demonstration in 1929 was followed up by Cournand and Richards, who have used the method to measure pressure and other conditions within the heart and to follow the transfer of blood between the heart and the lungs. Heart catheterization is now a standard diagnostic technique.

Kalinga Prize

George Gamow, professor of physics at the University of Colorado, received the 1956 Kalinga prize for popular scientific writing. The award, worth 1,000 pounds, is made by the United Nations Educational, Scientific and Cultural Organization. It was established by B. Patnaik, an Indian industrialist, to recognize outstanding interpretation of science and to strengthen scientific links between India and other nations. The winner is invited to attend the annual meeting of the Indian Science Congress.

Among Gamow's well-known popular books are *The Birth and Death of the Sun*, *Mr. Tompkins Explores the Atom*, *Mr. Tompkins Learns the Facts of Life* and *One, Two, Three . . . Infinity*. He has contributed a number of articles to SCIENTIFIC AMERICAN, the most recent, on cosmology, appearing in the issue of September, 1956.

Calder Hall

On October 17 the world's first large-scale nuclear power plant began to feed into England's power grid. The reactor, the first of four to be located at Calder Hall in Cumberland, produces 28,000 kilowatts of electricity.

The design of the reactor is "primitive." It uses natural (nonenriched) uranium, is gas-cooled (by pressurized carbon dioxide) and operates at low temperature. Its very simplicity makes it interesting to countries in which nuclear technology is not far advanced, and which do not have facilities for separating uranium 235.

Atomic Energy Agency

An international agency to promote peaceful applications of atomic energy was finally agreed upon last month by 82 participating nations. The statute they adopted authorizes the agency to: encourage and assist in research and development; foster cooperation among its members; arrange for the provision of necessary materials and equipment; establish health and safety standards for atomic activities; supervise the use of its fissionable materials to ensure that none is diverted to military purposes.

An 18-country preparatory commission has been set up to bring the agency into being. The headquarters are eventually to be located in Vienna.

After the statute had been adopted, President Eisenhower announced that the U. S. would donate 5,000 kilograms of fissionable material to the agency when it begins to function. Britain and the U.S.S.R. have also indicated that they would provide fissionable material.

Efficient Reactor

A nuclear power plant which may pay its way in areas of high power cost is being developed for use in Alaska. The reactor will be the first to combine in the same device two highly efficient components—heavy water to moderate or slow down neutrons and liquid sodium to transfer heat from reactor to steam boiler.

The advantages of the materials have long been obvious. Heavy water absorbs fewer neutrons than other moderators. Sodium has a high boiling point; hence it need not be pressurized to operate at high temperatures and to produce the hot steam required for efficient turbines. However, sodium and water react violently if they come together, so designers were reluctant to put them into the same system for fear of leaks. Furthermore, heavy water was expensive and scarce. Recent advances in adapting stainless steels for reactor use, and a drop in the price of heavy water from several hundred to 28 dollars per pound have made the combination more attractive.

The Alaska reactor will produce 10,000 kilowatts of electricity. Because of its high efficiency it is expected to operate on very slightly enriched fuel. A larger version would supposedly run on natural uranium. This makes the design especially attractive to most foreign countries, since it avoids the need for building facilities for extracting uranium 235 from the natural metal.

Other advantages claimed for the reactor are that it will burn up a high percentage of its fissionable material and that the fuel elements will last for a couple of years without replacement.

The project is part of the Atomic Energy Commission's reactor demonstration program. The Nuclear Development Corporation of America is to design and build the reactor, and the Chugach Electric Association of Anchorage, Alaska, will operate it. The AEC will contribute up to $18.3 million for development, design and construction, of which $5.5 million is the cost of the reactor itself.

Reactor-Fixed Nitrogen

A promising new application of atomic energy has been reported. It would be used to fix nitrogen from the air. P. Harteck and S. Dondes of Rensselaer Polytechnic Institute demonstrated, on a laboratory scale, that they can make nitrogen dioxide by irradiating air in a nuclear reactor. This gas is a raw material for nitric acid and nitrate fertilizers.

Radiation converts the nitrogen and oxygen in air into a complex mixture of ionized molecules and atoms which interact in a bewildering variety of ways. Harteck and Dondes, who describe their process in *Nucleonics*, list 27 important reactions. Only a few are desirable, but they can be promoted at the expense of the others by proper adjustment of the temperature and pressure. The highest yield of nitrogen dioxide is obtained at a temperature of about 200 degrees centigrade and a pressure of 10 atmospheres or more.

The chemists have hit on a further trick to increase the productivity of the reaction. They mix a small amount of fissionable material (oxide of uranium 235) with the air to be treated. Neutrons from the reactor cause uranium atoms to fission, and the flying frag-

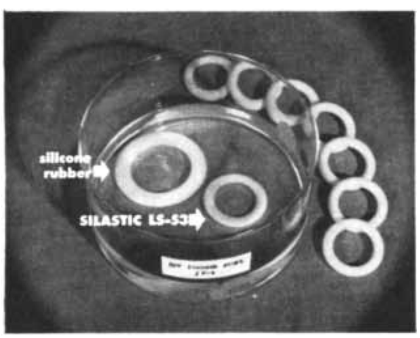
SILICONE NEWS

DOW CORNING

New Silicones Solve Old Problems

- New fluorosilicone rubber resists jet fuels, solvents, heat and cold
- Silicone-glass laminates superior to light metal for high temperature use
- Invisible silicone surface for glass containers speeds bottling, packing

FLUOROSILICONE RUBBER — is a new kind of heat and cold resistant rubber developed by Dow Corning research chemists in conjunction with the Materials Laboratory of Wright Air Development Center. Identified as Silastic LS-53*, it stays rubbery at temperatures from −80 to 400 F . . . but most remarkable feature is its outstanding resistance to the fuels, oils and solvents that limit the use of ordinary rubbers.



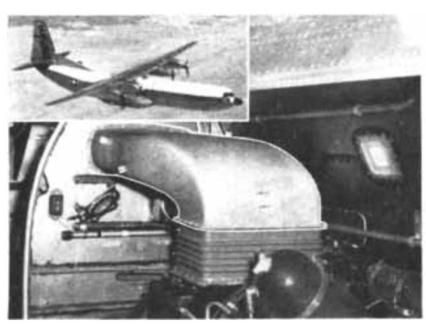
As illustrated, O-rings made of Silastic LS-53 swell only 20% when immersed in an aromatic jet engine fuel while those made of the best general purpose silicone rubbers swell over 200%. Presently limited to use in essential Air Force applications, new fluorosilicone rubber should help solve many problems for commercial aircraft, chemical, petroleum and automotive industries . . . wherever rubber parts are exposed to oils, solvents and extreme temperatures.

*T.M. REG. U.S. PAT. OFF. No. 40

"WHAT'S A SILICONE?" — is answered in a documentary movie available free of charge for showings to industrial management, production and engineering audiences. In full color and sound, this informative 16 mm film shows silicones in action . . . helping designers, improving products, solving production and maintenance problems. No. 41

WHERE THE SPOT'S HOT — a growing number of designers and materials engineers are specifying silicone-glass laminates in place of metal parts. Here's why: laminates made with glass cloth and Dow Corning silicone resins retain a higher strength-to-weight ratio at "hot" temperatures than many light metals; another reason—large and complicated pieces are easier to shape—simple plaster forms replace dies required to fabricate metal parts.

Typical application: Ducts used in the heating and air conditioning system of the C-133, a giant military turbo-prop transport now in production at Douglas' Long Beach Division. Tests prove the silicone-glass laminate ducts withstand jarring punishment, like engine backfiring, that might split stainless steel ducts. Many other promising commercial applications now in development. No. 42



NO MORE JAM-UPS — A durable, invisible "silicone surface" for glass bottles and jars permits food packers and volume bottlers like Pepsi-Cola to get greater output from filling equipment. Treated bottles have better "slip", so there is less wedging and jamming on filling lines. The Dow Corning silicone surface also provides greater resistance to bruising and scratching . . . thus, line breakage is sharply reduced; appearance and life of all types of glass containers is improved. Applied to exterior of new containers by glass manufacturers, the silicone surface is available at little or no extra cost. No. 43

TREAT FOR FEET— Shoe Saver, silicone water repellent for do-it-yourself application to all kinds of shoes and boots . . . leather, canvas, suede. . . is proving to be a popular repeat item at shoe counters, repair shops, sporting goods stores. Just swab it on—Shoe Saver keeps feet dry . . . keeps leather soft so shoes stay comfortable . . . protects against water and waterborne stains, keeps shoes new looking longer. Retails at $1.00 a bottle—enough for 2 to 4 pair of shoes.

ALL NEW — 1957 Guide to Dow Corning Silicones has just been released. Completely indexed, this illustrated 12-page reference contains up-to-date information on properties and applications for silicones of most commercial interest. No. 44

FOR MORE INFORMATION on silicones used in these applications, circle reference nos. in coupon.

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ments help ionize nitrogen and oxygen.

From the trial results with the Brookhaven National Laboratory reactor, Harteck and Dondes estimate that more than 500 tons of nitrogen dioxide could be produced for every pound of U-235 burned up in the processing reactor. On this basis a reactor capable of manufacturing $4 to $6 million worth of electric power per year could turn out $10 million worth of nitrogen dioxide in the same period. As a by-product it would also give 200-degree heat equal to that obtainable from 500,000 tons of coal and large amounts of nitrous oxide (a product for which there is no large scale use at present).

Strontium 90

During the current public debate on the testing of atomic weapons, official sources have released some definite figures which outline the dimensions of the fallout problem.

The short-term hazard lies chiefly in strontium 90. This isotope (half-life: 28 years) is stored in bones, because it is chemically like calcium. In sufficient concentration it is known to cause bone cancer. It is one of the most abundant products of nuclear fission. In very powerful explosions a considerable fraction of it gets into the stratosphere and spreads over the entire earth before falling to the ground. After getting in the soil it is taken up by plants and grazing animals.

Last month Willard F. Libby, of the Atomic Energy Commission, estimated that from the strontium 90 now in the soil the average child born in the U. S. today will accumulate between .2 per cent and 1 per cent of the "maximum permissible concentration." Libby pointed out that regions of heavy rainfall may have twice the average concentration, and that in areas where the soil is particularly poor in calcium a person may take up strontium at five times the normal rate.

Authorities do not agree on what is the maximum safe concentration in the body. The National Academy of Sciences said in its recent report on the biological effects of atomic radiation: "There seems no reason to hesitate to allow a universal human strontium burden of one tenth of the permissible [occupational maximum]." On the other hand, a similar report by the British Medical Research Council expressed the belief that anything above one hundredth of the occupational limit might be considered dangerous as a general population average. This is close to the

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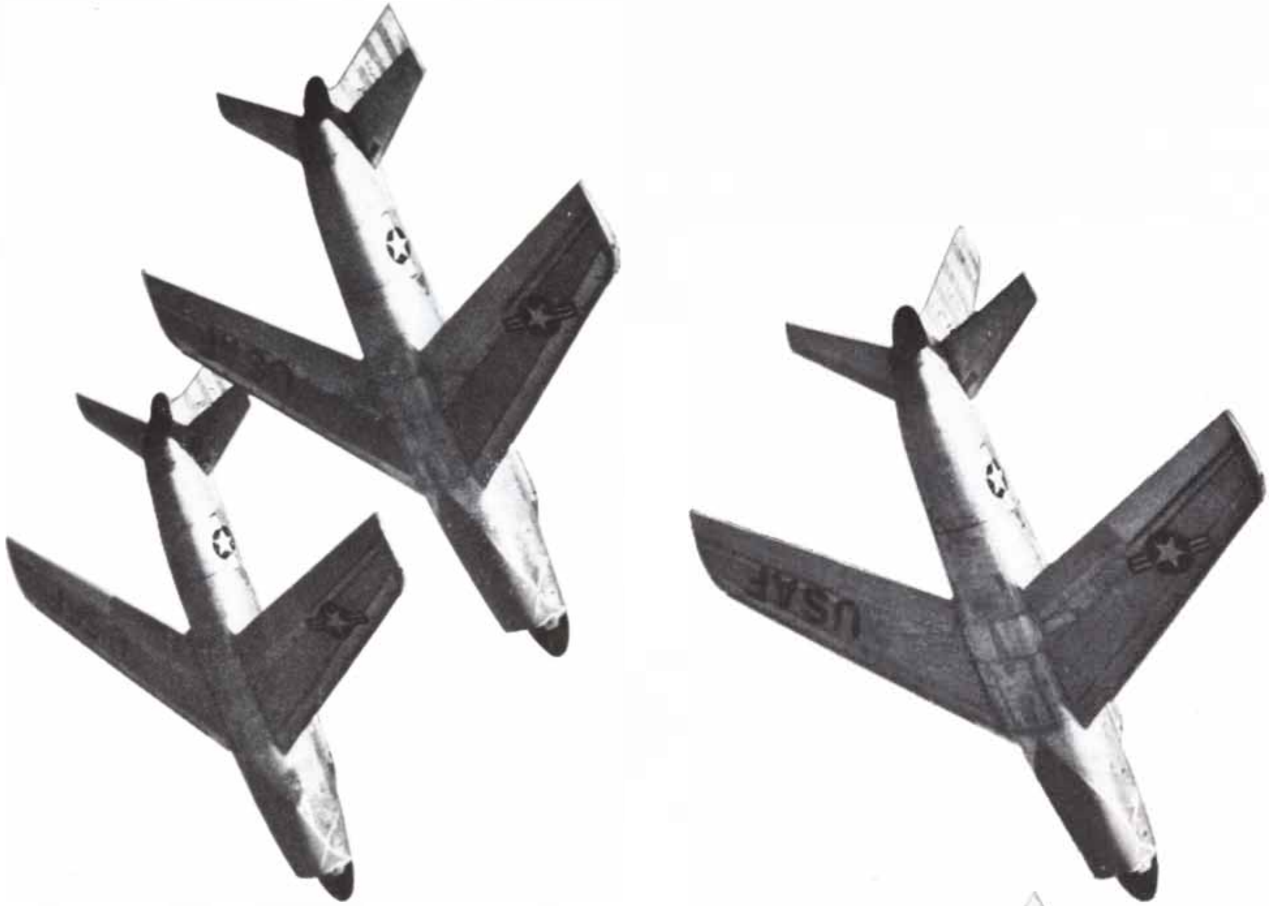

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amount U. S. children can expect to accumulate from strontium 90 now on the earth, according to Libby's figures.

An attempt to predict the effect of continued bomb tests was made recently by Charles I. Campbell, assistant to the executive officer of the National Academy of Sciences. His calculations, published in *Science*, indicate that if strontium is added to the stratosphere by bombs at the estimated average rate of the last four years, the eventual maximum concentrations would be about six times Libby's present figures.

Time Out

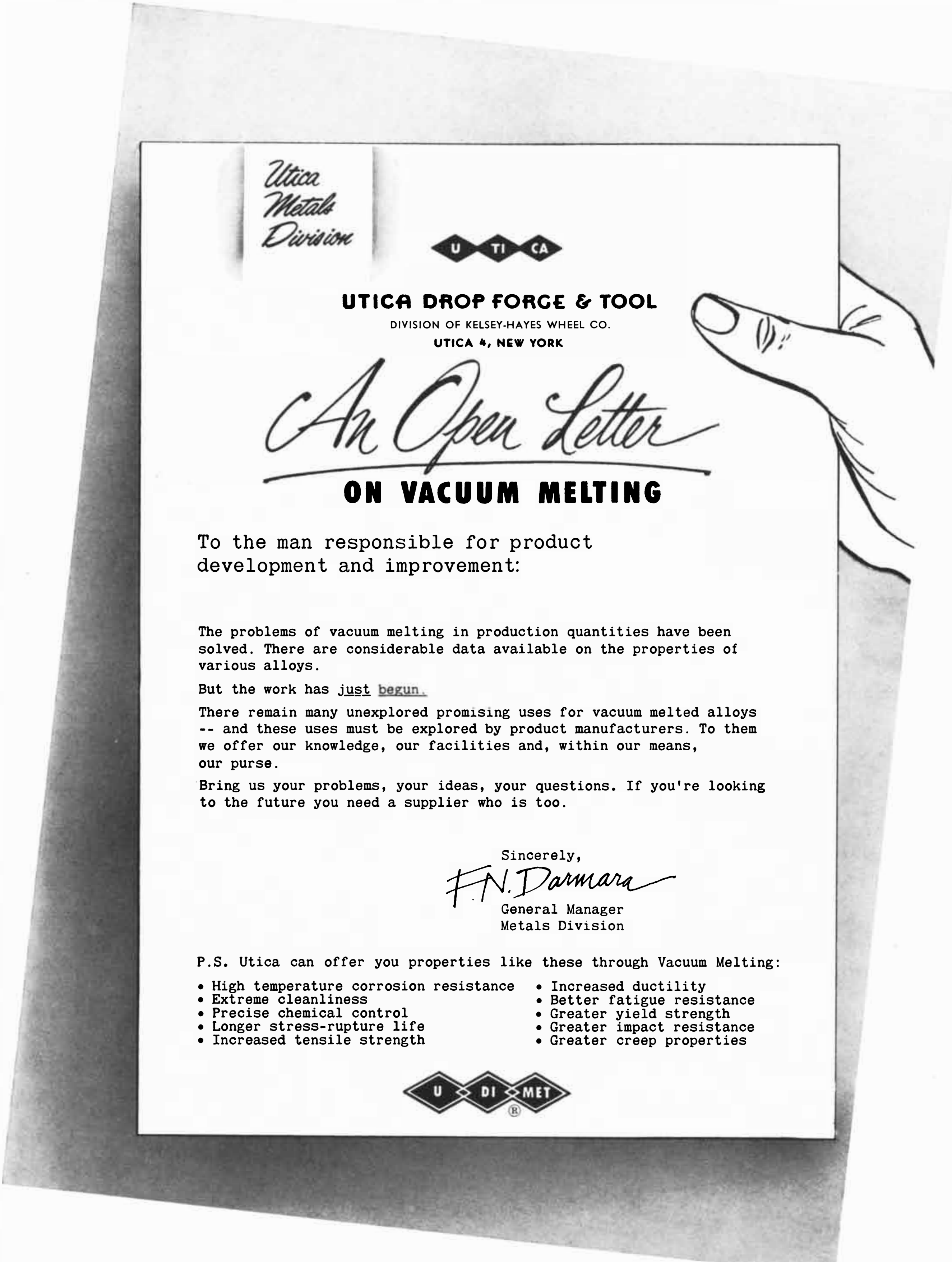
According to the theory of relativity, motion causes space and time to contract. In a laboratory moving at high speed with respect to the earth, meter sticks would be substantially shorter and clocks would run slower than in earthly laboratories. Some relativists calculate that if a spaceship traveled to the nearest star and back in 17 years, its clocks would show an elapsed time of only 14.5 years, and its occupants would have "aged" by only this amount.

Others disagree, and the question was hotly debated by two champions of the opposing schools in a recent issue of *Nature*.

Fiercely taking the negative was Herbert Dingle, professor of the history and philosophy of science at University College, London. The special theory of relativity, he said, "is very imperfectly understood, even by mathematical physicists of high distinction. . . . The question is no longer an academic one. . . . If the public is led to believe that it is possible to postpone the date of one's death by space travel, some very undesirable consequences might ensue."

Motion between two bodies, Dingle argued, "is a relation between them and not something belonging to one or the other, so that all its effects, if any, must apply equally to both. If, then, the two clocks in question, which would have continued to agree if they had not separated, show different times on reunion, something must have happened to one which did not happen to the other, and nothing is in question except their relative motion. Hence they cannot show different times on reunion."

W. H. McCrea, a mathematical physicist of high distinction who is professor of mathematics at the University of London, took the affirmative. There is an "absolute distinction," he said, between the travelers and those who remain behind on earth. The former need an engine to carry out their motion while the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An Open Letter
ON VACUUM MELTING
To the man responsible for product development and improvement:
The problems of vacuum melting in production quantities have been solved. There are considerable data available on the properties of various alloys.
But the work has just begun.
There remain many unexplored promising uses for vacuum melted alloys -- and these uses must be explored by product manufacturers. To them we offer our knowledge, our facilities and, within our means, our purse.
Bring us your problems, your ideas, your questions. If you're looking to the future you need a supplier who is too.
Sincerely,
F.N. Darmara
General Manager
Metals Division
P.S. Utica can offer you properties like these through Vacuum Melting:
• High temperature corrosion resistance
• Extreme cleanliness
• Precise chemical control
• Longer stress-rupture life
• Increased tensile strength
• Increased ductility
• Better fatigue resistance
• Greater yield strength
• Greater impact resistance
• Greater creep properties
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latter do not. If the ship were brought to rest too rapidly at either end of its journey, "the space travelers, not Professor Dingle, would be killed." Hence it cannot be argued that all effects must apply equally to both. "There is no *a priori* reason for the journey to have the same duration by the clocks of the two observers. In general the journey does not take the same time by the two clocks."

A method for settling the argument experimentally, without waiting for interstellar spaceships, was suggested by R. Herman of the Standard Telecommunication Laboratories in England. He pointed out that any radioactive atom of known half-life is a clock. He proposed that a beam of such atoms be accelerated to relativistic speed for a measured time in a synchrotron and their aging be measured afterward. If the decay of the atoms was less than would normally be expected, this would show that the clock had indeed slowed down. Herman remarked that in that event, "there might be interesting applications for this technique of 'freezing' short-lived particles."

College Teachers' Salaries

Starting salaries at some accredited U. S. engineering colleges range from $2,700 for instructors to $4,800 for full professors. At the other end of the scale, some institutions pay experienced instructors a maximum of $7,350 and professors a maximum of $18,000. These figures were published by the Engineers Joint Council, after a survey of 116 engineering schools. Most of the schools pay instructors $3,500 to $5,000, assistant professors $4,000 to $6,500, associate professors $4,500 to $7,500 and professors $5,000 to $10,200.

A study of all college and university salaries by the National Educational Association indicates that the engineers do a bit better than average. The median salaries reported by the N.E.A. are: professor, $7,076; associate professor, $5,731; assistant professor, $4,921; instructor, $4,087. Salaries are highest in the Far West, lowest in the Southeast.

Yellow Fever Again

A new wave of yellow fever moving northward through Central America poses a serious threat to the U. S., according to Colonel Norman W. Elton, of the First Army Area Medical Laboratory. The Public Health Service is preparing to take control measures.

The outbreak began in Panama in 1948, and it has been advancing at an

Introducing USS TENELON*

Cr-Mn-N

—austenitic stainless steel without nickel

EVER SINCE WORLD WAR II, American steelmen have been painstakingly searching for high-efficiency steels using as little nickel and other critical materials as possible. This is a decidedly worthwhile objective, especially so in view of the fact that no one knows when a national emergency will again confront us.

It now appears that this desirable objective has been attained in the field of austenitic stainless steels. For in USS TENELON—developed by United States Steel—we have a remarkable new steel which, if it lives up to its early promises, should be a potent aid in helping this country conserve the supply of critical nickel. TENELON *stainless steel requires no nickel whatsoever*.

Aptly called a stainless steel milestone, nickel-free USS TENELON is a *completely austenitic* stainless which in the annealed condition has higher mechanical properties—higher yield strength and higher tensile strength—at both room and elevated temperatures than many of the conventional nickel-bearing austenitic grades.

With the development of USS TENELON, a new term has been introduced in the vocabulary of steel metallurgy: Cr-Mn-N steel—an unfamiliar abbreviation that clearly reveals the secret of USS TENELON. In this steel, manganese and nitrogen replace nickel inasmuch as they exert similar beneficial effects on the microstructure and mechanical properties. Here is a typical analysis of USS TENELON:

C	Mn	P	S	Si	Ni	Cr	N
.10 Max	14.50	.045 Max	.03 Max	1.00 Max	—	17.00	.40

Notice that, to enhance corrosion resistance, the carbon content has been kept low and the chromium level maintained equal to that of Type 301 stainless steel. The combination of Mn and N at the indicated levels produces an austenitic structure over a wide temperature range. Moreover, it assures the good hot workability necessary for commercial production.

At elevated temperatures, TENELON stainless steel has tensile and creep rupture properties superior to those of 18Cr-8Ni stainless steel and about equal to those of 18-8 Cb and 18-8Mo, all three of which require large amounts of critical elements.

Exposure tests now underway indicate that in rural, industrial and marine atmospheres, the corrosion resistance of USS TENELON in all these environments is comparable to Type 302 (18Cr-8Ni) stainless. Extensive laboratory tests show that in milder acids—lactic, phosphoric and acetic—the corrosion losses of USS TENELON are about equal to those of Types 301, 302, and 201 stainless steels. In stronger acids such as 5% sulphuric and boiling 5% nitric, this new stainless, though inferior to these grades, is equal to or better than Type 430.

USS TENELON is new and, although a number of commercial heats of this steel have been produced, the testing program is still incomplete. However, on the basis of tests made to date and others nearing completion, TENELON is emerging as a stainless steel eminently suited for rail cars, automotive vans and tank-trailers, liquid fertilizer tanks, and for various military and other applications where it can be used in its annealed as well as cold rolled condition to save structural weight and conserve nickel.

The trademark name, TENELON, is derived from the steel's *high tensile* strength and unusual *elongation* (indicative of very great ductility). In short, this steel is named for the very properties that should lead to its use in place of many stainless steels that, to achieve comparable properties, depend on relatively large amounts of critical alloy elements.

• • •

The development of TENELON is typical of the unremitting efforts of United States Steel to continually produce better steels that not only more effectively meet the needs of American Industry but will benefit the Nation as a whole. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

**Trademarks*

UNITED STATES STEEL

average rate of 13 miles per month. Its progress is marked by long periods of quiescence, alternating with sudden "whiplash fronts," such as the deadly Costa Rican epidemic of five years ago. During 1957 the disease is expected to reach Mexico and begin to move up the Gulf Coast. A sharp rise in the population of *Aedes aegypti* mosquitoes, such as occurs periodically, would bring yellow fever to U. S. cities by 1960. The entire southern U. S., where the mosquitoes flourish, has been declared a "yellow fever receptive area." The usual public health measures, Colonel Elton suggests, should be supplemented by thorough aerial mapping of the jungle valleys that form the migration routes of the yellow fever virus. Much might also be learned, Elton believes, from a study of ancient Indian texts, such as the Mayan Books of Chilam Balam, which describe a terrible epidemic of 1484 under the name of *xe-kik* or "bloody vomit."

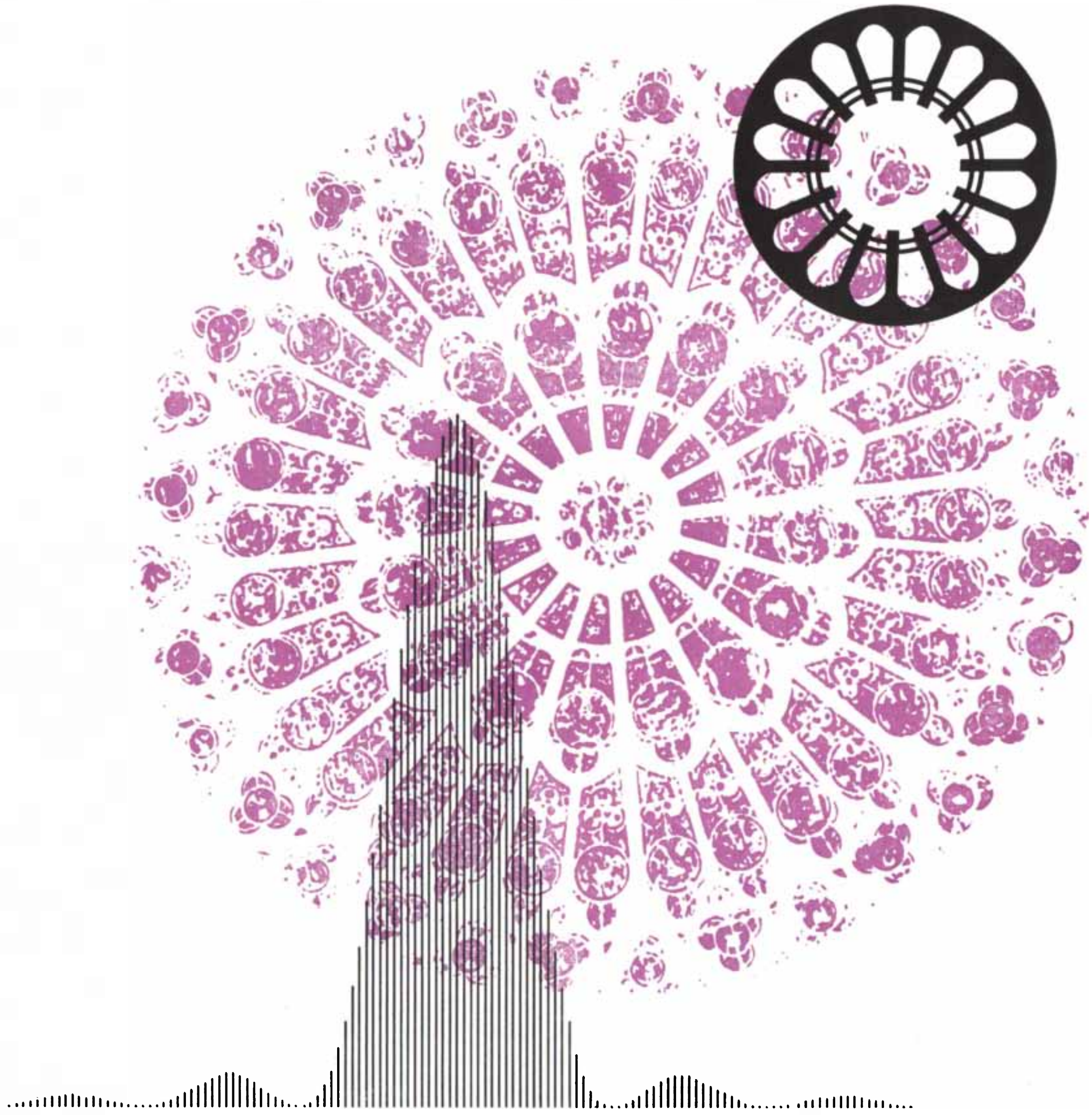
Asparagus, Beets and Genes

Two additions have just been made to the list of hereditary chemical traits [see "The Chemistry of Hereditary Disease," by A. G. Bearn, page 126]. They account for the strong odor of urine after eating asparagus, and its red color after eating beets. The discoveries were reported in *Nature* by A. C. Allison and K. G. McWhirter of Oxford University.

Contrary to the common impression, this effect of asparagus is not general: indeed, Allison and McWhirter found that less than half of their subjects excreted the odorous urine. The odor is produced by methyl mercaptan. A study of the families of excretors and nonexcretors of this substance indicates that the trait is controlled by a single dominant gene.

The reddening of urine after eating beets had been supposed a rare anomaly, but the British workers found 10 people who exhibited the characteristic in a random sample of 104 subjects. This trait also appears to be carried by a single gene, but the gene is recessive.

Another useful genetic discovery was announced by an English group. They found an apparently hereditary disease of sheep which resembles muscular dystrophy in man. Frances D. Bosanquet, P. M. Daniel and H. B. Parry reported this in *The Lancet*. *The Lancet* commented that the discovery "will not only be important to agriculture but should also lead to a better understanding of the human myopathies [degenerative muscle diseases]. At last we have a suitable experimental animal."



In Which We Reveal a Proprietary Secret

THE ANODE of a Litton Industries Magnetron brings to mind the symmetry and beauty of ancient cathedral windows. Another relationship exists. To create beauty in a cathedral window, or reliability in a magnetron, Man needs something more than mere knowledge of the chemistry and physics of glass and metal. He needs an Art. In our design and construction of these intricate generators of microwave power there has always been as much creative Art as deductive Science, and there always will be. Such a philosophy, evident throughout the several areas of activity of our company, is the principal reason why Litton Industries Magnetrons are international standards of quality.

LITTON INDUSTRIES BEVERLY HILLS, CALIFORNIA

Plants and Laboratories in California, Maryland, Indiana and New York

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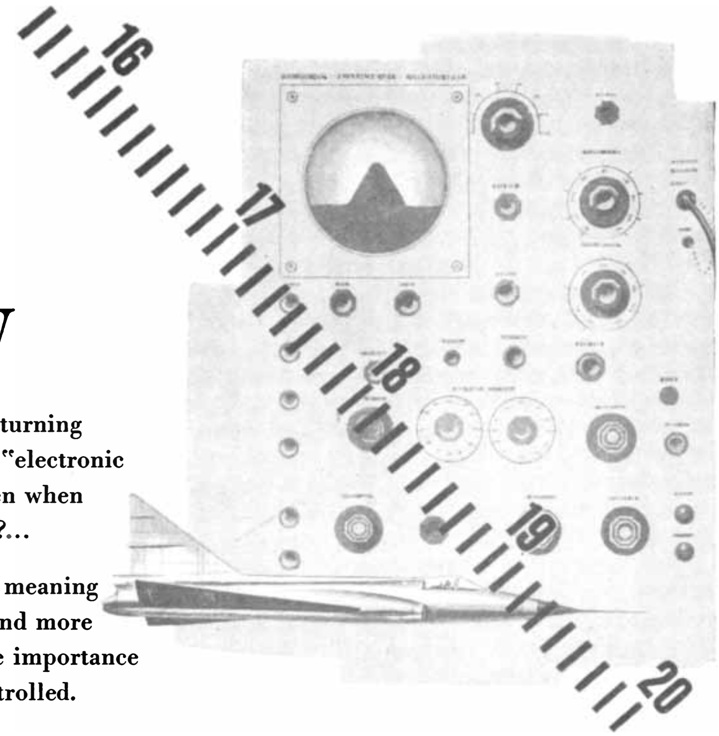
PRECISION COMPONENTS   AUTOMATIC DATA PROCESSING SYSTEMS   SERVOMECHANISMS   SPACE SIMULATION RESEARCH

How to get reliability



Got the automation jitters?...worried about turning complex manufacturing operations over to an "electronic brain"?...worried about what can happen when one component in the control system fails?...

Reliability takes on a new and different meaning as American industry becomes more and more automated. Here are a few thoughts on the importance of reliability and how it can be controlled.

All of us are going to have to pay more attention to "reliability."

We'll have to pay more attention to individual "devices" within a system.

We'll have to guard ourselves carefully when we design the entire system.

The industrial pendulum is swinging more and more toward automatic controls, servo-mechanisms, computers, and automatic "watchers." As it does, the reliability factor becomes more and more important. Let's see why. For example, you probably have three radios at home. If one fails because a soldered joint comes apart, your home life is probably not disrupted to any alarming degree. But . . . consider the automatically controlled steel mill. One soldered joint failing, unless all controls are installed in duplicate (which is expensive) could tie up the entire production process for valuable minutes, if the maintenance crew has second sight. For hours, if automatic trouble-indicating and locating systems are not installed (and these are expensive, too). Last, but not least, lend a thought to the dependence of guided missiles and man-made satellites upon the reliability of electronic circuits and components. So . . . let's start to examine "reliability." Let's begin by looking at this definition which is currently popular in the technical field:

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

Now . . . this is a relatively well-accepted definition, and it offers the key to the problem of coping with failure control. Take the word "probability" in this definition. Let's discuss its implication.

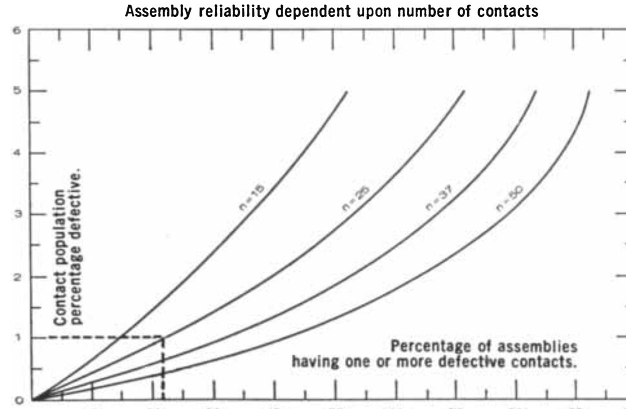
Many of today's systems, simple or complex, are a chain of components. So picture a system as a chain with its successive links. In the field of statistics the over-all reliability of the chain is the mathematical product of the reliabilities of the individual links . . .

Overall Reliability, $R_o = r_1 \times r_2 \times r_3 \ldots r_n$

Now, let's consider a system made up of 100 different components, each of which has a reliability of 99%. In applying the formula, multiplication of .99 by itself 100 times gives an over-all reliability for the system of only 36.5%. Two out of three systems you have put together will probably fail!

Cannon becomes involved with this problem because our main business is making electric connectors. So, let's look at the following chart that covers contact reliabilities and reliability of the assembly in which they are mounted.

Assembly reliability dependent upon number of contacts



This chart illustrates the reliability of four connectors having 15, 25, 37 and 50 contacts respectively. As an example, assume that the contacts have a contact population of 1% defective (1 in 100 defective . . . this percentage is considered a fairly high standard in most fields). On the 15-contact assembly, we find from our chart that 14% of the connector assemblies would have one or more defective contacts! With 25 contacts, 22% would have one or more defective contacts. With 50 contacts, 41½% . . . is your hair starting to curl? Obviously, a 99% contact reliability standard for guided missile components is absolutely unacceptable. And, in between the simplest system and that of a guided missile, are hundreds of assemblies and systems whose reliability factors must be analyzed with utmost care.

But all is not lost! There's another side to the picture. With proper care, analysis, and control, our Cannon organization has actually achieved, in special "missile quality" contacts, a known level of only 2.85 x 10^{-3}% defective . . . only 1 part in 35,000! Naturally, we don't achieve that with all our contacts . . . but we do try to design and manufacture the utmost in reliability required for specific applications.

We have pictured this chart to show the direction we must all take, whether we're talking about connectors, other components, or systems. It boils down to two steps . . .

- ✱ The number (n) of components must be kept low . . . *simplicity.*
- ✱ The level of component reliability must constantly be improved . . . *hard work for all of us.*

Now . . . if we refer to our reliability definition on the previous page we note the phrase "do what it is supposed to do." So be sure *you* define these objectives for your component assembly, or system . . . failure to do so carefully can cause undue failure or the expenditure of unnecessary dollars for needless, excessively-reliable parts or design.

Further on in the same definition, we note the words "operating conditions." This brings up many new points for consideration. Here we are concerned with such things as temperature, pressure, humidity, corrosive atmosphere, stray electric and magnetic fields, low and high frequency noise, shock and vibration. Do your design standards need upgrading? Are your components designed and then tested to meet the operating conditions you specify . . . or are they designed to meet "average" conditions? Are you using adequate "safety factors"?

In a simple component, manufacturers have always looked for, recognized, and corrected faults when they occurred. We use component quality control to achieve and maintain Cannon's world famous product quality. But in complex systems such component quality control is not enough. Actually . . .

Reliability control over the system is needed. It should be all-encompassing. When you get right down to it, *reliability* is the product of procedures, equipment, and people . . . in the design, manufacture, testing, control of quality, transportation, and use of products or systems.

Do you have a reliability control system?

Here are a few of the steps that are needed to get a reliability control system operating:

1. Determine Your Requirements. Specify the environment, operating time, performance limits, and the percent of reliability required. Allow an adequate safety factor keeping in mind the end use of the finished product.

2. Collect Reliability Data. Set up facilities for the continuous accumulation of data on component or system failures and their causes.

3. Establish quality control and test procedures which show high degree of correlation with end-use conditions.

4. Analyze. Determine if reliability requirements are being met. Establish the most important causes of failure by analyzing the data you collect.

5. Improve. Take action to eliminate the most important defects or causes of failure. Reduce the failure rate to the required level.

6. Maintain Continuous Vigilance. You have emphasized system design . . . you have used statistical analysis of failures . . . now exert continuous and critical control to be sure your "improvements" actually improve reliability. Examine new and unforeseen failure sources. Review and modify your requirements with changing conditions.

✱

We at Cannon Electric are proud of our historical emphasis on quality and reliability. Since 1915 we have adhered to a design philosophy embracing the highest quality and reliability in each and every Cannon Plug for the specific application for which it is to be used. *If we can't design to that principle, we don't make it!* In manufacture, we are proud of our know-how in depth, proud of our fine quality control systems, proud of our personnel and proud of our reliability control group.

Whenever *you* have an electric connector reliability problem . . . in design, engineering, production, or prototype phases . . . we would appreciate the opportunity of discussing it with you.

Cordially,

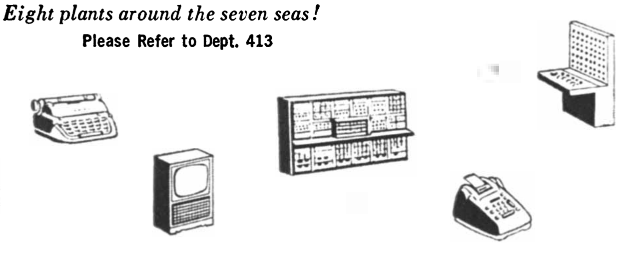
Robert J Cannon *President*

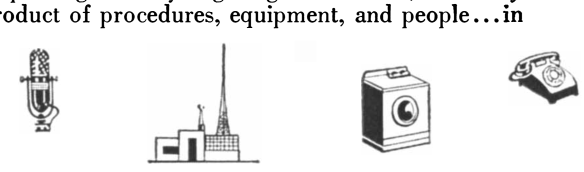
CANNON ELECTRIC COMPANY
3208 Humboldt St., Los Angeles 31, California

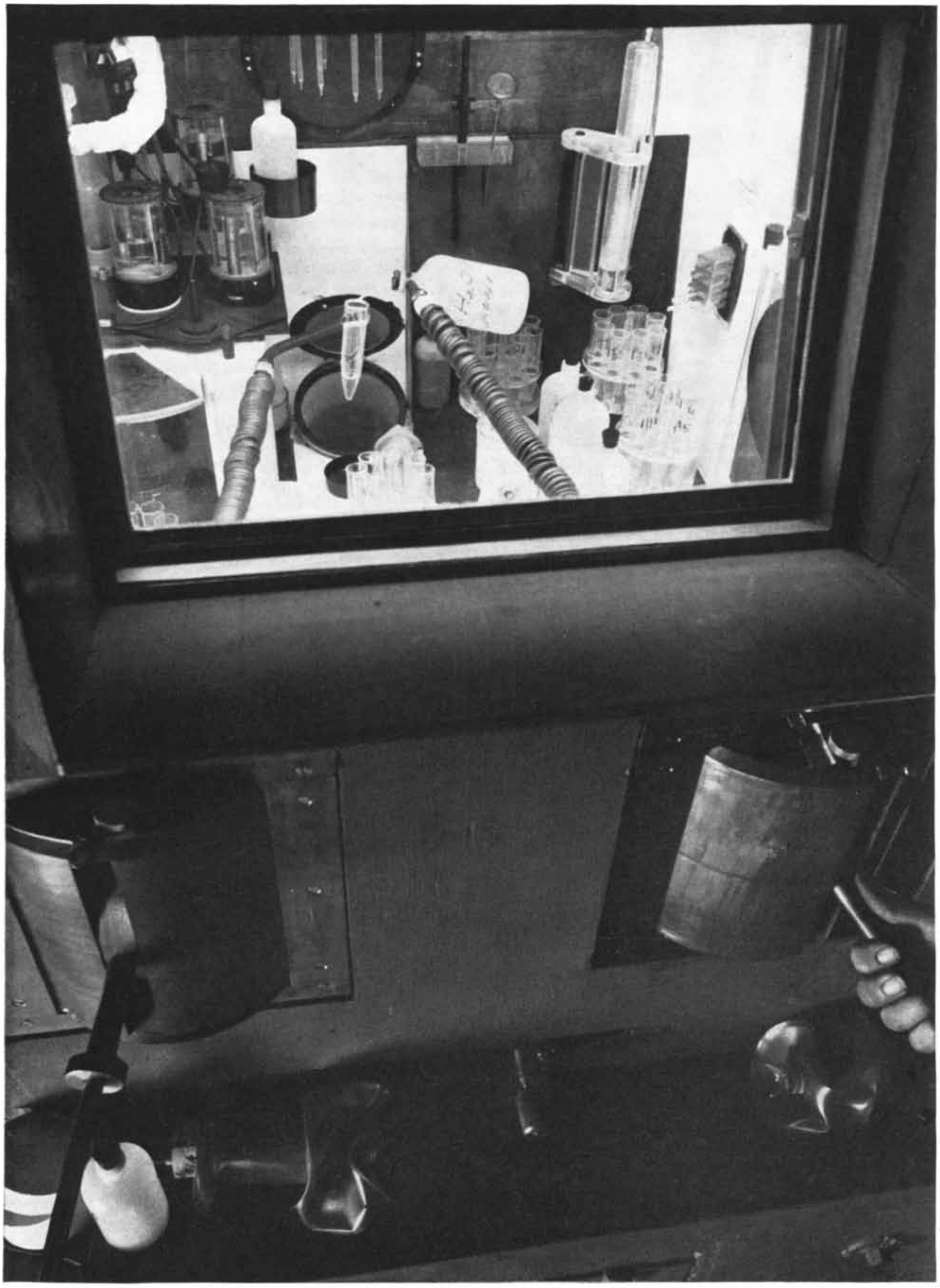
CANNON PLUGS

Eight plants around the seven seas!

Please Refer to Dept. 413







"CAVE" in the Radiation Laboratory at the University of California is used for the chemical manipulation of highly radioactive substances. The chemist performs his operations by remote control and observes them through a thick glass window. After production by intense neutron irradiation of plutonium, the elements berkelium, californium, einsteinium and fermium were isolated in this way.

THE NEWEST SYNTHETIC ELEMENTS

Presenting a sequel to "The Synthetic Elements," which appeared in the April, 1950, issue of this magazine. Since then nuclear chemists have synthesized and detected elements 98 through 101

by Albert Ghiorso and Glenn T. Seaborg

An atmosphere of gloom permeated the laboratory that night. In the attempt to produce and identify element 101—the next step in the build-up of a sequence of man-made elements beyond uranium—we had carried out a number of very careful experiments, and all had failed. Now a last experiment was being tried, on the basis of what seemed only a farfetched possibility. At best the minuscule sample of material we had prepared might contain one or two atoms of the elusive 101st element. There was some reason to believe that an atom of element 101 might decay in an hour or two into an atom of element 100, which in turn might break up spontaneously by the fission process. If this barely possible combination of events took place, the creation of element 101 would be signaled in an ionization chamber by a comparatively large pulse of ionization, produced by a fission fragment of its decay product, element 100.

We watched with eyes fixed on a pulse recorder connected to the ionization chamber. An hour went by. The night dragged on toward dawn. The waiting seemed interminable. Then it happened! The recorder pen shot up to mid-scale and dropped back, leaving a neat red line which represented a large ionization pulse—10 times larger than would be produced by an alpha particle. No such pulse had been recorded from natural background radiation in test runs conducted for many days prior to the experiment. It looked highly probable that the pulse was indeed a signal of the hoped-for fission. The vigil continued. An hour or so later the pen recorded a second pulse like the first. We were now confident that we had witnessed the decay of two atoms of element 101—and had added a new member to the roster of chemical elements.

This experiment was probably the most dramatic of the many that have been performed in the University of California Radiation Laboratory in the program of creating new elements. The discovery of element 101 was especially exciting because it was identified on the basis of only a couple of atoms, produced by transmutation in an amount of target material itself so small that it was unweighable. New developments in the sensitivity of techniques had made the discovery possible, and this indeed has been the pattern of additions to the list of elements. Each discovery followed a period of advances in knowledge and methods of analysis. The synthetic elements have been discovered in pairs, so to speak—elements 93 and 94 at nearly the same time, elements 95 and 96 some five or six years later, 97 and 98 four or five years later, and so on. After each pair of discoveries there was a period of mobilization of forces for the next search. The newly discovered elements had to be produced in appreciable amounts for transmutation to the next stage. Techniques and instruments had to be refined.

In a previous article ["The Synthetic Elements," by I. Perlman and Glenn T. Seaborg; Scientific American, April, 1950] the story of the creation of man-made elements was carried up to element 97. Here we shall deal with the discoveries since then—elements 98 to 101—and the growing information about this strange family of heavy elements. The discovery and identification of these elements rests upon the fact that they *are* a family—moreover, a family whose members correspond, in chemical traits, to the members of another family of known and natural elements. This helpful fact [*originally pointed out by Seaborg in 1944 when the chemical properties of the first synthetic elements, neptunium and plutonium, were determined*] makes it possible to predict the chemical properties of each transuranium element before it is actually created. It was the key to the discovery of elements 95 and 96 (americium and curium), and without this clue the elements beyond 96 could not have been discovered at all.

The Actinide Family

The family serving as the guide comprises the so-called rare earths, running from lanthanum to lutetium—elements

Editor's Note

Among the many investigators who participated in the work described in this article, in addition to Ghiorso and Seaborg, were S. G. Thompson, K. Street, Jr., G. H. Higgins, G. R. Choppin, B. G. Harvey and G. B. Rossi of the University of California at Berkeley; M. H. Studier, P. R. Fields, S. Fried, H. Diamond, J. F. Mech, G. L. Pyle, J. R. Huizenga, A. Hirsch and W. M. Manning of the Argonne National Laboratory; and C. I. Browne, H. L. Smith and R. W. Spence of the Los Alamos Scientific Laboratory.

57 to 71. The series of heavier elements corresponding to this group begins with actinium (element 89) and includes thorium, protactinium, uranium and the transuranium elements up through the still undiscovered elements 102 and 103 [*see chart on next page*]. Because the first member of the series is actinium, this family of elements are called actinides (as the rare earths are called lanthanides). The family resemblance between the actinides and the lanthanides provides a key to chemical separation and recognition of the individual transuranium elements. A sensitive ion-exchange method has been developed to separate actinides in a mixture: the heaviest transuranium element comes out of the exchange column first and the lighter ones follow it in succession. Thus it is possible to concentrate a newly made element for detection and analysis.

Not only do the heavy elements show a pattern of chemical relationships, but a pattern has also emerged in their physical properties. In the past decade highly sensitive methods have been developed for counting the alpha particles emitted by radioactive atoms and for measuring the energies of these particles accurately. Since each decaying isotope usually radiates its alpha particles predominantly at a single, characteristic energy, the accurate resolution of alpha energies makes it possible to identify isotopes simply by the energy of their alpha emission. Furthermore, the heaviest elements show definite and regular patterns in this emission, so that it is now possible to predict fairly accurately the half-life and alpha-emission energy of a new isotope which one is seeking to synthesize.

To this signature there has been added the identifying marker of spontaneous fission, by which element 101 was discovered. The energy of spontaneous fission does not differ enough from one atom to another to distinguish between them, but the half-life of such fission *is* characteristic for each atom: it varies in a regular manner with increasing atomic weight [*see chart on page 74*]. We were able to predict that the spontaneous-fission half-life of the unstable element 100 isotope to which element 101 decayed would be two to three orders of magnitude shorter than that of any known, and so it proved to be.

We also have some knowledge now of the statistical probability of producing new isotopes when a given heavy element is bombarded with particles of a given energy. Needless to say, all these advances in knowledge of the systematic nuclear properties of heavy elements have been very important in the planning of experiments aimed at finding new elements and isotopes.

Elements 97 and 98

We shall begin this account with elements 97 and 98, which were discovered at the end of 1949 and the beginning of 1950. To make them it was necessary to manufacture substantial amounts of the two preceding synthetic elements, 95 and 96. Those elements, americium and curium, are intensely radioactive. In order to detect the new elements to which they were transmuted, extremely efficient methods of separating the new products had to be developed, so that their identifying radioactivity would not be drowned in the radioactivity of the parent elements. The separation of the dangerously radioactive materials required the development of complicated remote-control apparatus.

Element 95 (americium) was the starting material. It was made by bombardment of plutonium with neutrons. Intense bombardment of plutonium in reactors over a long period produced milligram amounts of element 95, and this then became the target material for the next steps. Bombarded with alpha particles accelerated to 35 million electron volts in the 60-inch cyclotron at Berkeley, some of the atoms of element 95 were transmuted to element 97. The new element emerged in the form of an isotope which has the mass number 243 (*i.e.*, five more nucleons than uranium 238) and a half-life of 4.6 hours. It decays primarily by the nucleus' capture of electrons from the electronic part of the atom—which is equivalent to emission of positrons by the nucleus.

Element 98, the next step, was produced from element 96, which had been prepared in microgram amounts by bombardment of element 95 with neutrons. The transmutation of 96 to 98, like that of 95 to 97, was accomplished with 35-Mev alpha particles from the 60-inch cyclotron. It yielded an element 98 isotope with the mass number 245 and a half-life of 45 minutes. This new element was identified on the basis of a tiny amount which came to only about 5,000 atoms—less than the number of students at the University of California!

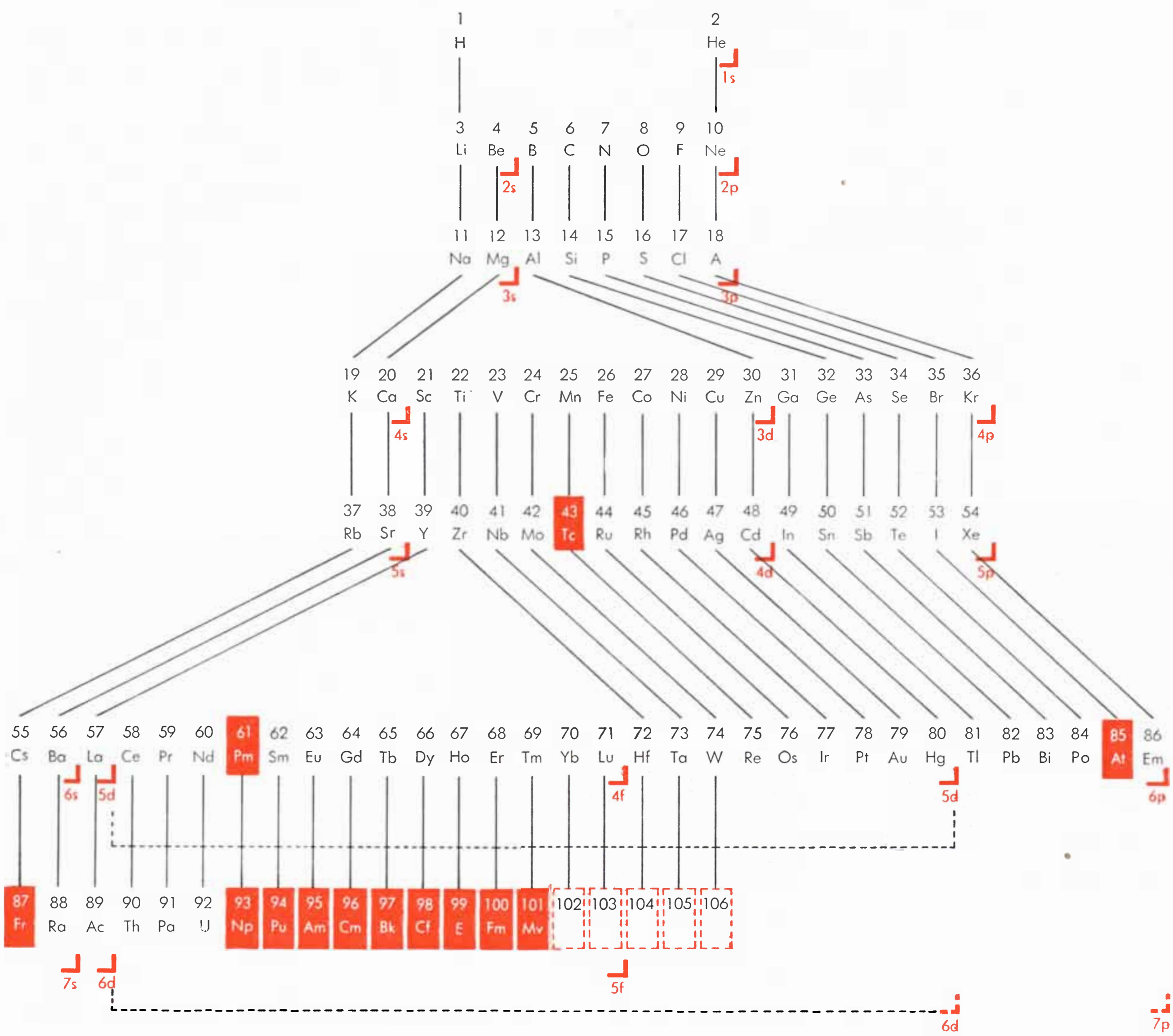
After the discovery of elements 97 and 98, it was found that longer-lived isotopes of them could be made, in substantial quantities, by neutron irradiation of plutonium, americium and curium, which builds up the heavier elements by a series of neutron captures. Eight isotopes of element 97 and 11 of element 98 have now been manufactured, and the long-lived isotopes are available in sufficient amounts for study of the elements' chemical properties on a macroscopic scale. One isotope of element 98 (252) decays in part by spontaneous fission. Since fission always releases some free neutrons, this isotope offers the possibility of use as a tiny, portable source of neutrons for experimental work.

The member of the rare-earth family that is analogous to element 97 is terbium (Tb), named for the town of Ytterby in Sweden, where it was found. Element 97 therefore was given the name berkelium (Bk), after Berkeley. But in naming element 98, whose rare-earth analogue is dysprosium (Dy), the discoverers departed from precedent and

THE PERIODIC TABLE at the bottom of the opposite page presents the 101 natural and synthetic elements in horizontal rows to display the similarities in their chemical properties. Elements of similar chemical properties are connected by the lines running from top to bottom. Above the symbol for each element is its atomic number, *i.e.*, the number of positive charges in its nucleus or the number of electrons bound by them. The 13 synthetic elements are indicated by the solid colored rectangles. The positions of synthetic elements not yet discovered are indicated by the open colored rectangles. In each horizontal row is one or more colored brackets designated 1s, 2s, 2p and so on. Each of these brackets denotes the filling of a shell of electrons—more properly a subshell—in the succession of the elements. The electron-shell structures of two synthetic elements are given in the schematic drawings at the top of the page. In X-ray terminology the shells are designated K, L, M, N, O, P and Q. In spectrographic terminology they are designated 1, 2, 3, 4, 5, 6 and 7. The spectrographic subshells are designated s, p, d and f. The maximum number of electrons (*black dots*) in any s subshell is two, in any p subshell six, in any d subshell 10 and in any f subshell 14. The number of electrons in each subshell is indicated by a superscript number; for example, $7s^2$ in the outermost subshell of einsteinium (E) indicates that there are two electrons in the s subshell of shell 7. In most of the elements all of the inner subshells are filled. The case of the transuranium elements (elements 93 to 101) is more complex. In the rare-earth series from element 58 (cerium) to element 71 (lutetium) the number of 5d and 6s electrons remains approximately the same; in successive elements electrons are added in the 4f subshell. The transuranium elements belong to a series similar to the rare earths.

EINSTEINIUM

FERMIUM

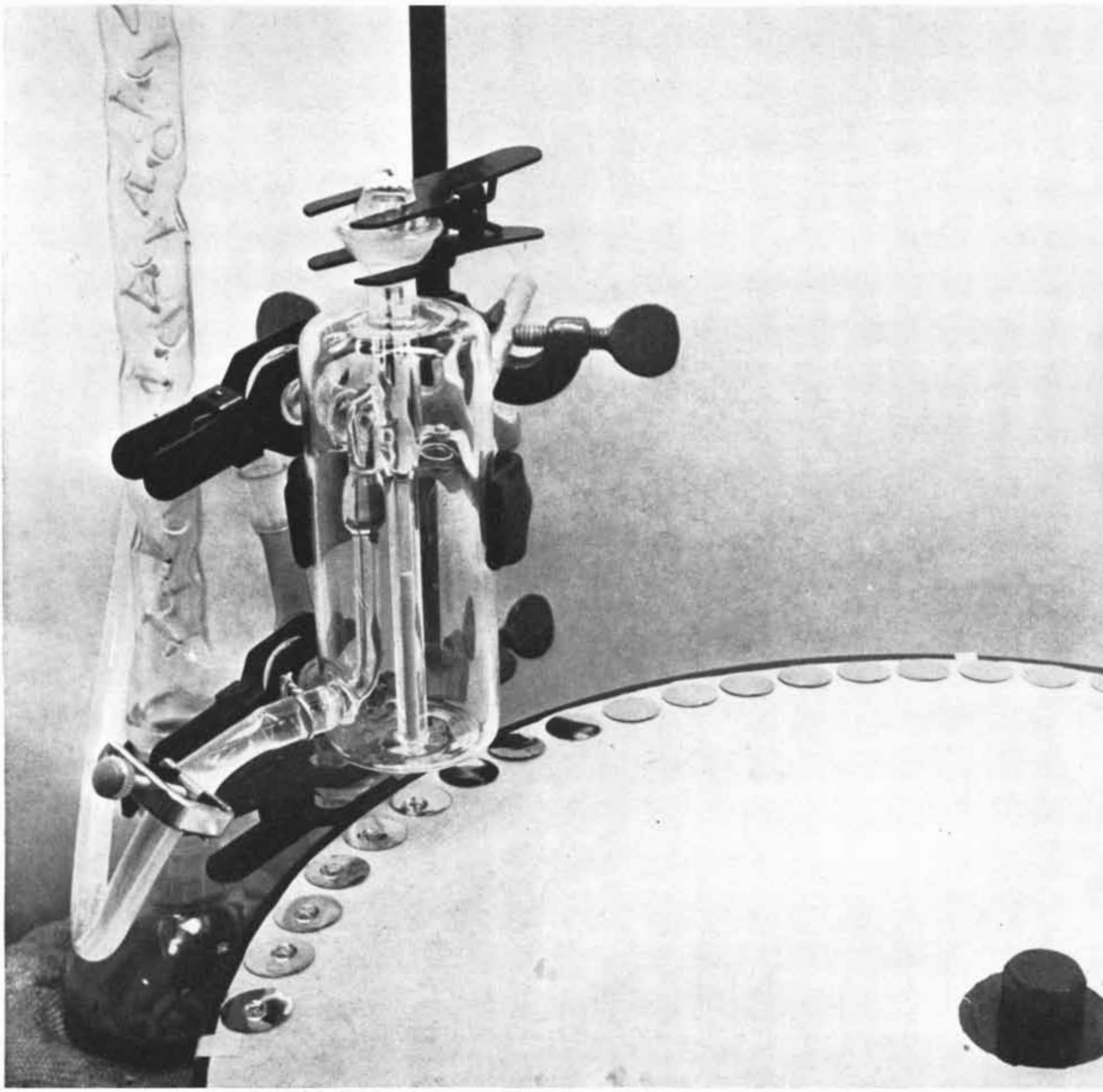


chose the name californium (Cf). In announcing the discovery in *The Physical Review* they remarked: "The best we can do is point out, in recognition of the fact that dysprosium is named on the basis of a Greek word meaning 'difficult to get at,' that the searchers for another element a century ago found it difficult to get to California."

As we have pointed out, the new elements were identified chemically by their behavior in an ion-exchange column. In the drops collected at the bottom of the column the heaviest element of a series comes out first and the following drops carry the other members of the series in order of decreasing atomic number. For any given element, the successive drops have increasing and then decreasing amounts of the substance (the amount being measured by radioactivity). This information is presented in the form of curves on a chart. In two charts shown here [*see next page*] we have plotted this information for the transuranium elements and for their analogues in the rare-earth series. The plots bring out clearly the chemical correspondence between elements in the two groups.

99 and 100

Elements 99 and 100, the next two elements found, represent an outstanding example of unexpected, and incidental, discovery. They were discovered in debris from the test thermonuclear explosion of November, 1952, in the Pa-

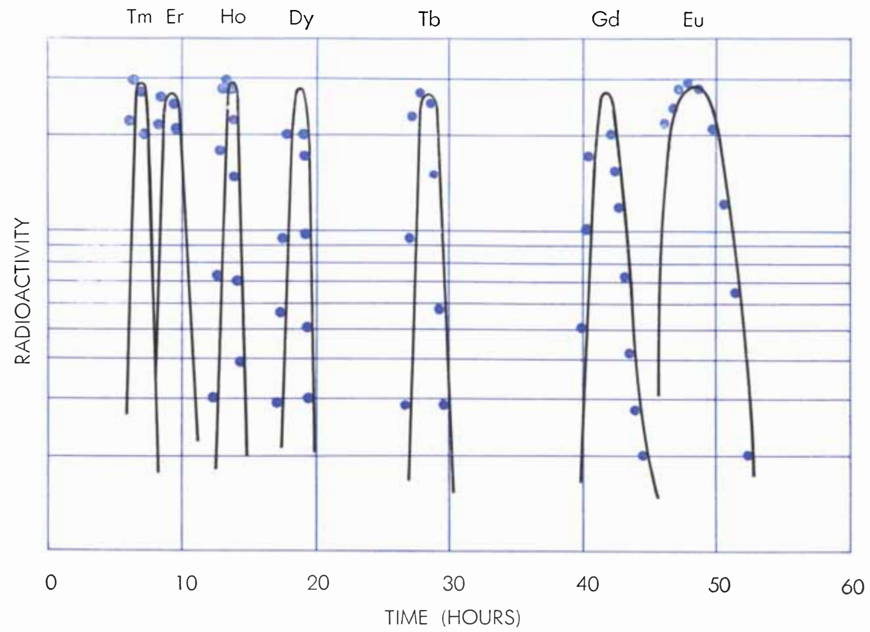


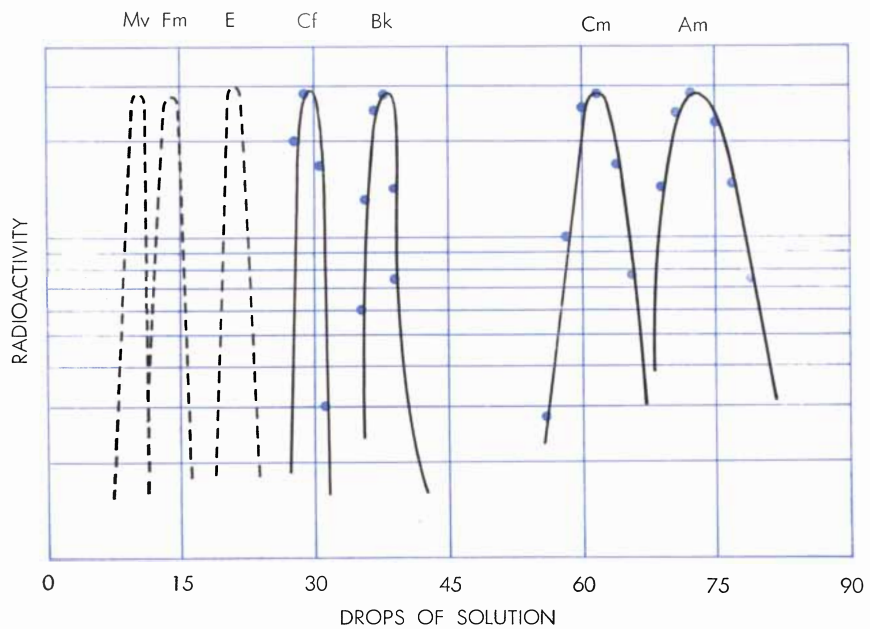
ION-EXCHANGE RESIN is used to fractionate a mixture of transuranium elements. The resin may be seen in the bottom half of the tube contained in the larger vessel at the left. A solution of the mixture is poured into the top of the tube. Each of its constituents passes through the resin at a characteristic rate. Thus the constituents emerge in sequence from the bottom of the tube. They are kept separate by means of the turntable below the tube. As each drop of solution emerges from the tube and falls on a small metal disk, the turntable rotates to bring another disk into position. The drop can now be analyzed by its chemistry and radioactivity.

cific ("Operation Mike"). Material collected on filter paper by drone airplanes flying through the explosion clouds and later in the "fallout" on a neighboring atoll, was brought to a number of U. S. laboratories for chemical investigation. At the Argonne National Laboratory and the Los Alamos Scientific Laboratory it was found to contain some new heavy isotopes of plutonium. This suggested that new elements might have been built up from uranium by many successive captures of neutrons in the explosion, and we undertook at Berkeley to look for elements beyond 98 in the material. Ion-exchange experiments immediately brought one to light. To identify it, more material was called for, and many hundreds of pounds of coral were collected from an atoll near the explosion area and worked over. The material was given the nonsecret code name of "Paydirt"! Paydirt it proved to be, for it led to the positive identification of isotopes of elements 99 and 100 [*see chart on next page*]. The first identification of element 100 was made with only about 200 atoms. The large group of investigators at Berkeley, Argonne and Los Alamos who took part in the work proposed for element 99 the name einsteinium (E), in honor of Albert Einstein, and for element 100 the name fermium (Fm) in honor of the father of the atomic age, Enrico Fermi.

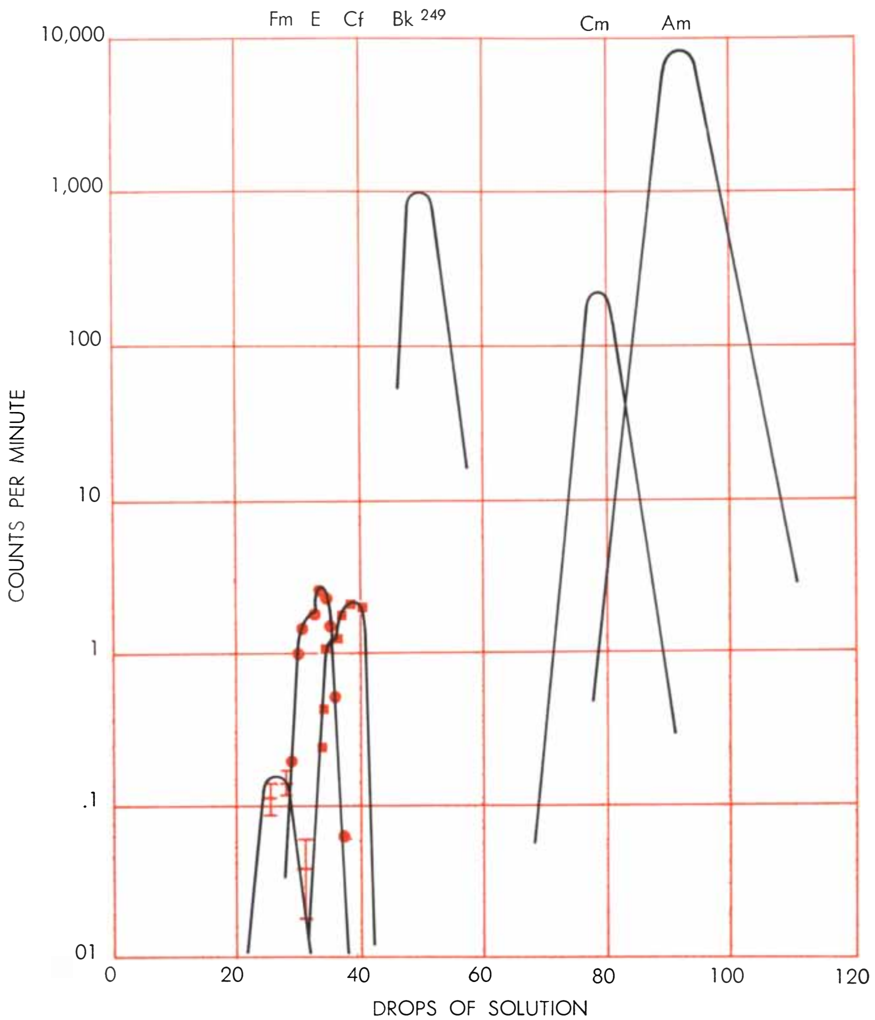
Before these discoveries were declassified and announced to the world, elements 99 and 100 were produced by a number of other methods. Chief among these was prolonged irradiation of plutonium with an extremely high flux of neutrons in the Materials Testing Reactor at Arco, Idaho. The complex series of nuclear reactions (neutron captures and decays) that leads to formation of the elements up to 100, both in the reactor and in the "Mike" explosion, are shown in an accompanying chart [*see page 76*]. To produce all these isotopes in a reactor it is necessary to bombard gram quantities of plutonium for two or three years; in the fusion-fission explosion the parent isotopes are created from uranium in a matter of microseconds.

Only tracer amounts of einsteinium and fermium have been available for investigation of their chemical properties. However, there is an isotope of einsteinium which has a half-life of about 270 days, so it should be possible to isolate weighable amounts of this isotope, and substantial quantities of others may be produced by very long and intense neutron bombardment of large amounts of preceding elements. But it appears that

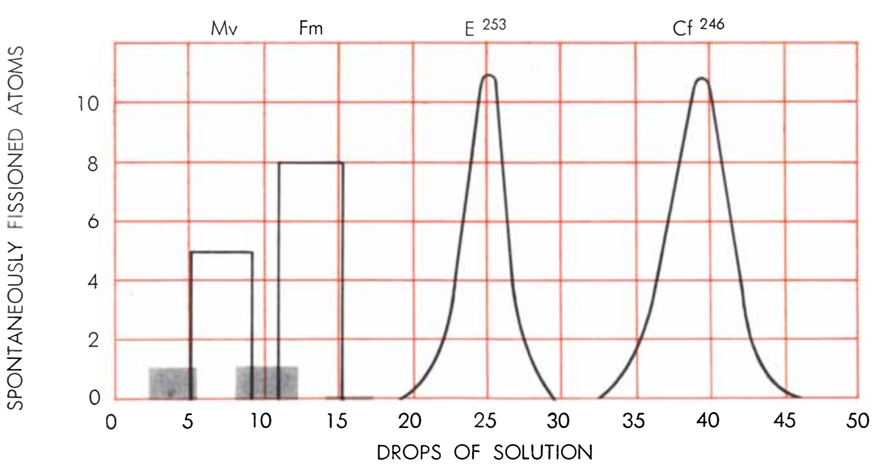




ION-EXCHANGE IDENTIFICATION of californium (Cf) and berkelium (Bk) is presented in the bottom chart. The horizontal coordinate is the number of drops of solution emerging from an ion-exchange column containing a mixture of the transuranium elements californium, berkelium, curium (Cm) and americium (Am). The vertical coordinate is the amount of radioactivity in each sample (*colored dot*). The top chart shows the position of the lanthanide rare earths chemically analogous to the transuranium elements: thulium (Tm), erbium (Er), holmium (Ho), dysprosium (Dy), terbium (Tb), gadolinium (Gd) and europium (Eu). Europium, for example, has chemical properties resembling those of americium, which appears directly below it in the bottom chart. By this analogy the positions of mendelevium (Mv), fermium (Fm) and einsteinium (E) were predicted (*broken curves*). The horizontal coordinate of the top chart (*hours*) differs from that of the bottom chart (*drops of solution*) for the reason that much larger quantities of solution were used to separate the lanthanide rare earths. Actually the coordinates are comparable. The lanthanide rare earths are not naturally radioactive; they were made artificially radioactive by bombardment with neutrons in a reactor to simplify the process of their identification.



EINSTEINIUM AND FERMIUM (E and Fm) were separated by ion exchange from californium (Cf), the berkelium isotope of mass number 249 (Bk-249), curium (Cm) and americium (Am). They were detected by their radioactivity. They could be distinguished in the ionization chamber by the energies of the particles emitted in their radioactive decay.



MENDELEVIUM (Mv) was similarly separated but was detected by the spontaneous fission of its daughter atoms. The open bars indicate the number of fissions in samples emerging from the ion-exchange column in the order expected of mendelevium and fermium (Fm). The gray bars indicate the fission activity of other samples. The curves for einsteinium 253 (E-253) and californium 246 (Cf-246) are based not on fission activity but on alpha-particle activity. The shape of the curves covers measurement of the activity of many samples.

einsteinium is the heaviest element it will be possible to isolate in visible quantities.

Element 101

The discovery of element 101, as we related at the beginning of this article, was in many ways the most difficult and most exciting of all. We decided to make the attempt before there was even a weighable amount of the target material—einsteinium (element 99). The plan of attack was to bombard the isotope einsteinium 253 with the most intense beam of alpha particles achievable by the Berkeley 60-inch cyclotron. All the target material available (from the Arco reactor) amounted to only about a billion atoms. We estimated that the element 101 isotope created would have a half-life of only 10 minutes. It could be calculated that bombardment of the billion atoms of einsteinium with the alpha-particle beam for several hours would yield one detectable atom of the new element! This single atom would have to be separated from the billion atoms of einsteinium and identified by the ion-exchange method in less than 10 minutes.

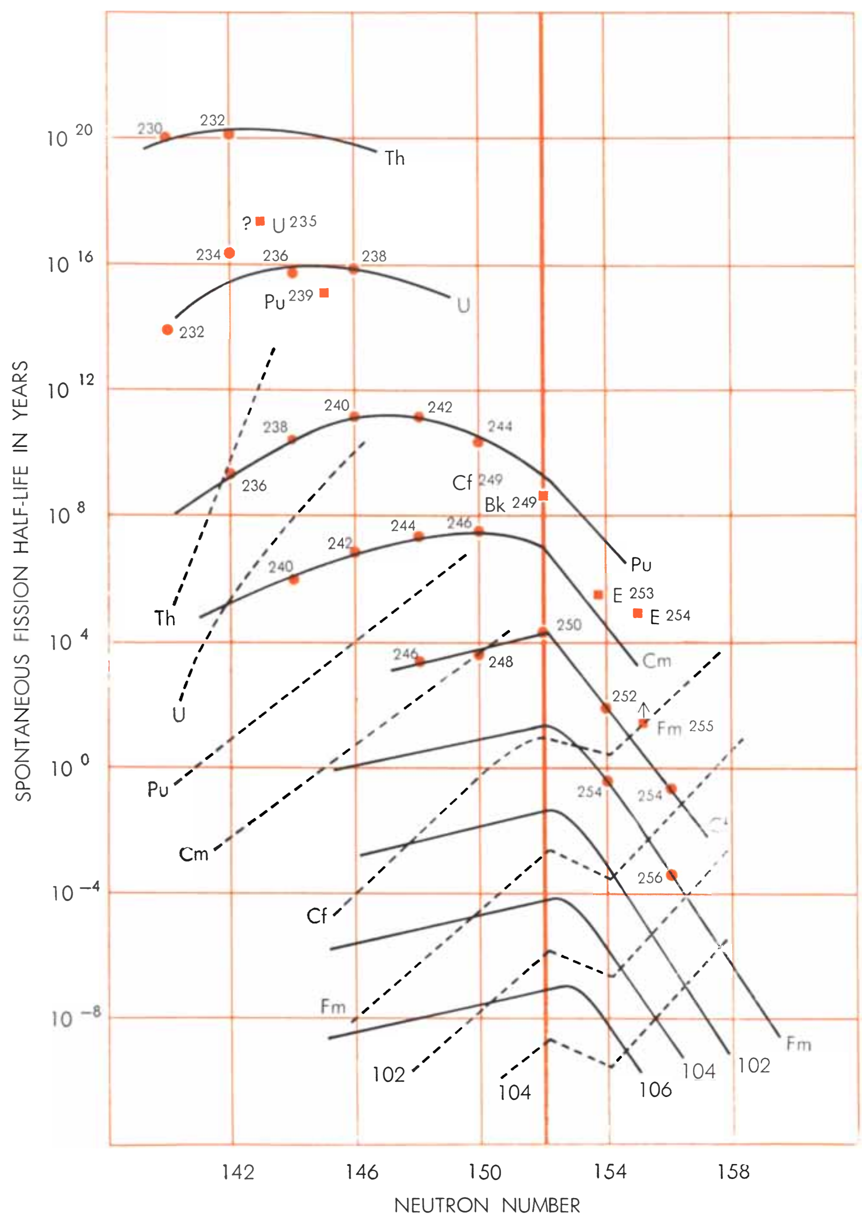
These requirements indicated a desperate need for new techniques, together with some luck, and fortunately both were forthcoming. The advance in technique was a new method for separating the transmuted element from the target material. The einsteinium target was prepared in the form of an invisibly thin layer electroplated on a gold foil, and the alpha-particle beam bombarded this layer after traversing the foil. Atoms of element 101 produced in the layer would recoil, because of the impact of the alpha particles that effected the transmutations. The recoiling atoms were caught on a second gold foil. This foil, containing the new atoms and relatively free of einsteinium, was dissolved, and the new atoms were then isolated by means of the ion-exchange column.

We first tried to identify element 101 by its decay emission of alpha particles. But we were unable to detect any alpha activity that could be attributed to element 101, even when the time between the end of bombardment and the beginning of the alpha-particle analysis was reduced to five minutes. One of our persistent troubles was that the decay of radon, the rare radioactive gas in the earth's atmosphere, releases alpha particles with about the same energy as that expected for the isotope of element 101. Moreover, the radon decay product in question comes out of an ion exchange column at about the place expected for

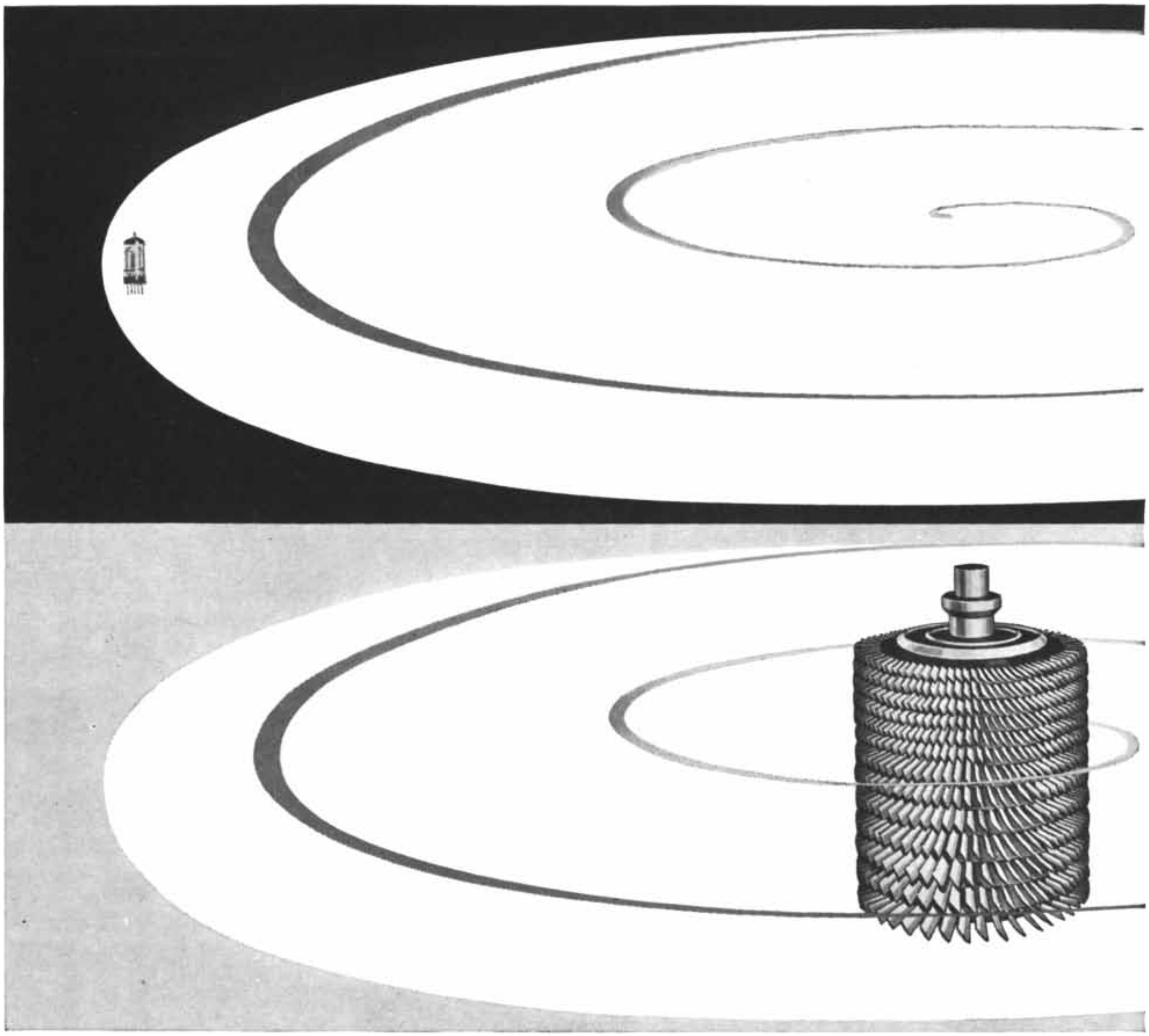
element 101! With this type of competition it was very difficult to single out a 101 decay and be sure it was genuine.

Nevertheless, one of these first experiments yielded an event of great significance, as it turned out. Our counter recorded what seemed to be a spontaneous fission! Although we could not be absolutely sure of it, we conjectured that if the event were indeed a spontaneous fission, it might indicate the formation of a new, very short-lived isotope of element 100 from the decay of 101. If that were so, the event might be a means of detecting the existence of 101.

What seemed at the time only a remote possibility turned out to be an actuality. The experiment was revised to look for spontaneous fissions rather than for alpha emissions. The troublesome background interference was now reduced to zero, and the chances of re-



TIME REQUIRED FOR THE SPONTANEOUS FISSION of undiscovered isotopes can be predicted on the basis of the time required for the fission of known isotopes. The round colored dots in this chart indicate the fission half-lives of known isotopes with various numbers of neutrons. The solid curves are based on these points, and suggest where the fission half-lives of undiscovered isotopes will fall. The square colored dots represent anomalous observations. The arrow above the point for fermium 255 (Fm-255) indicates that its fission half-life is at least this long. The broken curves similarly plot the time it takes various elements to decay by emitting an alpha particle. These latter curves are based on actual observations except for the undiscovered elements 102 and 104. The heavy vertical colored line is at 152 neutrons, the point at which fission half-life of isotopes abruptly decreases.



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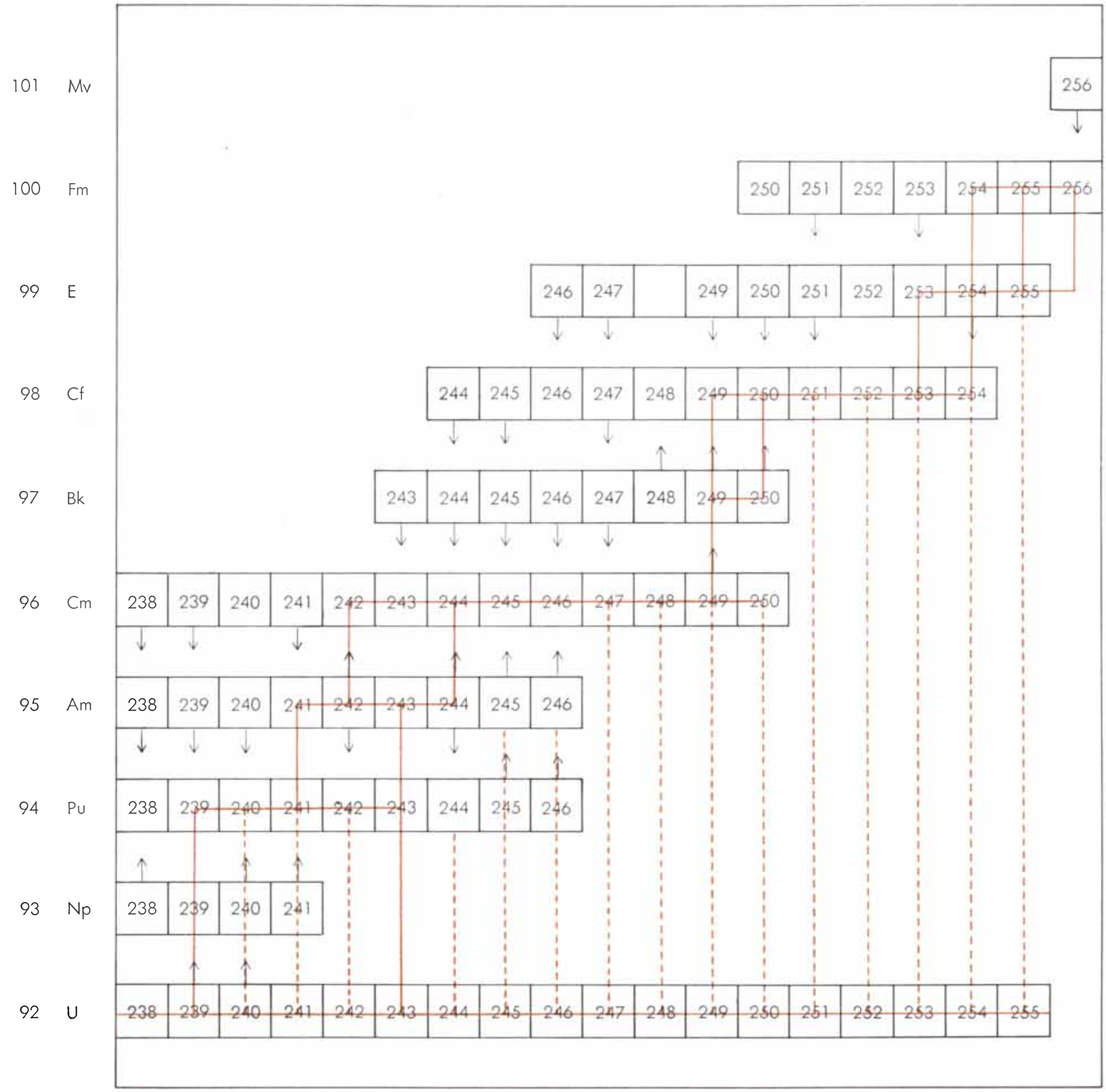
cording fissions in the counter were twice as good as for alpha particles. It turned out that the half-life of the 101 isotope was closer to an hour than to 10 minutes, as we had estimated, but this gain was counteracted by the fact that the probability of formation of the element was considerably smaller than we had thought. The net result was that on the average it was possible to make only one of these new atoms in each experiment: sometimes there were two, sometimes none. A huge fire bell in the hall of the chemistry building was connected to the counting circuit, so that each of these rare events pealed a loud clang of rejoicing. But this sport was put to a justifiable end when it came to the attention of the fire department.

Could the chemical behavior of one or two atoms faithfully reflect the chemistry of the new element? We decided that, under the conditions of our experiments, it actually did so, because each



EINSTEINIUM AND FERMIUM were first made by sequences of nuclear reactions in the "Operation Mike" thermonuclear explosion and later in the Materials Testing Reactor at Arco, Idaho. In this chart the elements are listed vertically according to their atomic number; the isotopes of the elements are listed horizontally according to their mass number, or atomic weight. In the thermonuclear explosion the starting material was ordinary uranium (U-238). By the instantaneous addition of neutrons in the explosion this was built up into a whole sequence of uranium isotopes from U-239 to U-255 (*bottom row*). These rapidly decayed by the emission of negative beta particles into the isotopes above them (*broken colored lines*). In the Materials Testing Reactor the starting material was plutonium (Pu) 239, which had already been made from U-238. By adding two neutrons Pu-239 was transmuted into Pu-241, which decayed into americium (Am) 241. This isotope was in turn built up by the addition of neutrons and so on, following the solid colored lines in the chart. The isotopes of einsteinium and fermium that are not on the pathways were made later by other processes. Some of the pathways in this sequence of reactions are alternative, but they all end at the same point: fermium (Fm) 256. The small black arrows pointing up indicate that these isotopes decay up the scale of elements by the emission of a negative beta particle. The black arrows pointing down indicate that these isotopes decay down the scale by capture of electrons outside the nucleus.

atom went through the same chemical reactions (adsorption and dissolution) perhaps a thousand times during its travel down the ion-exchange column. In other words, we had a substantial statistical sample of its behavior.

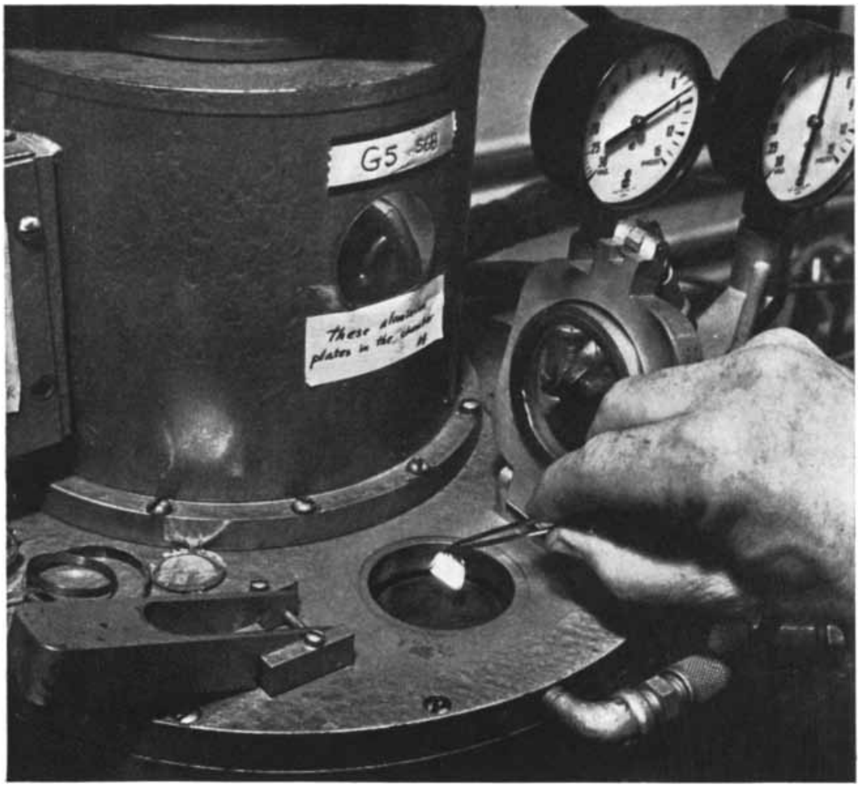
The definitive experiments that established the discovery of element 101 were performed in a memorable all-night session. The group bombarded three separate targets of einsteinium for three hours each, and then quickly separated the transmutation products by the ion-exchange method. In each case there was some einsteinium, californium and curium in the mixture in the column, so that it was possible to define the positions in which the elements came off the column. Measuring simultaneously with five counters, we detected five spontaneous fissions in the drops containing element 101 and eight in those in the position of element 100, but none in any other position [*see chart at bottom of page* 72].

By combining the results of all the experiments we deduced that the element 101 isotope has the mass number 256, that it decays by capturing an orbital electron with a half-life of the order of a half-hour, and that the decay product, the element 100 isotope designated as fermium 256, breaks down by spontaneous fission with a half-life of about three hours.

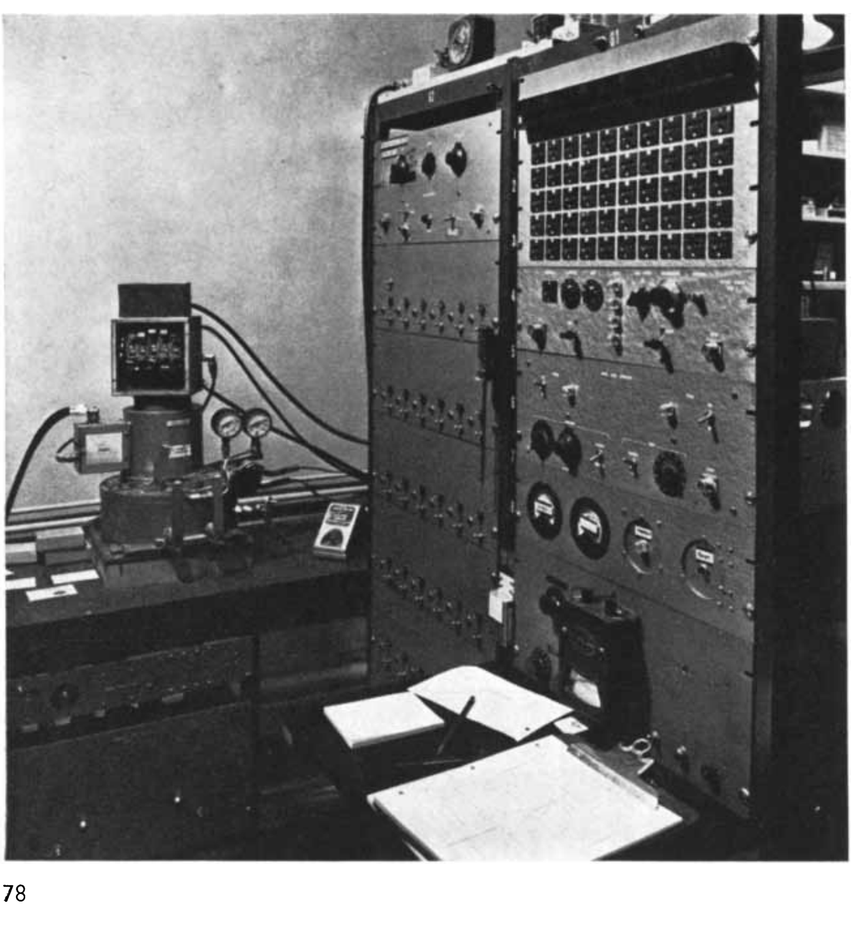
The group taking part in the discovery suggested that element 101 be named mendelevium, in recognition of the great Russian chemist Dmitri Mendeleyev, who was the first to use the periodic system of the elements to predict the chemical properties of undiscovered elements—a principle which has been the key to the discovery of the last seven transuranium elements.

With larger amounts of einsteinium in the target, it is now possible to produce more than 100 atoms of mendelevium at a time. The decay of mendelevium 256 to fermium 256 has been proved by chemical methods. There is an accumulation of evidence that mendelevium is a typical member of the actinide family, ionizing to the "tripositive" state (*i.e.*, a triple positive charge), and that it has the expected chemical kinship to thulium, its counterpart in the rare-earth family.

We would like to record here a tribute to one of the unsung members of our team, G. Bernard Rossi. His untimely death early in 1956 is a great loss to the Radiation Laboratory. He was chiefly responsible for the more or less continuous modification of the 60-inch cyclotron which has been necessary for the suc-



IONIZATION CHAMBER measures the energy of particles emitted by radioactive atoms. It does so by emitting a pulse of electric current, the strength of which is proportional to the energy of the particle. In the photograph at the top a sample disk of the kind shown on page 70 is inserted into the ionization chamber. The drop of solution on the surface of the disk has been dried. At the right in the photograph below is the instrument which analyzes the pulses emitted by the chamber. The chamber is at left in this photograph.



cessful completion of so many of our group's research efforts. For the mendelevium work he improved the operation of the 60-inch cyclotron so as to obtain a useful high-density beam. The successful experiments were due in large measure to his accomplishment of this task.

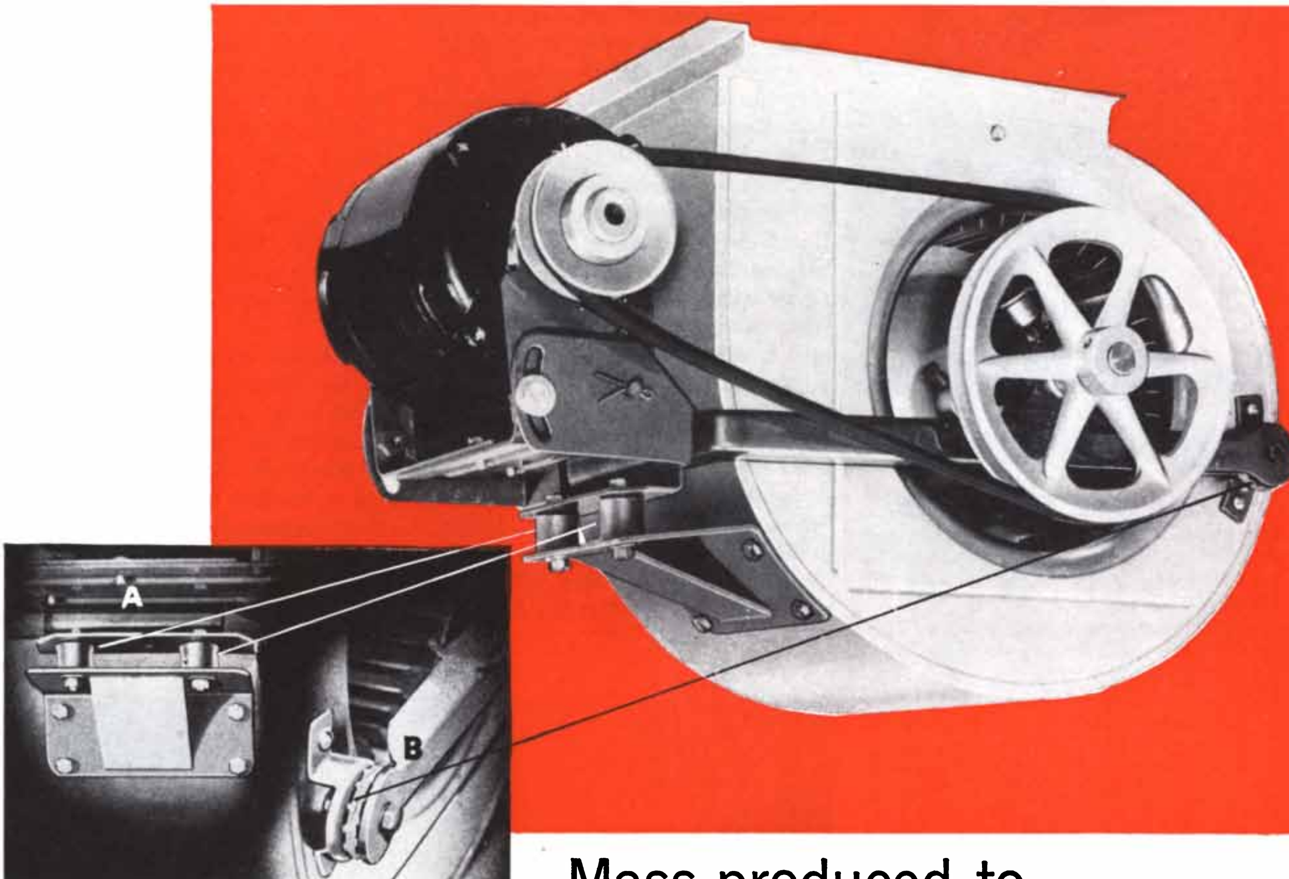
Beyond Mendelevium

In the 15 years since the discovery of the first transuranium element, about six dozen radioactive isotopes of new elements beyond uranium have been made by man. From this work nuclear scientists have learned so much about the radioactive decay of heavy elements that they can now generally predict the decay properties of new isotopes before their discovery. They have also learned that among the very heaviest elements, beginning with fermium, decay by spontaneous fission begins to become about as common as decay by emission of alpha particles. They have found that for both alpha and spontaneous fission decay, predictable regularities are most easily discernible in nuclei with an even number of protons and an even number of neutrons. Isotopes with an odd number of protons or an odd number of neutrons or an odd number of both have slower rates of decay than do those of the regular, even type.

With these considerations in mind, let us have a look at what the future may hold. Unfortunately the half-lives seem to become shorter and shorter with increasing atomic number. By the time elements 104 and 105 are reached, we shall probably find that the longest-lived isotopes that can be made will exist barely long enough to enable chemical identification to be made. It is likely that thereafter we shall have to rely entirely on predicted decay properties, rather than on chemical identification, for the discovery of any further elements. Careful measurements of these properties should allow us to extend the list up to about element 108.

How may these heavy elements be synthesized? The method of build-up by multiple neutron additions seems to hold little promise for making elements beyond fermium, because some of the necessary steps are too short-lived. For example, the isotope fermium 258 will probably have a half-life of only about one minute. It will not accumulate to sufficient concentration to continue the build-up sequence.

Fortunately there is a type of nuclear reaction that does seem to offer hope for the production of heavier elements. This is the method of bombardment with



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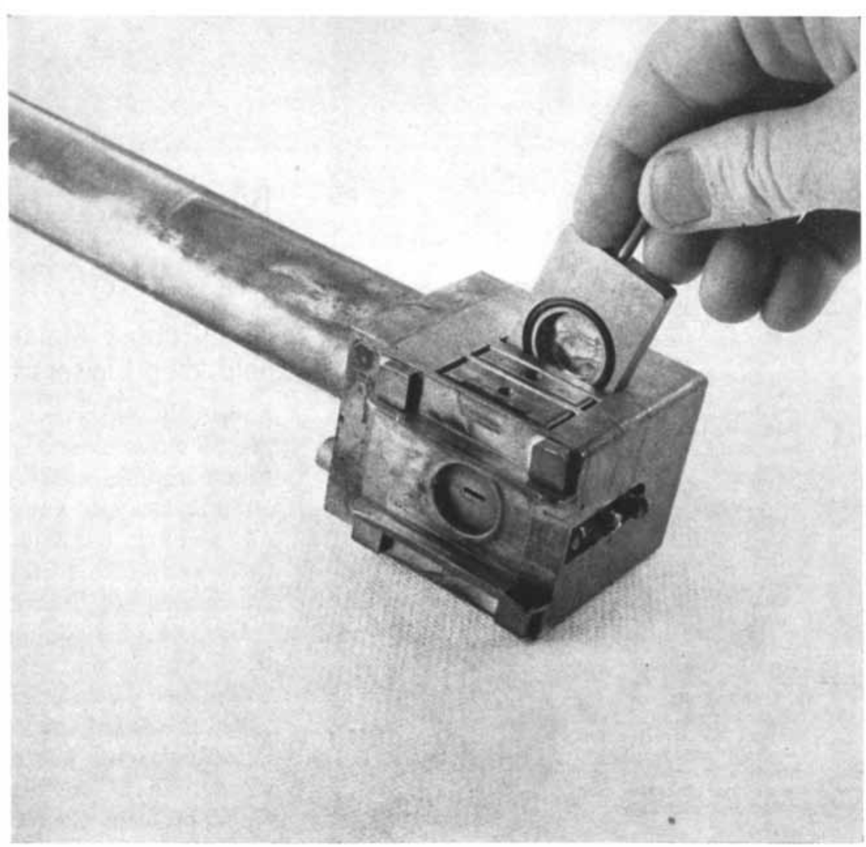
projectiles heavier than alpha particles, which are helium nuclei. For example, isotopes of californium, einsteinium and fermium have already been produced by bombardment of uranium with nuclei of carbon, nitrogen and oxygen, respectively. These nuclei can be accelerated in cyclotrons of the conventional type, and the University of California and Yale University are building linear accelerators which will be devoted exclusively to the acceleration of heavy ions to energies sufficient to allow them to transmute the heaviest elements. The two machines are designed to produce rather substantial beams of all the nuclei up to neon, and possibly will be able to give usable beams of nuclei as heavy as argon.

The prediction of the chemical properties of the undiscovered elements beyond mendelevium seems to be quite straightforward. Elements 102 and 103, corresponding to ytterbium and lutetium in the rare-earth series, should complete the actinide group. This will involve filling what is known as the 5f shell of electrons, which, like the last shell (4f) of the rare-earth group, has 14 places. It is expected that element 104 will begin a new series, whose members will correspond to hafnium, tantalum, tungsten and so on, as the periodic table shown here indicates [*see page 69*]. This series would end with the filling of the 6d electronic shell. The next series, assuming that heavier elements could be found (which, as we have noted, is very doubtful), would have a 7p shell and would close with hypothetical element 118. The chemical properties of all of these elements can be estimated from their postulated positions in the periodic table.

Thus the current chapter in the story of the synthetic elements has not yet come to its end. It is the hope of the authors that this article will already be out of date by the time many of our readers see it, because of the discovery of elements beyond mendelevium. The exciting field of modern alchemy is proceeding at such a pace that this possibility does not seem at all unlikely.



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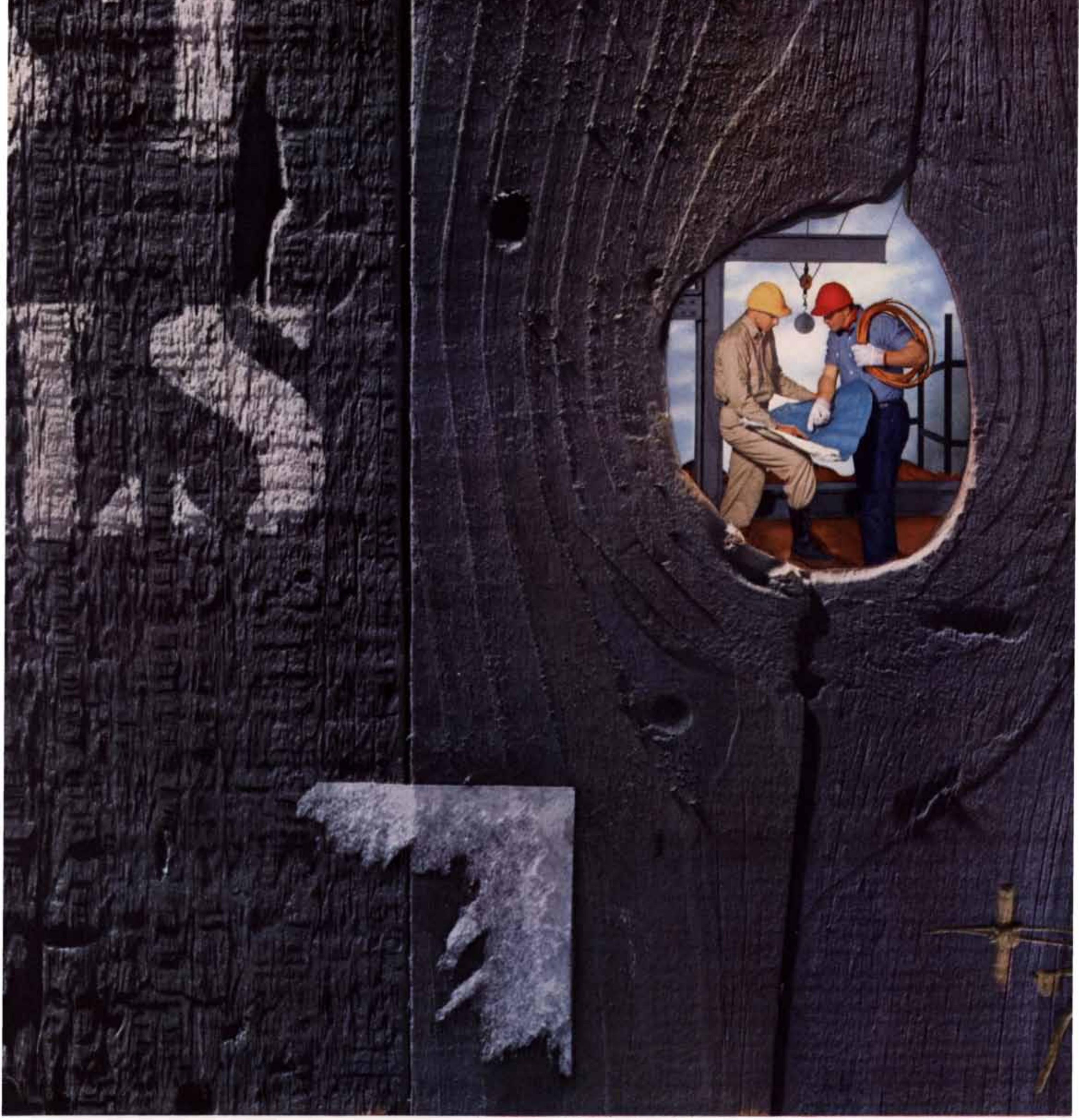

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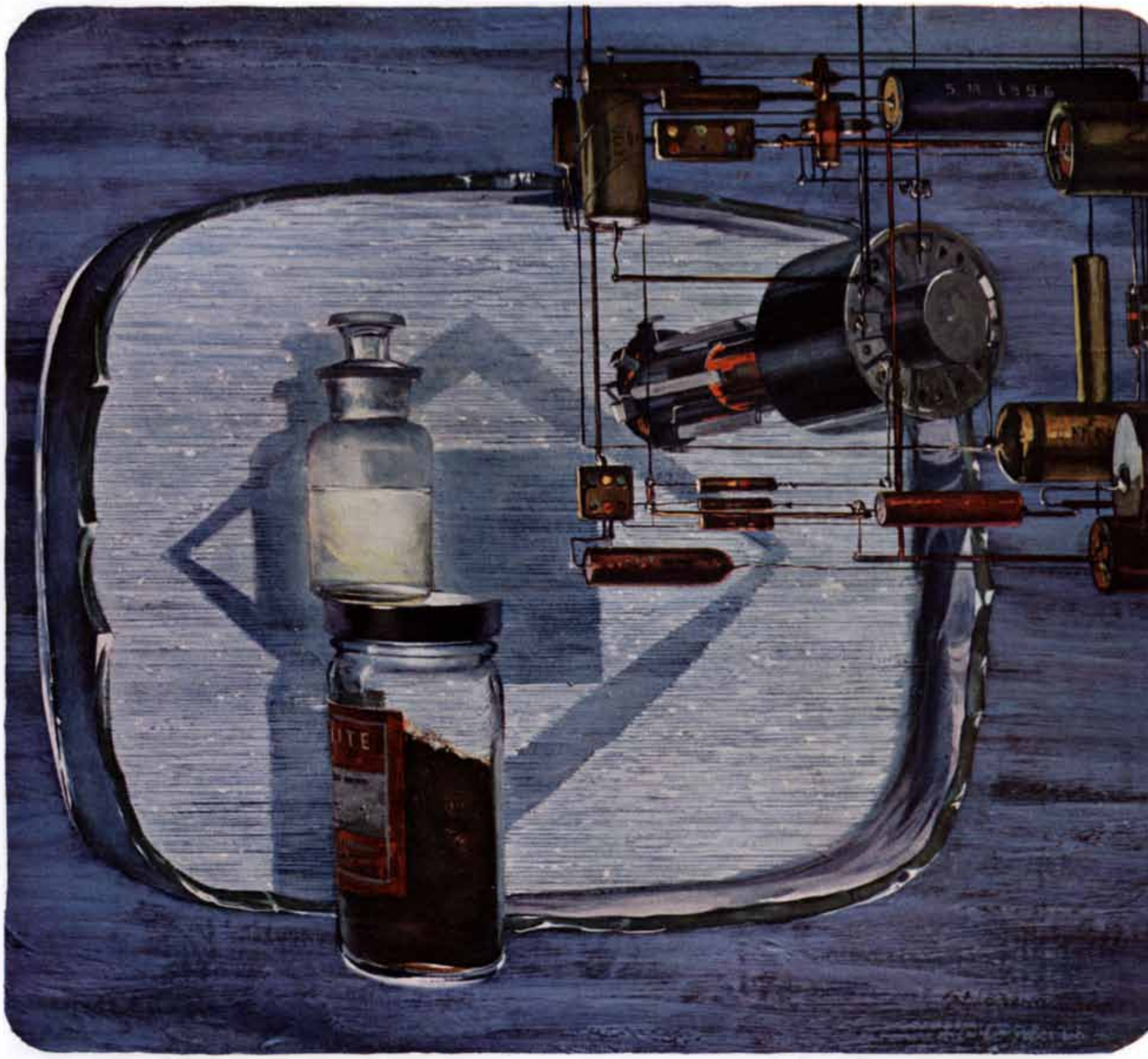

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The Lamont Geological Observatory

At a handsome estate on a cliff beside the Hudson River Columbia University scientists study the Earth. Their special concern is the three fourths of the Earth's crust that lies beneath the sea

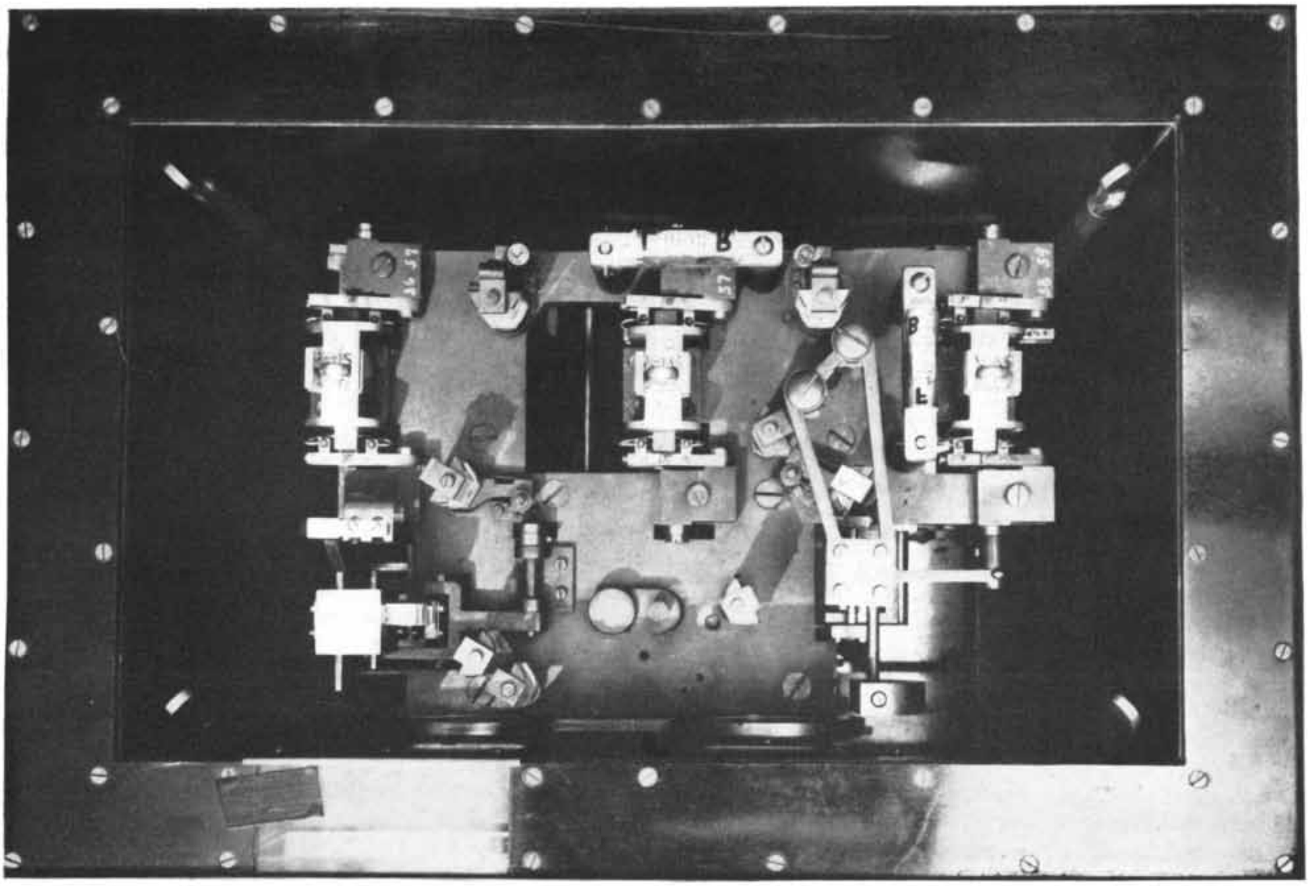
by George W. Gray

One summer day more than a century ago the professor of chemistry and botany at the College of Physicians and Surgeons in New York City discovered a paradise of plant life atop a rocky cliff above Sneden's Landing on the west shore of the Hudson River. John Torrey was so captivated by the unspoiled beauty of the spot, and by the view it gave of the Hudson, that he bought a few acres and built himself a summer home near the edge of the cliff.

Torrey's career included not only teaching in medical school but also service as the chief assayer of the U. S. Mint in New York, but the dominating interest of his life was the world of plants, and he became the leader of American botanists. He accumulated a herbarium of many thousands of specimens which he presented in 1860 to Columbia University, along with his botanical library. He never dreamed that his Palisades cliff would also become a part of the University one day.

After the professor's death in 1873 the property changed hands several times. In 1928 the financier Thomas W. Lamont acquired Torrey Cliff and adjacent tracts and built an estate of more than

Stone residence of Thomas W. Lamont now houses geophysical and geochemical laboratories of the Observatory.



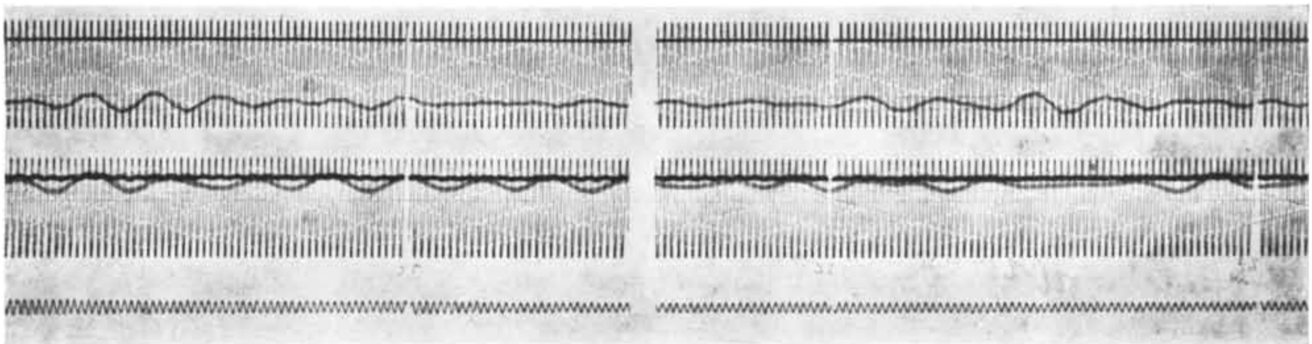
Pendulum apparatus, here seen from above, measures tiny variations in the gravity of the Earth

100 acres. By then Torrey's cottage had disappeared, having been wrecked by lightning, but Lamont found the overgrown remains of the botanist's garden and restored it.

Today a handsome modern house stands on the site of Professor Torrey's cottage. It is the director's house of a world-famous geological observatory. For after Lamont's death in 1948, his widow presented the property to Columbia, and the University turned it over to its department of geology. Lamont's palatial country estate was transformed into a center of research in the earth sciences. A battery of seismographs was set up in an underground vault built on a ridge of rock; laboratories of geophysics and geochemistry were installed in the big stone residence; the greenhouses were converted into an instrument shop; the big recreation building with its indoor swimming pool was adapted for laboratory use; the garages were turned into storage houses for sea-bottom samples taken on ocean expeditions. A year and a half ago a new $100,000 building was erected to house a geochemistry laboratory. To its laboratory facilities on Torrey Cliff the Lamont Geological Observatory has added a three-masted schooner, the *Vema*, as an oceanographic research ship, and a branch station on St. David's Island in the Bermudas.

The director of the Observatory is Maurice Ewing, a former teacher of physics who became keenly interested in oceanography and during World War II worked on underwater acoustics for the Navy at the Woods Hole Oceanographic Institution. Columbia asked Ewing in 1943 to head up a new program in geophysics at the University, and Ewing took up his post when the war ended, bringing a group of his students at Lehigh University as the nucleus of his staff.

"My assignment," Ewing explains, "was to establish at Columbia a center of instruction and research in which every branch of geophysics would be



Traces in this picture record the motions of six pendulums in the apparatus. Straight trace near top records temperature pursued at the highest level of authority. It was recognized from the first day we talked about it that such a program, requiring seismographs and other sensitive instruments, could not come to maturity on the Morningside Heights campus because of the vibrations and other interferences inseparable from a city. So from the start we were looking for a sheltered place where this work could grow up. Mrs. Lamont's offer of the Torrey Cliff estate was most opportune."

Since three fourths of the Earth is covered by water, it was recognized that a most promising road to knowledge of the physical structure of the globe was via the sea. Oceanography therefore assumed the central place in the program, and most of the activities during the seven years of the Observatory have had to do with the problem of determining the nature and structure of the ocean basin.

"It is a problem that was called to my attention more than 20 years ago, when I was serving as physics instructor at Lehigh," Ewing relates. "I was deeply interested in geophysical prospecting—a holdover from my student days in Texas, where I had spent several summer vacations with oil-company field teams. At Lehigh we made some seismological observations of quarry blasting in the nearby Pennsylvania cement district and occasionally published a paper on these studies. The observations caught the attention of two distinguished scientists—Richard M. Field, professor of geology at Princeton, and William Bowie, chief geodesist of the U. S. Coast and Geodetic Survey. In 1934 they asked whether I would be interested in extending my seismographic measurements to the continental shelf of North America in the Atlantic. Little was known of the geological structure of this area of transition from continent to ocean. If I could get seismic readings of it comparable to those I had been getting on land, the information might provide an approach to the fundamental question: Why are some parts of the Earth's surface continent and other parts ocean?"

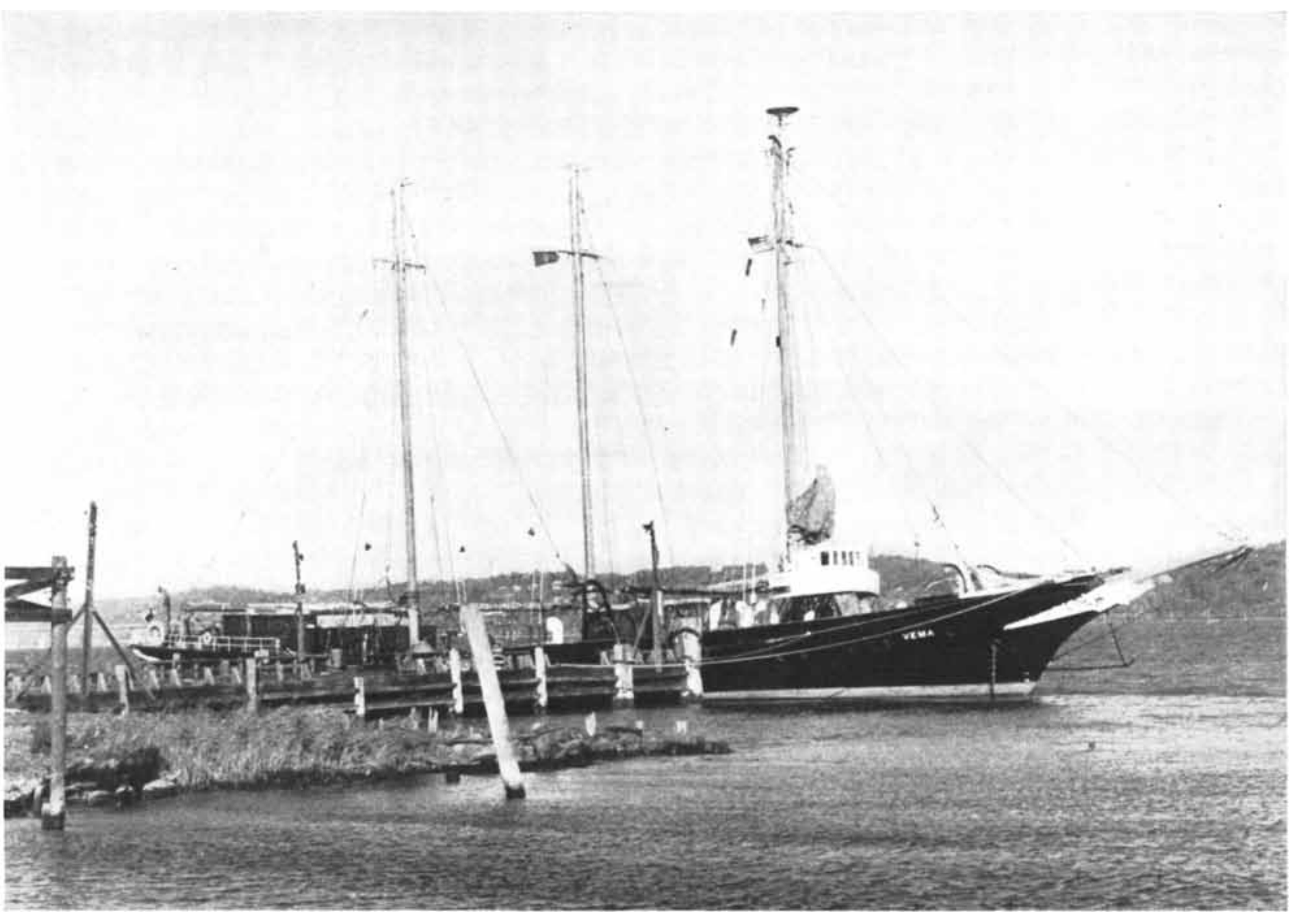
The proposal was exciting. Ewing was still in his twenties and "so desperate for a chance to do research that if they had said the Moon instead of the ocean, I'd have tackled it." He applied to the Geological Society of America for a $2,000 grant to finance the study, and set forth with two associates, A. P. Crary and H. M. Rutherford. Using a portable seismograph, they ran a line of measurements across the coastal plain of Virginia from Petersburg to Cape Henry. At Cape Henry they took to the sea, hitching a ride on the Coast and Geodetic Survey vessel *Oceanographer* and working eastward some 75 miles for a reconnaissance. Later they retraced this route on the *Atlantis*, the research ship of the Woods Hole Oceanographic Institution, and completed the survey. A seismograph was lowered to the ocean bottom from the ship, and the three young men, pushing off in a whaleboat, dropped charges of blasting gelatin to the bottom at intervals of a few miles. When a charge was fired, the seismograph picked up waves refracted and reflected by layers in the Earth beneath the sea bottom, and the time of the waves' travel gave clues to the density and thickness of the layers.

"When we delivered the results of our summer's work to Professor Field and Dr. Bowie," says Ewing, "they suggested: 'Now go on and extend these measurements to the deep ocean.' My chief efforts from that day to this have been devoted to the problem these two great men propounded."

The Lamont Geological Observatory uses many techniques in its ocean explorations: seismographs, echo sounders, coring devices, undersea cameras, special buckets to take samples of water at various depths, meters to clock the speed of ocean currents, thermocouples to record temperatures, instruments to determine differences in salinity and magnetometers to plot terrestrial magnetism. J. Laurence Kulp, chief of the Observatory's geochemical laboratory, is employing the carbon 14 dating method to determine how long the bottom water at great depths has been out of contact with the atmosphere; his age measurements indicate that it takes from 300 to 500 years for the slow undersea circulation to replenish the bottom water of the Atlantic with a fresh supply from the surface.

The coring device is a convenient tool for punching vertically into the ocean floor and bringing up a section of the accumulated sediment. It is a sharp-edged steel tube, two and a half inches in diameter and up to 70 feet in length. When the corer has been lowered to within 15 feet of the sea bottom, a trigger trips the holding mechanism and the falling tube is driven by a weight into the sediment. Cores 60 feet long have been brought up, representing the successive deposits of hundreds of thousands of years. The Observatory's collection of cores, ranging from 20 to 60 feet in length, now numbers 1,195. Two of them were taken in the deepest part of the Atlantic—in the bottom of the Puerto Rico Trench at a depth of about 28,000 feet below the ocean surface.

"We are steadily increasing the length of our core samples," says Ewing. "The seismological data indicate that the thickness of the sedimentary layer on most of the ocean floor is only about 2,000 feet, and they also show that this sediment is unconsolidated—no firmer than a fine clay. We have every reason to believe that in that 2,000 feet of unconsolidated sediment the whole history of the Earth is better preserved than it is in the continental rocks, which have been subjected to heat, folding and mineral changes. As we punch deeper into the ocean sediments, we may reach levels holding traces of the first animals that concentrated calcium carbonate, then evidence of atmospheric oxygen from the earliest green plants, and ultimately the primeval sediment of the ear-

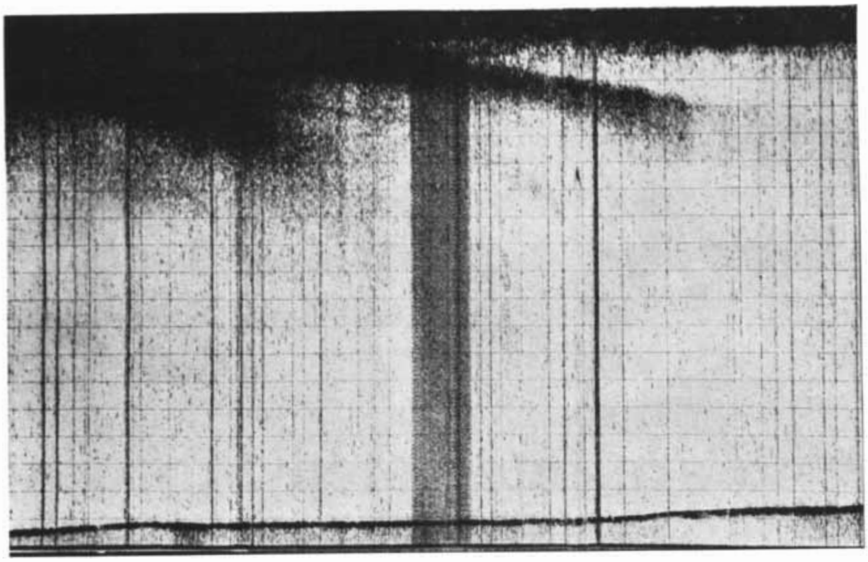


Columbia's research vessel is the "Vema," a 202-foot schooner. It accommodates a crew of 16 and a scientific staff of 13 liest erosion, marking the advent of water in the sea. The entire record of terrestrial conditions from the beginning of the ocean is there in the most undisturbed form it is possible to find anywhere—and the dream of my life is to punch that hole 2,000 feet deep and bring the contents back to the lab and study them."

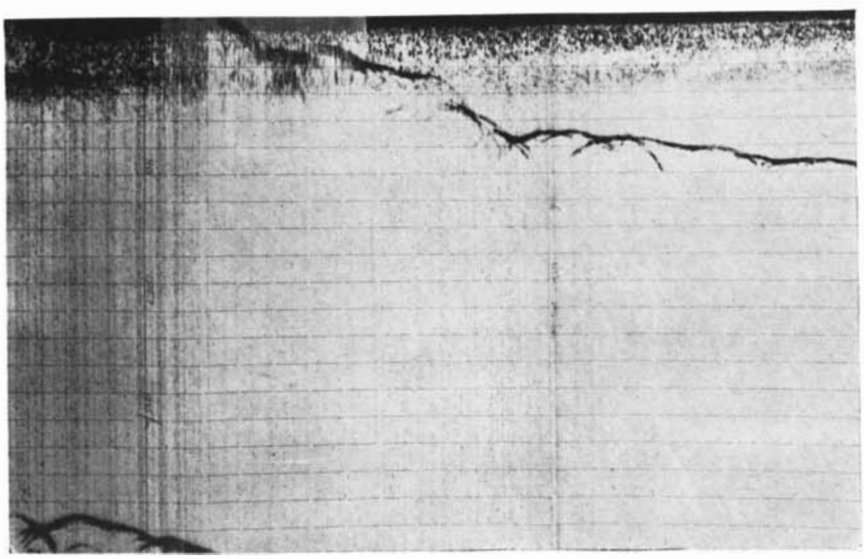
Another tool of the survey is a pendulum apparatus which measures variations in the force of gravity and thereby provides data for determining the shape of the Earth. The undersea form of this instrument was invented in 1922 by the Dutch geodesist F. A. Vening Meinesz. It is taken down in a submarine, and the U. S. Navy has cooperated in the Lamont Observatory's research by making berths available on submarine cruises and providing funds. Geodesists calculating the shape of the Earth now have available some 3,969 measurements of gravity taken over ocean floors, of which 2,572 were made by the Lamont group, 942 by Vening Meinesz and 455 by other investigators. The gravity determinations are useful also in exploring density differences in the underlying strata. The pendulum apparatus and the seismographs thus complement each other, and together they have clarified the scientists' picture of the rock that underlies the ocean floor and have shown that it is strikingly different from the basement of the continents.

The technique of seismic explorations at sea today is far more sensitive than when Ewing and his colleagues began their pioneering work 20 years ago. It is no longer necessary to fire the charge on the ocean floor; the bomb is simply thrown overboard with a fuse set to explode it at a designated depth. The detecting devices are hydrophones suspended a few hundred feet from the "listening ship." The water is regarded as the top layer of the section to be investigated, the sediment as the second layer, the rock of the Earth crust as the third, and so on. Each layer, according to its density and hardness, refracts the shock waves at a different angle and transmits them at a different speed.

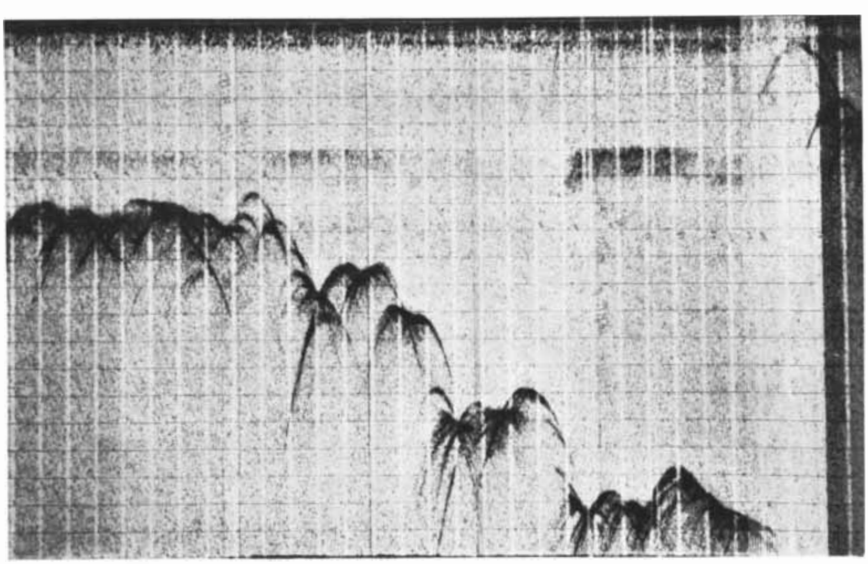
"Our object, when we began to shoot the deep ocean, was simply to measure the thickness of the sediment," explains Ewing. "Some authorities estimated that this sedimentary layer might be 12 miles thick, and from that extreme the guesses ranged down to as little as 500 feet. But nobody knew, and in designing our technique we had to plan for the possibility of having to get through miles of deposits. It was a pleasant surprise when



Sonic depth recorder draws a trace (bottom) *of the abyssal plain near the Canary Islands*



This trace shows the rise of the continental slope near the Canaries



This trace shows rugged contours of the continental slope in the eastern Mediterranean

the refracted waves showed that the sedimentary layer was only 1,500 to 3,000 feet in thickness.

"We found that by shooting from a ship 50 to 60 miles from the receiving ship, we could measure the thickness of the first layer of rock beneath the sediment. This turned out to be basalt, not granite as in the continents. The seismic waves went through the basalt into the rock below, so that we were able to measure the successive strata of the ocean floor down into the massive mantle which surrounds the molten metal core of the earth."

The measurements made on the *Vema* are checked by continuous recordings of Earth tremors at the Observatory itself. A battery of 20 seismographs buried in the vault on Torrey Cliff makes a record of natural Earth vibrations. Each seismograph is attuned to a certain band of frequencies in the earthquake spectrum, which ranges from the tiny microseisms generated by storms at sea to the gigantic waves of major earthquakes. The waves produced by the Kamchatka earthquake of November, 1952, had a frequency of one every 400 seconds and measured 1,200 miles from crest to crest. It took only 20 of them to encircle the globe. Newly designed seismographs on Torrey Cliff recorded motions from this earthquake for an incredible 24 hours, as the Earth rang like a bell from the shock.

The seismographs designed to receive high-frequency waves are amazingly sensitive. They pick up the Earth reverberations from trucks passing over a highway 1,500 feet from the vault, and the rhythmic throb from an old-fashioned steam engine two miles away. The seismograph attuned to that particular frequency has to be operated at only a tenth of its sensitivity to screen out the engine tremors.

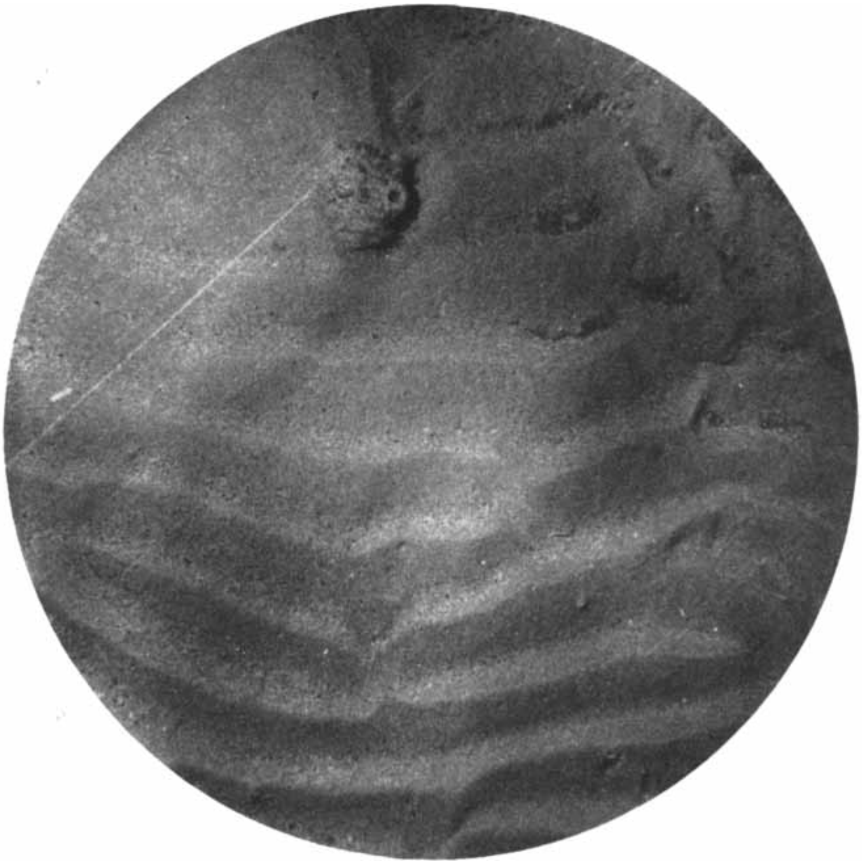
"Surface waves from distant earthquakes bring to our Observatory seismographs reports from all the ocean basins in the world as well as from all the continents," says Ewing. "Thus they have enabled us to determine whether the structure we found in the Atlantic floor with shots from the *Vema* is characteristic of all the ocean floors. The seismographic findings made with our research ship have been confirmed by the seismographic readings recorded on Torrey Cliff, and these have been supported by the results of our gravity studies, which are under the direction of J. Lamar Worzel."

From these three methods of inquiry a consistent picture has emerged. It portrays the rocky floor of the ocean basins as remarkably uniform throughout. All of them are paved with a layer of basalt about two and a half miles thick. It seems reasonable to assume that this layer is primordial rock, perhaps the first of the Earth's stuff to solidify. The base of the continents, in contrast, is about 20 miles thick and consists of granite, a lighter material than basalt.

"Some geophysicists believe that a thin strip of basalt may underlie the granite masses of the continents," Ewing observes. "We have no conclusive evidence of this; our studies have been focused on oceans rather than continents, and they point to the conclusion that the ocean floors are built exclusively of basalt. Granite seems to be a younger rock, and geologists have to account for its sporadic occurrence on the face of the planet in the great heaps that we call the continents. One hypothesis regards granite as a material fashioned in the mantle of the Earth, cooked by its heat and pressure and spewed up like lava. There is some evidence that this process is going on now in the deep trenches off the coasts of island arcs such as the Philippines, the West Indies and the Aleutians. In these trenches heavy deposits of sediment are accumulating and sinking into the hotter layer below. It is believed that after the mixture has been sufficiently cooked and consolidated, the refashioned material will eventually be thrust up by the internal forces of heat and pressure to emerge as granitic additions to the continents.

"But there is another possibility. You may remember that some of our schoolbooks used to teach that the Moon was a blob of material which had been thrown off from the Earth, leaving a depression which is now the Pacific basin. Since that idea was proposed, many learned papers have been written, and a formidable array of mathematics has been marshaled, to prove that the laws of physics forbid such an event. Indeed, the same mathematical reasoning makes it conceivable that the opposite might have taken place: that the continents may have fallen into the Earth from space. On this rather wild hypothesis—and so far as I know it exists only in the minds of a few people on the staff of the Lamont Observatory—the great masses of granitic rock which we know as the continents might be foreign material that was added to the Earth after its crust formed.

"Whatever the origin of granite may turn out to be, there is little question in my mind that as a terrestrial ingredient it is younger than basalt. By the same



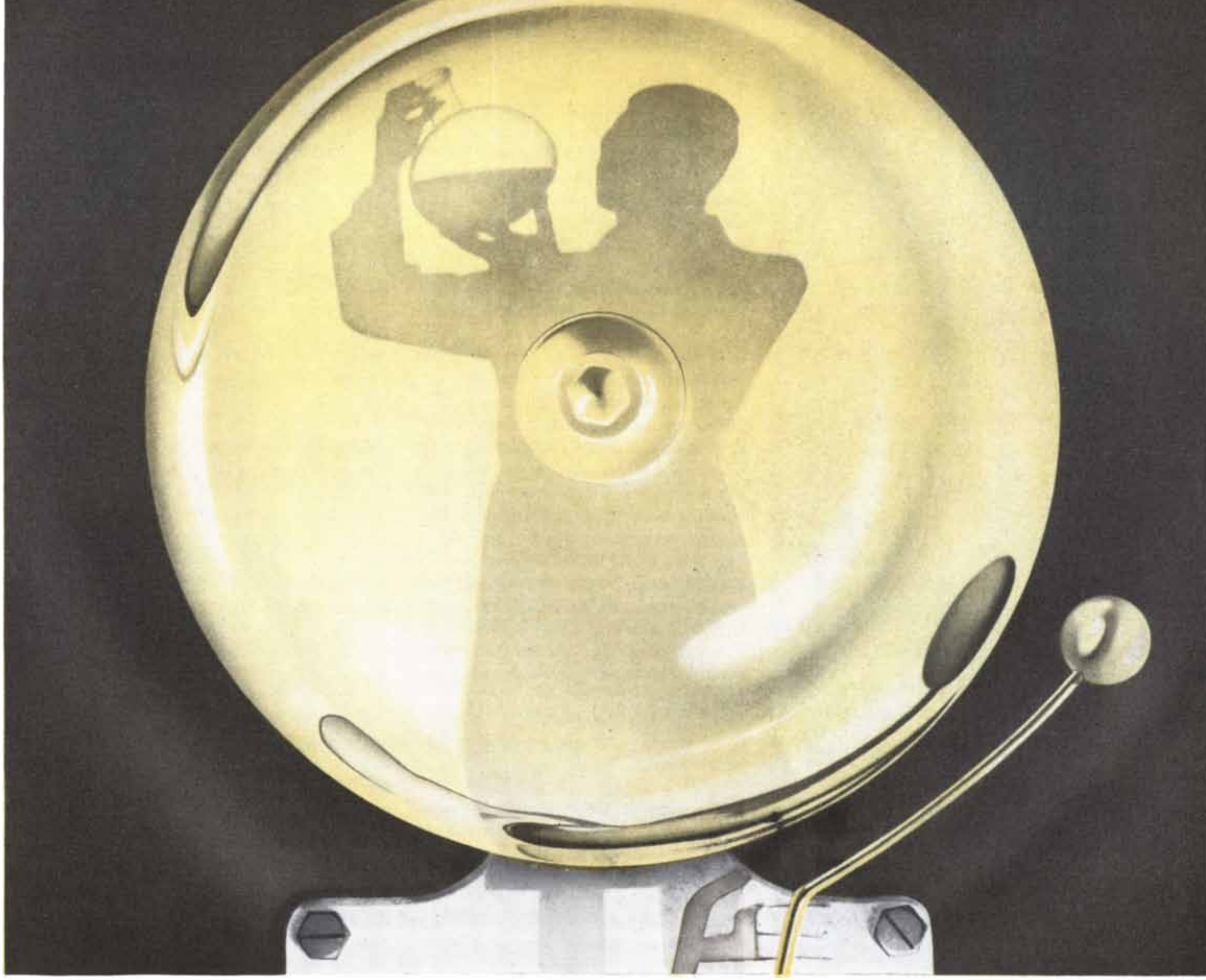
Photograph made at 900 fathoms shows ripples in the sand of Plato Seamount

Photograph made at 600 fathoms shows rocky bottom on Plato Seamount

token the continents are younger than the ocean basins. Moreover, it appears likely that all the ocean basins are of the same age and represent the original crust of the solidified Earth."

In the distribution of sediment over the ocean floor a critical role is played by undersea turbidity currents. Ewing first became aware of their effects in 1946, when, during an expedition in the North Atlantic, he was impressed by the flatness of large areas of the sea bottom. The investigation of these abyssal plains —found in all oceans—became a major interest of the Lamont Observatory, and Ewing's chief collaborators in the study have been David B. Ericson and Bruce C. Heezen. The story of how their examination of cores and of the history of breaks in submarine cables led to the conclusion that the plains and channels in the ocean bottom must have been formed by flows of sand and soil from the continental shores over the sea floor has been told in a recent article in this magazine [see "The Origin of Submarine Canyons," by Bruce C. Heezen; SCIENTIFIC AMERICAN, August]. The Lamont group is now in process of mapping the plains of the North Atlantic and is finding it possible to trace through their strata some of the sequence of world climate. "The greatest activity in turbidity currents," says Ewing, "apparently took place in the time of the last glaciation, which ended about 11,000 years ago. We are finding possible relationships between these great torrential movements of suspended sediment and the conditions that govern life on the ocean floor."

In 1954 the Lamont Observatory added biological research to its program and began to study the life of the ocean floor. Ewing was interested in how life is sustained at various levels in the sea by the organic material that continually rains to the bottom and possibly is raised again by upwelling currents. To direct this study the Lamont Observatory called Robert J. Menzies, an expert in deep-sea ecology, from the Scripps Institution of Oceanography. The former recreation building of the Lamont estate has been converted into a biological laboratory, and here deep-sea hauls made by the *Vema* are brought for sorting and analysis. The cores taken from the abyssal plains are being examined for shells and other animal remains. The biologists are searching through the Observatory's collection of more than 3,000 deep-sea photographs, and again and again they have been rewarded by a picture of some sea-floor animal which by good luck hap-



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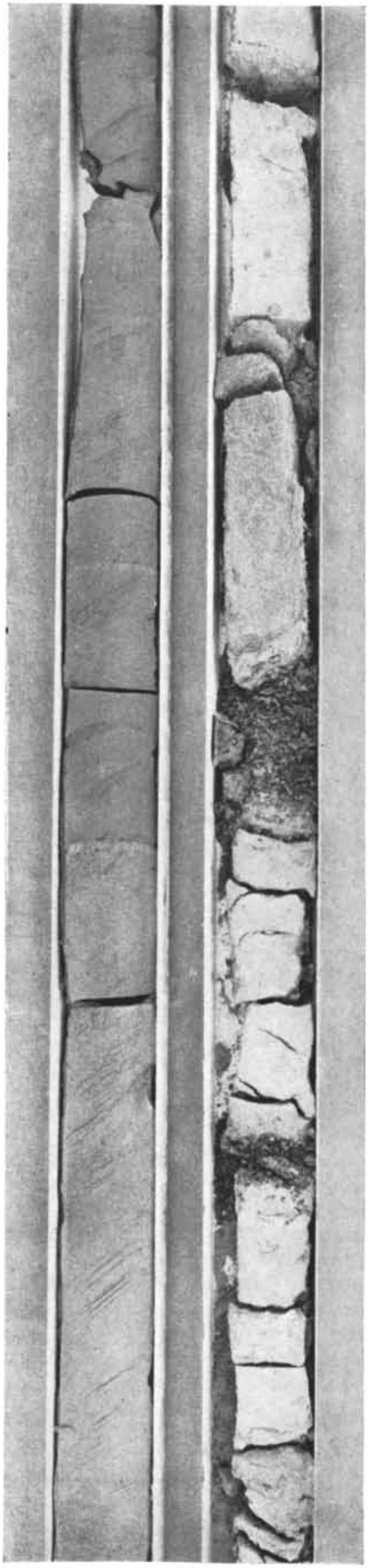

Deep-sea cores are cut in cross section

pened to be in the field of the camera when the light was flashed.

From a depth of 16,200 feet in the Puerto Rico Trench the *Vema* last November brought up a haul which contained many animals, including seven species of small isopod crustaceans. The strange thing was that the haul did not contain a single member of the isopod species found elsewhere in the North Atlantic at great depths. This suggests that climate is not necessarily a critical factor in the production of new species.

Menzies, Ewing and Heezen have concluded that turbidity currents may have both destructive and constructive effects upon life on the sea floor. A sudden avalanche of sediment may quickly overwhelm all life over many thousands of square miles. On the other hand, such currents may bring great quantities of nutritious organic matter to the abyss. "We have found in our deep-sea cores," says Menzies, "many instances of layered deposits of leaves and other entrapped nutrients. There is some evidence that certain species of bottom dwellers, known as echinoids, are selective feeders, and they may depend entirely on food originating in shallow water which is brought to them by turbidity currents."

The Lamont Observatory's chemical research, under the direction of Kulp, has been concerned primarily with dating and tracing the chemical evolution of material by analysis of isotopes. "For geochemists," says Kulp, "the isotope techniques are as revolutionary as the invention of the seismograph was for geophysicists. A whole new world is opening up, thanks to these variations of the chemical elements and what their ratios and rates of decay have to tell us of the age and past history of the rocks, lava and ores, the sediments and waters of the sea, the ice of the glaciers, and even the air that surrounds us."

By measurements of radioactive carbon 14 Kulp and his colleagues have been able to date the successive layers of sediment, the end of the last ice age (11,000 ± 100 years ago), the age of ocean-bottom water, and various specimens found on land—such as peat, charcoal, fossil wood, fragments of dried tissue from an ancient Alaskan superbison, a carved Mayan lintel from Guatemala. Their dating work has not been confined to radiocarbon: to go farther back into geological time (radiocarbon decays to a practically infinitesimal fraction in 50,000 years) they have studied radioactive uranium, actinium, thorium and potassium, which have half-lives ranging up to a billion years. Recently Kulp and his team of young geochemists looked into the question of the age of Manhattan schist (the bedrock under the City of New York) which has long been a matter of controversy among geologists. Many have argued that this rock is pre-Cambrian, up to 1,700 million years old. But Walter H. Bucher of the Columbia geology faculty has stoutly maintained that it is much younger. Kulp and his group found it possible to measure the ratio of potassium to argon (its decay product) in the rock, and their findings confirm Bucher's view: they estimate Manhattan schist to be some 380 million years old.

The oldest dated rocks in the Western Hemisphere are in the Canadian Shield. Petrologists using the uranium-lead clock have counted the age of rocks taken in eastern Manitoba as 2,600 million years. Kulp is confident that parts of the exposed Shield are older than that, and an expedition from Lamont went to various areas of eastern Manitoba last summer to collect rocks for dating in the Torrey Cliff laboratory. These samples are now being analyzed.

Isotopes are used not only for dating but as tags or labels for tracing the history of a substance back to its origin. Sulfur is extremely useful for this sort of genealogical research. Sulfur occurs in two forms—the common isotope with an atomic weight of 32 and a rarer isotope weighing 34. Neither is radioactive, so they can be identified only by their difference in weight. By measuring the ratio of sulfur 34 to sulfur 32 in metal ores, it is possible to learn something of the history of the deposits. In the case of the famous lead deposits in the Mississippi Valley, for example, the sulfur clue has given good evidence that the ores were formed in the crust of the Earth.

Variations in sulfur isotopes have also solved a long-standing mystery of the mineralogy of the oil fields in Louisiana and Texas. A peculiar feature of this area is the presence of immense, round-topped domes of salt thrust upward through the rock strata, with vast deposits of sulfur encircling the domes. For more than half a century geologists have debated the origin of these immense accumulations of sulfur. Kulp and Herbert W. Feely, following the trail of sulfur isotopes in the deposits, recently unraveled a complicated sequence of chemical processes which explains the phenomenon. The columns thrust upward in the rock originally contain a mixture of salt and calcium sulfate. Water gradually dissolves salt from the surfaces of the column, leaving the insoluble cal-

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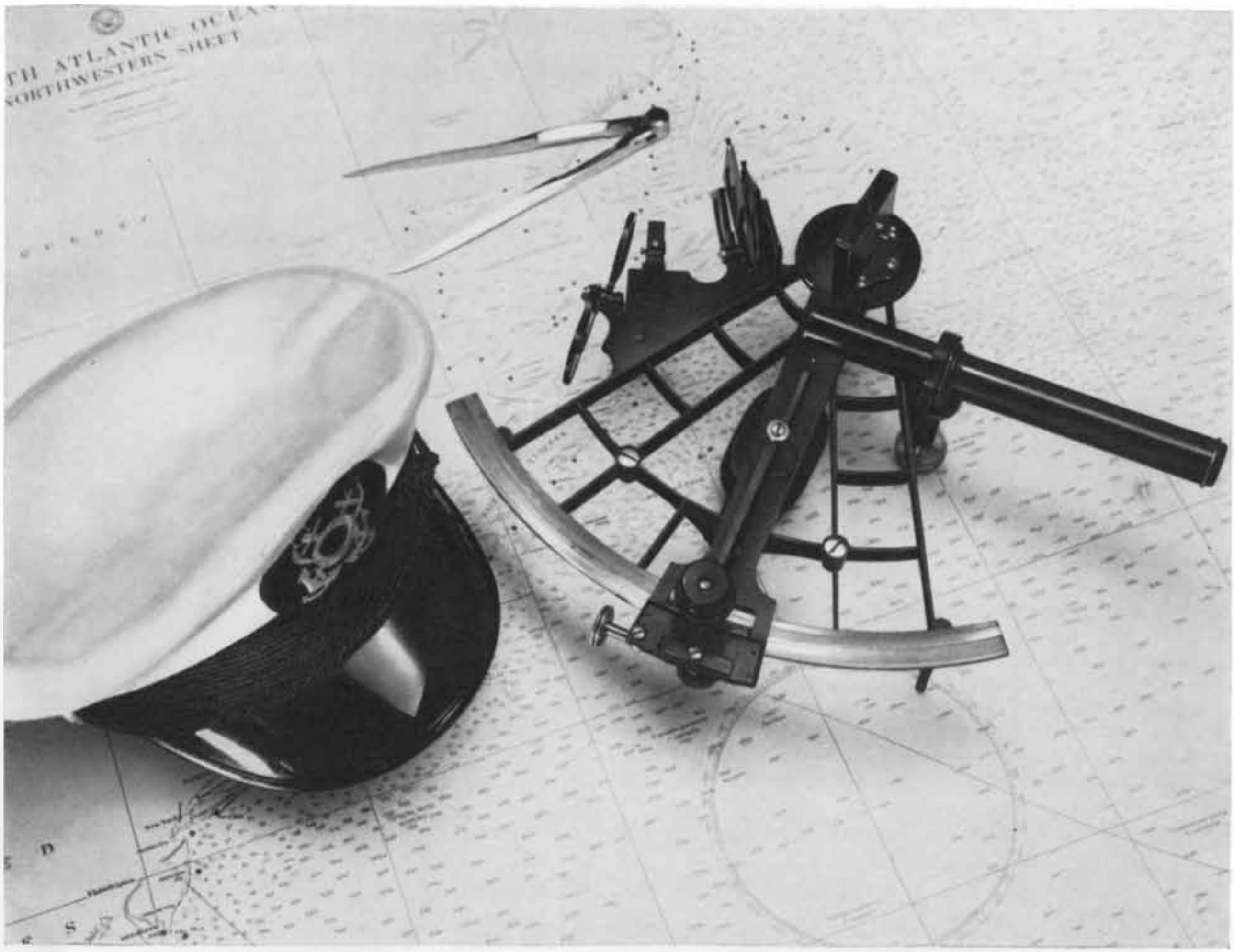
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY* cium sulfate behind. At the same time petroleum in the rocks migrates up the sides of the column and gathers in pools. Bacteria feeding on the petroleum reduce the calcium sulfate to hydrogen sulfide by a series of processes, and then finally remove the hydrogen. Thus uncombined sulfur accumulates in deposits around the salt domes.

The origin of petroleum is as challenging a question as the origin of the salt-dome sulfur beds, and has been a subject of controversy ever since we entered the oil age. Most authorities agree that organic debris deposited in the sea is the original raw material. The generally accepted hypothesis has been that this material is converted to petroleum only after it has lain for millions of years under the enormous pressure of accumulating sediments. But a few years ago Paul V. Smith, Jr., of the Esso Research Center in New Jersey found petroleum hydrocarbons in mud a few inches deep on the floor of the Gulf of Mexico off the Louisiana coast. How account for the presence of petroleum molecules so near the surface? One hypothesis suggested that they might have seeped up through the sediments from subsea oil deposits. To test this idea Smith sent his hydrocarbons to the Lamont geochemical laboratory for dating by the radiocarbon method. He could supply only minute quantities, for they were found in the mud in extreme dilution, and the geochemists had to devise special refinements to work with such amounts. Kulp and his associates were able to date some of the samples, and all turned out to be only 12,000 years old. This is a far cry from "millions," and leads to the conclusion that molecules of petroleum begin to form soon after the organic sediments reach the sea floor, although millions of years may be required to accumulate a vast pool such as that in East Texas.

The Lamont Observatory is concerned with various other matters, such as the geochemistry of trace elements (*e.g.*, strontium, chromium, nickel, copper) and the occurrence of tritium (radioactive hydrogen) in the waters of the Earth, including rains and glacial ice.

"Each of our programs—the geophysical, the geochemical and the biological—necessarily has problems of a specialized nature," says Ewing, "and some of the projects may seem to be isolated studies. But in the long run they fit into a broad pattern and all lead by different trails to the grand problem—which is the structure, composition, limiting conditions and history of the planet that is our home in the universe."



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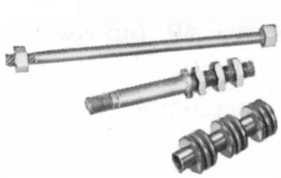

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even light. One of the wafer-thin panels is held by E. G. F. Arnott, Director of Research for the Westinghouse Lamp Division. Panels on display board show the range of colors possible.

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The future holds great promise. Incandescent and fluorescent lighting already have been developed to such a high degree that further radical improvement is unlikely. But electroluminescence opens a whole new field in lighting. Fortune Magazine has reported that Westinghouse is way out in front in research in this new field of electroluminescence.

This new source of light is typical of the steady flow of discoveries and product improvements coming from some 200 Westinghouse laboratories spread across the country. In light research, as in a hundred other fields, you can be sure . . . if it's Westinghouse.

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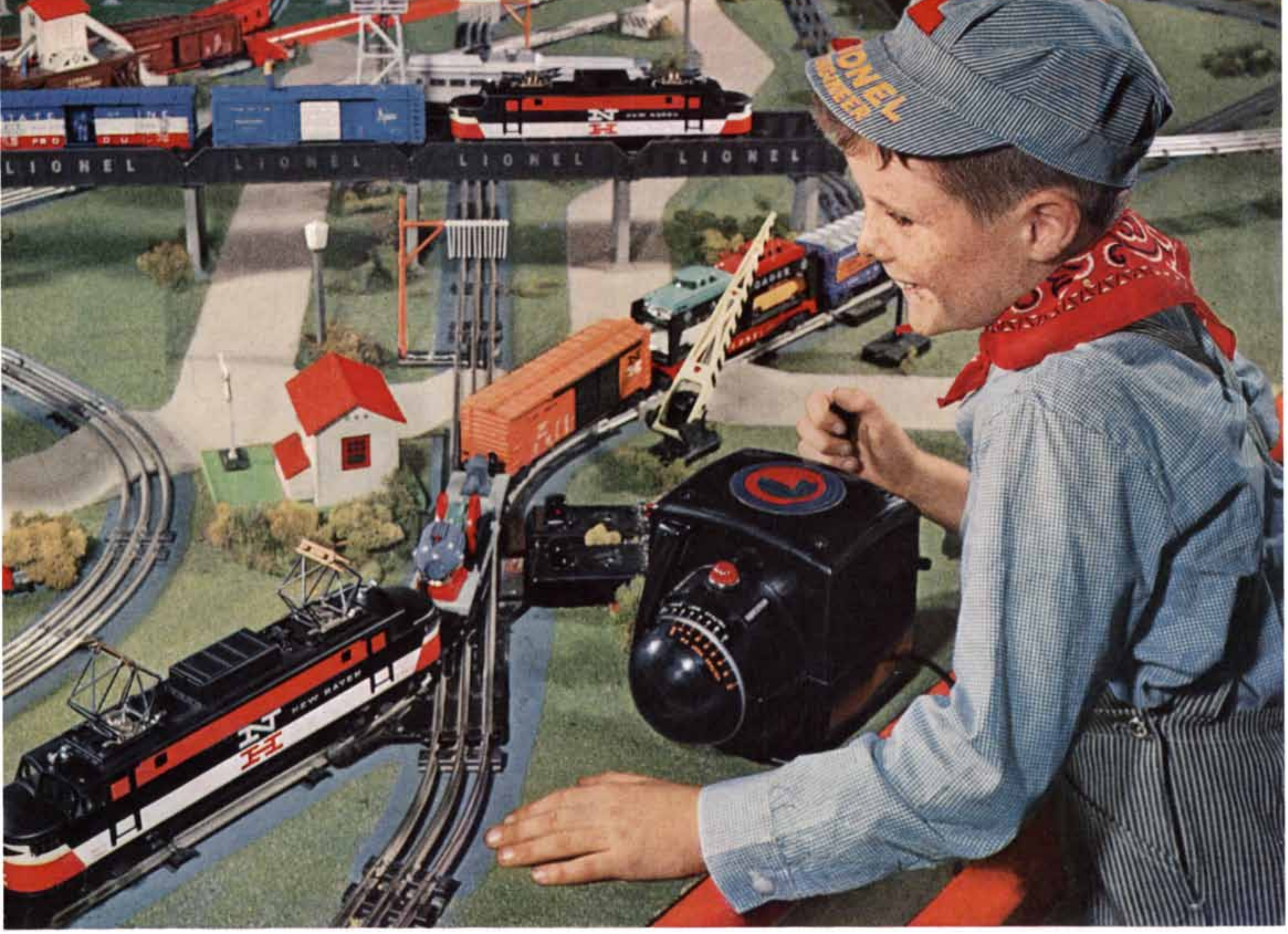

A Type ZW Lionel Trainmaster transformer can operate four trains simultaneously.

Tough new bronze makes railroading fun last longer

Two of the four movable arms of Duraflex (super-fine-grain phosphor bronze) in the control shown above. Turned by hand throttles and dials, they regulate voltage to control train speed.

THE PROBLEM: Much of the fun of model railroading depends on the controls. That's why Lionel insists that controls be tough precision instruments. For example, inside the Trainmaster transformer (above) movable arms regulate voltage to change train speed. These arms have to be good conductors of electricity—springy to maintain a steady electrical contact. And they must be tough enough to stand up under the exacting demands of engineers, young and old. But the design of these intricate parts called for sharp bends in the metal. Using regular phosphor bronze, Lionel had difficulty with fractures in making the bends. They considered turning to a different and more expensive alloy.

THE SOLUTION: First, however, they consulted specialists of The American Brass Company, who had developed a new kind of phosphor bronze called Duraflex®. Because Duraflex has an extremely fine grain, it can be formed more easily and has a harder, smoother, more scratch-resistant surface. It also has good electrical conductivity and high resistance to corrosion. Lionel tried it. Fractures were eliminated—the strength and resilience of the movable arms were improved. So Lionel cut rejects and now has controls that work better and last longer—at no extra cost, *because Duraflex costs no more than ordinary phosphor bronze.*

THE FUTURE: Superior new products like Duraflex—and Formbrite®, a super-fine-grain drawing brass that cuts polishing costs — typify the ways in which Anaconda and its manufacturing companies, The American Brass Company and Anaconda Wire & Cable Company, are helping industry make better products and reduce manufacturing costs. Whether you need a special alloy or shape in copper, brass, or bronze—electrical conductors of copper or aluminum —see the *Man from Anaconda.* The Anaconda Company, 25 Broadway, New York 4, N. Y.

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SEPARATING SOLIDS WITH BUBBLES

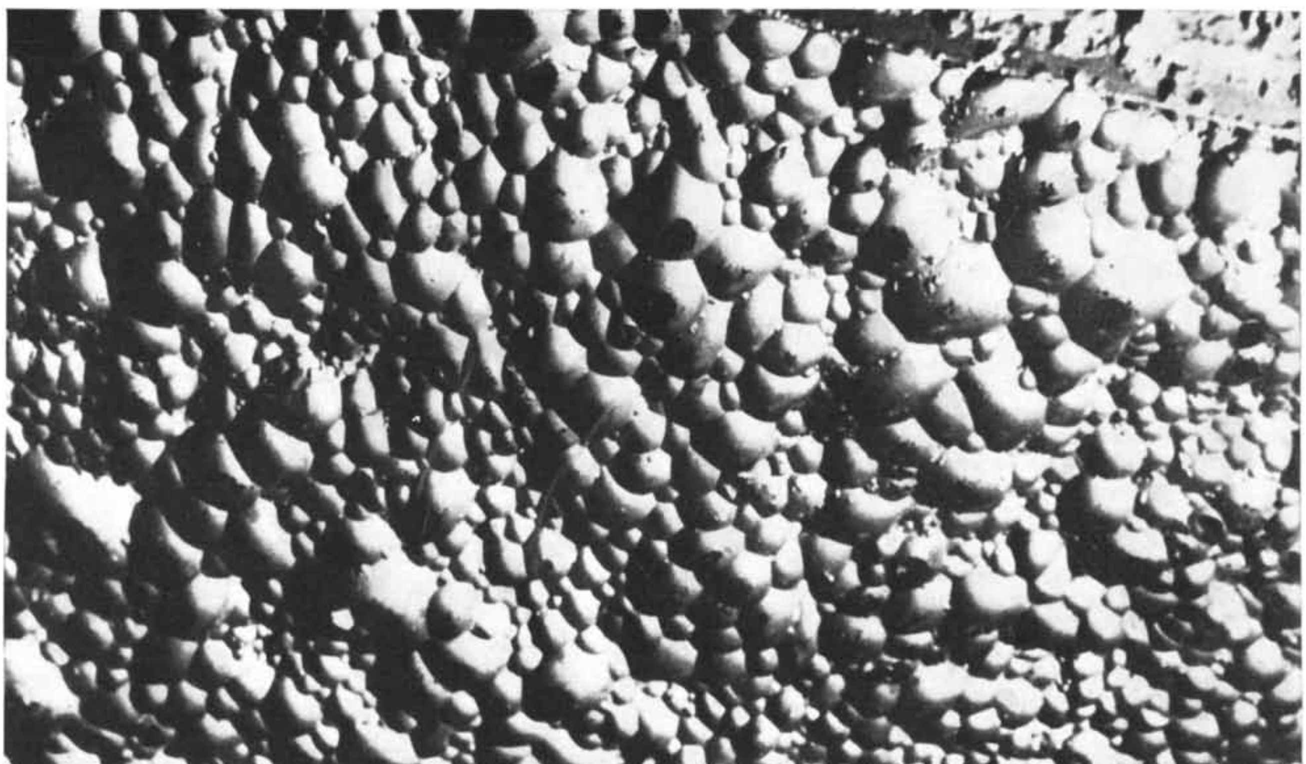
About flotation, in which ores are ground, mixed with water and infused with air bubbles. By manipulating the chemistry of the solution, various minerals can be made to stick to the bubbles

by A. M. Gaudin

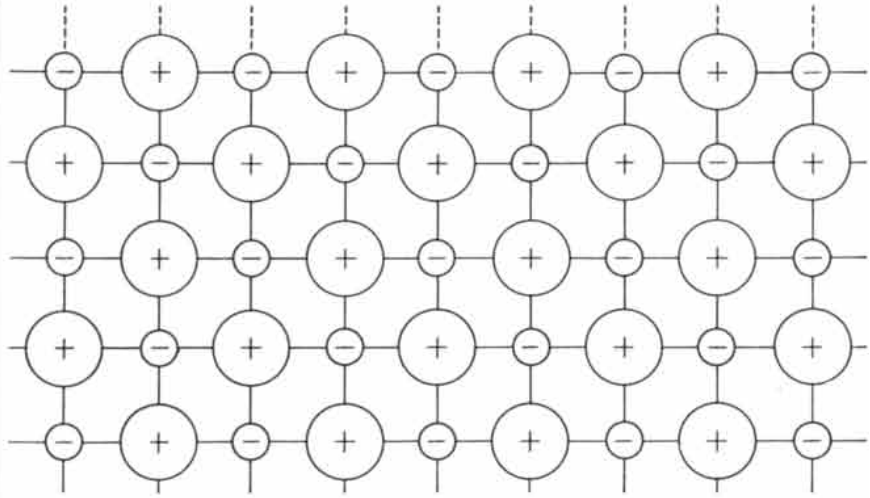
Much as we might like it otherwise in this metal-hungry age, the world store of minerals and ores is steadily declining in quality as man skims off the cream of nature's bounty. At the same time our advancing technology is requiring more and more minerals and metals of high purity. This situation has given great impetus in recent years to the extraordinarily simple and effective extraction process known as flotation.

Flotation is a method of sorting solids with bubbles. Consider two small particles of different substances suspended in water. One substance has so strong an affinity for water that the particle promptly becomes coated with water molecules. The other particle is less keen on adsorbing water; consequently if it encounters a bubble of air, its unwetted surface can attach itself to the bubble. Sticking to the bubble, the particle rises to the surface of the water and can be skimmed off.

For a typical illustration of how this method is applied in practice, let us take a copper ore. It may contain 1 per cent of copper, in the form of the mineral chalcopyrite—a compound of copper, iron and sulfur. The ore also contains, say, 10 per cent of pyrite, or iron sulfide (called fool's gold). The rest is quartz and other silicon compounds. From this mixture we wish to recover the chalcopyrite and the pyrite—the copper and iron minerals. The ore is first ground to fine particles in a little water (making a thick slurry). The solid is thus broken down to particles of chalcopyrite, pyrite and silicates. Now water is added, and with it certain chemicals. One of the chemicals reacts with the chalcopyrite to make the surface of the particles comparatively water-repellent. The pyrite,



BUBBLES at the surface of a flotation cell are coated with mineral particles. This froth may now be skimmed off and the remaining solution piped to another cell. By changing the chemical environment of the remaining minerals, they too can be separated by flotation.

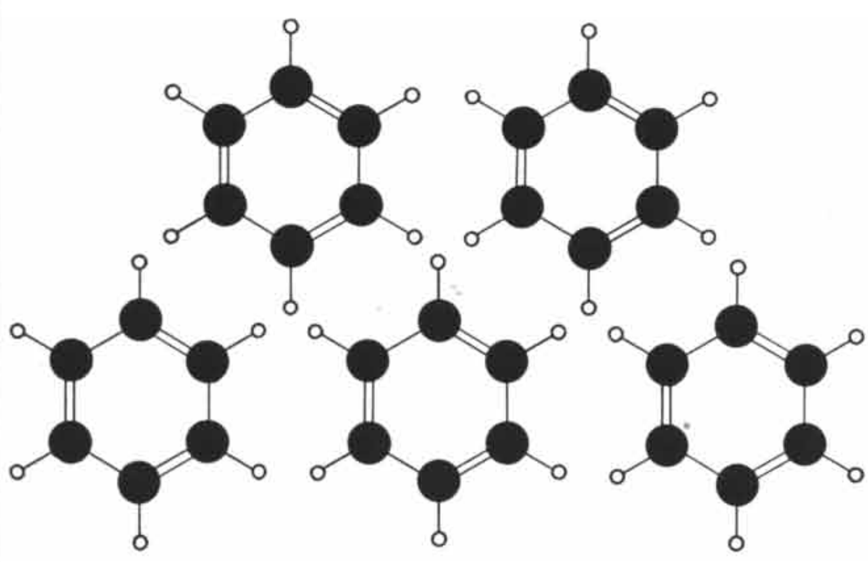


IONIC CRYSTAL is represented by this schematic drawing of table salt, in which ions of sodium (+) and chlorine (—) are joined by their opposite electric charges. An ionic crystal tends not to float because the bonds at its surface (*broken lines*) attract water molecules.

on the other hand, is water-avid in the chemical environment provided, and the silicon compounds are naturally water-avid. As a result, when the tank containing the mixture is filled with bubbles by a stream of air blown into the water, only the chalcopyrite particles stick to the bubbles. They rise to the surface, and the chalcopyrite-bearing froth is skimmed off. The remaining pulp then goes to a second flotation vessel, where the water is treated with chemicals which make the pyrite water-repellent, so that it is brought to the surface by bubbles and thus is separated from the unwanted silicates.

It is fascinating to watch a flotation cell in operation. As the mineralized bubbles come to the top, the froth takes on characteristic and sometimes brilliant colors. The chalcopyrite froth is golden; that of the mineral galena (lead sulfide) is a leaden blue; of malachite (basic copper carbonate), a bright green; of sylvite (potassium chloride) faintly stained with iron, a delicate pink.

Ways have been found to float, and thus concentrate, every solid mineral and many other substances, including products of the chemical industries and even substances in sewage. When flotation was first employed as a mineral-concentration process early in this century, there was little understanding of the basic chemical properties that made particles floatable. The art has now

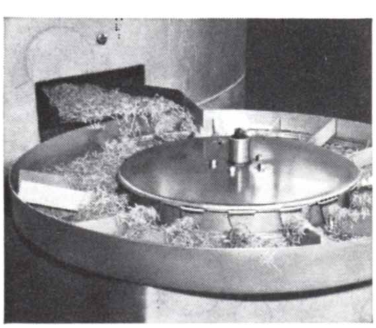


MOLECULAR CRYSTAL is represented by benzene, in which atoms of carbon (*solid circles*) and hydrogen (*open circles*) form molecules which are only weakly attracted to one another. Such a crystal tends to float because it has no bonds to attract water.

Chinese-food fancier's delight: La Choy chop suey and golden-brown noodles!

Here's where Dowtherm really pays off for La Choy

UNIFORM TEMPERATURE WITH DOW HEATING MEDIUM ENDS DIRECT-FIRE PROBLEMS



Uniformly cooked La Choy noodles coming from the fryer.

La Choy Food Products, Archbold, Ohio, has always thought quality control most important. With their previous direct-fire heating system it was necessary for them to give close inspection to the noodles to maintain their high quality. In keeping with La Choy's policy of quality improvement they installed equipment heated with Dowtherm®.

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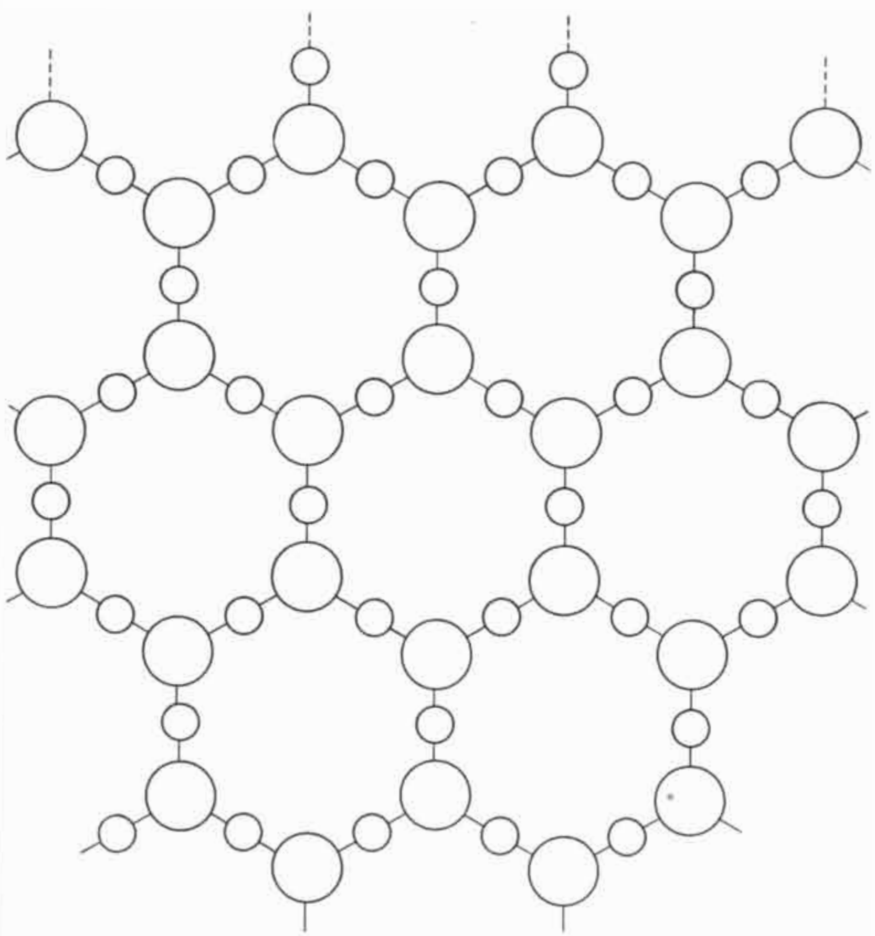
been developed to high finesse by contributions from crystal chemistry, surface chemistry and several other sciences. It has become not only a major tool for satisfying industry's appetite for materials but also an unmatched arena for study of many scientific problems.

To see what makes a substance floatable we may begin by examining the structure of a compound which will float in its native state, without chemical treatment. In general the "native floaters" are substances which have at least one unreactive, or "closed," surface on the molecule. A familiar substance that exhibits natural floatability is naphthalene (the material of moth balls). The naphthalene molecule contains 10 carbon and eight hydrogen atoms, tightly bound together and arranged in a figure 8 consisting of two joined hexagonal rings. A collection of naphthalene molecules forms a crystal—*i.e.*, a regular lattice structure. But the molecules are comparatively far apart and only loosely held together. We can say that the naphthalene crystal is a stack of molecules which are only slightly attracted to one another. The reason is that the atomic bonds are fully occupied within the molecule and there is very little reactivity left on the surface of the molecule. As a consequence the crystal does not adsorb water molecules and is readily floated by an air bubble.

In contrast to this is the crystal of common salt. The salt crystal is of the ionic type: the building blocks of the lattice are sodium and chloride ions [*see diagram on page 100*]. The surface of an ionic crystal, unlike that of a molecular crystal, is always reactive, because of the ions' electric charges, and it will go on growing endlessly if more ions are available. Its reactivity also makes it water-avid. Hence no ionic crystal is floatable unless its surface electric bonds are saturated in some way to block its affinity for water.

Metals, which can be regarded as consisting of positively charged ions permeated by a very fluid gas of electrons, behave like ionic crystals. So do quartz, diamond and certain other crystals which are built of atoms rather than



QUARTZ is represented by this two-dimensional analogue, in which the large circles are silicon atoms and the small circles oxygen atoms. The bonds between these atoms consist of pairs of electrons. When the crystal is fractured, the bonds (*broken lines*) attract water.

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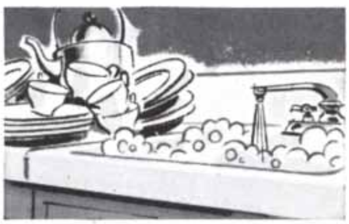
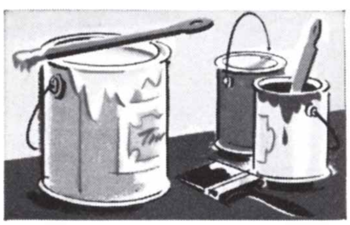


DETERGENTS



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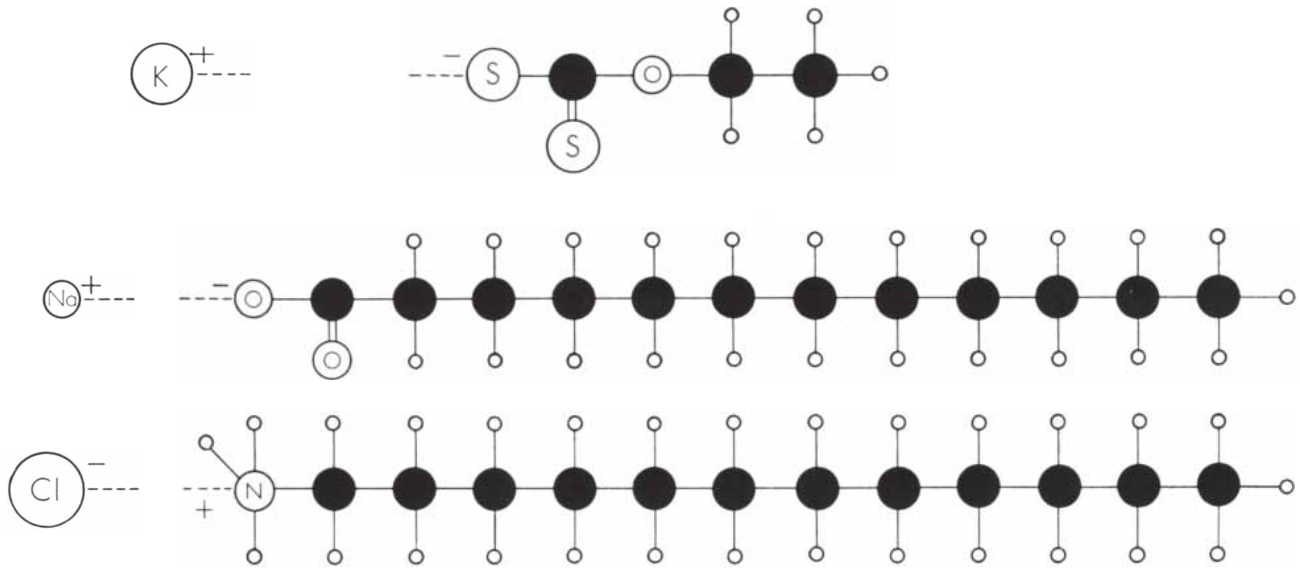
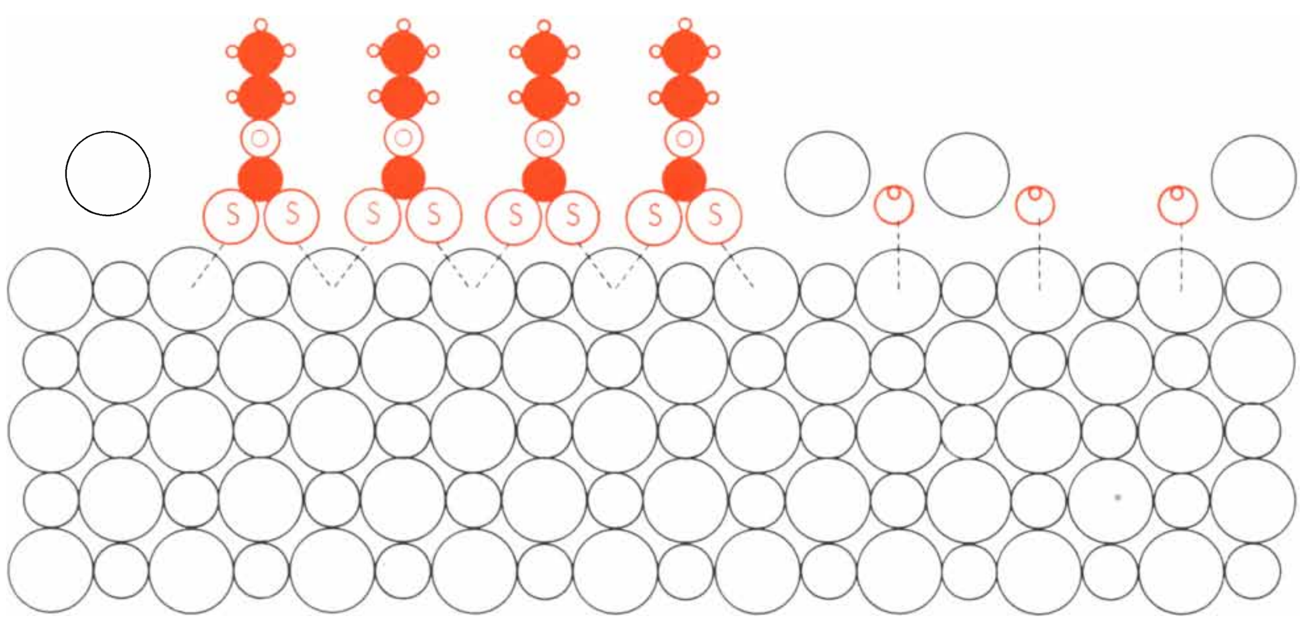


COLLECTOR MOLECULES may be introduced into the flotation cell to make water-attracting substances float. At the top is the collector molecule of potassium ethyl xanthate. In water this molecule dissociates (*broken lines*) into positive and negative ions. The negative ion containing hydrocarbon can replace the negative ion on the surface of a water-attracting substance. Thus water is no longer attracted to the substance, *i.e.*, it tends to float. In the middle is sodium laurate, whose hydrocarbon also is negative. At the bottom is laurylamine hydrochloride, the hydrocarbon of which is positive and can thus replace a positive ion. These molecules consist of carbon (*solid*), hydrogen (*open*), potassium (K), sulfur (S), oxygen (O), sodium (Na), chlorine (Cl) and nitrogen (N).

ions but have ruptured bonds at the surface [*see diagram on page 102*].

There are crystals which partake partly of a molecular and partly of an ionic nature. An example is stearic acid, the stuff of which candles are made. It is a hydrocarbon with a structure very like that of a paraffin. (Paraffin, meaning lacking in affinity, is a term for unreactive substances.) But the stearic acid molecule is not completely paraffin: one end of the molecule terminates in a carboxyl group (COOH), which readily links to other molecules. Hence stearic acid molecules, joining up at the carboxyl ends, form crystals two layers thick. The bimolecular flake is paraffin so far as the outside world is concerned, but it is sandwiched together with ionic bonds; in other words, it has a molecular outside and ionic insides. Its paraffin outside makes the stearic acid crystal a natural floater.

An extremely interesting example of the role of structure in floatability is provided by the two substances boric acid and gibbsite, an aluminum mineral. Superficially both have the same type of formula— $B(OH)_3$ and $Al(OH)_3$. Yet boric acid is an excellent floater while



COLLECTOR TENDS TO REPLACE OTHER IONS on the surface of a water-attracting substance. At the bottom of this drawing is a crystal of galena (lead sulfide); the large circles are lead and the small circles, sulfur. At upper right three hydroxyl ions are adsorbed (*vertical broken lines*) to the surface of the crystal. At upper left these ions have been replaced (*diagonal broken lines*) by the xanthate ions of a collector. The xanthate ion consists of carbon (*solid*), hydrogen (*open*), oxygen (O) and sulfur (S).

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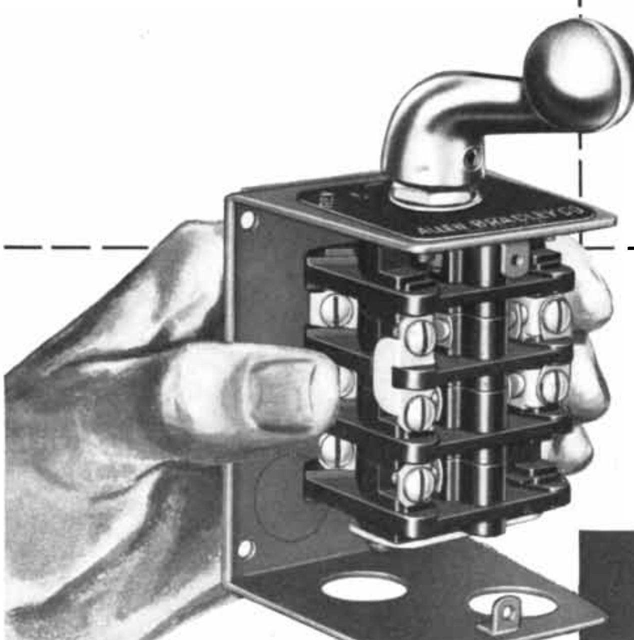

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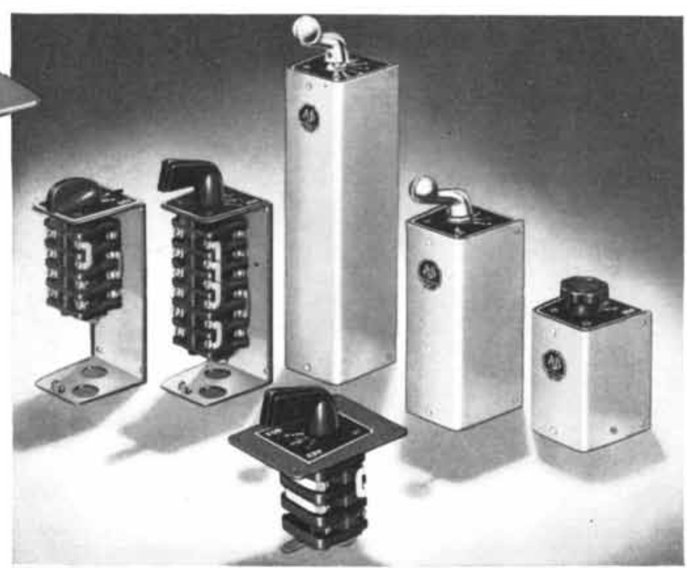
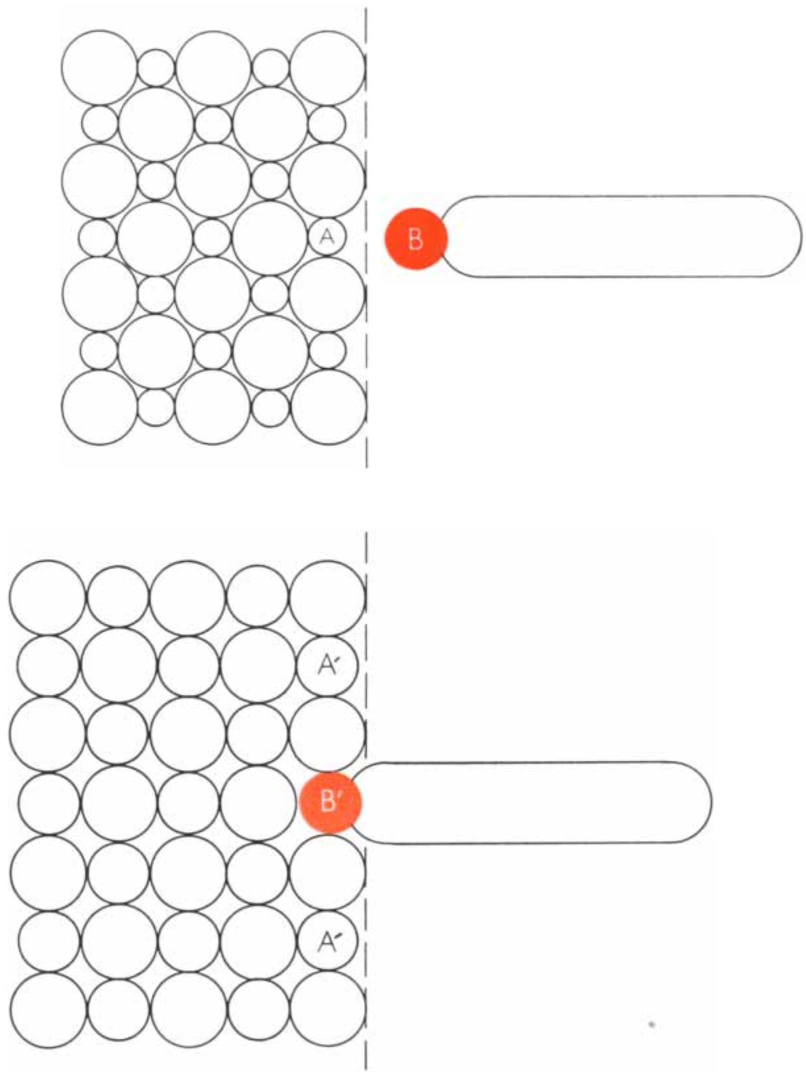


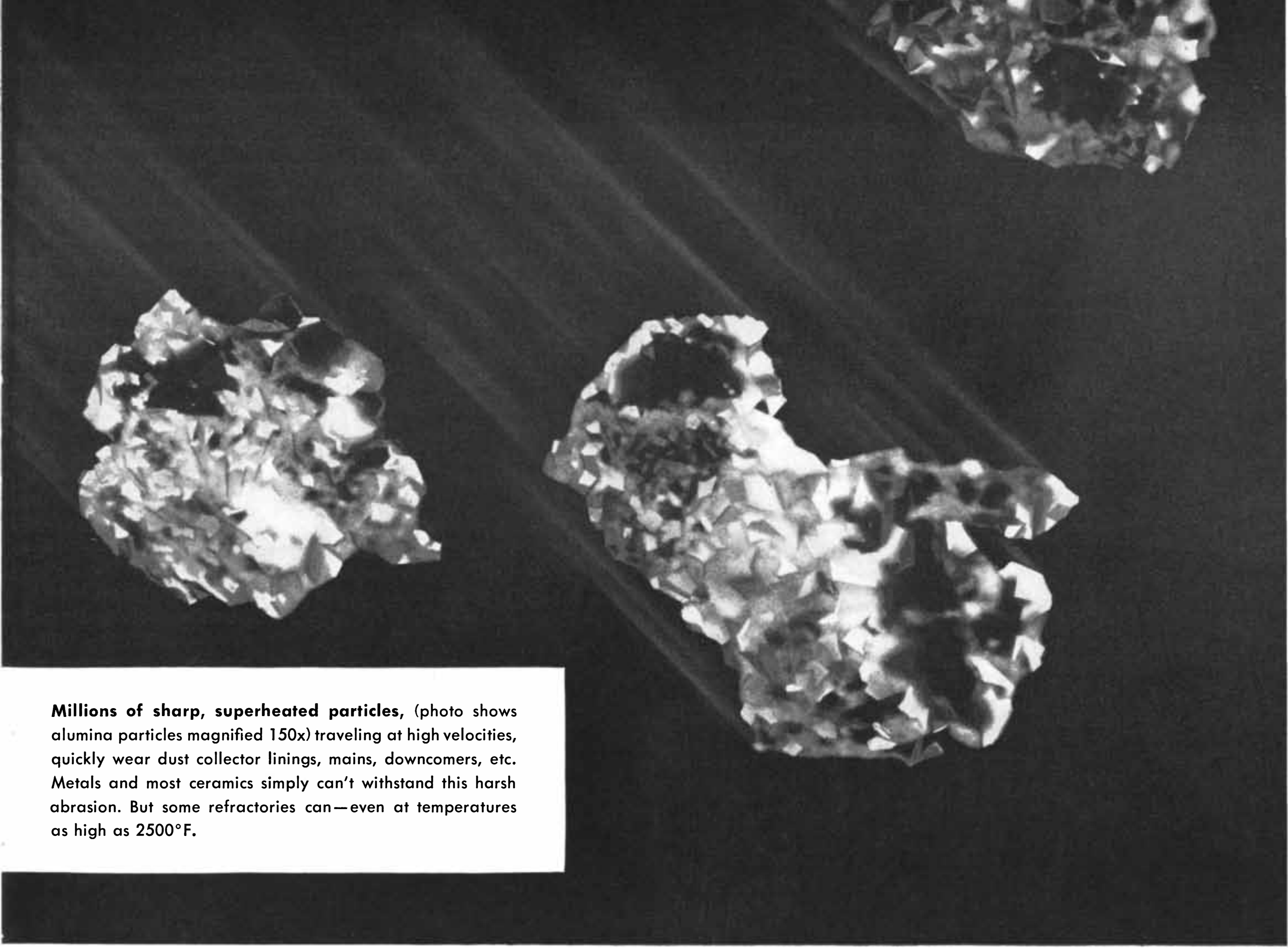
Allen-Bradley Drum Switches are made up of an assembly of individual, cam operated, contact sections. Available for surface or switchboard mounting, in various types of handles, as shown.

gibbsite has no native floatability at all. The difference lies in the way the oxygen atoms are arranged around the central atom. In boric acid three oxygen atoms surround each boron atom in the same plane, and the oxygens are tied together by the hydrogens, acting as hydrogen bonds. From one plane to another the connection is remote, so that a crystal of boric acid is actually just one atom thick. In gibbsite, on the other hand, the oxygen atoms do not lie in the same plane with the aluminum atom. Each aluminum is surrounded by six oxygen atoms—three in each of two planes parallel to the plane of the central atom. Hydroxyl (OH) bonds are available to connect the oxygens of adjoining layers, and so a crystal can build up without limit. Thus, although the same binding elements (oxygen and hydrogen) are involved in boric acid and in gibbsite, the differing angles of attachment result in one case in a limited crystal one atom thick, which is naturally floatable, and in the other in an endless ionic crystal which is not floatable.

How can a nonfloating substance be made floatable? The fact that hydrocarbons are natural floaters suggests a method: namely, cover the substance with a hydrocarbon coating. If ionic crystals, for example, are coated by a surface reaction with an ionized hydrocarbon, with the active end of the hydrocarbon-bearing ion turned in toward the crystal, the crystal should become water repellent and floatable. This is precisely what is being done in indus-



ACTIVE END OF THE COLLECTOR ION must be the right size to replace an ion on the surface of the target substance. At upper left is a crystal of sodium chloride; the sodium ions are the small circles and the chloride ions the large circles. At upper right is the amine ion of a collector; its active end (B) is too large to replace the sodium ion (A). At lower left is a crystal of potassium chloride; the potassium ions are the small circles. Here the active end of the amine ion (B′) is the right size to replace the potassium ion (A′).



Millions of sharp, superheated particles, (photo shows alumina particles magnified 150x) traveling at high velocities, quickly wear dust collector linings, mains, downcomers, etc. Metals and most ceramics simply can't withstand this harsh abrasion. But some refractories can—even at temperatures as high as 2500°F.

Refractories . . . where **abrasion** is a problem

Unequalled resistance to abrasion whether caused by tiny gas-borne particles or sliding steel billets—is one of the most useful properties of CARBOFRAX® silicon carbide refractories. For example, a CARBOFRAX dust collector lining on an ore sintering machine is still in use after 10 years service.

And when abrasion is combined with high temperature, the exceptional resistance of CARBOFRAX super refractories becomes even more apparent and useful. When used in the exhaust lines of gasoline catalytic cracking units in temperatures ranging around 1200°F, these refractories lasted 3 years, as compared to alloy rings which lasted for 6 months. On a gas fired extrusion mill furnace—where steel skids lasted 5 weeks—CARBOFRAX refractories lasted 156 weeks.

Wear resistance is not the only unusual property of these refractories. They also offer heat conductivity roughly 11 times that of fireclay, with sufficient hot strength to withstand 25 psi at 1720°C. CARBOFRAX refractories are but one of many super refractories pioneered by Carborundum and offering a wide range of unusual properties.

Carborundum's new magazine "Refractories" pinpoints many practical applications for these unusual products. The forthcoming issue carries a feature article on "Wear Resistance". Send for your copy today.

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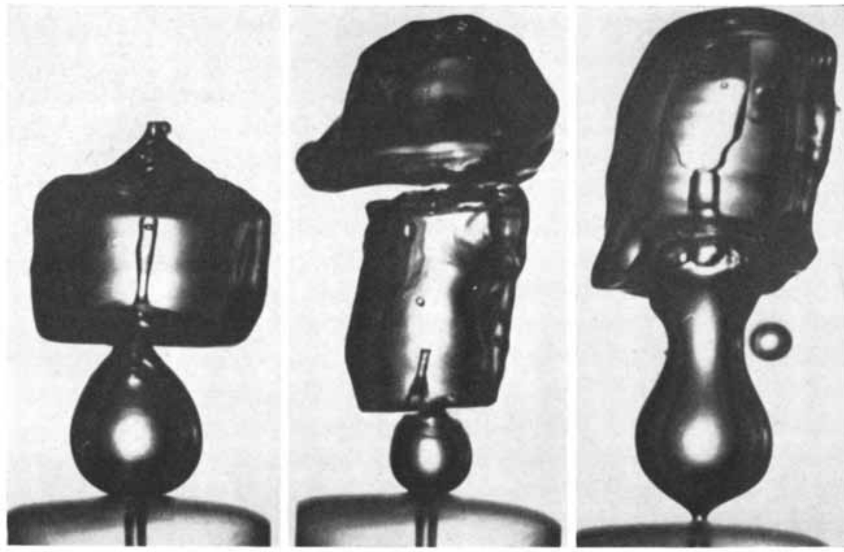


AIR BUBBLES issuing from a capillary tube were photographed by Douglas W. Fuerstenau at the Massachusetts Institute of Technology. The bubbles are usually sleeve-shaped.

try—on the scale of hundreds of millions of tons per year.

The special chemicals that the flotation engineer uses for this purpose are called "collectors." Most collectors are salts which, when dissolved in water, release an ion containing a hydrocarbon group. The collector usually employed to float chalcopyrite, for example, is potassium ethyl xanthate—a compound which dissociates into a positive potassium ion and a negative ion made up of sulfur and a hydrocarbon [*see top diagram on page 104*]. The negative ionic bond on the end of the hydrocarbon group attaches itself to the chalcopyrite, and the mineral particle thus acquires a hydrocarbon surface.

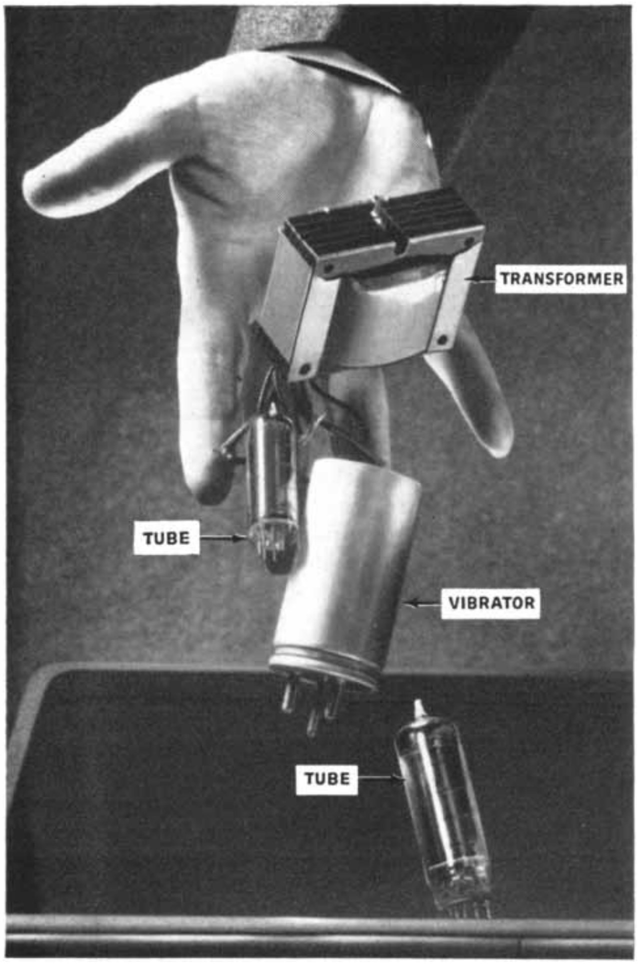
Evidently the hydrocarbon-bearing ion, negatively charged in this case, replaces a negative ion in the chalcopyrite. A very interesting size factor enters here. If a salt of an amine compound (a nitrogen-containing hydrocarbon) is put in a brine saturated with a mixture of potassium chloride and sodium chloride, the amine collector will float the potassium salt but not the sodium. The reason, it seems, is that the "head end" of the amine ion is just the right size to take the place of a potassium ion in a crystal but too large to displace a sodium ion [*see diagram on page 106*].

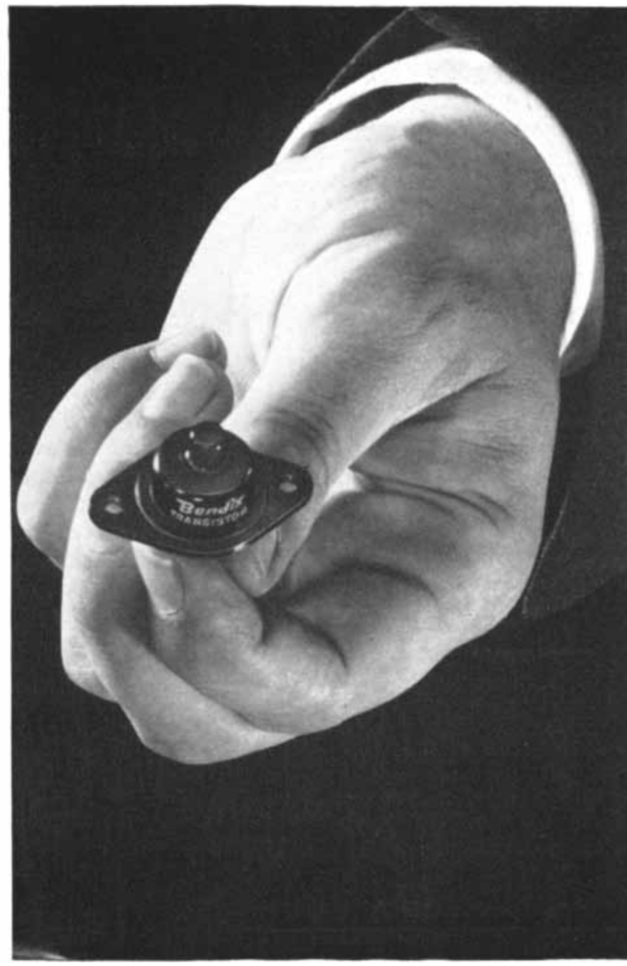
Only a tiny amount of collector is needed to bring about a big change in the floatability of a substance. In fact, the quantities of reagent used are so small that very little could be learned about what happened to collectors chemically until radioactive tracers became available. The tracers opened a new era in the study of flotation, and a research project at the Massachusetts Institute of Technology, sponsored by the U. S. Atomic Energy Commission, is building a sound chemical basis for the art.

These studies have shown that the ions of a collector readily displace other ions from the surface of a mineral particle, that the coating may move over the surface, that it need not cover more than a small fraction of the surface to be effective, and that even a few parts per million of the reagent in a tank will make particles floatable within a matter of seconds. To float the particles the collector does not have to eliminate their preference for water over air; all that is needed is to break into their exclusive affinity for water. So long as a place is provided on the surface of the particle for a bubble to gain a toe hold, the bubble will stick and float the particle.

Of course the particle must make contact with a bubble for an adequately long instant in order to be "collected." Some particles travel for a yard or more in a swirling pulp full of bubbles without encountering one; others are trapped before they have moved an inch. It is a complex hydrodynamic problem to compute the best conditions for trapping particles, because flow patterns and the sizes and spins of both the particles and bubbles are all involved.

It used to be thought that bubbles in water were always spherical, but high-speed cinematography has shown that they may be angular or may change shape like an amoeba. When the stream of air is pumped in at high speed, they take a sleeve shape [*see photograph above*]. We believe that nonspherical bubbles have a substantially greater





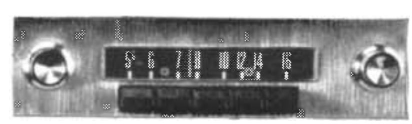
NEW BENDIX TRANSISTOR REPLACES PARTS THAT CAUSE 75% OF CAR-RADIO TROUBLE!

Bendix transistors have countless applications. For example, four standard radio parts—two tubes, the vibrator, and power transformer—headed for the discard above are gone forever from Bendix* car radios, replaced entirely by the tiny Bendix† transistor. Since most car-radio trouble has been caused by these particular parts, this represents a big gain in dependability.

Besides eliminating troublesome parts, this Bendix transistor produces plenty of power from low voltage, thus is much easier on your battery; it eliminates annoying vibrator hum; it has no filament like a radio tube requiring warm-up, so it goes to work instantly; it ignores shock and vibration, is extremely long-lived, saves much space.

Not just anybody can manufacture transistors. Bendix transistors are precisely made and subjected to heat and other tests not given ordinary transistors. We believe they are the highest-quality, mass-produced transistors made. They are manufactured by Bendix Red Bank Division, Eatontown, N.J., which also produces ruggedized electronic tubes for special purposes where transistors are not yet available. For further information about transistors or tubes, write direct to Red Bank Division.

*REG. U.S. PAT. OFF. †TRADEMARK



New Bendix transistorized car radio now being installed on hundreds of thousands of 1957 models. Bendix Radio Division has built over three million car radios.

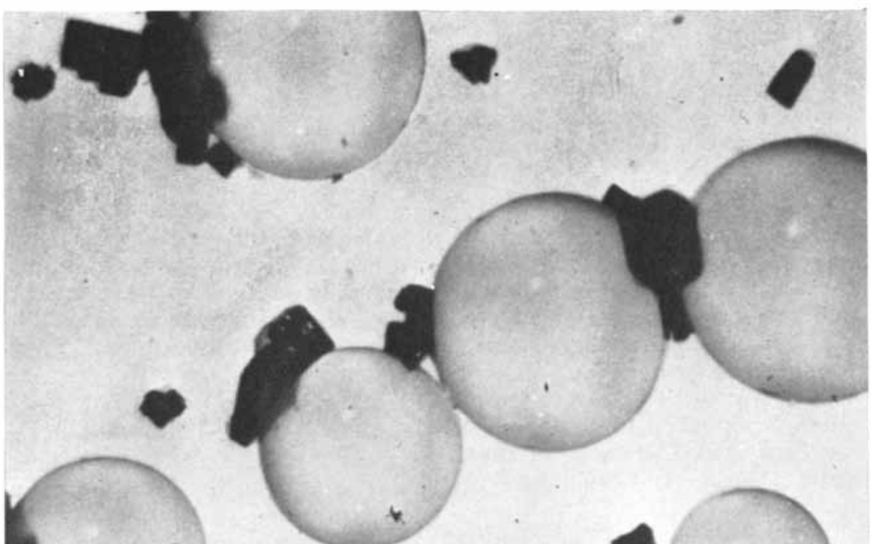
A thousand products — **Bendix AVIATION CORPORATION** Fisher Bldg., Detroit 2, Mich. — *a million ideas* probability of capturing particles than spherical ones. When the bubbles are spherical, they are more likely to collect particles on the rear side than on the front. A single bubble may pick up several particles, as H. Rush Spedden of the Union Carbide and Carbon Corporation has demonstrated in some remarkable photographs [*see below*].

How does the flotation process separate one type of particle from another? In the case of chalcopyrite and pyrite, the selection method used is based on the fact that one contains copper and the other does not. The separation process is often a fine art. A particularly good illustration is the extraction of the mineral sphalerite—zinc sulfide. The collector used here is ethyl xanthate. This reagent will not float pure sphalerite. But if a tiny concentration of soluble copper sulfate (less than one part per million) is maintained in the flotation tank, the sphalerite particles will extract copper from the solution and be activated so that they can adsorb the xanthate; they then stick to bubbles and are floated. On the other hand, sphalerite that has been activated by copper can be deactivated by an alkali cyanide, which pulls the copper back into solution. Thus by such chemical regulation of the concentration of copper ions in solution it is possible to float zinc sulfide or leave it unfloated at will.

The size of particles is a crucial factor in floatability. Coarse particles easily make contact with bubbles, but they also easily part company from them in a violently agitated pulp, because of gravitational and centrifugal forces. Fine particles, on the other hand, move very little and therefore have only a small chance of encountering bubbles. The most favorable sizes for flotation range from one tenth to one hundredth of a millimeter. To float particles a millimeter in size requires very special care, and particles of one micron (a thousandth of a millimeter) have given fits of despondency to mineral engineers!

The shape of particles also is a factor. Other things being equal, particles with flat faces are the easiest to capture, and those that approach a spherical shape, the most difficult. This helps to explain why flotation is particularly effective with minerals, for most of their particles are angular.

Flotation obviously is a large subject, and a single article can review only some of its high points. But even this brief review should make clear that it involves many sciences and has a fascinating future.



MINERAL PARTICLES adhere to bubbles in this photomicrograph made by H. Rush Spedden of the Union Carbide and Carbon Corporation. One bubble may carry several particles.

CORNING GLASS BULLETIN

FOR PEOPLE WHO MAKE THINGS

Etchings to excite exigent engineers

Next time someone says, "Make it small and accurate," reach for your file on *photosensitive glass.*

Using a process called "chemical machining," photosensitive glass now yields intricate and accurate components for both electrical and mechanical applications.

Starting with a Corning special glass, chemical machining makes it possible to achieve an intricacy never before thought possible. And it's all done *without* the need for costly grinding, drilling, cutting or engraving.

Let's take a look at some chemical machining in practice, a good example being this wire brush holder for a tiny airborne digital converter.

Made of glass by a combination of photo, heat and etch processes is this precision brush holder for a digital converter. In background are holders that have been exposed and developed but not yet etched.

As originally designed, this converter had 0.0065″ single wire brush contacts. Brush holders were of a glass fiber reinforced laminate. But, the smallest holes that could be drilled in this laminated material were 0.015″ in diameter. Result? Loose-fitting wires.

Turning to the miniaturization and precision offered by photosensitive glass, designers came up with a brush holder with *rectangular* holes, 0.0075″ x 0.015″.

Two wires (each 0.0065″) are inserted side by side in each hole. Holes are etched through the glass and have a conical cross section. The lip of this cross section serves as a reference point about which the free ends of the brush cantilever.

Spacing of the slots is held to a tolerance of 0.001″ over 1½″, making it possible to position the double brush contacts with close tolerances.

Etched glass also plays a role in assembly, with an alignment plate used to locate the free ends of the brush while fixed ends are cemented.

Behind this *accuracy-by-acid* is some quite ingenious exploiting of differential rates of etching glass. And there's also some interesting use of collimated ultraviolet light and heat.

You can learn a great deal more about photosensitive glass (including other uses) by writing for "Chemical Machining Photosensitive Glass," a reprint of an article that ran in *Materials and Methods.* Free with the coupon.

Viscosity, visibility and versatility

From the production lines of the Precision Scientific Company of Chicago comes this Transformer Oil Oxidation Test Apparatus.

This bit of precise plumbing is a second cousin to another Precision product, the Model "S" Kinematic Viscosity Bath.

Used profusely in both is PYREX brand glass No. 7740. First, there are PYREX brand jars (12″ x 18″) forming the main chambers of the test apparatus. Then you'll find an almost bewildering array of tubes and tubing, some of it quite intricate in shape. And there are also Erlenmeyer flasks and glass umbrellas.

Behind Precision's choice of glass is the need for visibility, plus *accuracy and precision.*

PYREX brand glass No. 7740 handles all these requirements admirably. It's known as the "balanced glass,"—balanced for chemical stability, heat shock and physical knocks.

No. 7740 demonstrates a remarkable reluctance to mix with, or be affected by, what you put *in* or *around* it. Among the usually destructive forces that bother it not at all are most acids and alkalies, as well as steam.

This *not adding to or detracting from* is one reason why No. 7740 is the favorite among those who must protect delicate flavors. That's why, for example, you'll find this glass in coffee makers, both commercial and household varieties.

And PYREX No. 7740 stands up to physical knocks. It takes thermal shocks in its stride, too, having a linear coefficient of expansion of 32.5×10^{-7} between 0° and 300° C.

A clear glass, it's available in economical quantities as blown or pressed ware, and in plates, panels, tubing and rod.

Even one-piece molding of fancy shapes has been done with this most popular of all glasses made by Corning.

Can some particularly knotty problem of yours find its answer in this or some other glass by Corning? Good way to start finding out is with our Bulletin B-83, "Properties of Selected Commercial Glassware." It details characteristics of many of the glasses sold under the PYREX, CORNING and VYCOR trademarks.

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"Glass and You," a profusely illustrated volume showing how many businesses and industries use glass profitably.

And there's Bulletin B-84, "Manufacture and Design of Commercial Glassware," a brief summary of design considerations in making glass by various methods; also data on sealing and assembling glass to metal.

Plus an invitation to consult with us via the written word, phone, or wire, on utilization and availability of *glass* as a basic material of design and construction.

With 105 years of experience in glass technology behind us, and with the formulas for some 65,000-odd different glasses on tap, we've acquired quite a bit of useful know-how.

You can make use of it at your convenience. And, if you're in the area, be sure to stop by at The Corning Glass Center. Here you will find both the oldest and the newest uses for glass. We would be glad to send you a preview of what may be seen. Check the coupon.

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THORIUM

URANIUM'S INTERESTING STEPCHILD

Teddy Roosevelt was President. The age of Victorian splendor was in full swing. And incandescent gas lamps were lighting America. The heart of these glowing lamps was the gas mantle—made, for the most part, of thorium.

Lindsay was a famous name in the gas-light era, a major producer of gas mantles.

The manufacture of gas mantles calls for the impregnation of a knit fabric cone of ramie or rayon with thorium nitrate and cerous nitrate. The organic fiber is burned off, leaving a relic structure of thorium and cerium oxide which glows white hot in a gas flame.

Around 1920, gas illumination was largely supplanted by electric lighting. Demand for thorium dropped. Then came the atomic age. Thorium again became important because of its value as a reactor fuel breeder.

At the present, there are two systems in which thorium can be used as a fuel material breeder. One is the use of metal or a thorium-bismuth alloy; the other, a thorium oxide slurry reactor. Both procedures are being investigated by the AEC and private industry. It is believed that at the assumed burn-up rate of thorium oxide (one pound of ThO_2 for six megawatt hours of electrical energy) the thorium-rare earth industry is probably capable of handling domestic demands without excessive expansion. Thorium looks good as a reactor fuel for private industry because it is much more plentiful and economical than uranium.

So much for the Buck Rogers stuff . . . what's ahead for thorium, excluding the energy field? The answer to that is "plenty" and chances are it can be of immense value to you—it already is in a number of industries.

The most common thorium salts are the nitrates, oxides, fluorides and chlorides. Lindsay produces all of them in purity ranges from that required for ordinary technical use to the most critical "reactor" grade where extremely high purity is a must.

Let's see how some of these salts are being used in industry. Perhaps you'll see a potentially profitable use for them in your own operations.

$Th(NO_3)_4 \cdot 4H_2O$—Manufacture of incandescent gas mantles. A starting material for other thorium compounds and thorium metal. Nitrate is the standard commercial thorium salt.

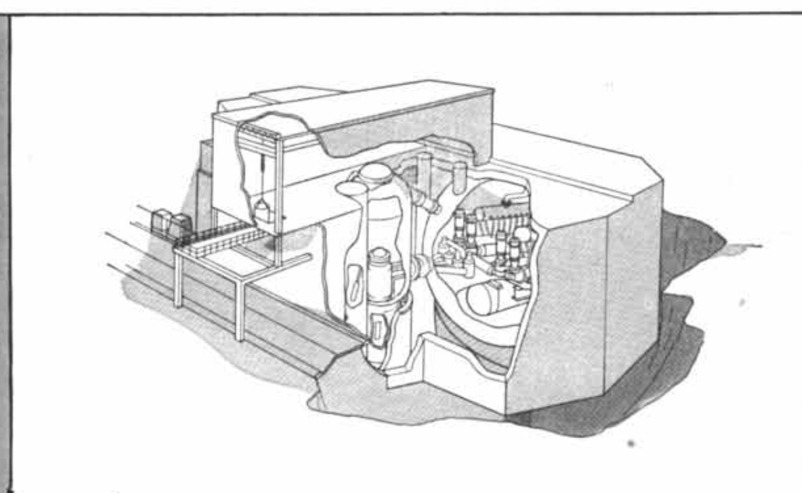
ThO_2—Thorium oxide has the highest melting point of any metallic oxide (3220°C) and has use as a refractory material. It is also used with lanthanum oxide in the production of "rare-element" optical glass for unbelievably accurate aerial camera lenses. It is a source material for making thorium metal. The AEC and several private companies are studying its use in a thorium oxide-water slurry reactor. It has some use as a catalyst.

Thorium-magnesium alloys have high strength, good creep resistance and elastic modulus values in the 600-700°F temperature range and are used in jet engine castings, supersonic air-frame constructions and satellite rockets where high temperature service is required.

Thoriated tungsten (tungsten containing 1 to 2% ThO_2) is used as a filament in electron tubes and as non-consumable electrodes in inert gas-shielded arc welding.

Lindsay is the oldest and largest producer of thorium compounds for the government and private industry but we don't make thorium metal. Naturally, since we've been in the business 54 years, we've learned a good deal about this remarkable, versatile element. Data is available to you and the counsel of our technical staff is yours for the asking.

We feel certain that thorium has enormous potentials in a variety of industries and we want to share our knowledge with you. If you think that thorium chemicals may be useful in improving one or more of your products or processes—or in the development of new products—let us be of help.



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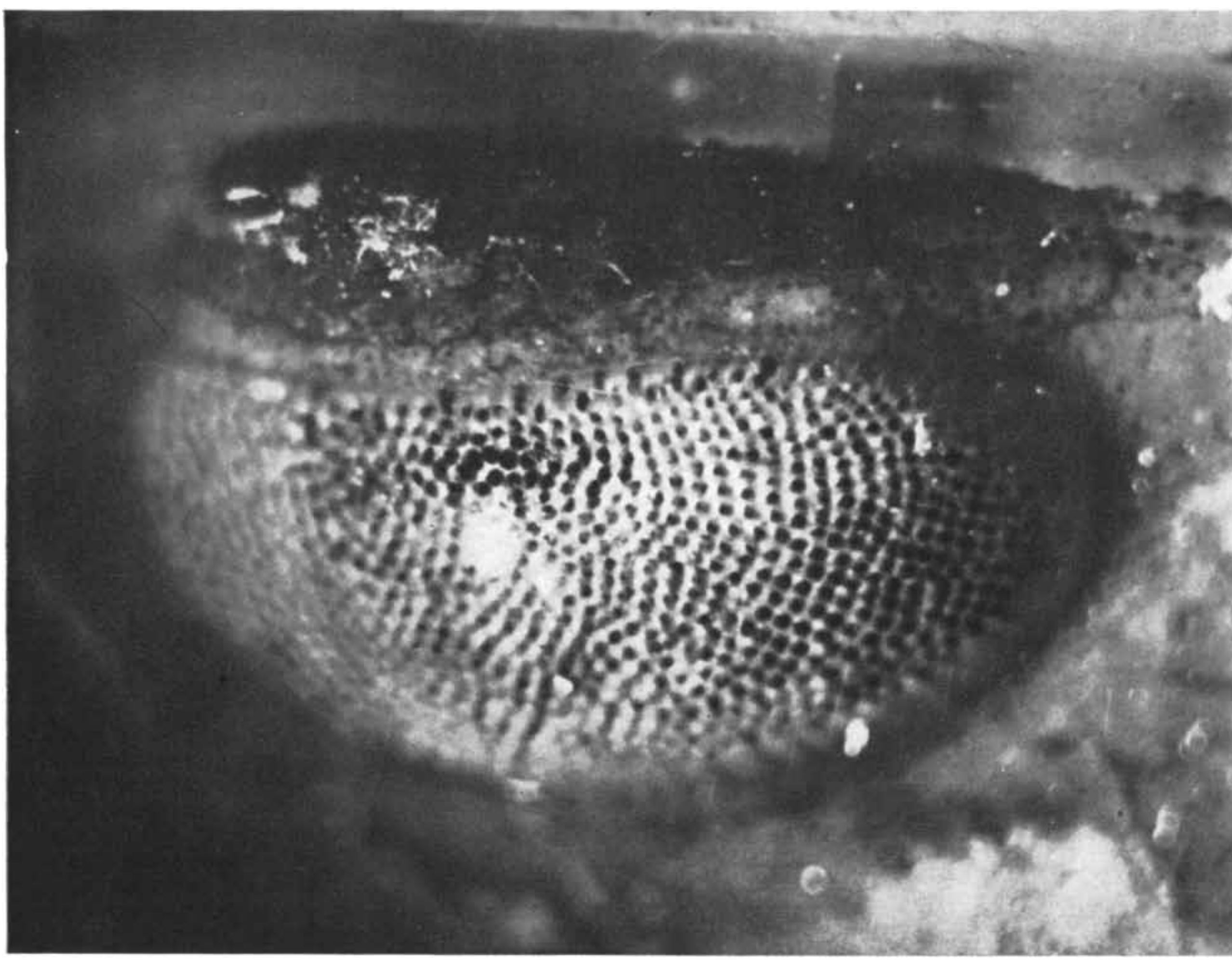
ELECTRICAL EVENTS IN VISION

When light falls on the retina, nerve impulses are dispatched to the brain. How these impulses convey the messages of vision is investigated with the elementary eye of the horseshoe crab

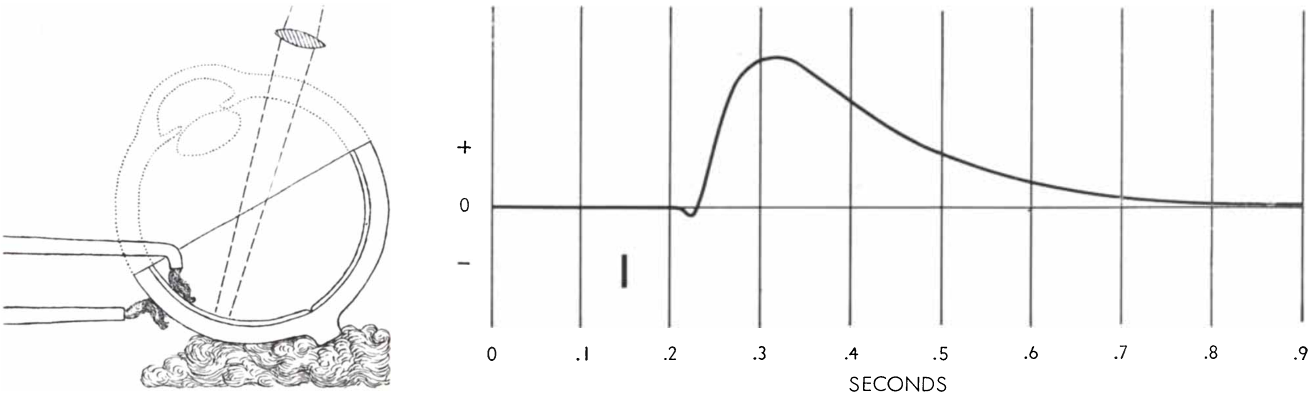
by Lorus J. and Margery J. Milne

What we "see" depends upon what the brain says we see. But since all seeing arises from messages sent to the brain by the eye, the investigation of vision must begin with the origin and nature of these messages. This takes us into an area where living functions go on at a very elementary level. All the information sent by the eye to the brain consists simply of electrical impulses. They in turn arise from the eye's absorption of elementary quanta of light. Probing and picking away in this area, where vision can be dissected, so to speak, a few physiologists have won some remarkable information about the elements of seeing—how sensitively our eyes respond to light, how they adapt to the dark, how they see color, and so on.

More than three quarters of a century



EYE OF A HORSESHOE CRAB is enlarged some 10 times in this photograph. The eye consists of individual units called ommatidia. Each ommatidium is connected to a large nerve fiber, which simplifies the recording of electrical impulses from the optical system.



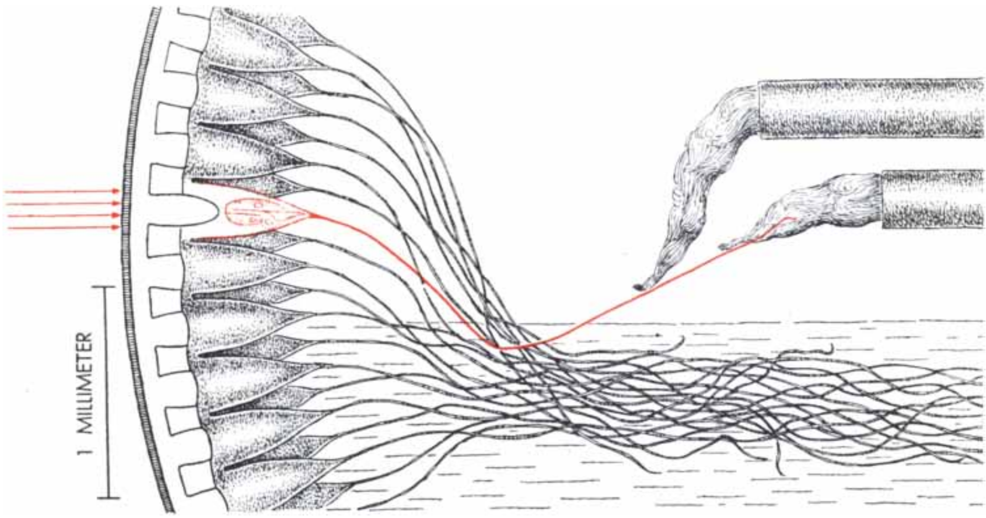
VERTEBRATE EYE may be dissected so that electrodes can be placed on its retina and outer surface (*left*). When light falls on the retina, the voltage across the electrodes changes (*right*). The time of the stimulus is indicated by the short, heavy vertical line.

ago the British scientists James Dewar (inventor of the famous Dewar flask, the forerunner of the vacuum bottle) and J. G. M'Kendrick opened this field by investigating electrical activity in the eyes of frogs, lobsters and sundry other animals. The eye of a frog can be removed and kept alive for many hours by keeping it moist. If the eye is cut open and an electrical connection is made between the outside of the eyeball and the retina on the inside, with wet wisps of cotton as the contacts [*see diagram above*], a difference in electrical potential can be detected. The retina is positive with respect to the outside surface of the eye. Now if the retina is stimulated by a flash of light, the potential difference jumps—to as much as a few thousandths of a volt. It quickly drops back again. The eye will repeat this response indefinitely if it is allowed a minute or so to recover between one flash and the next.

Dewar and M'Kendrick discovered that the size of the voltage jump in response to a flash was proportional to the logarithm of the intensity of the light: in other words, to double the electrical effect the light energy had to be increased about 10-fold. Psychologists had noticed that this relationship applied to sensations in general, and it had been named the "Weber-Fechner law." What Dewar and M'Kendrick demonstrated was that the sense organ itself, rather than a reaction in the brain, was responsible for the response ratio. Later it was found that the same logarithmic relationship held for all sensory cells, whether stimulated by light, touch or a chemical.

Nowadays, with an instrument using electronic amplifiers, the electrical response of the retina to light can be recorded as an "electroretinogram," just as the activity of the heart is recorded in an electrocardiogram and that of the brain in an electroencephalogram. In 1925 H. K. Hartline, then at the Johns Hopkins School of Medicine (he is now at the Rockefeller Institute for Medical Research), discovered that an electroretinogram could be made without removing the eye, and thereby opened the way to electrical studies of the human eye. He found that the electrical changes observed by Dewar and M'Kendrick had high-speed components which were detectable in the cornea at the front of the eye. Changes in the retina's voltage can therefore be recorded by means of wet cotton "electrodes" enabling measurements of the potential difference between the front of the eyeball and some other part of the body, such as the forehead.

Hartline and others proceeded to carry out many experiments testing how what a person sees is related to electrical events in the eye. One of the most interesting studies has been the adaptation of the eye to darkness and to light. If you keep one hand in a warm compartment and another in a cold one for a time, and then put both hands together in a bowl of water, the water will feel cold to the warmed hand and warm to the cooled one. The just-preceding experience of the temperature-sensitive cells in the hand influences the messages sent to the brain. Similarly the eye is conditioned by such experience. A simple experiment illustrates this dramatically. For 15 minutes or so the subject is in a brightly lighted room with one eye covered by a patch and the other exposed to the light. Then the room is darkened and the two eyes are tested alternately with accurately timed flashes of light. The eye that was shielded from light will detect the flash every time. It



EXPERIMENTAL SETUP used by H. K. Hartline and his colleagues to study the eye of the horseshoe crab is depicted in this drawing. At left is part of the eye in cross section.

will also show a corresponding rise in electric potential at each flash. But the previously exposed eye will not see the flashes at all for a minute or so, nor will its voltage change. Then it will begin to see the flashes dimly, and thereafter they will seem to become brighter and brighter. It takes about half an hour for the exposed eye to reach the sensitivity of the dark-adapted one.

Like camera film, the eye collects more light as the length of exposure (*i.e.*, of the flash) is increased. But it has a threshold of sensitivity: if the light intensity is so low that the eye cannot respond to it within one second, no lengthening of the exposure will make it visible.

Studies such as the foregoing are interesting and valuable, but they leave the investigator still far from the basic machinery of vision. They are comparable to an attempt to guess what is going on inside a factory by examining the smoke emerging from its stack. The emergence of smoke may show that operations have started, and the cessation of smoke indicates the end of the working day, but what is the factory doing? The investigator of vision wants to know how light is translated into electrical messages and what cells (machines) perform the specific functions involved.

By very delicate surgery Hartline was able to reach into the factory and connect his recording equipment to the output of a single machine—an optic nerve fiber. The technique that made this possible had been created by two physiologists, E. D. Adrian of England and Detlev W. Bronk of the U. S., who had found a way to isolate one living fiber in a nerve by destroying all the others with fine needles. In a single fiber one can study the elementary significance of nerve impulses. Each impulse—a sharp rise in electric potential from point to point along the fiber—is like every other: the only thing that varies is the rate at which the impulses follow one another. The rate corresponds to the strength of the stimulus on the sense organ (*e.g.*, the retina).

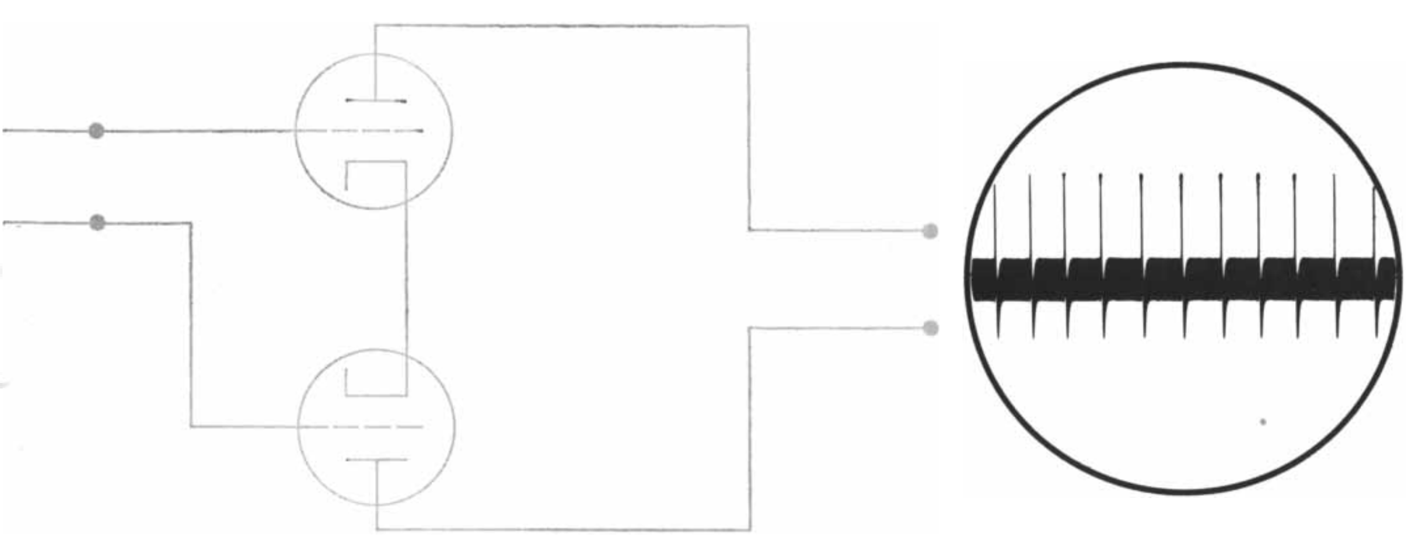
The retina of a vertebrate eye functions in a complicated manner: it is itself a kind of computer which partly interprets its own messages before sending them on to the brain. Hartline and his colleagues looked about for a simpler eye to start with. By good fortune he and Clarence H. Graham found exactly what they were looking for in the horseshoe crab, a familiar inhabitant of the Atlantic coast. They discovered that the eye of the horseshoe crab is amazingly simple. It is a compound eye composed of individual units (ommatidia), similar in type to the eyes of insects. But unlike any other known animal, the horseshoe crab has a separate nerve fiber proceeding from each of these units toward the brain.

Hartline dissected the horseshoe crab's eye and optic nerve and studied the messages transmitted along a single nerve fiber from a single ommatidium. When the ommatidium is stimulated by a flash of light, it sends toward the brain a series of identical impulses at a certain steady rate as long as the stimulus continues. If it is kept in the dark for a time before the exposure, it becomes more sensitive, and the same test flash will now elicit a more rapid barrage of impulses. As exposure continues, their rate drops to a lower level which can be maintained for hours. The experiment clearly shows that dark adaptation and other basic visual properties reside in the individual receptor cells of the eye.

The receptor cells are far more sensitive to some wavelengths, or colors, of light than to others. They are most sensitive to yellow or yellow-green, less to blue and orange and least sensitive to red [*see chart on page 120*]. A beam of red light must be made 600 times more intense than one of yellow-green light to elicit the same rate of nerve impulses from an average ommatidium of the horseshoe crab's eye.

The eyes of all vertebrates, and of many invertebrates, have much the same pattern of sensitivity. It is a striking fact, and in all likelihood no coincidence, that the color to which their eyes are most sensitive is the same as the color from the spectrum of sunlight that penetrates deepest into sea water. Our sensitivity to the yellow-green presumably is a chemical heritage from our remote ancestors in the ocean, where the animal eye originally evolved.

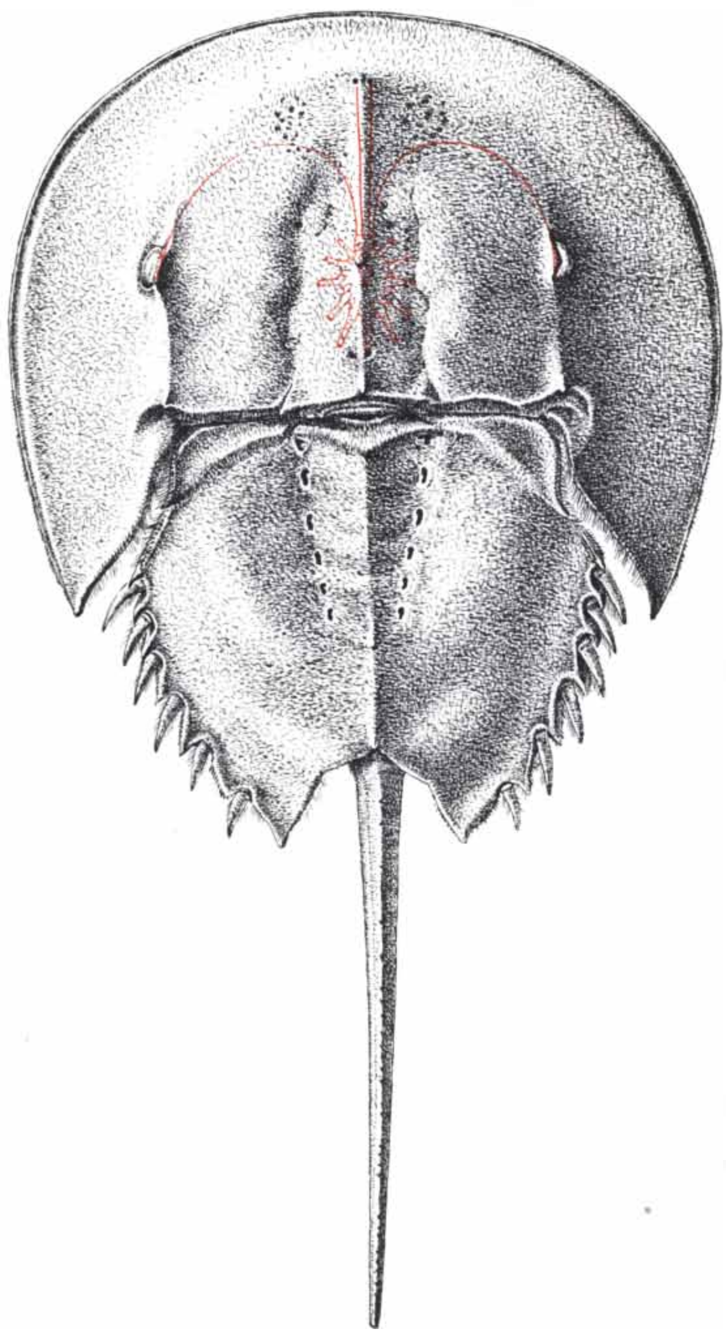
If the messages to the brain from the receptor cells in the eye consist merely of nerve impulses, how can the brain distinguish colors? How can it tell, for example, whether a given rate of impulses represents stimulation by faint green light or by intense red light? This



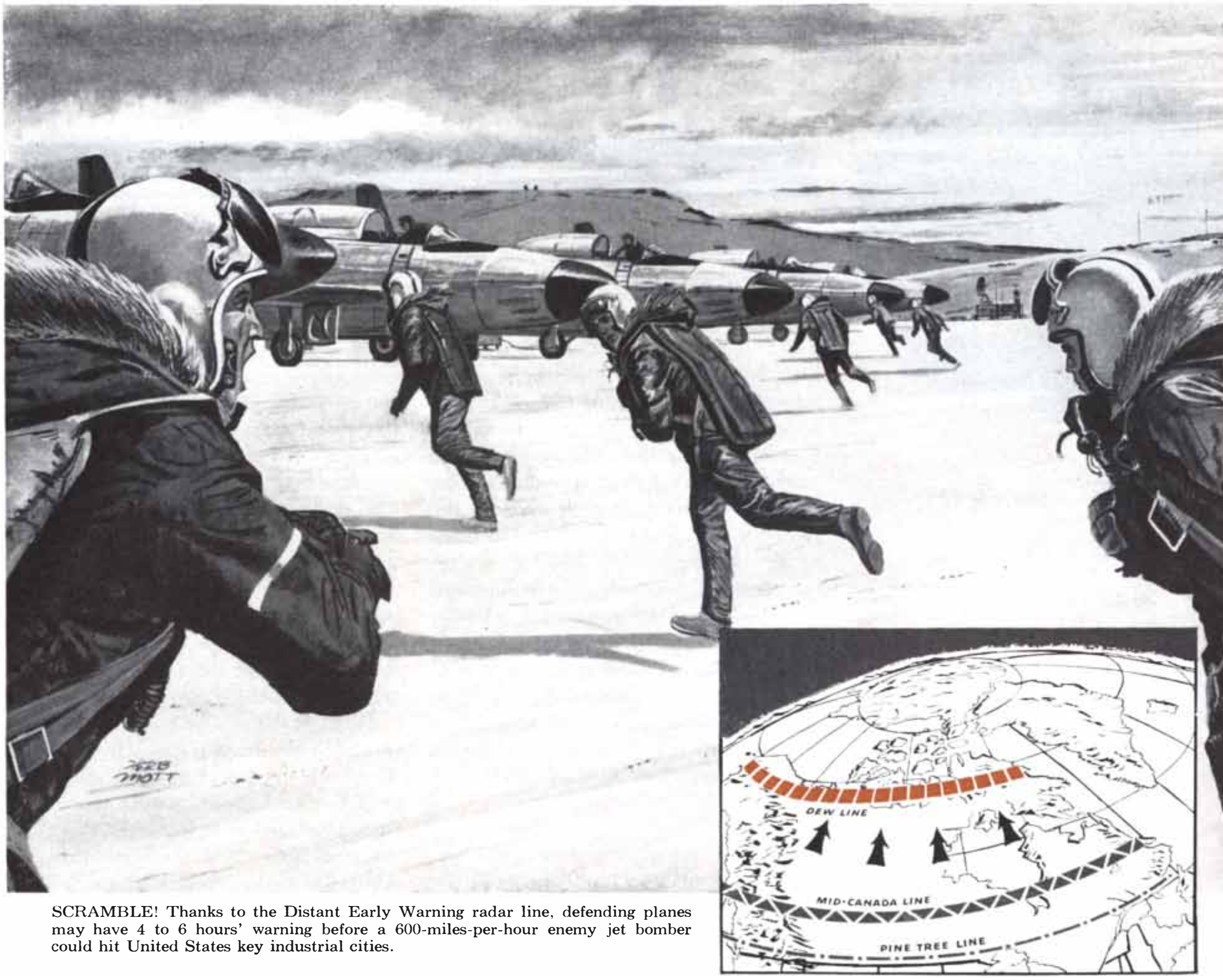
A nerve fiber leading to one of its ommatidia (*color*) is dissected out and attached to two electrodes. The electrical component of the nerve impulse may then be amplified. A continuous light stimulus produces a series of impulses (*oscillograph trace at right*).

is, indeed, a still unsolved question. The horseshoe crab seems to be completely color-blind. But it possesses what may be a rudimentary basis for the evolution toward color vision. Some of its ommatidia are slightly more sensitive to the blue end of the spectrum than the average, some to the red end. This indicates an evolutionary specialization of the retina's receptor cells. The most plausible explanation of our own color vision is that we have completed the specialization. We know that the rod cells in our retina, the cells most effective in the dark, are color-blind. But various experiments support the idea that the cone cells may have color specialization—one type being more sensitive to the blue end of the spectrum, a second type to the red end and the third type to the middle region. If this is true, we may assume that each type sends messages to the brain by a separate pathway and that the brain is able to correlate and interpret the messages to register colors.

Our rod cells are comparatively blind to red light. Since they are stimulated



OPTIC NERVES of the horseshoe crab are traced in color. The colored structure in the center is the brain. The compound eyes are at left and right; the simple eyes, at the top.



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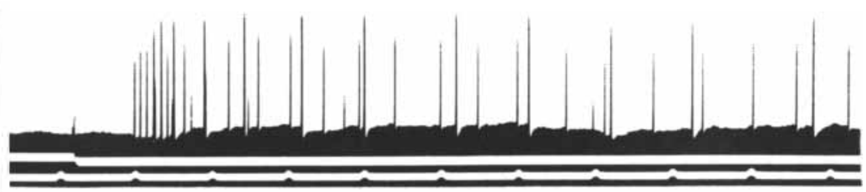
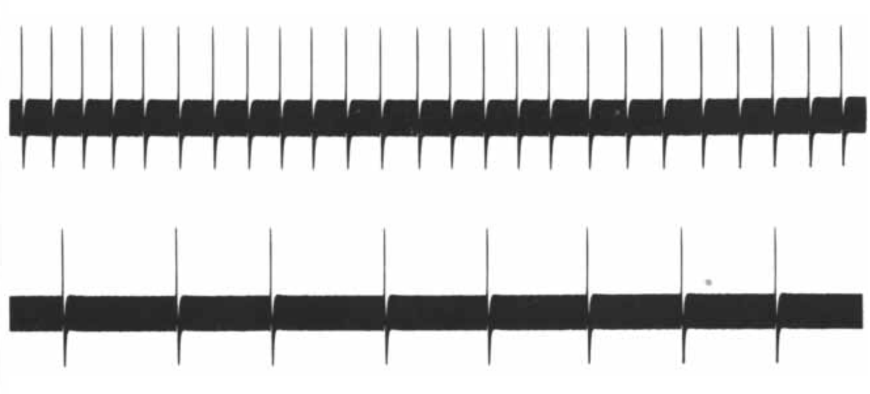


THREE FIBERS in the optic nerve of a horseshoe crab produced this record. Each spike is an impulse. Each fiber produces a spike of characteristic height. By dissecting the nerve while it is producing a record, the experimenter can tell when only a single fiber remains.

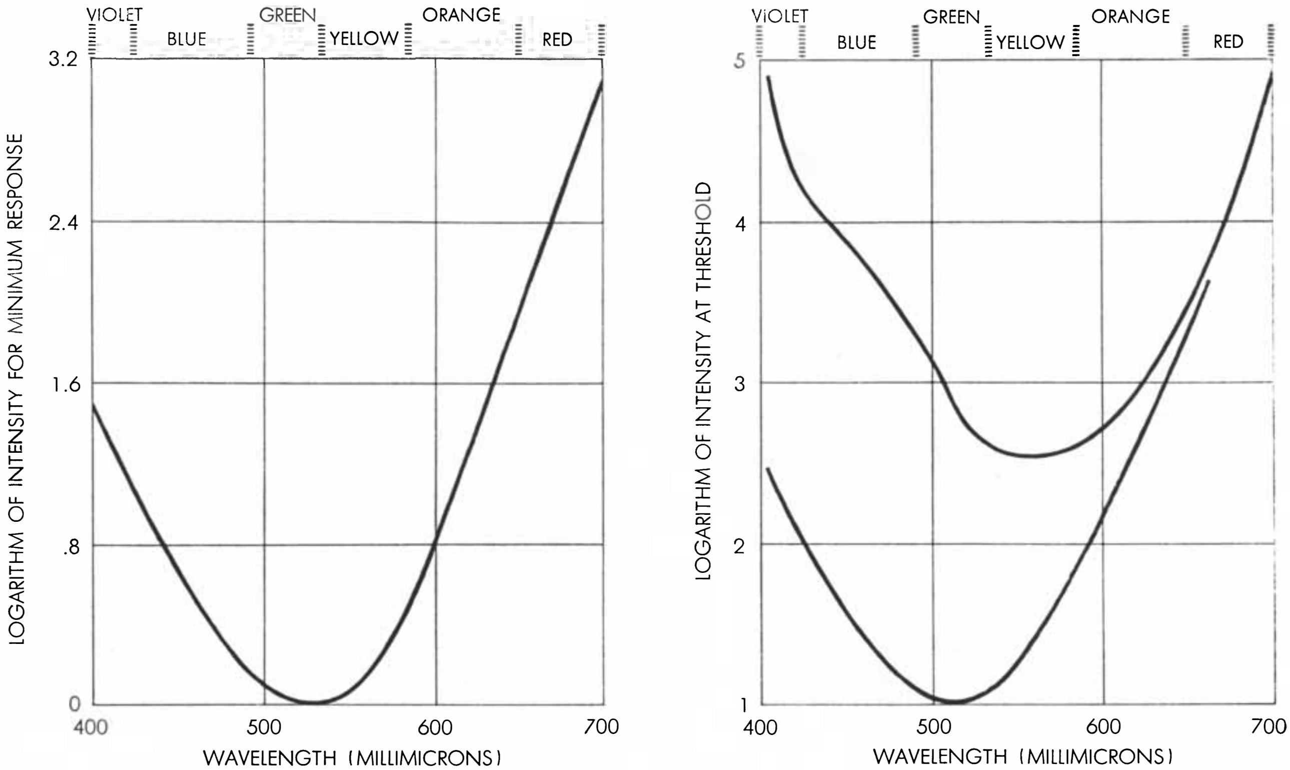
little or not at all by a red light of low intensity, the eye is able to look at such light without losing its dark adaptation, for the rods are the cells we use to see when the illumination is dimmer than moonlight. Our cone cells can see the red light and identify its color. The practical advantages were known, though the physiological reasons were not, when red was chosen as the warning color for railroad signal lights, automobile taillights and so on. During World War II the physiological knowledge was deliberately put to use in red lighting for airplane instrument panels and for posts where lookouts had to retain their dark adaptation.

The first event in vision is the absorption of light by pigments in the light-sensitive cells of the retina. This absorption triggers a complex series of chemical processes which lead to the production of electrical potential and nerve impulses. The chemistry of vision is a big subject outside the scope of this article [see "Eye and Camera," by George Wald; Scientific American, August, 1950], but we do want to mention an aspect of its relation to adaptation of the eye. A brilliant flash, *e.g.*, lightning, may produce a sensation of painful brightness, but it does not significantly impair the eye's adaptation to the dark. The chemical mechanism that has generated a burst of nerve impulses promptly recovers from the brief stimulation and subsides. On the other hand, any prolonged illumination, even at a low level, alters the balance of the chemical system in a way that destroys dark adaptation. The dim lighting on an automobile instrument panel does more to ruin dark adaptation than the brightest flash, or even the headlights of an occasional approaching car.

What is the smallest amount of light to which the human eye will respond? The late Selig Hecht and his co-workers at Columbia University obtained an approximate answer to this question. They directed flashes of variable intensity toward the highly sensitive rod cells of subjects whose eyes were fully adapted to the dark. Hecht calculated that at a threshold intensity (when the subject reported seeing 50 per cent of the flashes) the amount of light from a flash arriving at the eye was some 150 quanta. Allowing for reflection of some of these quanta by the moist cornea and for other losses within the eye, he estimated that about 24 quanta reached the sensitive cells of the retina, and that between 5 and 14 of these were absorbed by the cells. Hecht therefore concluded



SINGLE FIBER gave rise to these two records. A light stimulus of constant intensity produced the record at the top; a constant stimulus of lesser intensity, the record at the bottom. Impulses from a specific cell in the eye that is stimulated are always the same; only the rate of delivery of impulses to the nerve changes when the intensity of the stimulus is changed.

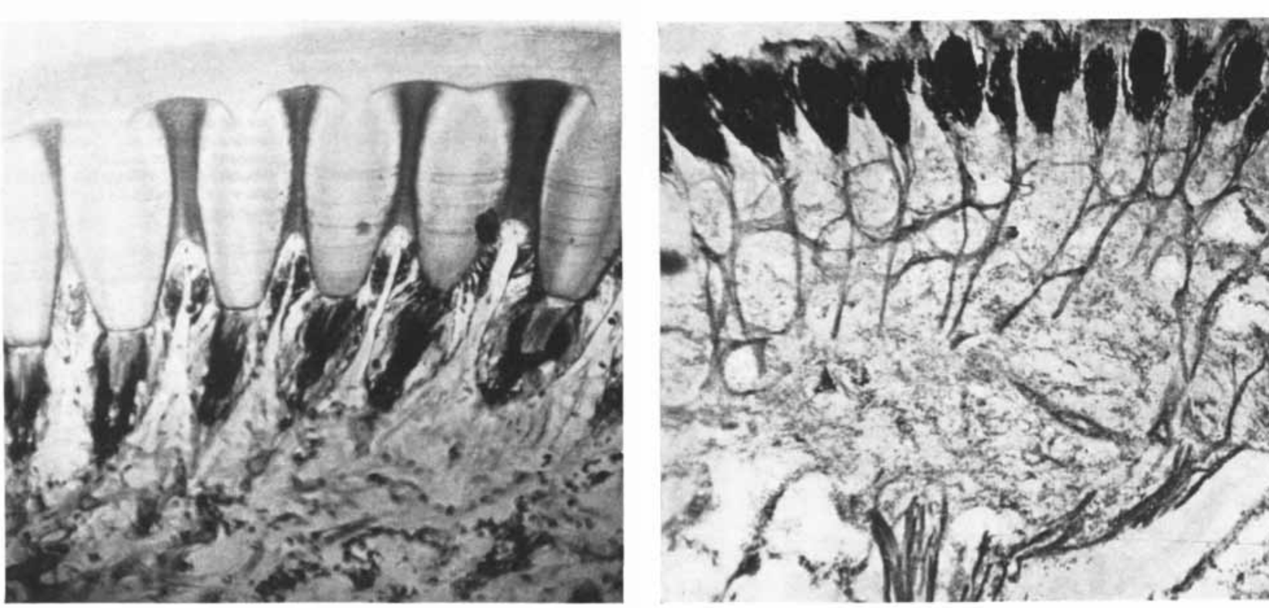


THRESHOLD OF RESPONSE to light of various colors is plotted for horseshoe crab (*left*) and man (*right*). The lower curve in the diagram for man is for rod vision, which is color-blind. The top curve is for cone vision, which discriminates between colors.

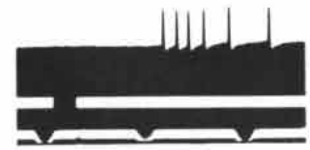
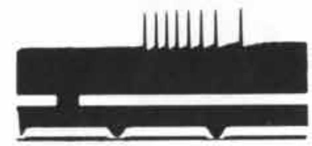
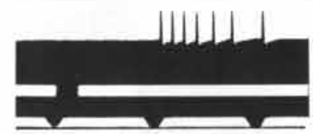
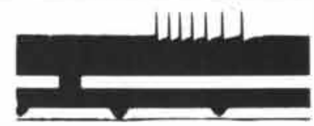
that 5 to 14 quanta, absorbed within a fifth of a second, was the lower limit of the eye's sensitivity. Other investigators, arguing that Hecht overestimated the absorptive ability of the cell pigments, have proposed that the eye is stimulated by as few as two to six quanta.

Hartline repeated Hecht's experiment in his own laboratory, applying it to ommatidia of the horseshoe crab's eye. The results matched those for the human eye amazingly well. Apparently the light-sensitive cells of the horseshoe crab, like the rods of a human eye, respond to just a few quanta of energy.

If two or three quanta of light can evoke nerve impulses and the sensation of sight, then the eye indeed approaches the ultimate in sensitivity. But this finding brings up an even more interesting question. Presumably each absorbed quantum of light energy alters one pigment molecule. If the alteration of two or three molecules produces a message,

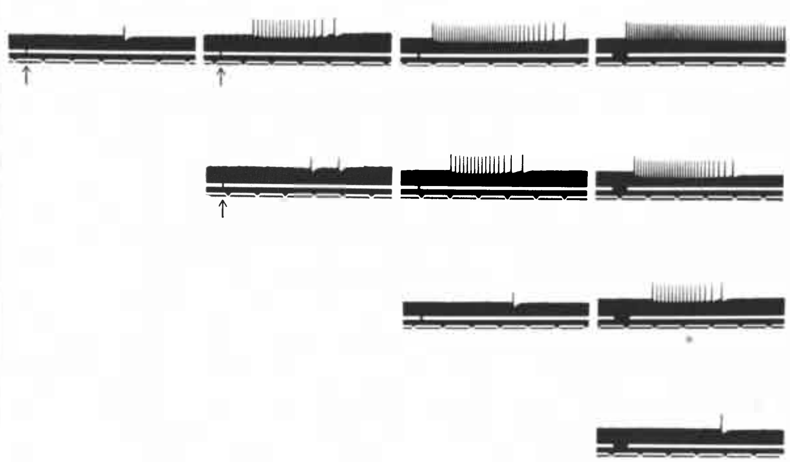


OMMATIDIA of the horseshoe crab are photographed. In the photomicrograph at left the cornea is at the top; the ommatidia are the carrot-shaped objects. In the photomicrograph at right the cornea has been removed and the section stained to show the nerve fibers.

COLOR SEEN BY MAN	WAVE LENGTH (MILLIMICRONS)	INTENSITY	ACTUAL RECORD
RED	690	690	
YELLOWISH ORANGE	610	9.6	
GREENISH YELLOW	530	1.0	
BLUE	440	6.7	

EFFICIENCY OF RESPONSE of ommatidia is affected by color of light. This chart shows the intensity of various colors required to produce similar impulses in an optic nerve fiber.

why is not a change in one molecule effective? Apparently we must look to the center of judgment on vision in the brain. Hecht used to remark that any molecule which could be broken down by a quantum of light must be precariously close to instability. Once in a while such a molecule might break down of its own accord. The brain may therefore dismiss a single impulse from a light-sensitive cell as fortuitous. But if two or three or four signals arrive from this center in the retina within a fifth of a second, the brain knows they are no accident—the eye must be responding to light.



DURATION AND INTENSITY OF LIGHT reciprocally affect the response of ommatidia. A weak flash lasting a tenth of a second produces the same response (*bottom right*) as a flash 1,000 times as bright with a duration of only a ten-thousandth of a second (*top left*).

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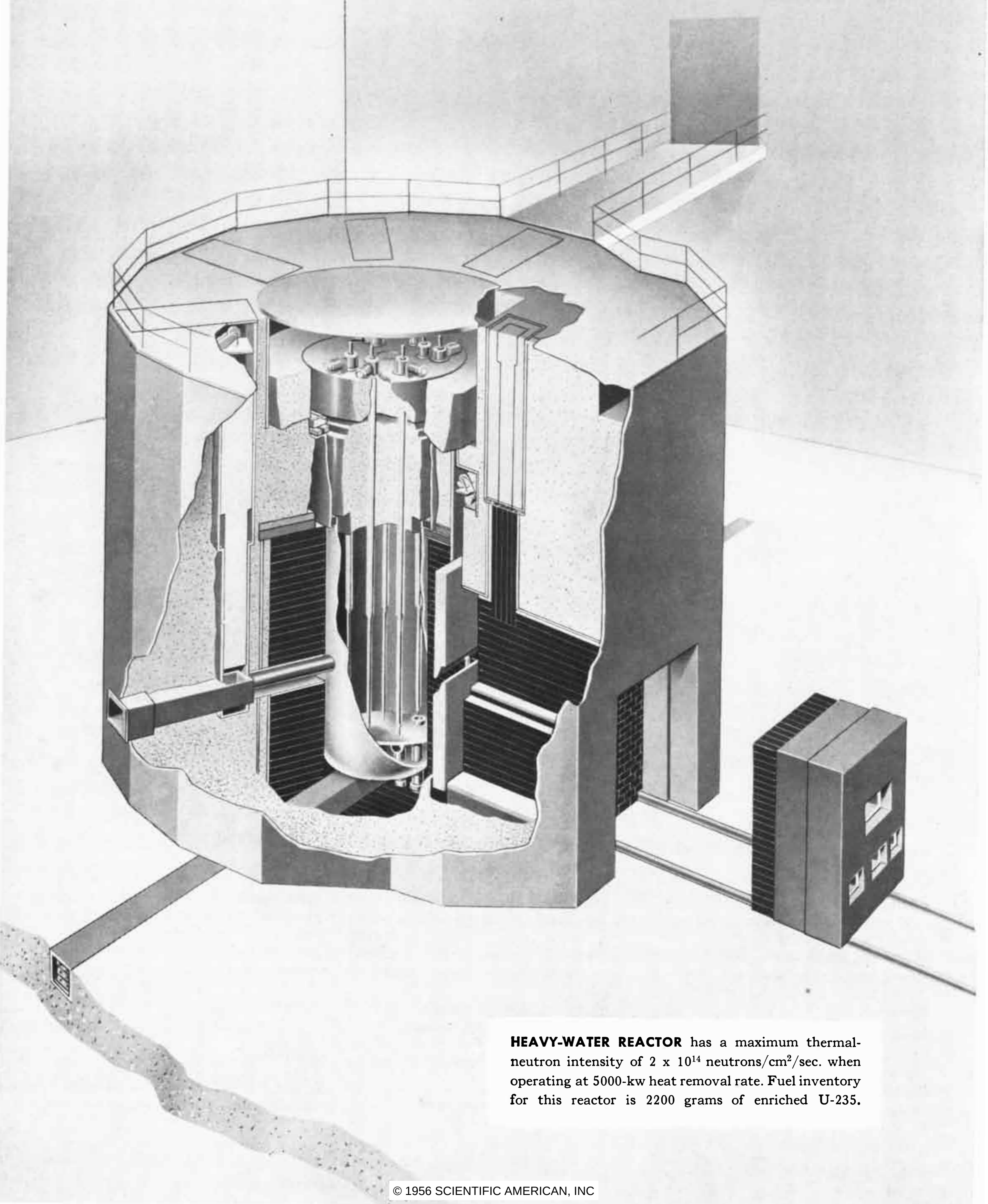

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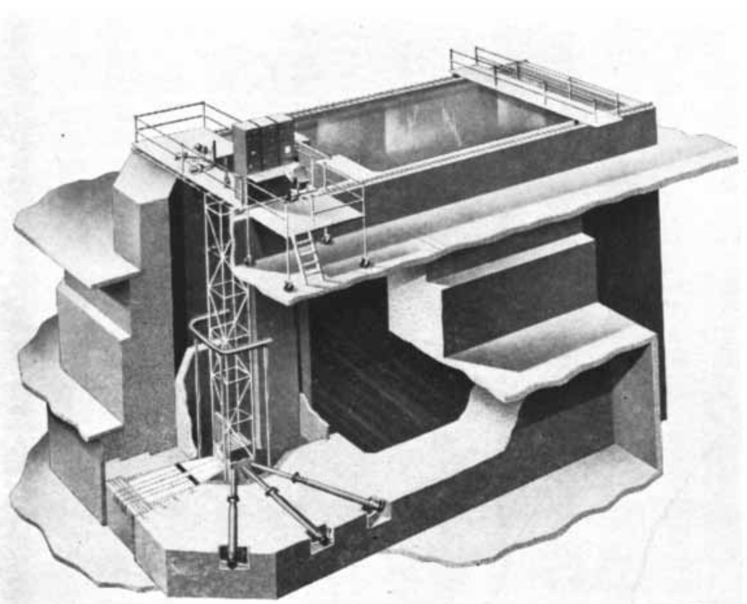

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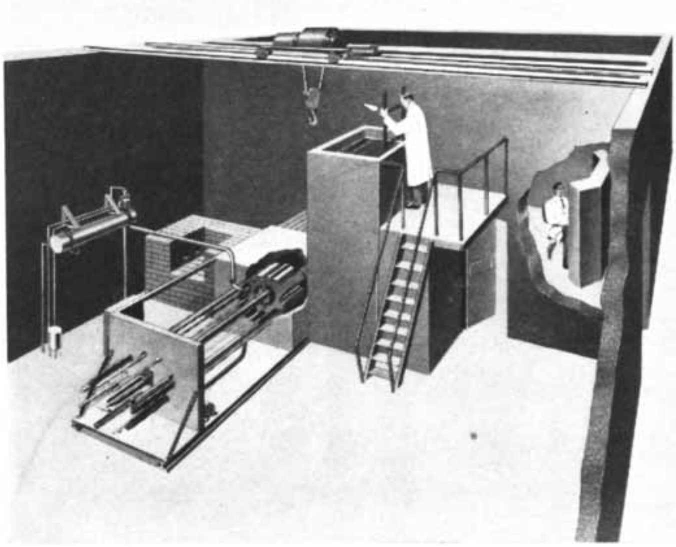

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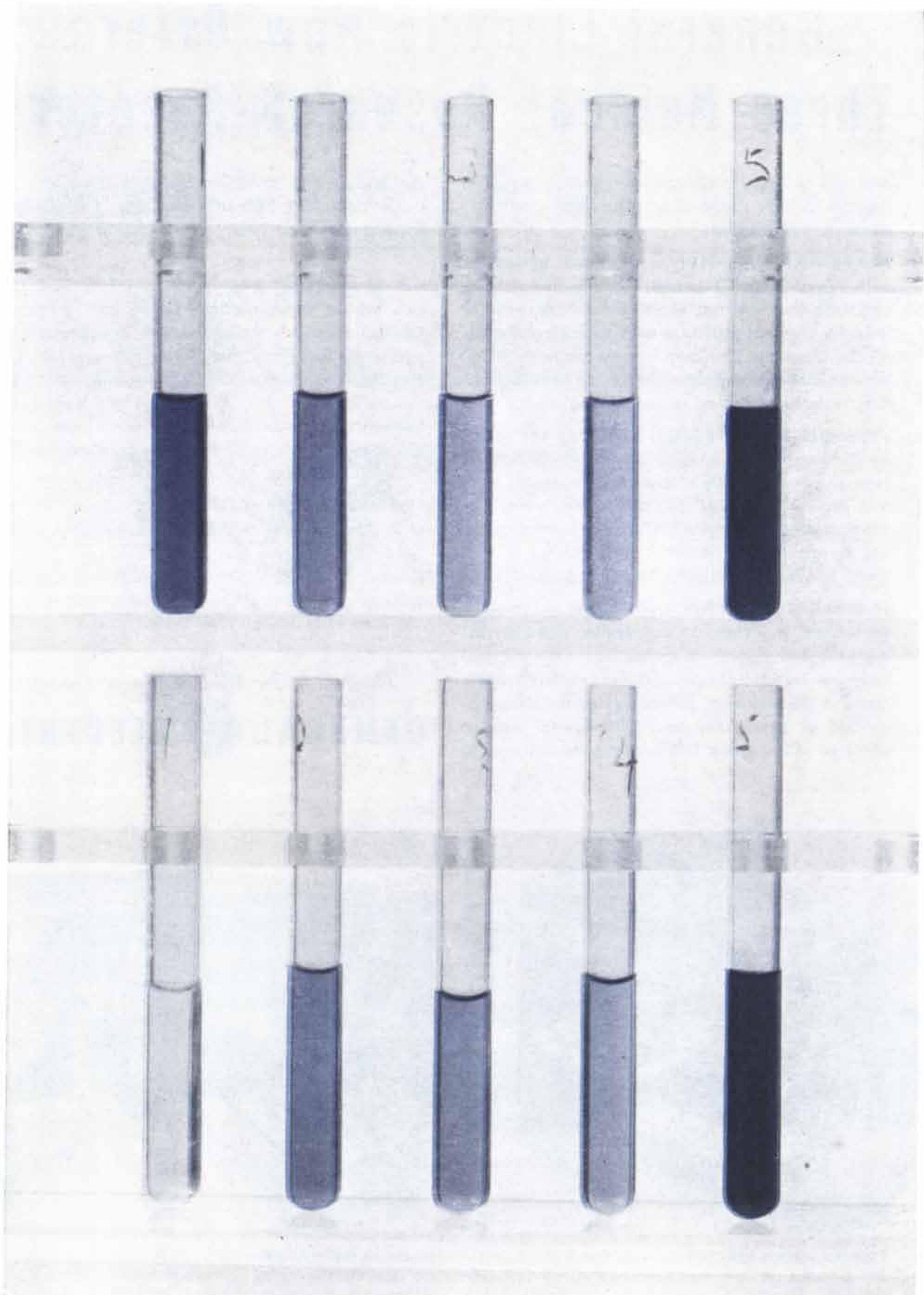

The Chemistry of Hereditary Disease

Several comparatively rare disorders are caused by inherited defects of metabolism. A description of how certain of these defects were discovered and how they produce their symptoms

by A. G. Bearn

Just over 50 years ago Archibald Garrod, a physician at the Hospital for Sick Children in London, read a historic paper to the Medico Chirurgical Society. His paper, on the face of it, could hardly have been duller, and it could not have been very exciting to the 28 staid London practitioners who formed his audience. It was a discussion of certain chemical constituents of urine. Dr. Garrod had been studying cases of the disease known as alkaptonuria, in which the patients excreted "black urine." The black color was due to the presence of a substance known as homogentisic acid, an intermediate product of the metabolism of the amino acid phenylalanine. Normally this product is broken down further in the body and does not appear in the urine, but patients with alkaptonuria seemed to be incapable of converting homogentisic acid to further products. Garrod, considering this defect in metabolism, called it a "chemical sport."

His insight initiated the modern study of the chemistry of human genetics. Pursuing his interest in the odd and incurable disease of alkaptonuria, Garrod noticed that it tended to run in families and was particularly apt to appear in children of cousin marriages in these families. He conveyed this information to his good friend William Bateson, who was one of the pioneers in rediscovering and extending the Mendelian laws of genetics at the turn of the century. Bateson pointed out that the black urine disease could easily be explained on the basis of a defective gene, which made its effects felt only when a child inherited the defective form from both parents. The double dose of the abnormal gene would prevent the body from completing the usual breakdown of phenylalanine, stopping the conversion sequence at homogentisic acid.

This hypothesis greatly appealed to Garrod, and he elaborated on it in 1908 when he was invited to deliver the Croonian Lectures to the Royal College of Physicians. Describing a number of "inborn errors of metabolism" he had collected, Garrod proposed the idea that genes were responsible for "chemical individuality" as well as for the obvious bodily distinctiveness of species. He postulated further that the most likely mode of action of a gene was the chemical control of a biochemical reaction.

A possible explanation for the finding of homogentisic acid in the urine of the alkaptonuria patients now clearly presented itself. One could suppose that there is a normal gene which causes the body to produce an enzyme that converts homogentisic acid to the next product (fumarylacetoacetic acid) in the usual sequence of metabolism of phenylalanine. This transformation is not blocked if a person inherits an abnormal gene from one parent. But if he receives the abnormal forms of the gene from both parents, he cannot convert homogentisic acid.

The idea that a single gene may control the making of a single enzyme was confirmed and developed many years later by George Beadle and E. L. Tatum in their elegant experiments on the red bread mold *Neurospora* [see "The Genes of Men and Molds," by George W. Beadle; SCIENTIFIC AMERICAN, September, 1948]. They showed that certain genes control the synthesis of certain amino acids by the mold, and it loses the ability to make an amino acid if the responsible gene is damaged or otherwise defective.

During the last 20 years a great deal of work has been done on a "chemical sport" which illustrates how fruitful the partnership of genetics and biochemistry can be in solving some mysterious diseases of mankind. In 1934 Asbjorn Folling, a Norwegian physician, noticed that certain mentally defective children excreted in their urine a substance known as phenylpyruvic acid. A year after recognition of this disorder by Folling, Lionel Penrose in England studied a family afflicted with it. Two first-cousin marriages in this family had each borne two female idiots, though the parents were apparently normal. This suggested strongly that a recessive gene was responsible for the abnormality. But Penrose found indications that the recessive gene may occasionally make itself felt even in a single dose, for the father and the grandfather of one of the idiot offspring developed mental defectiveness later in life.

The chemical defect has been thoroughly investigated and clarified. Phenylpyruvic acid, found in the urine of patients with this disease, is a product

AGAMMAGLOBULINEMIA, the disease which is characterized by the absence of the gamma globulin fraction of the blood proteins, is illustrated by the test tubes on the opposite page. The tubes in the top row contain the five fractions of normal blood serum: gamma globulin (*left*), beta globulin (*second from left*), alpha-two globulin (*third*), alpha-one globulin (*fourth*) and albumin (*fifth*). The blue color of the fractions is due to a reagent added after separation; its density indicates their concentration. The tubes in the bottom row contain the corresponding fractions of serum from an individual suffering from agammaglobulinemia. The solution in the first tube is almost colorless, indicating that the gamma globulin fraction is virtually absent.

from the amino acid phenylalanine. The patients were found to have an unusually high concentration of phenylalanine in their blood. Normally the body converts it to a slightly different amino acid, tyrosine, by the action of a liver enzyme, phenylalanine oxidase. George Jervis of Letchworth Village in New York was able to show that the imbecilic patients apparently lack this enzyme. A piece of liver from a normal person converted phenylalanine to tyrosine, but a piece of liver from a patient who had died of the disease failed to do so.

All this suggested that the disease might be treated by depriving the patients of phenylalanine, the source of their biochemical difficulties. But phenylalanine is present in all the proteins we eat. A synthetic diet was devised which included the necessary proteins but had the phenylalanine removed. The patients' response to this diet was dramatic. The level of phenylalanine in their blood fell rapidly to normal, the abnormal chemical constituents in their urine disappeared, and, even more striking, they recovered something approaching normal mentality. Slowly their mental performance improved, their convulsions stopped and their electroencephalograms showed normal brain waves. When they were given test feedings of phenylalanine, they promptly relapsed in every respect. Whether deprivation of phenylalanine will permit these young patients to grow and develop normally, only time will tell. Some have been on the synthetic diet for nearly two years without the development of any untoward reactions.

In the past few years physicians have been greatly interested in another hereditary disturbance in human metabolism. Ogden Bruton at the Walter Reed Army Hospital in Washington examined some children who were extraordinarily vulnerable to bacterial infections. He surmised that these patients might lack the ability to manufacture antibodies. An analysis of their serum soon showed that he was right. The serum lacked gamma globulins—the fraction known to contain antibodies. When gamma globulins were injected intravenously into these patients, they were not broken down at an abnormally rapid rate; this showed that the patients' usual lack of globulins was due to a failure to synthesize them, rather than to too-rapid destruction of them by the body.

As more cases were recognized, it became apparent that the defect ran in families. The disease, called agammaglobulinemia, seems to be restricted to

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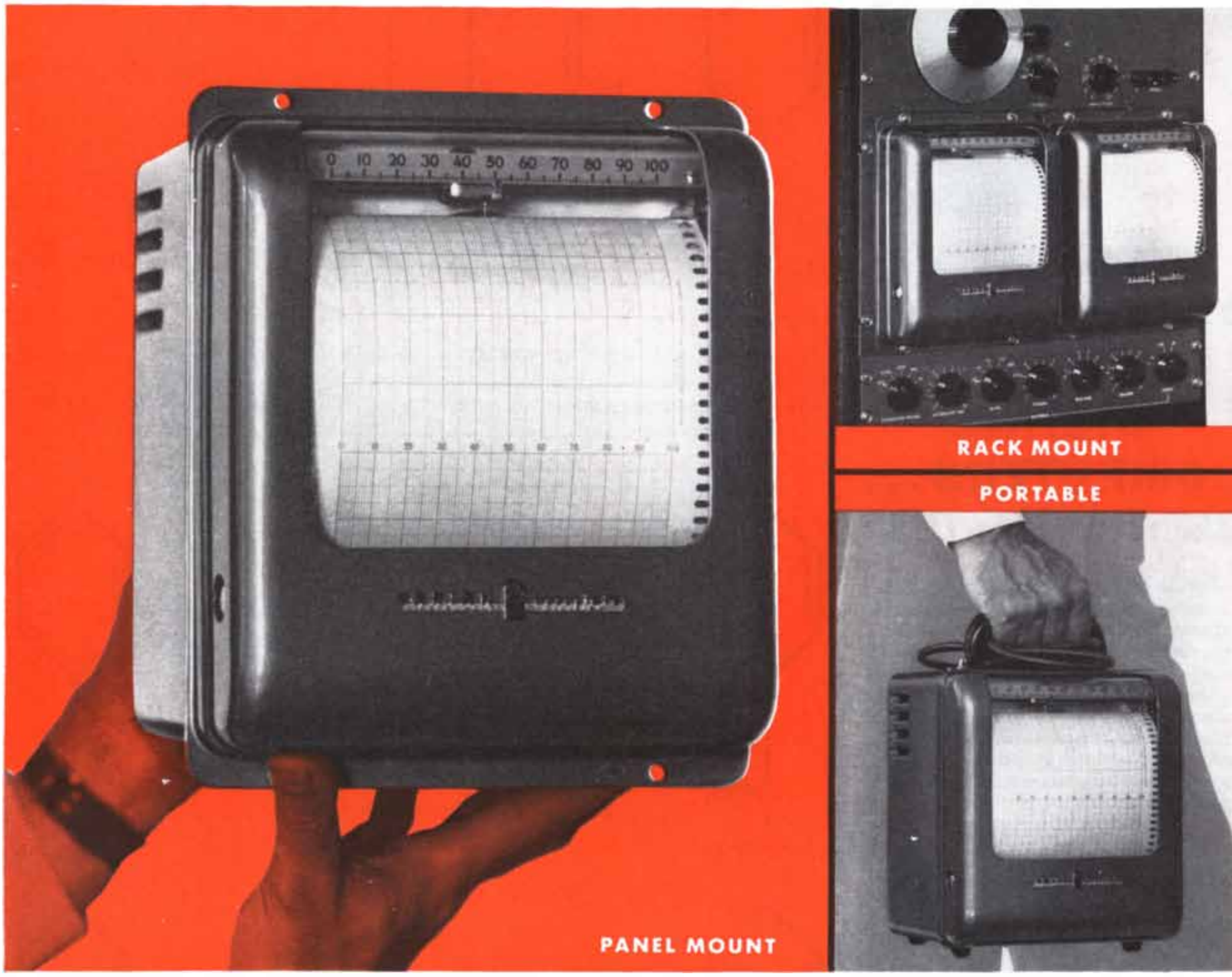

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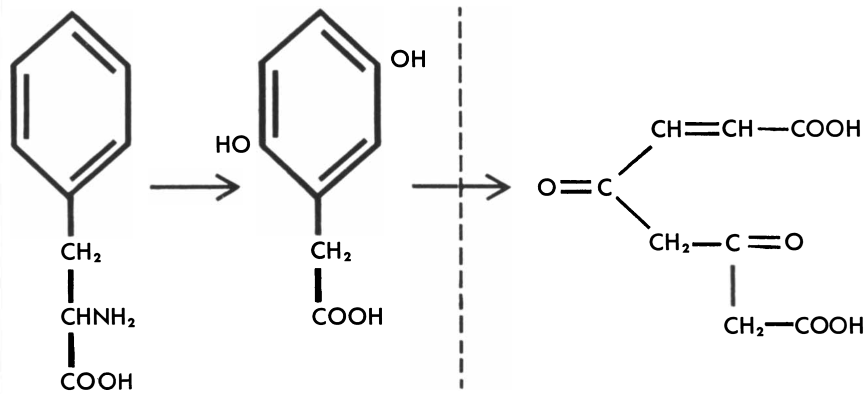
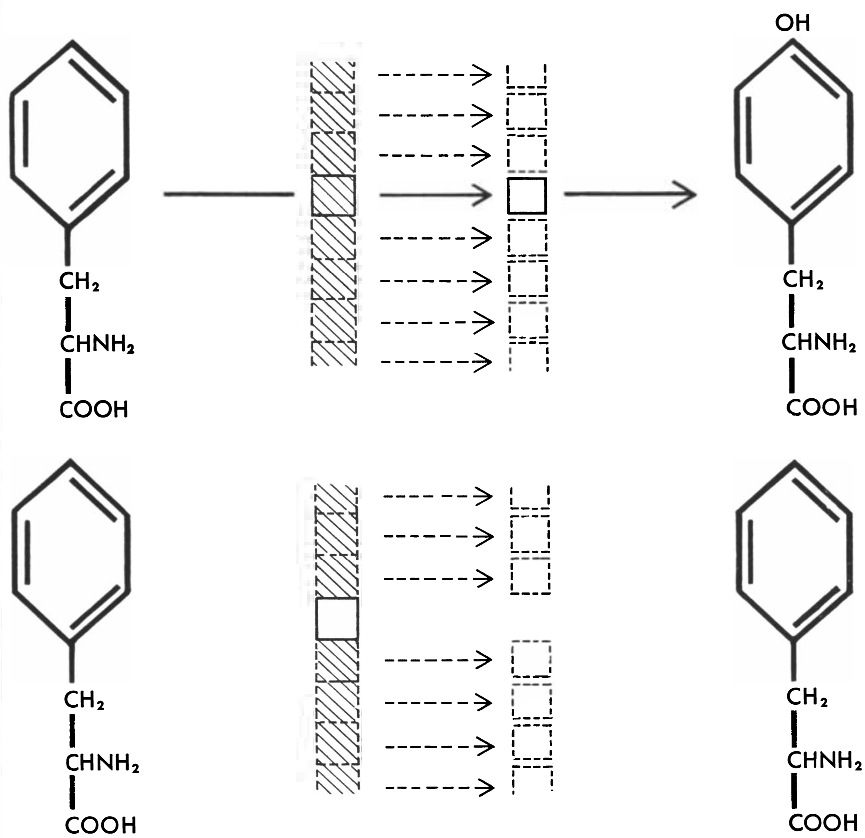
males, and probably is inherited as a sex-linked recessive trait. This means that the abnormal gene responsible for the defective synthesis of gamma globulin is on the unpaired part of the X chromosome. The well-known bleeding disease, hemophilia, is inherited in this way.

Robert A. Good and his collaborators in Minneapolis have demonstrated that patients with this defective gene are unresponsive to antigens of many other kinds. For instance, a patient with agammaglobulinemia fails to distinguish between blood groups A and B, and can



ALKAPTONURIA, which is characterized by black urine, is caused by a defect in the metabolism of the amino acid phenylalanine (*left*). In normal metabolism phenylalanine is converted into homogentisic acid (*middle*) and then into fumarylacetoacetic acid (*right*). In alkaptonurics the latter step is blocked. Homogentisic acid blackens the urine.



ONE GENE–ONE ENZYME HYPOTHESIS is depicted in the case of the mental-deficiency disease phenylpyruvic oligophrenia. In normal metabolism phenylalanine (*formula at upper left*) is converted into the amino acid tyrosine (*formula at upper right*). The squares in the column at left between the two formulas represent genes in linear order. The squares in the column at right represent enzymes. In normal metabolism a single gene (*crosshatched solid square*) presumably directs the synthesis of a single enzyme (*open solid square*) which catalyzes the conversion of phenylalanine into tyrosine. In individuals with phenylpyruvic oligophrenia the gene fails to direct the synthesis of the enzyme (*bottom of diagram*).

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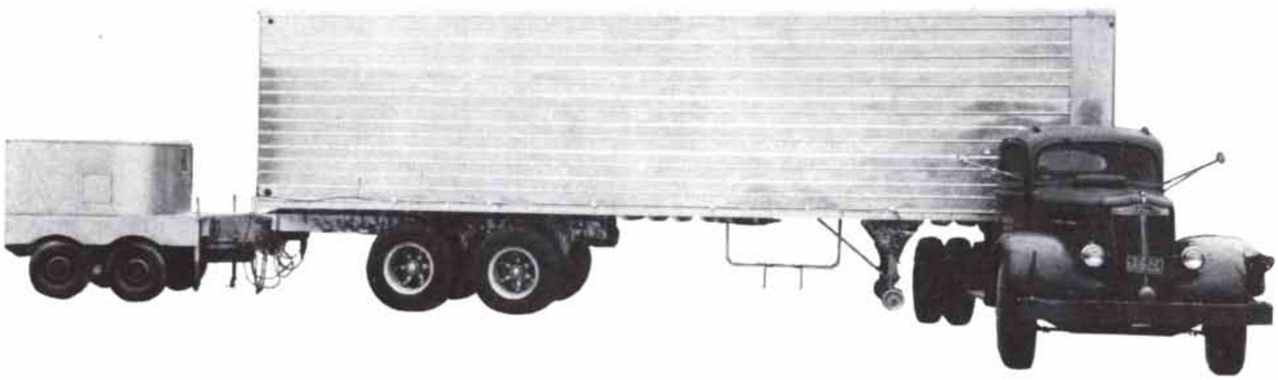

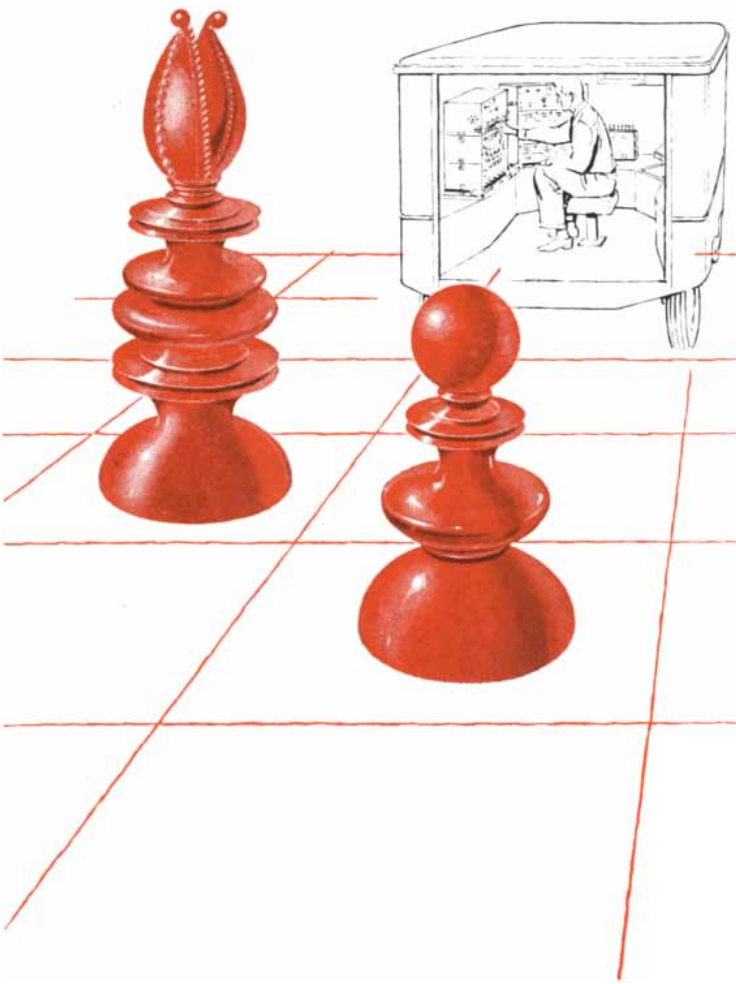

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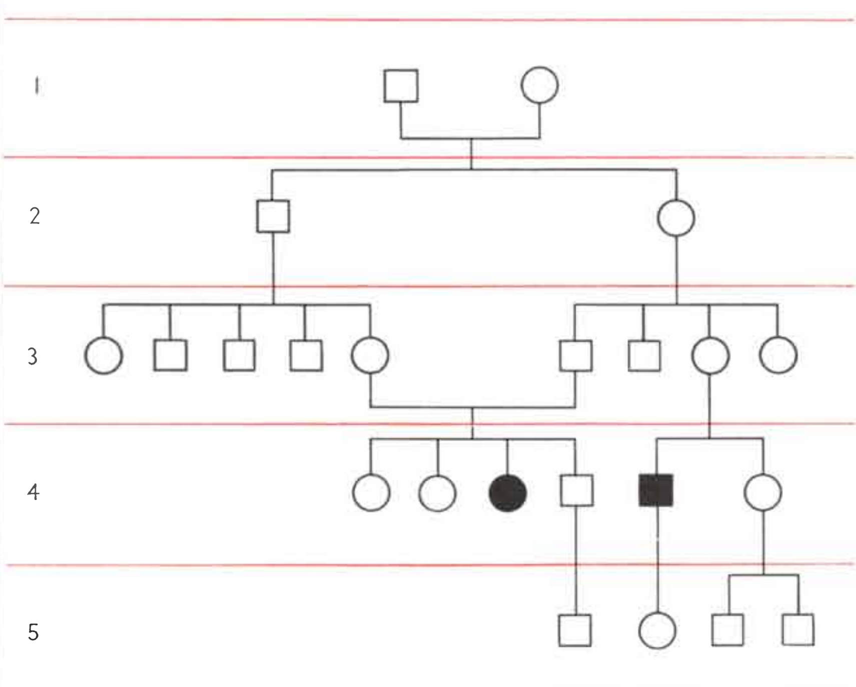
NATIONWIDE COMPANY-OWNED SALES & SERVICE OFFICES safely be transfused with a blood type different from his own. Good made the intriguing discovery that such a patient can even accept skin grafts from another person, because he does not react against the foreign tissue by manufacturing antibodies, as people normally do.

A single biochemical defect may have wide repercussions in the body. Such a condition is exemplified by Wilson's disease, a rare neurological disorder first described with great clarity by Kinnier Wilson in a classic monograph in 1912. The disease is characterized by degeneration of the liver and of that part of the brain concerned with the coordination of muscle movements. Unfortunately, in spite of the clarity of his clinical description, the cause of the disease remained obscure and the prospects for treatment gloomy. But in 1940 there came a break in the darkness so unexpected that it would have delighted the Princes of Serendip themselves.

A group at Oxford University, investigating multiple sclerosis, decided to look into the possibility that the disease might arise from a defect in the metabolism of copper. Such a defect was known to be responsible for a disease of sheep, resembling multiple sclerosis in man. The investigators were unable to find any evidence that patients with multiple sclerosis had a defect in copper metabolism. But they came upon something else. As in all properly conducted experiments, they had included control patients for comparison. Their controls were persons with neurological diseases other than multiple sclerosis, and one of them happened to be a sufferer from Wilson's disease. This patient was found to possess the metabolic defect they had failed to find in multiple sclerosis: he excreted a considerable quantity of copper in the urine.

Research on Wilson's disease increased abruptly. Paradoxically, it was discovered that patients with the disease had comparatively little copper circulating in their blood, and they also had an abnormally low concentration of a serum copper protein, called ceruloplasmin because it is blue in the purified state. As a result of this inability to synthesize ceruloplasmin, the copper in the food of these patients is taken up instead by serum albumin. It is bound only loosely to the albumin and is readily deposited in the tissues, particularly the liver, brain and kidneys. There it probably interferes with essential enzyme systems.

A study of the occurrence of Wilson's disease in families showed that it is in-



PEDIGREE of first cousins suffering from Wilson's disease suggests that the disease (*black symbols*) is caused by a recessive gene. The males are represented by squares; the females, by circles; the generations, by numbers. No member of the first, second or third generation suffered from the disease. Two cousins in the third generation married; one of their female offspring developed the disease, strongly suggesting that she had inherited a recessive gene for the disease from each of her parents. A male second cousin in the same generation suffered from the disease almost certainly because he carried one recessive gene from the same forebear and another recessive gene from his father (*not shown*).

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herited as a recessive trait. Only persons with a double dose of the abnormal inheritance (from both parents) suffer from the disease.

Another particularly interesting disorder of protein metabolism was discovered by a Japanese physician, Shigeo Takahara of Okayama. He was treating a little girl of 11 who had suffered from chronic ulceration of the gums since the age of 8. The ulceration had eroded the gums around the tooth sockets so badly that many teeth were loosened. After one of the teeth was extracted, a tumorous, ulcerated mass grew up into the right nostril. It was removed, and after the surgery the customary hydrogen peroxide was applied to the cavity as a disinfectant. The tissues promptly turned black! Takahara at first assumed that he had accidentally used silver nitrate instead of peroxide, but when he applied hydrogen peroxide about whose identity there could be no mistake, the tissues again went black.

The mother and father of this child were first cousins. They had five children, of whom two others had gum ulcers like those of the little girl. Takahara examined the blood of all five children. He found that peroxide blackened the blood of the two ulcerous siblings and of one of the children who appeared normal. The blood of these children did not cause peroxide to release oxygen, as normal blood does. Takahara then determined that their blood lacked a specific enzyme, catalase, which decomposes hydrogen peroxide.

Why did the lack of catalase make these patients susceptible to bacterial infection? Takahara recovered from the nasal and oral cavities of these patients considerable amounts of hemolytic streptococci, organisms which are known to generate peroxide. He reasoned that in the absence of peroxide-destroying catalase, this peroxide oxidizes the red hemoglobin in the red blood cells to a blackish form called methemoglobin. As a result of this removal of oxygen from the hemoglobin, the tissues may suffer from a relative oxygen deficiency—precisely the right condition for multiplication of the bacteria. But the hypothesis has not yet been conclusively established.

Hereditary disturbances of metabolism are by no means limited to amino acids and proteins. There is, for example, a recessively inherited disease of young children involving sugar. They appear to be unable to metabolize the form of sugar in milk, called galactose. This sugar accumulates in the blood and

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In a series of elegant experiments during the past year Herman Kalckar and his collaborators at the National Institutes of Health in Bethesda have been able to pin down the biochemical defect in this disease. It arises from deficiency of an enzyme called P Gal Transferase, which is required to convert a galactose phosphate to a glucose phosphate in the red blood cells and the liver (galactose differs from glucose very slightly). While the overt disease occurs only when the victim has a double dose of the abnormal gene responsible for this deficiency, the parents, who have only a single defective gene, also show some abnormality in handling galactose. When it is fed to them, their blood galactose level remains high for an unusually long time.

This disease is an extraordinary case in which mother's milk is not "best" but actually lethal. When galactose is excluded from the diet of these children, they promptly recover from their symptoms of illness and their mental condition slowly improves. It may be that if the condition can be recognized and the children placed on a galactose-free diet early enough, the illness and mental retardation of victims of this defect can be entirely avoided.

The biochemical approach to human genetics that was launched by the pioneering work of Garrod 50 years ago has brought enlightenment on many disorders of mankind, only a few of which could be discussed in this article. Among the others are certain anemias, disorders in blood clotting and a condition in which the infection-fighting white blood cells fail to develop. Perhaps the most exciting discovery has been that even a hereditary disease can be treated effectively once the nature of the biochemical defect is understood. Deficiencies of specific proteins, including gamma globulin and a special globulin needed by hemophiliacs, can be made good. Phenylalanine or galactose can be excluded from the diet of those who cannot metabolize it normally, and these simple remedies can restore physical and mental health to idiots and imbeciles. Who knows how many patients in mental institutions might be restored to complete health by the recognition and treatment of a hidden biochemical defect?

U. S. Army Photo

AA Fire Control System T50 mounted on "Duster", the Army's twin 40mm self-propelled vehicle M42. This is a major advance in control of fire for this weapon.

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The major operating organizations of Frankford are the Pitman-Dunn Laboratories Group, the Ammunition Group, the Gage Laboratory, and the Fire Control Instrument Group. The latter is a small arsenal in itself, consisting of research and development, industrial procurement and production, and field service elements. Working with weapons systems contractors in private industry, its scientists and engineers have been responsible for successful application of optical range finders to tanks, for the Skysweeper AA System and the AA Fire Control System M33. Today, Frankford maintains close relations with the Army Ballistic Missile Agency and Redstone Arsenal for the solution of guidance problems. Recently this group has applied radar ranging to the twin 40mm self-propelled light AA gun, the "Duster", enlarging this weapon's capabilities for dealing with high-speed, low flying aircraft.

That segment of industry interested in fire control instruments, ammunition components, and recoilless weapons relies for definition of the problem, and allocations of programs, on Frankford Arsenal, whose goal has been defined as Total Technical Teamwork.

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

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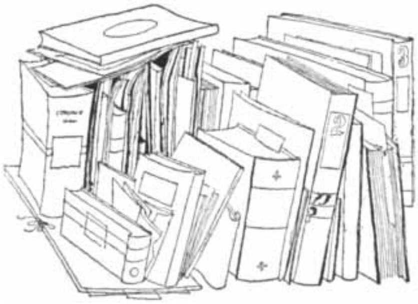

CHILDREN'S BOOKS

The annual Scientific American survey of books on science for young readers

by James R. Newman

These annual reports on science books for children represent selections from hundreds of books that have been read. To give something of a general view of what is being published for children in the name of science, the selections include some low points as well as the high ones. I want to direct particular attention to a few outstanding books that have appeared this year. In biology and natural history there are Bessie M. Hecht's excellent primer *All about Snakes; Penguins,* by Louis Darling; *Mankind against the Killers*, by James Hemming; *You and Your Senses*, by Leo Schneider; *Life in Fresh Water*, by E. S. Brown; and a delightful survey by Edward Osmond, *Animals of the World*. The physical sciences, as usual, are less richly served, but at least three books commend themselves. Irving Adler skillfully presents the rudiments of astronomy in *The Stars: Steppingstones into Space;* Isaac Asimov's *Inside the Atom* is a literate and better-than-average guide; John Scott Douglas' survey, *Caves of Mystery,* is an enjoyable introduction to speleology. Anyone interested in bridges, the handsomest and most elegant of human artifacts, will treasure Henry Billings' book on the subject, admirable both for its descriptions and its explanations of the theory of bridge construction. Maria Leach's *The Beginning: Creation Myths around the World,* is an absorbing collection of different people's conjectures as to how the world began. I cannot imagine a child who would not enjoy reading these stories or hearing them read. In the social sciences I recommend *Worlds without End,* a history of exploration, by Isabel Barclay; Patricia Lauber's *Battle against the Sea,* a stirring story about the gallant struggle of the Dutch to hold back the water from their small country; Marguerite Clément's charming and sensitive *In France,* an essay about the country and its people; and *Cave of Riches*, by Alan Honour, a very good young people's book on the Dead Sea Scrolls. My candidate for the most distinguished children's book of the year is Random House's *The Witchcraft of Salem Village,* by Shirley Jackson. I would not have believed it possible to tell this story so that children could appreciate its enduring importance and timeliness as well as the true dimensions of its horror. But Miss Jackson in a quiet-paced narrative loses none of the tremendous drama, while making its social lesson unforgettable. Finally, the year deserves to be celebrated for providing children in the middle grades of primary school with a really first-class dictionary, *Webster's Elementary*.

> **Editor's Note**
>
> The illustrations that accompany this article are not from the books reviewed here. They were made by Joseph Low.

Biography

Leonardo da Vinci, by Emily Hahn. Sequoyah: Leader of the Cherokees, by Alice Marriott. Balboa: Swordsman and Conquistador, by Felix Riesenberg, Jr. Random House ($1.50 each). Miss Hahn writes informatively about Leonardo for 12- or 13-year-olds. She keeps a fair balance between his artistic and scientific achievements, his paintings, sculpture, designs, inventions and prophecies. She does not swoon over the "Mona Lisa," and in general she achieves a nice, level tone in describing the life and work of a man whose greatness is so well established that plain talk about him is just what is needed in an introduction for children. Balboa, as is generally known, discovered the Pacific; apart from that he was the usual type of Spanish conquistador and soldier of fortune who infested the New World in the 16th century. Riesenberg makes him out to have been noble and kindly—which seems unlikely. (There is evidence that Balboa was not as brutal as his compatriots, but not much more can be said.) At any rate this is a smooth yarn for youngsters of 10 and up. A less spectacular figure was Sequoyah: he neither conquered nor plundered nor did he make any dramatic geographic discoveries. He is remembered for a quieter but vastly more important accomplishment. All alone he developed a true writing system, a syllabary by means of which the Cherokee people were able to read and write their language. There is no other comparable system of communication in the world invented by a single person. Miss Marriott's account, for children of 10 to 14, is cast in the familiar vein of fictionalized biography, which I usually find a bore. Her explanation of Sequoyah's work could be clearer, but she has written a moving story of a figure not too well known, and many children will enjoy her book.

Albert Schweitzer: Man of Mercy, by Jacquelyn Berrill. Dodd, Mead and Company ($3). Mrs. Berrill's latest book for high-school-age youngsters chronicles the life of the great organist, musicologist and biographer of Bach, who at the age of 30 turned from theology and music to the study of medicine, and, having qualified as a physician, went to Africa to establish a mission hospital at the jungle station of Lambaréné in the French Congo. His adventures and struggles, his gallant assault on ignorance, poverty and disease in a climate fit only for crocodiles and creepers, are ably described, as is his rise to almost legendary fame, capped by the award in 1952 of the Nobel peace prize. Schweitzer is obviously an admirable man, but for all his sensitivity, devotion to noble causes and "reverence for life," he seems curiously lacking—at least as he has been portrayed to us by his biographers—in what might be called ordinary human warmth. Mrs. Berrill is no more successful than other biographers in making you feel you have something in common with Albert Schweitzer.

American Women of Science, by Edna Yost. J. B. Lippincott Company ($3). A revised edition of a collection of short biographies of American women scientists. The group includes Annie Jump Cannon, astronomer; Libbie Hyman, zoologist; Katherine Blodgett, physicist; Florence Sabin, anatomist; Margaret Mead, anthropologist.

Biological Sciences

Animals of the World, by Edward Osmond. Oxford University Press ($2.25). What a rare and gratifying experience to come across a relaxed, simply written natural history primer, stuffed with just the right kind of information! This attractive little book for children 8 to 12 (in fact for anyone) has graceful illustrations by the author, an English artist, and a text which flows by itself. There are four main subjects: elephants, camels, polar bears and chimpanzees—a nice selection. Elephants, we are told, live in herds of 20 to 30. The herd is led by a cow, which is not as strong as the bulls but makes up this deficiency by being more cautious and therefore leading the herd more safely. Despite their enormous ears elephants do not hear very well, nor is their eyesight sharp. However, thanks to their magnificent revolving and flexible noses, they can pick up a scent miles away. Elephants cannot gallop, jump or trot, but they can walk 15 miles an hour and keep up a speed of eight miles for hours on end. On steep slopes they sit down and slide; they are excellent swimmers, and can wade rivers with water over their heads by holding the tip of the trunk aloft periscope-fashion to breathe. African elephants are peaceable, live to be 50 or 60 years old, eat as much as a ton of food at a time, don't fully mature until they are 20. They have been known to build themselves pools in which to bathe. Indian elephants are shorter but stouter, can be trained for all kinds of transportation jobs, and, when so employed, work regularly for three days, rest for two, and get three months of complete holiday every year. Arabian camels are seven feet high, travel two and a half miles per hour and can keep up that speed with a heavy load for six hours. Their interior lining is evidently stainless steel, for they can eat the thorniest plants without damage. They can go for a month without drinking. Bactrian camels thrive on salt water. Polar bears can swim hundreds of miles out to sea; have yellowish fur; gobble berries, seals, herrings, whales—indeed anything they can find; weigh a pound and a half at birth; are lonely travelers, and tread the ice in perfect silence. They lie in wait for hours by a seal's air hole and conk him over the head, quite fatally, when he comes up. Chimpanzees are like us, with shorter legs, longer arms and more powerful muscles. They live in bands of two to 20, are nomadic, spend most of their time in trees, drum on a tree trunk with their hands when nervous or excited, often have a natural center parting of the hair, get gray and bald when they are old, make splendid faces, fight only in self-defense, love bananas, become full-grown at 12 and live to be over 50. This book stands high on the Christmas list for young readers.

Life in Fresh Water, by E. S. Brown. Oxford University Press ($2.75). This attractive volume presents in 60-odd pages a surprising amount of information about the plants and animals living in pond, stream and marsh. Among the topics treated are the origins of fresh-water life, breathing under water, food and its capture, methods of reproduction, movement in water, the role of surface film. The story abounds in fascinating details. For example, the water-spider spins a small, tentlike web which it attaches to plants under water and fills with air carried down in the hair coat covering its body. In this bubble it spends much of its time, living in an atmosphere it has transported to its new home. Or consider how the small beetle *stenus* makes use of the surface film of water. A small piece of camphor placed on water will sometimes skid over the surface at considerable speed, because it dissolves at one point more rapidly than at others, lowers the surface tension at that point and so is pulled by the stronger surface tension in other directions. *Stenus* moves in a similar way by secreting at its hind end a substance which has the same effect on the surface film.

You and Your Senses, by Leo Schneider. Harcourt, Brace and Company ($2.75). Our Senses and How They Work, by Herbert S. Zim. William Morrow & Company ($2). These two books cover substantially the same ground. They describe the structure and functioning of the eye and ear, the perceiving of colors and human sensitivity to sound, the mechanisms of taste and smell, the various forms of the sense of touch, the inside senses of hunger and thirst and the remarkable sense of balance, which will be put to its most severe test when some of us shuffle off the coils of New Mexico and go rocking and rolling to the moon. Zim's primer for

"Animals of the World"

youngsters of 10 or 11 is accurate and straightforward, with helpful illustrations by Herschel Wartik. Schneider, addressing himself to slightly older readers, provides a great deal more substance and supports his exposition with many simple but illuminating experiments. His chapter on the eye is first rate, and he also offers a nice summary of the workings of the nervous system. I recommend his book to anyone of 11 and older who has appetite for more than a smattering of knowledge.

"All about Snakes"

Wonders of the Aquarium, by Sigmund A. Lavine. Dodd, Mead & Company ($2.50). If your children belong to the large tribe that has a passion for keeping tropical fish, they may as well learn how to keep them properly. Lavine's book tells how to set up a tank, what appliances to buy to keep the proper temperature and pump, filter and clean the aquarium. The size of your purse, even more than that of the aquarium, will dictate the fish you buy. A guppy is only 19 cents, but a pompadour fish costs $50. Midnight mollies (named after François Nicolas Mollien, Napoleon's Minister of Finance, who apparently had nothing to do either with finding or raising them) are inexpensive and ornamental; labyrinth fishes, which include Siamese fighting fish, are fascinating but often ill-tempered, in which case they have to be kept in a separate container; catfish (talking, upside-down, glass or electric variety) are efficient scavengers and keep the tank clean; snails are less efficient, besides which they provoke hostile impulses in tropical fish, which are apt to nip off the snails' feelers and cause them to die. Other interesting specimens are butterfly fish (*Pantodon buchholzi*) which can be taught to feed from your hand; piranhas, which, if you let them, will feed *on* your hand; archer fish, which shoot their insect food with drops of water emitted at machine-gun speed; the gourami family, which makes bubble nests for its young; the silver dollar, discovered by Theodore Roosevelt in South America; the pencil fish, the Guiana headstander, and the hopping, black and gold-banded bumblebee fish.

Penguins, by Louis Darling. William Morrow & Company ($2). Penguins are grave, decorous-looking birds which cannot fly. They can wriggle, toboggan along on their bellies and dive and swim beautifully; they can walk for hours, and when they trudge along in a column they look like mourners in a French funeral procession. The cold, desolate areas they inhabit are unfit for man or other beasts; therefore penguins have no fear of strangers and are inquisitive and social. But now that man is prowling around the Antarctic, looking for uranium, dominion and heaven knows what else, the birds are learning that he is not their best friend. Among other things, he steals their eggs—a practice which has almost wiped out the species in some localities. Penguins are monogamous and build their nests in colonies on favored high spots. The colonies are a continual scene of cackling, squawking and squabbling, of night-and-day fighting over mates and over the pebbles used to build scoops for nests. (If you are a penguin, it is considered good form to steal pebbles from your neighbor if you can get away with it.) After the female has laid her eggs, the male takes over the job of keeping them warm and the female goes to sea to feed on the small crustaceans that make up a penguin's diet. When she returns, after two weeks or so, the male leaves for a feed, and they spell each other until the chicks are hatched. Then one parent hunts fish for them while the other guards and warms them. When the chicks are old enough, they gather together in crèches, where a few grownups can monitor the lot. Penguins love to play, diving from the ice into the water, popping up and then frolicking about. When they have had enough of this, they stand about in groups "chattering away." The emperor penguin weighs as much as 70 pounds, and unlike other species lays its eggs and rears its young in winter on the ice along the Antarctic coasts where temperatures fall to 70 below. Most other species, of which there are 17, breed in spring on lonely South Atlantic, South Pacific and Indian Ocean islands. Though penguins walk well and

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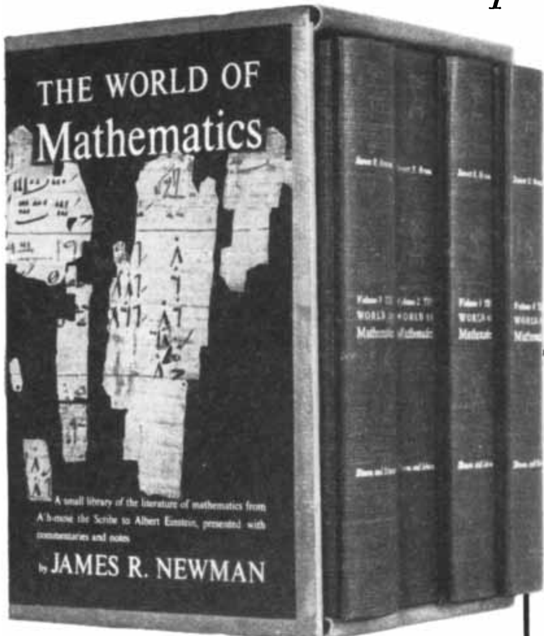

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even like to climb mountains, they are most at home in the sea. When diving for food they stay down for half a minute or more, come up for a second to take a breath, and dive again. They eat nothing but living, moving food. In captivity, if no live food is available, they have to be trained to eat by having food forced down their throats. "Left to itself, a penguin would starve to death while sitting next to a heap of fish." These facts, and many more, are to be found in this attractive primer, almost as appealing as its subject. Fine for 8-year-olds and up. Illustrations by the author.

SEE THROUGH THE FOREST, by Millicent Selsam. Harper & Brothers ($2.50). Mrs. Selsam is one of the ablest writers on biological subjects for young people, but this book is not up to her usual performance. It is a brief account for young children of the life of the forest: the flora and fauna that abide together in an ecological community, each acting on the others and helping to maintain the balance of competing forces for survival. The underlying idea of the book is excellent, but too many facts are crowded into too few pages and there is little opportunity for the author to practice her skill in explaining the processes of nature. The illustrations, by Winifred Lubell, do little to help the story along.

PLANTS THAT FEED US, by Carroll Lane Fenton and Herminie B. Kitchen. The John Day Company ($2.75). A brief history of grains and vegetables for 10-year-olds and up. Corn is believed to be a New World cultivation, Columbus having first learned of it in 1492. Wheat was grown in the village of Jarmo, Iraq, 6,000 years ago. Tomatoes, which first grew wild in Peru, are fruits, but the U. S. Supreme Court has defined them as vegetables for tax purposes, which shows that where there's a will there's a way. Spaniards took potatoes from South America to Europe in 1550, and later they were introduced by the colonists to New England. Persian kings ate cultivated lettuce almost 3,000 years back. The Egyptians cultivated endives for salad. The Jerusalem artichoke is not an artichoke and does not come from Jerusalem. Sweet potatoes are not potatoes. Spinach is Iranian; carrots are south-central Asian; celery was eaten by the ancient Greeks to purify their blood; onions are ancient, as is garlic, and were eaten by workmen who built the Great Pyramid; a place where wild garlic grew thickly was called Shikai-O by an American Indian tribe living near the southern end of Lake Michigan, so when white men settled there they called their town Chicago. The authors have collected many interesting facts and present them well. Illustrations.

CRICKETS, by Olive L. Earle. William Morrow & Company ($2). A cricket on the hearth is said to be a lucky omen. One can raise these omens as pets. They eat bread, cake crumbs, pieces of lettuce, cucumber slices, dog-biscuit chips. An empty fish bowl will serve as a home. Some cricket pets are chosen for the musical tone of their chirpings (one kind, in Asia, is called *Kin Chung*, or golden bell), some for their fighting ability. More than a thousand varieties of crickets are known. They include the snowy tree cricket, the mole (underground) cricket, the cave, camel and stone crickets and the Mormon cricket, a serious pest of the Western states first sighted by the early settlers of Utah. When crickets ravaged the settlers' crops for three successive seasons, the Mormons faced starvation, but then sea gulls arrived in great numbers and ate the marauders. In memory of this event the sea gull is the state bird of Utah. Miss Earle says that if you count the number of chirps made by a snowy cricket in 14 seconds and add 42, the result will be close to the ambient temperature. For children of 8 to 12.

THE SEA AND ITS RIVERS, by Alida Malkus. Doubleday & Company, Inc. ($2.75). An inoffensive jumble of facts about the oceans and marine life. Mrs. Malkus ambles somewhat aimlessly but

"The Stars"

agreeably through the salt-water world, touching upon oceanographic research, the features of the Gulf Stream, tides and currents, "monsters of the deep," "islands strange and lovely," William Beebe's bathysphere, polar ice, life along the shore, the migrations of eels, hurricanes, octopuses, whales, sea flora, coral reefs, the Marianas Trench, the origins of life. Her book is for young teen-agers and will do them no harm.

The Wonders of Seeds, by Alfred Stefferud. Harcourt, Brace and Company ($2.75). Children of 12, give or take a couple of years, will find here accurate and interesting information on the longevity and toughness of seeds (lotus seeds dug up at Lake Pulantien in South Manchuria blossomed prettily in a Washington, D.C., greenhouse, although according to radiocarbon tests they were more than a thousand years old), on seeds' structure and growth processes, on how they are scattered and proliferate, on their uses and on amateur botany. The author is editor of the U. S. Department of Agriculture's yearbooks.

Green Darner: The Story of a Dragonfly, by Robert M. McClung. William Morrow & Company ($2). For 6- to 10-year-olds, a brief tale of the life cycle of this beautiful insect. It sheds its skin 13 times in evolving from a nymph, has enormous compound eyes, flies very fast, moves its jaws sideways like a nutcracker, eats insects and tiny sunfish. It is, however, quite unable, though the punishment fits many a crime, to sew people's ears shut.

Insects and Their World, by Carroll Lane Fenton and Dorothy Constance Pallas. The John Day Company ($2.95). Miscellaneous facts about miscellaneous insects, for 10- or 11-year-old readers. The praying mantis holds its food between its feet; lady beetles hibernate; during the coal age the ancient cockroach lived outdoors; the cricket has an ear on each foreleg, and so on. An innocuous book.

All about Snakes, by Bessie M. Hecht. Random House ($1.95). Mrs. Hecht is an experienced herpetologist who feels about snakes as most of us feel about dogs. In addition, she knows how to write. Her primer discusses the habitats of snakes, their habits, their size and age limits, their enemies, their victims. It is not suggested that you take to bed with you a coral snake (deadly but shy), a rattler (deadly), or a king cobra (deadly and pugnacious), but few

"Worlds without End"

snakes are as dangerous as generally believed, and antivenom serums are pretty effective. A fine natural history book for youngsters of 9 to 12.

THE BOOK OF REPTILES AND AMPHIBIANS, by Michael H. Bevans. Garden City Books ($2.50). For 10- to 13-year-olds a large, clear picture book of snakes, lizards, turtles, salamanders, frogs and toads. The text describes each species, its locale, disposition and habits, what it eats, whether or not its bite is dangerous. (It doesn't tell you what to do if you get bitten.) There are illustrations in color by the author.

DESERTS, by Delia Goetz. William Morrow & Company ($2). Miss Goetz enlightens young children as to why and where there are deserts, the kinds of plants and animals found in them, the habits of nomads. They should enjoy her modest little book.

DOCTORS, AND WHAT THEY DO, by Harold Coy. Franklin Watts, Inc. ($2.95). A sprinkling of information about the medical profession, from "Say ah" to Rorschach's ink blots. The book presents a portrait of the family doctor, followed by chapters on diagnostic methods and tools, new drugs, medical specialties, a typical community hospital, famous clinics, industrial medicine, occupational therapy, psychiatry, world health organizations, medical education, the frontiers of medical research. Somewhat cheery and sentimental, but on the whole a sensible book. For 12-year-olds and up.

MAGIC BULLETS, by Louis Sutherland. Little, Brown & Company ($3). This volume for young readers treats the invention of the microscope, the nature of microbes, the spread of epidemics and their effects upon history, the human body's defenses against disease, the development and uses of sulfa drugs and antibiotics. Average.

THE CAT FAMILY, by Dorothy Childs Hogner. Oxford University Press ($2.75). About short- and long-haired cats, jaguars, mountain lions, lynxes, tigers, lions, bear cats and such. A pedestrian book with misfit illustrations.

HAWKS, by Charles L. Ripper. William Morrow & Company ($2). Under the name hawk are subsumed many species, including falcons, rough-legged hawks, kites, harriers, caracaras, ospreys. The physical appearance, habitats, habits and methods of flight of these handsome and powerful birds are described and illustrated in this book for 10- to 12-year-olds.

Physical Sciences

THE STARS: STEPPINGSTONES INTO SPACE, by Irving Adler. The John Day Company ($2.95). Adler is a most capable guide in science, as he showed in his books on time and fire. Here he explains astronomy to teen-agers: the constellations, how the constitution of the stars is determined, the measurement of their masses, brightness, distances and motions, the properties of galaxies, the structure of the universe. Some of the chapters are particularly skillful.

YOUR WORLD IN MOTION: THE STORY OF ENERGY, by George Barrow. Harcourt, Brace and Company ($2.95).

"God order'd motion, but ordain'd no rest," said the poet Henry Vaughan. Everything everywhere is in motion all the time—probably a good thing. The story of motion, which is the story of energy, is told in this book. It treats of motions we see (of water and wind and physical objects) and of motions we do not see (of heat and atoms and sound and electromagnetic waves). It explains the action of the sun in sustaining organic life, the mechanics of the weather, the working of heat engines, the principles of electronics, the basics of electricity, the rudiments of radio, television and the telephone. Twelve-year-olds and up will come across interesting new concepts and will appreciate an interpretation which ties together a vast range of phenomena. The writing itself, however, is plain gingham. It would be a pity if reading this book were to deflect anyone from sampling the masters of popularization in physical science—James Jeans, say.

INSIDE THE ATOM, by Isaac Asimov. Abelard-Schuman, Inc. ($2.75). THE TENTH WONDER, ATOMIC ENERGY, by Carleton Pearl. Little, Brown & Company ($3). It cannot be said that the appearance of two more primers on the atom is cause for celebration, but on reading through Dr. Asimov's I was pleased to find the same sound treatment of a difficult subject that he has exhibited in his other popular books. This is a well-organized text, replete with effective analogies. It lays out the structure of atoms, the nature of isotopes, the causes of atomic disintegration, the experiment that led to nuclear fission, the constructive uses and dangers of atomic energy. Asimov's book is a good introduction for adolescents and their parents. Pearl's survey, except for the fact that it describes the pioneer work of the Columbia University group—which is strangely neglected in other popularizations—is undistinguished. The explanations do not capture the imagination, and the illustrations are inadequate.

THE MAGIC OF SOUND, by Larry Kettelkamp. William Morrow & Company ($2). Books on physics for young people generally fall far below the standard in biology and natural history. It is probably harder to write about light or electricity or sound than about worms or seals or ferns, but the challenge provokes only a faltering response. This book is a model of mediocrity. The author uses terms such as "frequency" and "pitch" without defining them; he speaks of a machine "tracing the path of sound vibrations by means of an electron beam" and of the electromagnetic action of a telephone without explaining either process. The illustrations fail to illustrate. The only redeeming feature of the book is the last chapter, which describes various radio and television studio methods for reproducing sounds: *e.g.*, crumpling cellophane to imitate the sound of an egg frying or a forest fire, dropping bird seed on a ping-pong ball and a paper cone to imitate rain.

THE WORLD WE LIVE IN, by the Editorial Staff of *Life* and Lincoln Barnett. Simon and Schuster ($4.95). With the help of Jane Werner Watson this popular and colorful history of our planet has been adapted for young readers. Children of 11 or 12 and older will enjoy the many pictures showing the birth of the earth; the formation and nature of the sea, the mountains and the landscape; the origin and evolution of plant and animal life; the diverse features of coral reefs, Arctic barrens and rain forests; the population and shape of the heavens. Whatever the educational value of the book, there can be no doubt it will excite a lively scientific curiosity in many youngsters who are indifferent to more sedate presentations.

THE STORY OF THE ICE AGE, by Rose Wyler and Gerald Ames. Harper & Brothers ($2.50). This is an account for children of 10 and up. It tells how the Ice Age came about, what it did to the earth's surface, how long it lasted, how geologists and archaeologists have reconstructed the events and life of the period. The book compares life in the glacial age and in the tundra regions today.

Exploration

WORLDS WITHOUT END, by Isabel Barclay. Doubleday & Company, Inc. ($3.95). Here are stories of the great feats of exploration from 2000 B.C. to today. Miss Barclay's episodes include the expedition of the Egyptian Hannu to Somaliland, the voyages of the Phoenicians, Alexander's explorations and conquests, the incredible Arctic journey of Pytheas of Massilia, Chang Ch'ien's travels across Asia, the adventures of diverse questing Romans and Vikings, Marco Polo's odyssey, memorable Portuguese and English sea voyages, Magellan's circumnavigation, the marches of Cortez and Pizarro, the penetrations of explorers into the North American interior, the Russian discoveries in Siberia and North America, Captain Cook's epic travels, the achievements of the river-seekers Livingston and Stanley, Peary's and Amundsen's dashes to the North and South Poles. A well-written, unfailingly interesting chronicle, just right for restless adolescents.

"Caves of Mystery"

ARCTIC ASSIGNMENT, by F. S. Farrar, edited by Barrett Bonnezen. The Macmillan Company ($2.50). In the summer of 1940 the 104-foot wooden schooner *St. Roch*, a cutter of the Royal Canadian Mounted Police, was ordered to depart its berth at Vancouver and proceed by the Northwest Passage to Halifax. The purpose of the wartime voyage was to patrol various bodies of water—or perhaps more accurately, ice—such as Lancaster Sound, Barrow Strait, Prince of Wales Strait, and maintain "sovereignty over the Arctic islands." Ninety days were allowed for the task. In the event, this first navigation of the fabled Passage from West to East took more than two years, the *St. Roch* finally docking at Halifax on October 11, 1942. Ice, fog and fierce storms were encountered almost every mile of the voyage above the Arctic Circle. One of the eight-man crew died of a heart attack. (A Catholic priest mushed 400 miles from Pelly Bay to the *St. Roch* to perform the funeral service.) Sergeant Farrar's account of the *St. Roch*'s 10,000-mile journey, of the side patrols, winters in the ice, visits to trading posts and Eskimo settlements, is an exciting story of true adventure and presents a fine picture of northern life.

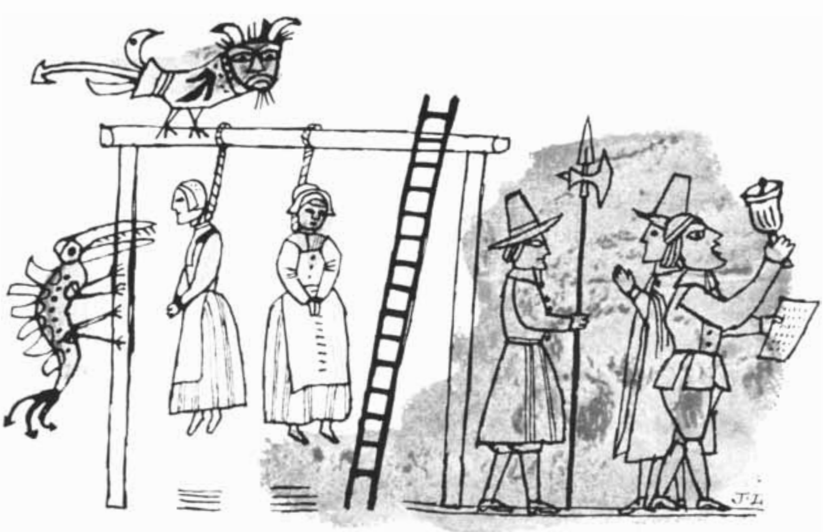
CLOUDS, RINGS AND CROCODILES, by H. Percy Wilkins. Little, Brown & Company ($3). A British astronomer takes adolescents on a spaceship journey around the planets. The building of the rocket vehicle is described, its take-off and navigation, the various experiences en route and the places visited. These include the moon (both sides), Mars, Jupiter's moon Io, Pluto, the neighborhood of Saturn's rings, Mercury and lush and steamy Venus, where creepers grow all over the rocket within a few hours. The travelers have a close call when they fall into the gravitational clutches of the sun: the ship is exposed to a roaring dose of radiation which makes some of its metal parts "white hot," but the travelers emerge unscathed and glide back in fine fettle. The illustrations are dreary, and the Uncle Wiggly text fails to draw a line between fact and fevered fiction.

Caves of Mystery, by John Scott Douglas. Dodd, Mead & Company ($3). The First Book of Caves, by Elizabeth Hamilton. Franklin Watts, Inc. ($1.95). It cannot have escaped the notice of social historians and psychologists that there is a rising interest today in exploring the underneath and overhead sections of our world—as if any place were safer and more attractive than man's natural habitat. Undoubtedly it would be nice to have a place to hide when things get bad. These two books reflect the growing popularity of cave crawling. Douglas gives an absorbing account of the subject, beginning with the systematic study of caves in the latter part of the 19th century by a sturdy French lawyer, Edouard-Alfred Martel. Martel wore a goatee and permitted himself to be lowered on a rope by his half-dozen assistants into an unknown abyss. He went down sitting stiffly astride a board, wearing a high collar, a bowler hat and a sack coat. Despite this formal garb, resembling that of the Wright brothers at Kitty Hawk, he was a determined and courageous speleologist, the first to explore such important caves as Padirac, Rabanel and the Baumes Chaudes. John Douglas' book describes the most spectacular caverns here and abroad, the imprudent adventures of sundry spelunkers, the hazards of underground floods and water traps, the animals found in caves and subterranean rivers, the great archaeological cave discoveries, the historic 1954 descent to the "deepest depth on earth" in the Berger Cave in the western Alps of southeastern France. Mrs. Hamilton's brief introduction to cave exploration for younger children is plainly written and presents the essentials, including a set of rules which, if followed, would reduce the misfortunes attendant upon this wayward but undoubtedly fascinating recreation.

Technology

BRIDGES, by Henry Billings. The Viking Press ($3.50). This absorbing book describes the development of the most exciting and beautiful of man-made structures. After briefly sketching the history of some of the famous stone arches built in Roman times and during the Renaissance, the author turns his attention to the first iron bridges of England, the sturdy wooden bridges of the old National Pike between Baltimore and Wheeling and the iron-truss railroad bridges built by the thousands throughout the U. S. in the midyears of the 19th century. He writes about Captain James Eads's epoch-making bridge across the Mississippi at St. Louis, John Roebling's magnificent Brooklyn Bridge, the Hell Gate arch, the George Washington spanning the Hudson, the Rainbow crossing the Niagara River, the great San Francisco Bay and Golden Gate bridges, the widely used bascule bridges that open like the drawbridges which crossed the moats of medieval castles, the Lake Washington permanent floating bridge, the enormous Quebec cantilever over the St. Lawrence, whose construction cost so many lives. Among the bridges still in the planning stages is the proposed structure from the boot of Italy across the Messina Strait to Sicily, which will require a main span of 5,000 feet and to withstand gales and earthquakes will have foundations sunk 400 feet into the Strait. A most interesting chapter deals with the famous collapse of the Tacoma Narrows Bridge in 1940. Billings' book gives admirably clear explanations of the principles of different types of bridge construction and of practical engineering problems. The illustrations, also by the author, enrich the text. Highly recommended.

TOOLS IN YOUR LIFE, by Irving Adler. The John Day Company ($2.95). MAN AND HIS TOOLS, by William A. Burns. McGraw-Hill Book Company, Inc. ($2.75). Both of these books survey man's inventions from the Stone Age to the present. Adler, writing for the junior high-school age group, begins with the hand ax and in 126 pages touches lightly upon a host of artifacts such as hunting tools, needles, travois, agricultural implements, spinning and weaving devices, saws, adzes, the potter's wheel, pumps, windlasses, simple and automatic hammers, lathes, looms, the steam engine, dynamos, ships, adding machines, machine tools, computers and even cyclotrons. The writing is passable; the explanations are reasonably penetrable but skimpy; the illustrations, by Ruth Adler, are nicely done but there are too few of them. Most of the book is talk, and a talk book about tools simply isn't enough for youngsters. Burns, aiming at a somewhat lower age level, covers a narrower field. He presents separate chapters on the knife, the hammer, the saw, boring and finishing tools, fire-making, transportation, power, measurement. About simple things he sometimes goes into considerable detail, but the steam engine, the electric motor and the internal combustion engine each gets a paragraph, which is worse than nothing. There are many pictures, of the illustrated dictionary type, which show what



"The Witchcraft of Salem Village"

"Battle against the Sea"

a machine looks like but not how it works.

Passengers, Parcels and Panthers, by John W. R. Taylor. Roy Publishers ($3). An unpretentious account, for teen-agers, of the many tasks performed by modern aircraft. Elephants have been transported by air: it was discovered that they travel with peace of mind when a hen sits on their head. Planes serve in agriculture to pollinate plants, spread fertilizer, destroy pests and weeds and mitigate frost damage—the downdraft from a helicopter's blades being used to push warm air over orange and tomato crops. Birds have been given airlifts to help them along in their annual migrations from Europe to Africa. Buffalo have been squirted with paint from the air to help zoologists study their migratory habits. In Idaho beavers have been transplanted to remote areas by parachute, their cages springing open as soon as they touch the ground. In Australia a Royal Flying Doctor Service provides medical care for the vast Australian inland. Farmers can call for a doctor on small hand-driven radio transmitters. Some doctors make more than 1,000 such emergency flights a year.

Ships of the Great Lakes, by Walter Buehr and Lemuel B. Line. G. P. Putnam's Sons ($2.75). In this attractive book Line's full-color drawings of representative Lake ships are accompanied by a brief text which sketches the development of Great Lakes navigation, the building of the Erie and Welland canals and the Soo locks, and the character of the vessels that ride these busy waters. For 8-year-olds and up.

The First Book of Trains, by Russel Hamilton. Franklin Watts, Inc. ($1.95). An up-to-date primer about locomotives, freight and passenger cars, signals, train dispatching, marshaling yards, track construction, trestles and bridges, switches, piggyback trains and the new cabooses that have bay windows.

Social Sciences

The Witchcraft of Salem Village, by Shirley Jackson. Random House ($1.50). Early in the year 1692 a madness swept Salem Village, a small community in the Massachusetts colony. A group of girls ranging in age from nine to 19, who belonged to an informal club which met nearly every afternoon in the kitchen of the house of Samuel Parris, the local minister, began to show signs of being bewitched. The chief attraction of their meeting place was Parris' Indian slave Tibuta, who spun tales of magic and superstition which made the girls shiver with delight. After a time they started to act strangely. Without provocation they wept, moaned, screamed, fainted, fell into fits. These shenanigans were relatively harmless, but grownups who witnessed them were alarmed and pressed for an explanation. The girls decided it was best to put the blame for their antics on local witches. At random they accused a large number of men and women of being agents of the devil. The time, place and circumstances were hospitable to such denunciations. England, the mother country, had severe laws against witchcraft: the first offense was punishable by death. It was well known that demons were everywhere, commanded by infernal princes. Cotton Mather, a pre-eminent figure of the colony, was noted for his personal struggles with the devil. The accused persons, including Dorcas Goode, who was not quite five years old, were duly examined before learned magistrates. "Spectral evidence" was heavily relied upon; guilt

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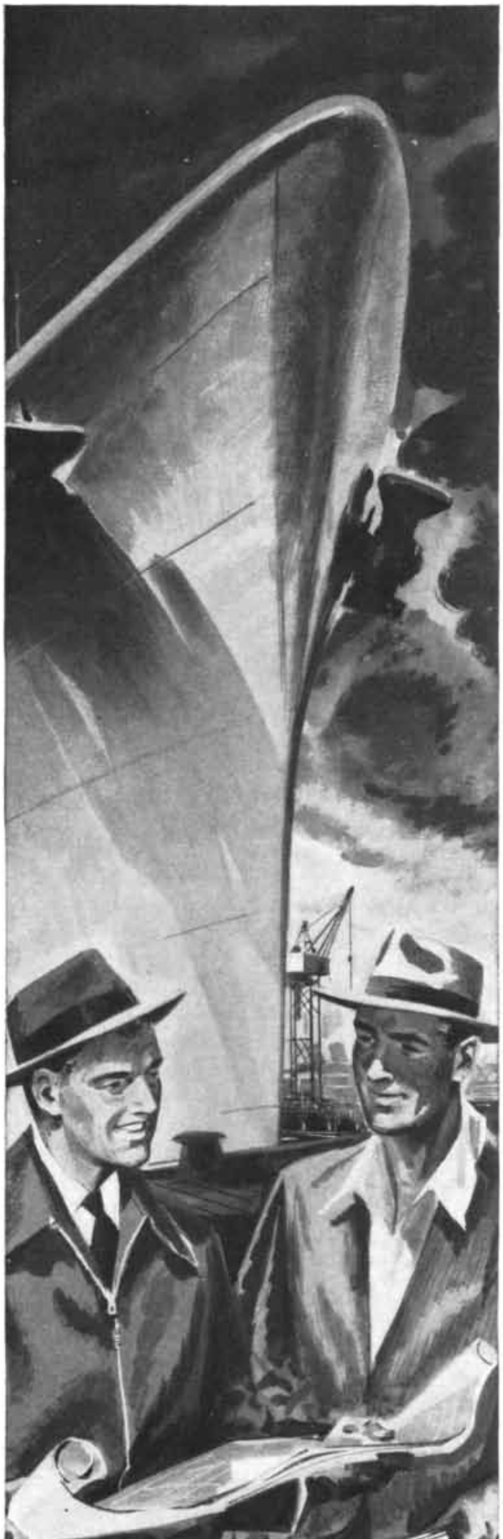

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by association was accepted as a matter of course; the burden was on the defendant to prove his or her innocence. All the accused were committed. Mass trials followed, and mass executions. In September the devil departed Salem, but the cost of his visit had been fearful. Twenty innocent persons had been executed, and others had died in jail. Many of those ordered released by proclamation of the Royal Governor, Sir William Phips (who, when his own wife was accused, decided things had gone far enough) had to stay in prison because they could not pay the court and jail fees. Others, including persons of wealth, fame and influence, fled Massachusetts to escape the epidemic of insanity. Their property was plundered and they never returned. Salem Village itself—not to be confused with the large town of Salem nearby—never recovered from the obscenity to which it gave birth: today it no longer exists. Miss Jackson's account of the whole terrible episode deserves the highest praise. I can imagine no better introduction for youngsters of 10 and older to the problems of social psychology and social pathology.

MANKIND AGAINST THE KILLERS, by James Hemming. Longmans, Green and Company, Inc. ($3.50). This is an uncommonly readable account of man's battle against disease and starvation, for adolescents and older readers. The author is a British lecturer and educator who has interested himself especially in the work of the World Health Organization. His book, illustrated with good photographs, deals with the history of plagues and epidemics, the great medical discoveries, the way diseases are carried and spread, the remarkable achievements of WHO in making the world a safer and pleasanter place for millions. One of the best chapters recounts the strange problems arising from national habits and customs that an international health body has to solve. An African farmer would rather have two sickly cows than one healthy one, because the number of his cows determines his wealth and social position. In India, the cow, being sacred, cannot even be forced to move, much less killed, whatever its ailments. Moslems refuse to eat pork, an aversion which aggravates the already huge task of feeding them. In Thailand the United Nations Food and Agriculture Organization bred minnows in the shallow waters of the rice fields to add relish and nourishment to the staple diet of rice, but the Thais decided that minnows had a right to live, and refused to eat them. FAO officials found a way to give the Thais their protein by switching to larger fish, for which the Thais have less pity. A WHO team, battling plague in an area of India, was confounded by the local Buddhists, who would release the plague-carrying rats from traps as soon as they were caught. WHO had to station at each trap a policeman with a long pole, which enabled him to discourage would-be rescuers with a poke, while standing far enough not to scare rats away from the trap.

BATTLE AGAINST THE SEA, by Patricia Lauber. Coward-McCann, Inc. ($1.95). Miss Lauber narrates the inspiring story of the Dutch people's long struggle to hold back the sea and to enlarge their country by making land where before there was only water. The Netherlands is about half the size of South Carolina. One quarter of this area is reclaimed land; one quarter lies so low that if there were no dikes the North Sea would roll in and cover it at high tide. In other words, half of the entire country is habitable only because of the Netherlanders' ingenuity, hard work and ceaseless vigilance. The great reconstruction of the contours of Holland began 2,000 years ago with the Frisian settlers. They piled up huge mounds of clay, perched their thatched-roof houses on top of them and in time learned to make their houses more secure by building dikes. When the Roman armies arrived, at the beginning of the Christian Era, they brought skilled engineers who introduced new techniques of dike, bridge and road building. They discovered how to lay out dikes to encircle a piece of land only shallowly covered by water and then by draining and washing away the salt to make the soil fit for cultivation. Farm land like this, taken from the sea, is called a *polder*. Gradually the size and number of *polders* increased. The Dutch developed methods, notably the use of windmills, for pumping out the water that seeped in. But the sea kept coming back and chewing at the land. Strong dikes, canals, windmills were no adequate match for the "water wolves"—the inland lakes stirred to fury by the wind—and the tides. Fierce storms turned what was once an inland lake into an arm of the sea, the Zuider Zee. In the 19th century a bold proposal was made for closing the Zuider Zee. This engineering feat was finally begun in 1923 and completed nine years later. It shortened the coastline of Holland by 300 miles and was the first step toward adding more than a half-million acres of farm land to the country. Much of Miss Lauber's book is devoted to a dramatic

account of the catastrophic gales and floods that struck Holland on January 31, 1953. They killed 1,800 persons, wiped out dozens of villages, drowned 50,000 farm animals and reclaimed for the sea some 400,000 acres of land. The Dutch set about rebuilding their dikes with giant brushwood mattresses which were towed out and then sunk under masses of rock, with huge walls of clay armored with carefully fitted stones, with immense concrete caissons. The author describes the work of reconstruction with admirable clarity and in engrossing detail. Maps and photographs effectively support the text. For youngsters of 10 and up.

PEOPLE, by Irvin Block. Franklin Watts, Inc. ($2.95). There is always need for books which make it clear that we are not the only pebbles on the beach, that the ways of living are many and that ours are not in all respects the best ways. The author of this book, addressed to teen-agers, describes the habits, customs and beliefs of simpler, and in some cases gentler, societies than our own: the Tchambuli and Arapesh of New Guinea, the Kwakiutl and Pueblo Indians of North America, the Dahomeans of West Africa, and many others. A worthwhile introduction to anthropology.

THE BEGINNING: CREATION MYTHS AROUND THE WORLD, by Maria Leach. Funk & Wagnalls Company ($3.50). Mrs. Leach, the editor of the excellent *Standard Dictionary of Folklore, Mythology and Legend,* has gathered in this volume the conjectures of peoples in different parts of the world as to how and when the world began. Archbishop Ussher of Ireland, a careful student of Ancient Hebrew chronology, fixed the date of creation precisely on Wednesday, October 26, 4004 B.C. The Haida Indians of North America say the world was created by a Raven, who, perched one day on a little rocky island in the sea, said "Become earth," and it became earth, for "Raven was god in those days." Man himself was pulled by Raven out of a clamshell. The concept that the universe began with chaos or the primeval water is practically world-wide. Courageous animals or water birds often figure as the agents of the creator in forming the earth from a bit of slime or scum or mud. The Senecas imagine a turtle's back to have been the scene of creation—Turtle having had help from his female assistant, Toad. The Mosetene Indians of Bolivia say the name of the creator is Dobitt, and he made the world in the shape of a great raft, which floats in space supported by innumerable spirits. In Micronesia worms are held to be the creators: for example, a tribe in a chain of the Marshalls tells that the first living beings were two worms, Wulleb and Lejman, who lived together in a shell, the top of which they raised to make the sky, and the lower portion became the earth. Another Micronesian people conceive creation as follows: "Long ago when all was water, Lowa, the uncreated, was alone in the sea. 'Mmmmmm,' he said, and islands rose out of the water. 'Mmmmmm,' he said, and reefs and sandbanks were created." Plants and birds were made the same way; then Lowa sent a man into the world, and later two tattooers to give every living thing its own mark. Mbere, the Bantu creator, made a man out of clay. "Thank you," said the man to Mbere. This is a superb review of mythology for almost any reader.

IN FRANCE, by Marguerite Clément, The Viking Press ($3). THE YOUNG TRAVELER IN GREECE, by Geoffrey Trease. THE YOUNG TRAVELER IN INDIA AND PAKISTAN, by Geoffrey Trease. E. P. Dutton and Company, Inc. ($3.50 each). The Trease travel books, cheerful, accurate and well illustrated, describe a country through the formula of a pair of youngsters visiting well-known cities, landmarks and picturesque places, learning about local history, customs, occupations, methods of schooling, forms of government and the like. The Clément book is less a travel guide than a charming, lovingly perceptive essay by a Frenchwoman on her own country and people. She describes the diversity of its climate and landscapes, the historical evolution of its great cities, the school curriculum and study habits of different age groups of French children, the cultivation of the land, the sports and shops of France, family relationships, the routine of the housewife, the lives, pleasures and hardships of factory workers, salesgirls and Frenchmen of various social strata. Two chapters are devoted to great men of France from Saint Louis to Louis Pasteur. Miss Clément sentimentalizes a little, but she knows France and does not refrain from criticizing it. Her book, an ideal gift for adolescents, is enriched by William Pène du Bois's delightful drawings.

THE FIRST BOOK OF THE WEST INDIES, by Langston Hughes. Franklin Watts, Inc. ($1.95). A colorful introduction to lands and people by the well-known poet. Cuba, Haiti, the Dominican Republic, the Virgin Islands, Jamaica and

Trinidad are among the places described. Hughes writes feelingly about the landscape, birds, trees and flowers, about the customs and occupations of the people, their foods and glamorous fruits, about the history of each island and how it is run today.

CAVE OF RICHES, by Alan Honour. Whittlesey House ($2.75). A knowledgeable and literate account of the finding of the Dead Sea Scrolls. The author narrates the suspenseful story of how the two main batches of the scrolls were delivered after many vicissitudes to Archbishop Samuel at the Syrian Orthodox Monastery of St. Mark and to Eleazar Sukenik, head of the department of archaeology at the Hebrew University. He describes the contents of the scrolls, the difficult task of unrolling and deciphering them, the tests made to date them and the excavations at the site of the cave where they were discovered. Excellent reading for children of 11 and up.

LOOKING AT HISTORY, by R. J. Unstead. The Macmillan Company ($4). A social history of Britain from the Stone Age to television. Among other things it tells about Norman, Stuart and Victorian amusements, children's games, the first use of postage stamps, Roman furniture and Georgian gardens, weapons, transport and travel, inns and famous roads, witchcraft, guilds and slums, police, press gangs, robbers, inventors, great fires, castles, ships, newspapers and canals. There are 1,000 illustrations, mostly from contemporary sources. Originally published in four volumes for British school use, the book is an easily assimilable, agreeably varied and instructive young people's introduction to the changing ways of a great people.

WEBSTER'S ELEMENTARY DICTIONARY. G. & C. Merriam Company ($2.88). The publishers describe this work as written specifically for children in the fourth, fifth and sixth grades. It contains some 18,000 entries based upon a reading of schoolbooks used in these grades throughout the U. S. The definitions are unusually clear; the 1,600 supporting illustrations are simple and helpful; the volume has excellent typography, good paper, fits well into the hand and is intelligently designed for frequent use. This dictionary appeals to me, and to sundry children (including mine, whom I used as testers), as the best of its kind and one which will gather no dust on the juvenile shelf.

G. D. Schott (second from left), Flight Controls Dept. Head, discusses new techniques in the mechanization of autopilots with R. D. Wertz (left), Flight Controls Research Engineer; R. J. Niewald, Flight Controls Analysis Section Head, and B. C. Axley, Servomechanisms Analysis Group Engineer.

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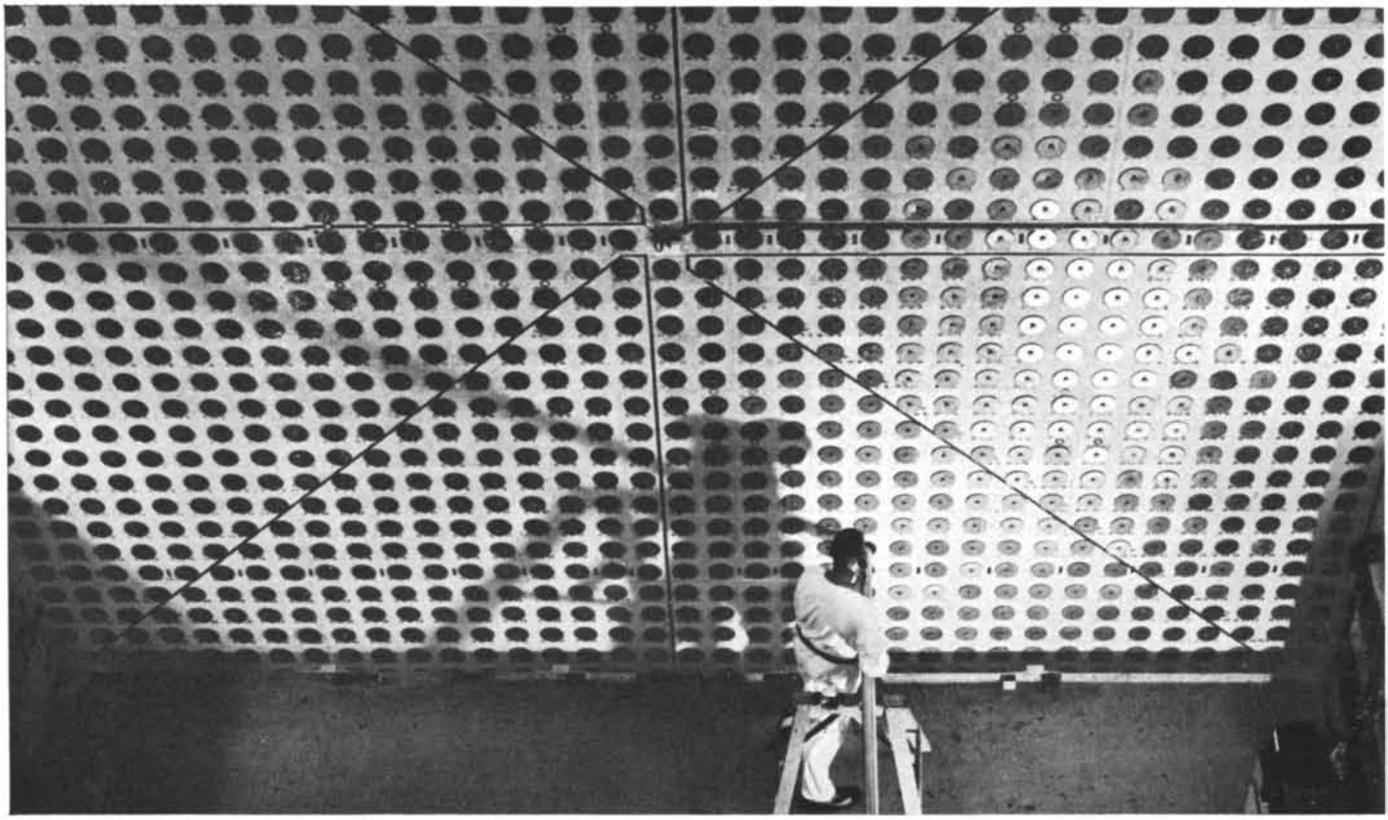

Spectacular devices aid the atomic scientist in his quest for knowledge. Here a uranium fuel element is loaded into the Research Reactor at Brookhaven National Laboratory. The reactor provides neutrons and radioactive isotopes for hundreds of experiments, both at Brookhaven and at other research laboratories in universities, hospitals and industry.

Should your child be an Atomic Scientist?

by LAWRENCE R. HAFSTAD

Vice President in charge of the Research Staff, General Motors Corporation
(As told to DONALD ROBINSON)

AT THE SPEARHEAD of human knowledge is atomic science. Since 1939 it has raised from zero an industry we now reckon in billions of dollars, an industry based on something no one ever will see, the neutron, a little part of the atom.

This unseen portion of matter is a monument to man's intellect—something that materialized out of creative, disciplined imagination. Once pure theory, today it is an immense reality, a tremendous force for good.

What atomic science will do for tomorrow's world I would hesitate to predict, although much of my lifetime as a physicist has been spent helping to find both military and civilian uses for this new form of power. But I can say this emphatically. Its future is unlimited.

Already we have a nuclear-powered submarine. It has cruised more than 50,000 miles without refueling.

With casual assurance, scientists and engineers are discussing the idea of nuclear-powered ships.

They are talking also about "package" atomic reactors for developing power in the world's wastelands. This would be one of mankind's greatest boons.

A distinguished diplomat put it succinctly. "Can you imagine what atomic energy will mean to the peasants of Afghanistan?" he said. "For the first time in their lives, they will have electric light."

Here at home, scientists even visualize an era in the foreseeable future when atomic energy may begin to supplant the power we extract from coal and petroleum, should our reserves of them commence to dwindle.

There is no reason for any feeling of mystery about this. It is just another physical phenomenon.

Accept the fact that such a thing as a neutron exists, exactly as you accept the fact of electricity each time you switch on a light. Accept the fact, too, that if this neutron collides with the uranium 235 nucleus, a peculiar process called "fission" occurs. Two fission fragments fly apart at high velocity and let loose large amounts of energy.

Then consider that from one pound of fissionable uranium you get as much energy as from 2,600,000 pounds of coal. Now, you'll understand why enthusiasts grow so excited about atomic energy.

But power isn't the sole miracle in atomic energy.

The by-products of atom-splitting are equally challenging. Gamma rays that are released in the fission process can be utilized for food sterilization. And in other chemical reactions. Many plastics, for example, can be stabilized against temperature changes by treatment with gamma rays.

Radioactive isotopes that come out of the split atom are still more valuable. Every day, they are turning up new clues in the endless war against disease. Medical researchers are employing them right now to track down brain tumors.

In agriculture, plant biologists and agronomists are using isotopes to enrich the soil and improve farm crops. By means of isotopes, they recently brought forth new species of rust-resistant oats that stand to save American farmers $100,000,000 a year.

Isotopes are even being utilized today to make chickens lay more eggs.

And that's not all their uses, by far. We need to know more, for instance, about the wearing qualities of metal. Just why do certain machine parts wear out?

Isotopes are telling us.

We need a better understanding of the manner in which one part of an alloying element in 10,000 parts of base metal produces such striking improvements.

Isotopes may shed new light on it.

It is actually impossible to enumerate the packets of new knowledge that isotopes and other radioactive materials are revealing to us. We scientists are like kids turned loose in a toy department; there are so many things beckoning for our attention, we hardly know where to start.

So, you see, the boys and girls who select nuclear science for a livelihood will have the privilege of working on the frontiers of knowledge.

Deep intellectual and spiritual satisfactions await them. I never knew a true scientific explorer who was bored by his work.

"Are there any openings for newcomers in atomic science?" you ask.

I can honestly answer that the opportunities are infinite—for boys and girls both. The need for new blood in this line is vast. It is one of the fastest-growing categories in science, and its demands for trained manpower have seriously outstripped the supply.

A few years ago, merely a handful of scientists were dealing with the atom. This year, 15,000 scientific people are engaged in atomic activities for the government and private industry. Tens of thousands more are wanted.

The Atomic Energy Commission has officially estimated that 40,000 more scientists and engineers will be required within the next several years to work on applications of nuclear power. This is just one phase of atomic science. There are scores of others.

The salutary fact is that the *idea* of research no longer has to be "sold" to industry, the government, or the public.

Industrial firms now realize that their survival depends upon scientific alertness in the laboratories. The government is continually enlarging its technical horizons. Colleges and universities, traditional incubators of scientific thought, are broadening the scope of their research programs. And there are burgeoning scientific foundations, privately operated and financed, which are setting up hundreds of specialized research projects for government and industry.

With all of these organizations, expansion in the atomic field is checked only by the scarcity of trained personnel.

In medicine, the atom has opened vast new horizons. Above, a scientist at Sloan-Kettering Institute uses radioactively-tagged compounds to study the difference between normal cells and cancer cells in the search for cancer-controlling chemicals.

What types of scientists and engineers are welcome in atomic science?

Almost every kind. Physicists are needed to do basic research on the underlying facts of nature; we have nearly exhausted our present store of basic research. Mathematicians are necessary to predict neutron behavior. Chemists must search out better methods for processing fission products. Metallurgists must determine materials that can withstand the incredible heat and stress involved in atom-splitting. Medical men and biochemists must ascertain the effects the atom can have on health. Biologists and agronomists must seek methods by which the atom can improve crops. Engineers of every variety—mechanical, civil, electrical, metallurgical, mining, to mention a few—are equally essential. They must translate the broad findings of the scientists into practical usage.

No matter what aspect of science a person is interested in, he is likely to find an outlet in the atomic arena.

What does atomic science demand of the boy or the girl who wants to make a profession of it?

First, in my opinion, he (or she) must have imagination. Second comes intellectual curiosity, a deep-rooted desire to understand how and why things behave as they do. Third, the young scientist must have patience. Often he will reach dead-ends in research. He must be willing to keep on trying.

As one of my very good scientist friends declared, "The only time you don't want to fail is the last time you try."

A fourth and especially urgent requirement is a mathematical bent. And the boy who aspires to go far in atomic science must have a true mathematical talent. Math is the language of "the trade."

A fifth characteristic is the ability to collect data, organize facts and analyze them. A sixth requirement is that a boy enjoy hard work, for the problems are everlasting.

And, seventh, the good scientist-to-be should be a non-conformist. He must be willing to get off well-traveled mental highways and strike out for himself. The brief history of atomic science is the story of men and women who had the intellectual courage of their convictions. Too much cannot be said for this.

The financial rewards?

Latest government studies indicate that a college graduate with a Bachelor of Science or an engineering degree can easily get a job paying $400 a month. Within not too many years, he should be up to $750 a month. Men who reach the higher levels of management will, of course, earn considerably more. In industry, salaries of $25,000 and $35,000 are not unusual.

"Show me a man of ability and experience, and I'll meet his price, whatever it is," the head of a large company in the atomic field recently remarked.

The possibilities for advancement are splendid. Visit any atomic laboratory and one of your first impressions is that the staff is made up of young people. The working conditions are excellent, too. In this connection, let me stress that it is not a dangerous business. Its accident rate is so low that the National Safety Council rates it as one of the two safest industries in the country.

As in any profession, disadvantages can be cited. The hours are long. The work is arduous. For scientists, the risk of lack of success is great. In research, many failures must be expected for every success.

One can certainly select an easier way of making a living.

If your child does settle on atomic science for his lifework, he must have a thorough education. Were I the parent of a youngster with a scientific gleam in his eye, I would do my best to impress him with the truth that his future is starting in his classroom today. Nuclear science is only an extension of the basic fundamentals he learns in his early science courses.

I would tell him, "Steep yourself in fundamentals. Make them part of your consciousness. The rest of what you learn will come naturally."

A Bachelor's degree in science or engineering is the least a boy should have, and a Master's degree is better.

Anyone thinking of basic research in physics or chemistry should go on to get a Ph.D. It's a virtual necessity for landing a good job in government, industry, or the academic world. Besides, it brings a better salary.

Just recently, a study was made to compute how much more money a scientist with a Ph.D. was likely to earn during the course of his life than one with a Bachelor's degree.

It came to $100,000.

I might point out that opportunities to acquire graduate degrees have improved greatly. More than thirty universities are giving graduate courses in nuclear engineering and other atomic sciences. A number of industries encourage their young laboratory employees, financially as well as otherwise, to continue their graduate education in special courses or night classes while they hold down their regular jobs.

I believe it is also worth emphasizing that atomic science, because of its stringent requirements, is not a calling for the average student. It insists upon a high level of mental refinement, and I think it is important for us to try to train our youth up to it.

HOW TO HELP YOUR CHILD HAVE THE CAREER HE WANTS

Many factors will enter into your child's choice of a career: his interests, his ambitions, his abilities, the counsel he receives from teachers, friends and family. But, most of all, it will depend on his opportunities *to get the training he needs to enter the field of his choice.*

Even though his college days are still years away, it's never too soon to start making sure that your child will have the opportunity to continue his education when the time comes.

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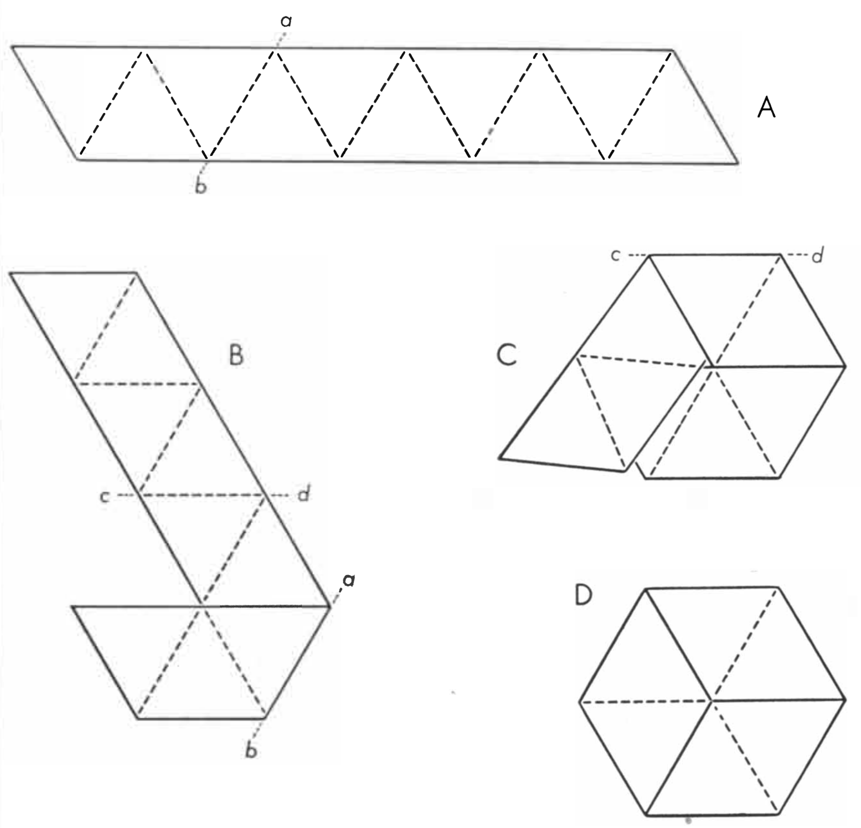
FLEXAGONS

In which strips of paper are used to make hexagonal figures with unusual properties

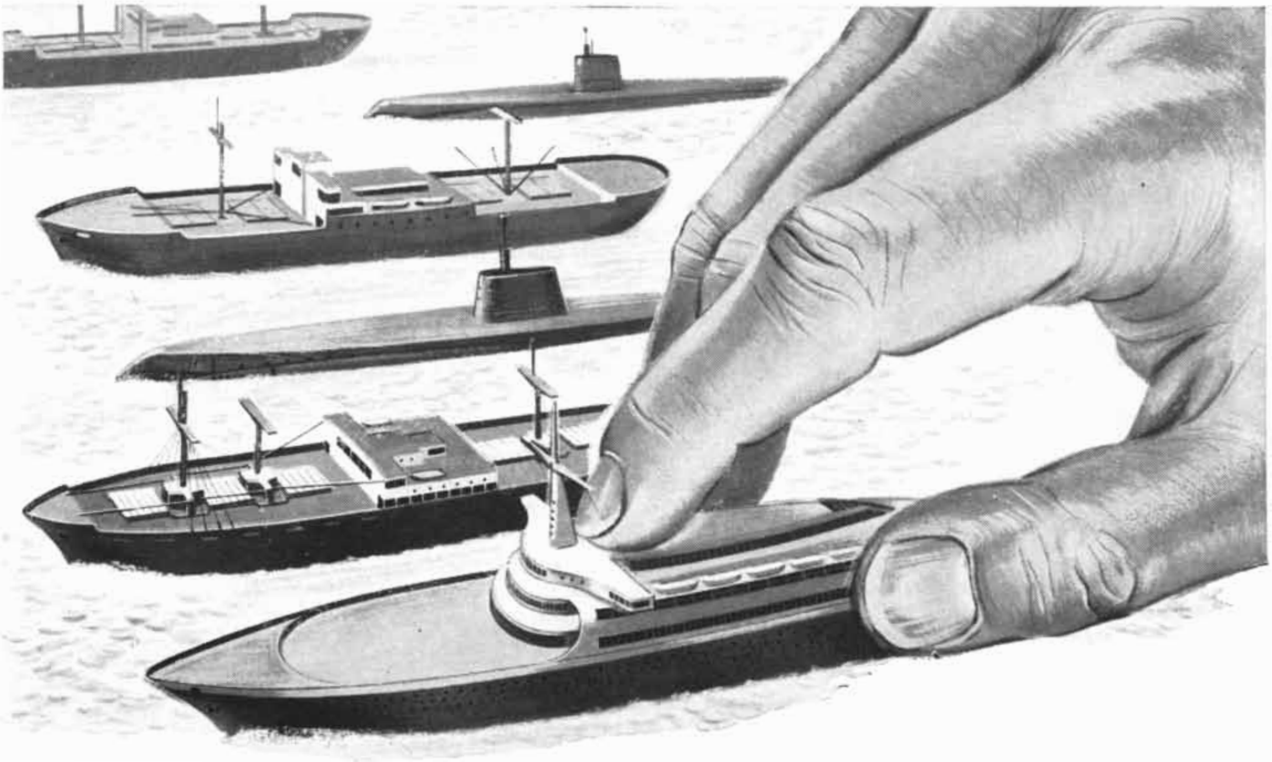
by Martin Gardner

Mathematics owes a lot to games, and *vice versa.* There is an engaging little exercise with strips of paper which has fascinated some first-class brains in recent years. It was discovered in an idle moment by a British mathematics student at Princeton University. The whole thing grew out of the trivial circumstance that British and American notebook paper are not the same size. Arthur H. Stone, a 23-year-old English graduate student who came to Princeton on a fellowship in the fall of 1939, found that he had to trim an inch off American notebook sheets to fit them into his English binder. For amusement he began to fold the trimmed-off strips of paper in various ways, and one of the figures he made turned out to be particularly intriguing. He had folded the strip diagonally at three places and joined the ends so that it made a hexagon [*see illustration below*]. When he pinched two adjacent triangles together and pushed the opposite vertex of the hexagon toward the center, the hexagon



TRIHEXAFLEXAGON is constructed by cutting a strip of paper so that it may be marked off in 10 equilateral triangles (A). The strip is folded backward along the line *ab* and turned over (B). It is then folded backward again along the line *cd* and the next to the last triangle placed on top of the first (C). The last triangle is now folded backward and glued to the other side of the first (D). The figure may be flexed as shown on page 164. It is not meant to be cut out. Fairly stiff paper at least an inch and a half wide is recommended.

ENGINEERS, SCIENTISTS...



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These include: the development of new uranium alloys for use in reactor cores; greater understanding of reactor physics, of heat transfer, and of the effects of radiation on materials; development of new and improved components such as valves, pumps, heat exchangers, and instruments to meet the new severe requirements.

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would open out again, like a budding flower, and show a completely new face. If, for instance, the top and bottom faces of the original hexagon were painted different colors, the new face would come up blank and one of the colored faces would disappear!

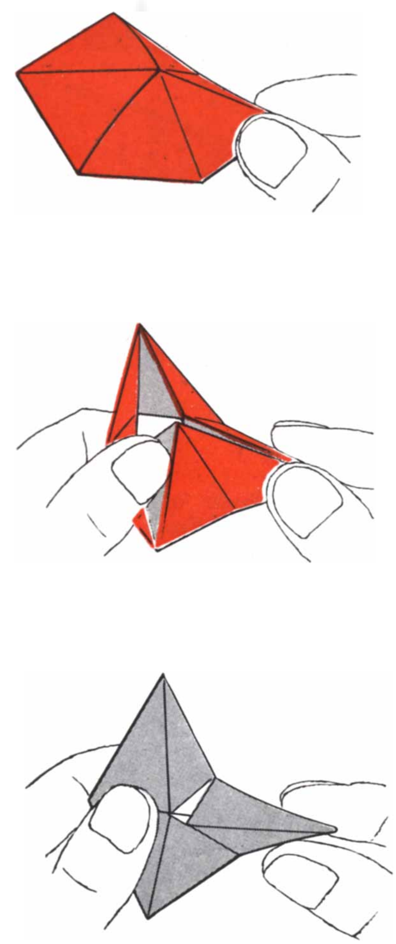
This figure had three faces—say, red, green and blank. Stone experimented further with longer strips, and, with considerable patience and creative insight, was able to construct a model which had the same hexagonal shape but could be opened to six different faces instead of only three. At this point Stone found the game so interesting that he showed his paper models to friends in the graduate school. Soon "flexagons" were appearing in profusion at the lunch and dinner tables. A "Flexagon Committee" was organized to probe further into the mysteries of flexigation. The other members besides Stone were Bryant Tuckerman, a graduate student of mathematics; Richard P. Feynman, a graduate student in physics; and John W. Tukey, a young mathematics instructor.

The models were named hexaflexagons—"hexa" for the six triangles that form the hexagonal face, and "flexagon" for the structure's ability to flex. Stone's first model is a trihexaflexagon ("tri" for the three different faces that can be brought into view); his elegant second structure is a hexahexaflexagon (for its six faces).

To make a hexahexaflexagon you start with a strip of paper (the tape used in adding machines serves admirably) which is divided into 19 triangles [*see illustration on page 166*]. You number the triangles on one side of the strip 1, 2 and 3, leaving the 19th triangle blank, as shown in the drawing. On the opposite side of the triangles are numbered 4, 5 and 6, according to the scheme shown. Now you fold the strip so that the same underside numbers face each other—4 on 4, 5 on 5, 6 on 6 and so on. The resulting folded strip, illustrated by the second drawing in the series on page 166, is then folded back on the lines *ab* and *cd* [*third drawing*], forming the hexagon [*fourth drawing*]; finally the blank triangle is turned under and pasted to the corresponding blank triangle on the other side of the strip. All this is easier to carry out with a marked strip of paper than it is to describe.

If you have made the folds properly, the triangles on one visible face of the hexagon are all numbered 1, and on the other face all are numbered 2. Your hexahexaflexagon is now ready for flexing. You pinch two adjacent triangles together, bending the paper along the line between them, and push in the opposite vertex; the figure may then open up to face 3 or 5. By random flexing you should be able to find the other faces without much difficulty. Faces 4, 5 and 6 are a bit harder to uncover than 1, 2 and 3. At times you may find yourself trapped in an annoying cycle that keeps returning the same three faces over and over again.

Tuckerman quickly discovered that the simplest way to bring out all the faces of any flexagon was to keep flexing it at the same vertex until it refused to open, then to shift to an adjacent vertex. This procedure, known as the "Tuckerman traverse," will bring up the six faces of a hexahexa in a cycle of 12 flexes, but



TRIHEXAFLEXAGON IS FLEXED by pinching together two of its triangles (*top*). The inner edge of the two opposite triangles may be opened with the other hand (*middle*). If the figure cannot be opened, the adjacent pair of triangles is pinched. If the figure opens, it can be turned inside out, revealing a side that was not visible before.

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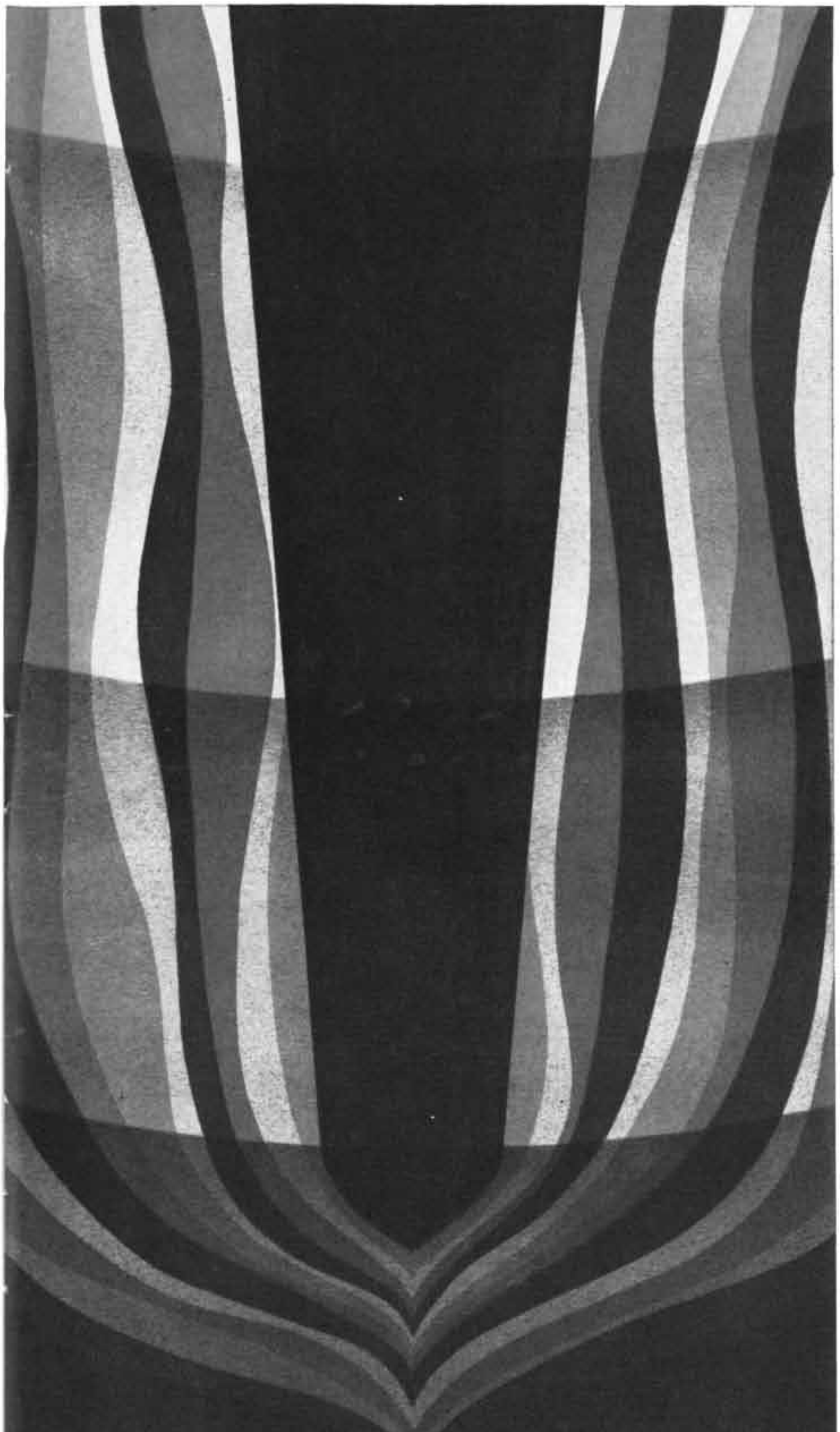

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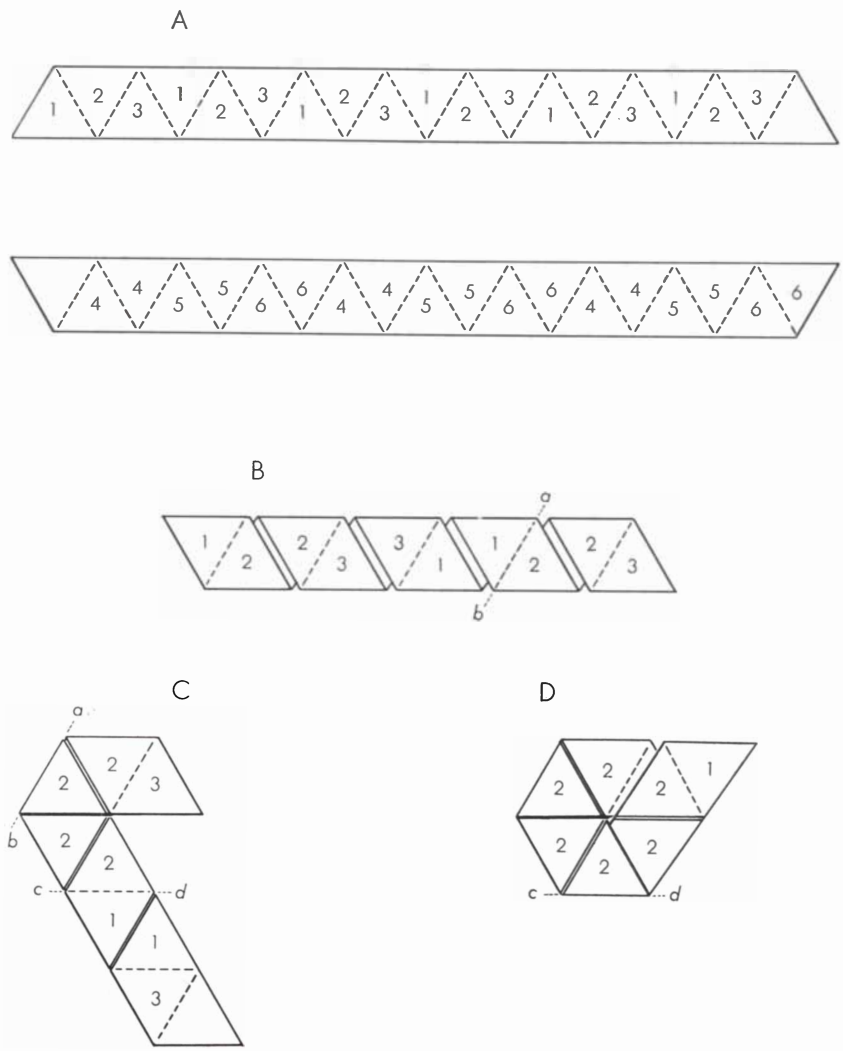
1, 2 and 3 turn up three times as often as 4, 5 and 6.

By lengthening the chain of triangles, the Committee discovered, one can make flexagons with 9, 12, 15 or more faces: Tuckerman managed to make a workable model with 48! He also found that with a strip of paper cut in a zigzag pattern (*i.e.*, a strip with sawtooth rather than straight edges) it was possible to produce a tetrahexaflexagon (four faces) or a pentahexaflexagon. There are three different hexahexaflexagons—one folded from a straight strip, one from a chain bent into a hexagon and one from a form that somewhat resembles a three-leaf clover. The decahexaflexagon (10 faces) has 82 different variations, all folded from weirdly bent strips. Flexagons can be formed with any desired number of faces, but beyond 10 the number of different species for each increases at an alarming rate. All even-numbered flexagons, by the way, are made of strips with two distinct sides, but those with an odd number of faces have only a single side, like a Moebius surface.

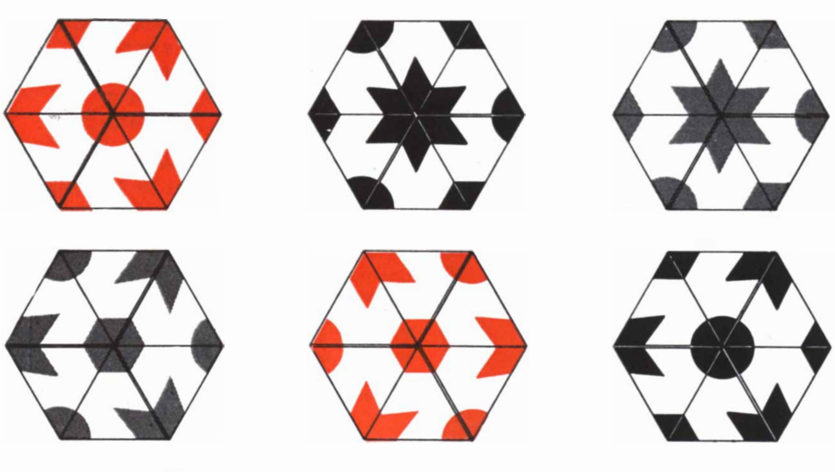
A complete mathematical theory of flexigation was worked out in 1940 by Tukey and Feynman. It shows, among other things, exactly how to construct a flexagon of any desired size or species. The theory has never been published, though portions of it have since been rediscovered by other mathematicians. Among the flexigators is Tuckerman's father, the distinguished physicist Louis B. Tuckerman, who was formerly with the National Bureau of Standards. Tuckerman senior devised a simple but efficient diagrammatic notation for the theory.

Pearl Harbor called a halt to the Committee's flexigation program, and war work soon scattered the four charter members to the winds. Stone is now a lecturer in mathematics at the University of Manchester in England. Feynman, now at the California Institute of Technology, is a famous theoretical physicist. Tukey, a professor of mathematics at Princeton, has made brilliant contributions to topology and to statistical theory which have brought him world-wide recognition. Tuckerman is a well-known mathematician at the Institute for Advanced Study in Princeton, where he works on the Institute's electronic computer project.

One of these days the Committee hopes to get together on a paper or two which will be the definitive exposition of flexagon theory. Until then the rest of us are free to flex our flexagons and see how much of the theory we can discover for ourselves.



HEXAHEXAFLEXAGON is constructed by cutting a strip of paper so that it may be marked off in 19 triangles (A). The triangles on one side are numbered 1, 2 and 3; the triangles on the other, 4, 5 and 6. A similar pattern of colors or geometrical figures may also be used. The hexagon is then folded as shown. The figure can be flexed to show six different faces.



"TUCKERMAN'S TRAVERSE" exposes all six faces of a hexahexaflexagon in 12 flexes. Here the numbers of the flexagon at the top of the page have been replaced by geometrical figures in the same pattern. Faces 1, 2 and 3 turn up three times as often as faces 4, 5 and 6.

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THE AMATEUR SCIENTIST

A computer to solve a problem of mechanical translation, and an ingenious cloud chamber

In March, 1955, this department described several electrical switching systems for playing games against human opponents and solving puzzles. All were essentially simplified versions of circuits commonly used in digital computers for expressing logical relationships between the terms of a problem. Jules O'Shea, a student at Ecole Polytechnique in Montreal, now submits a complete machine—one equipped not only with logic circuits but with sensing elements for accepting raw information, memory units for storing it, a "brain" for processing the data and an output register for transforming the final electrical impulses into Arabic numerals. He calls his machine a "Grammatical Word Computer," and he managed to build it for less than $15.

"As 'thinking' machines go," writes O'Shea, "my special-purpose computer stands pretty low on the I.Q. scale. It has just enough of a 'brain' to count words as they are written on a typewriter. The project was suggested by the article, 'Translation by Machine,' which appeared in the January, 1956, issue of SCIENTIFIC AMERICAN. A translating machine, the author pointed out, must first of all be capable of recognizing a word when one is presented for translation and of keeping track of sequences of words. In short, it must count and record dissimilar entities occurring at random without apparent logical or mathematical relationship. The pronoun 'I' must count as heavily as the noun 'antidisestablishmentarianism,' and the machine may draw no distinction between a simple word such as 'cat' and a compound one such as 'brother-in-law.'

"At first glance the problem looks easy. Why not solve it simply by counting the spaces invariably left between words? The space bar of a typewriter could be fitted with a mechanical device which would register a count for each space and, hence, for each word. This obvious solution is ruled out by several difficulties, including the fact that there is no space after a sentence ending a line and that a word may be broken by a hyphen at the end of a line. Punctuation also introduces some problems: for instance, a comma usually ends a word, but it may also come within a set of digits making a number.

"In addition, there are certain limitations imposed by the typewriter itself. In my case, for example, the proposed computer was to be associated with a portable typewriter used daily both at school and at home. The computer could not be permitted to impair either the operation or portability of the machine. Moreover, I did not wish to mar the appearance of the typewriter by drilling holes in it or cluttering the frame with switches or other electrical parts. This requirement was finally met but at some cost, under certain circumstances, to the accuracy of the count of words.

"The computer I have designed for the purpose is a separate machine housed in two units. One holds the sensing elements and logic circuits; the other houses the memories, 'brain,' output register and power supply. The sensing elements are electrical switches, actuated mechanically by the typewriter keys. The switches are assembled in an inch-high rectangular box which serves as a base for the typewriter [*see drawing at the bottom of the next page*]. The homemade switch arms are L-shaped pieces of plywood hinged at the outer end of the L's horizontal arm, which also carries contacts of strip copper. The upper end of each L touches the bottom of the appropriate typewriter-key lever. The compromise with the accuracy of count was made in the case of the line-space lever. Ideally the line-space lever and its switch would be linked directly. Instead I arranged for the carriage, when extended, to bear against a roller carried at the end of one oversized L. Thus the carriage, not the line-space lever, actuates the switch. The contact arrangement of this switch is such that a single impulse is transmitted when, and only when, the carriage is returned to the beginning of a line. The electrical circuit is completed when the movable contacts wipe across the fixed contacts in one direction. The opposite face of the movable contacts is insulated by a layer of friction tape. Hence no connection is made during the return wipe [*see drawing at the top of the next page*]. All switches are wired to a multiprong receptacle mounted in the rear wall of the shallow box. Connection with the computer unit is made through a multiprong plug and cable.

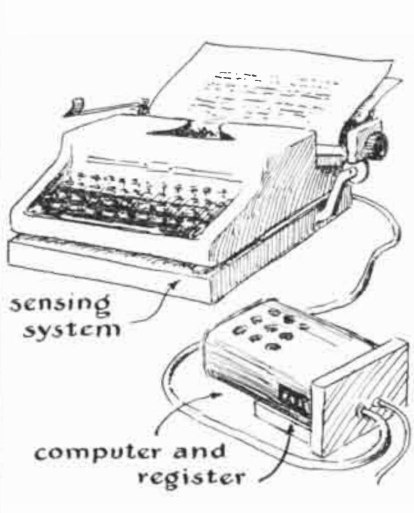
"When amateurs first became interested in building complex switching systems, good relays could be picked up inexpensively on the surplus market, and most early computers were designed around them. That source is now largely exhausted. So my design is based on electronic components. These have proved not only cheaper than relays but more effective and far more interesting. Electrolytic capacitors serve as memory units. I could find no reference in the literature to such an application of electrolytic capacitors in commercial computers. Conventionally they are equipped with magnetic components such as recording tapes, ferrite cores and so on. But I took a chance on capacitors because they are inexpensive and available in all radio supply stores.

"The brain of the machine consists of a single 'neuron'—an RCA-5823 gas triode. The mechanical structure of this tube resembles that of a conventional high-vacuum triode, but its operating characteristics are different. In a high-vacuum triode the flow of current between the plate and cathode can be minutely controlled by varying the charge on the grid. The gas triode, on the other hand, is an all-or-nothing device. When its grid is at zero potential with respect to the cathode, substantially no current can flow in the plate-cathode circuit if the plate voltage is below a critical value—about 200 volts in the case of the RCA-5823—at which the gas in the tube becomes ionized. But if a positive charge of about 75 volts is placed on the grid, it initiates a self-sustaining ionization of the gas, and current starts to flow in the plate-cathode circuit. It will continue to flow until the potential across the plate-cathode terminals is interrupted—even though the charge on the grid is reduced to zero. In other words, the grid loses control the instant conduction is initiated in the plate-cathode circuit. Like a neuron, the gas-filled triode either fires or refuses to fire, depending upon the state of charge on the grid.

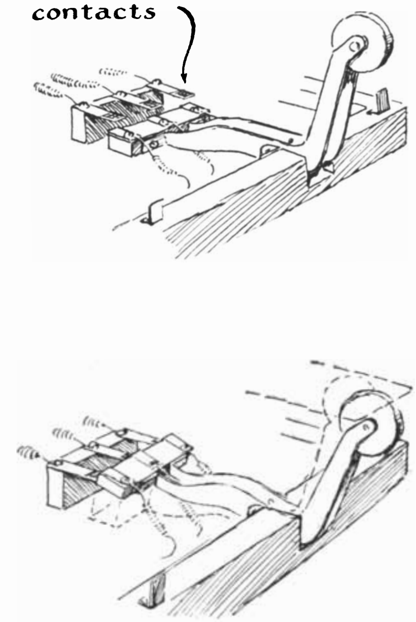
"A message register of the type used in telephone central offices to meter calls serves as the output mechanism of the computer. It consists of a modified and elaborated relay in which the armature actuates a wheel-type counter through a ratchet. The energizing coil is wired in series with the plate-cathode circuit of the gas triode [*see diagram on page 172*]. Whenever the tube fires, a count is registered.

"The circuit includes a starting button to charge the memory capacitors beforehand and a slow-release relay for restoring the charge in the capacitors automatically according to the requirements of the text as typing on the typewriter proceeds. The memory capacitors are wired to the grid of the triode. The tube either fires or does not fire, depending upon the information present in the memories as represented by the state of their charge.

"To put the computer into operation, the typist presses the button, then writes the first word and hits the space bar. The first of two sets of contacts of the switch beneath the space bar closes, grounding the cathode of the triode and sending a



General appearance of word computer



Details of line-space lever switch

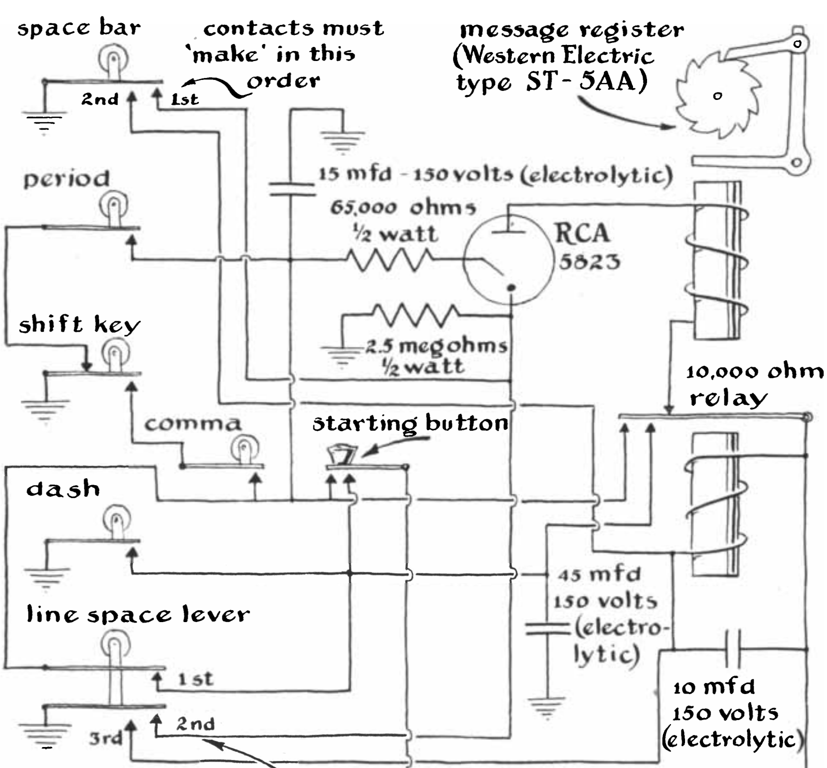
pulse through the register for a count. The second set of contacts then closes, energizing the relay. The armature moves down and breaks the set of contacts between the register and power supply. Since the plate derives power through the coil of the register, the tube is extinguished automatically. 'Make' contacts of the armature then close, restoring both of the capacitors to full charge.

"The end of a sentence is customarily followed by two spaces, but the computer must register only one count for the last word in the sentence. When the typist hits the period key, this closes a set of contacts on the switch actuated by the period key-lever and discharges the 15-microfarad capacitor to ground. The absence of charge represents the information that a period has been inserted. The grid of the triode is at zero potential and the tube is immobilized. Accordingly, when the space bar is depressed no count registers. The second set of contacts on the space-bar switch energizes the relay, which restores the capacitors to full charge in readiness for the succeeding operation of the space bar. Thus in effect the computer remembers that it should not register a count following a period until the second of two spaces has been inserted.

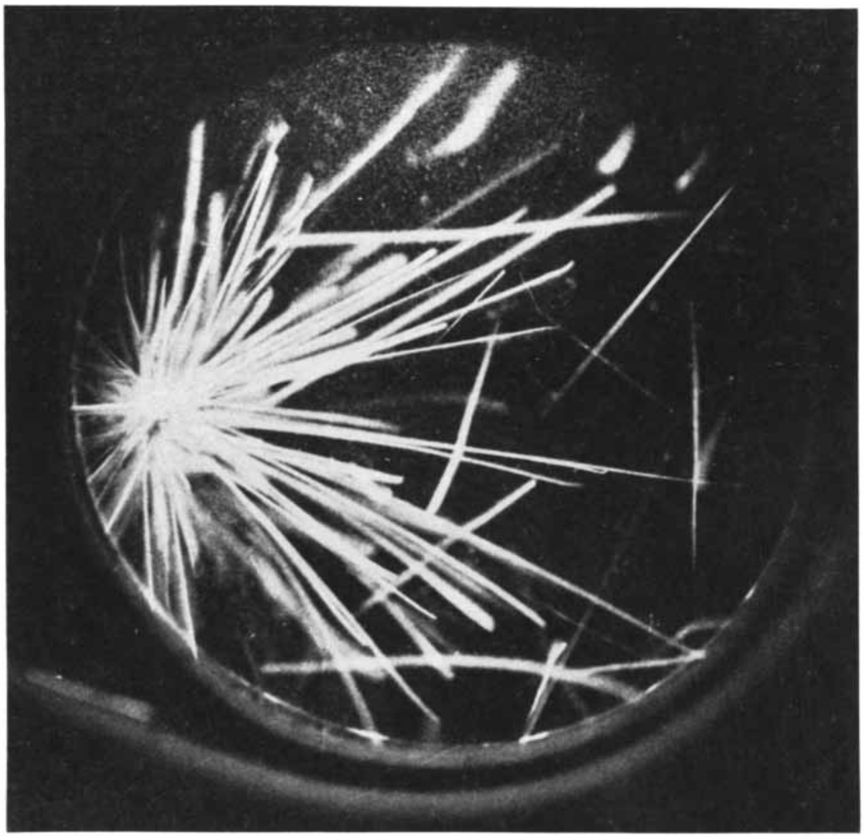
"Different makes of typewriters may have their punctuation marks in different positions on the keyboard. On my

machine, a Royal portable, the question mark appears in the upper-case position on the comma key. This means that the question mark is distinguished from the comma by the fact that this key and the shift key are pressed down simultaneously. My computer recognizes the event by means of a connection in series between the 'make' contacts of both keys, so that the capacitor is discharged when the two keys are operated simultaneously. When they are so operated, the action of the circuit is identical with that of the period-key circuit, and the computer registers only one count after the question mark just as it does after the period. The shift key is equipped with a second contact of the 'break' type through which the switch arm of the period key reaches ground. Hence operation of the shift key automatically inhibits the action of the period key.

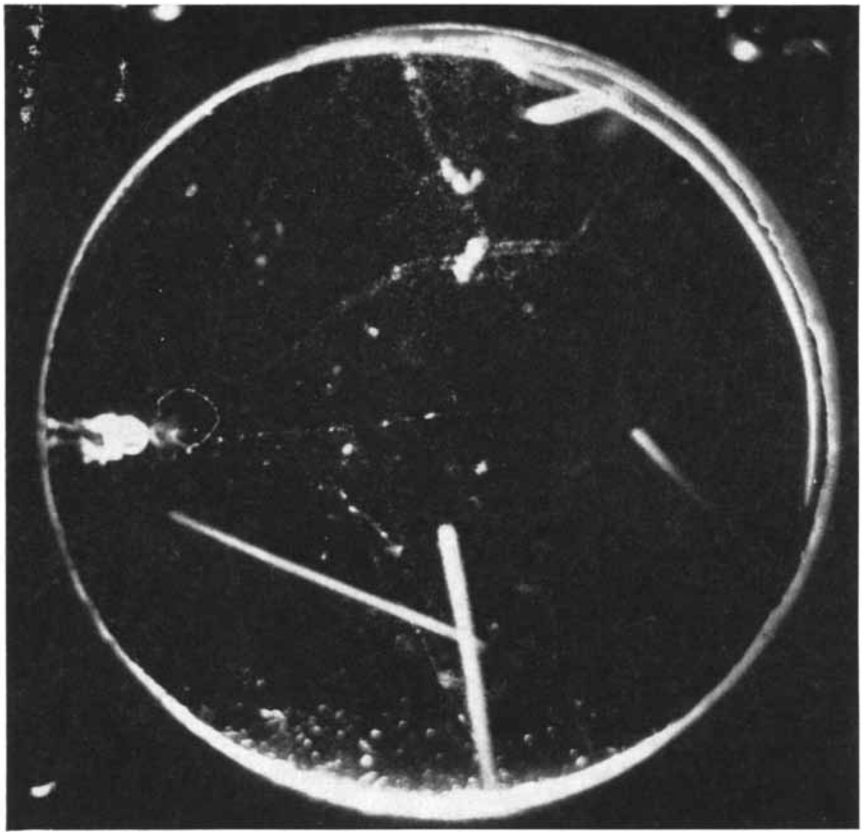
"For the situations in which the end of a sentence comes at the end of a line or a word is split by a hyphen and carried over to the next line, the computer has a second memory. This is a capacitor of 45 microfarads; that is, it can store three times as much charge as the first one. A set of 'make' contacts on the line-space lever connects the two memories. The ratio of capacity of the two memories is such that the shared charge will not drop below 75 volts when the fully charged second capacitor is connected with the discharged first capacitor. But in the reverse case, when the first capacitor, in the fully charged state, is connected with the second in the discharged state, the potential of the combination drops below the critical value and immobilizes the tube. Now let us see what happens when a period comes at the end of a line. The striking of the period key discharges the small capacitor, thereby informing the memory that two spaces must precede the next count. At the same time the first of the sets of contacts on the switch of the line-space lever closes. The large capacitor discharges into the smaller one, restoring the critical potential. Thus the large capacitor remembers the exception and, in effect, instructs the brain to ignore the previous order. The second set of contacts on the line-space switch then closes the plate-cathode circuit for a count. Finally a third set of contacts on the line-space switch energizes the relay, restoring both capacitors to full charge and in effect



Circuit diagram of word computer



Heavy tracks of alpha particles in a homemade cloud chamber



Lighter tracks of beta particles emerge from same point in chamber

wiping out all information in preparation for the next event.

"The insertion of a hyphen at the end of a line closes a set of contacts associated with the hyphen key. This discharges the large capacitor. The succeeding operation of the line-space lever then connects the two capacitors. The small capacitor shares its charge with the large one, but the shared potential is below the critical value. The brain is thus informed that the line ended with a broken word. Consequently no count is registered when the second set of contacts on the line-space switch closes.

"The machine thus provides for every variation of spacing and punctuation encountered in ordinary English text. To do so it must remember only two 'bits' of information at a time. These are represented by any two of three possible capacitor states—fully charged, discharged or shared charges.

"The accuracy of the count is subject to three limitations of the equipment. If the typist lets the carriage stand idle for more than five minutes at the end of a line terminated by a period, the capacitors discharge through leakage. Operation of the line-space lever will then fail to register a count. The error can be avoided by pushing the 'start' button. Errors also occur if the machine is operated at more than about 50 words per minute: inertia then prevents the register from following accurately. The solution, of course, is a high-speed register. At high speed the contacts of my homemade switches tend to operate simultaneously instead of sequentially. Commercial microswitches appear to be the cure.

"In spite of its imperfections, my machine has supported the design theory, and since I am only a hunt-and-peck typist, the slowness of the apparatus gives me no trouble. I get as much fun out of it as if it were able to count 100 words per minute.

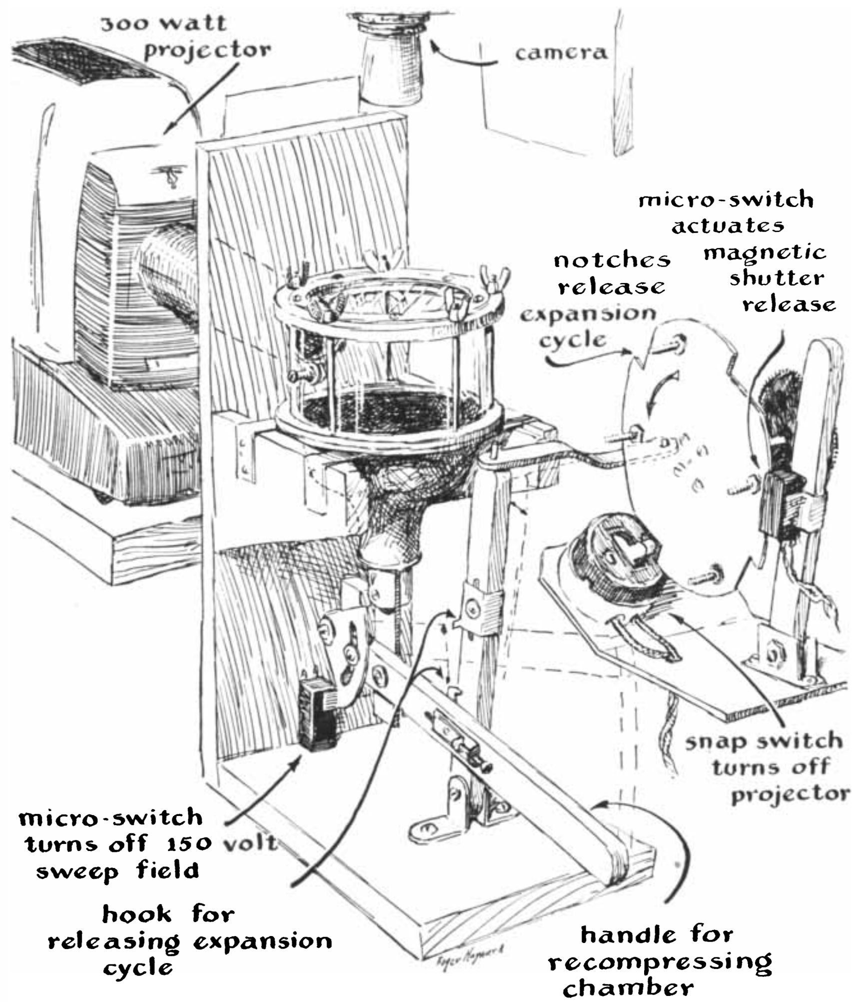
"The capacitors, brain assembly, register and power supply are mounted on a common chassis enclosed by a container made from a liquid-floor-wax can which measures only two inches wide, four inches deep and eight inches long. The power supply is of the conventional voltage doubler type. It operates from 110 volts a.c. and is designed around a 117Z6 twin diode, the circuit of which is described in standard reference texts. The 10,000-ohm relay is of the type used for controlling the heat of electric blankets. I converted it for slow release by connecting a 10-microfarad capacitor during times when the tube is conducting. The 2.5-megohm resistor be-

tween the cathode and the ground stabilizes the action of the tube.

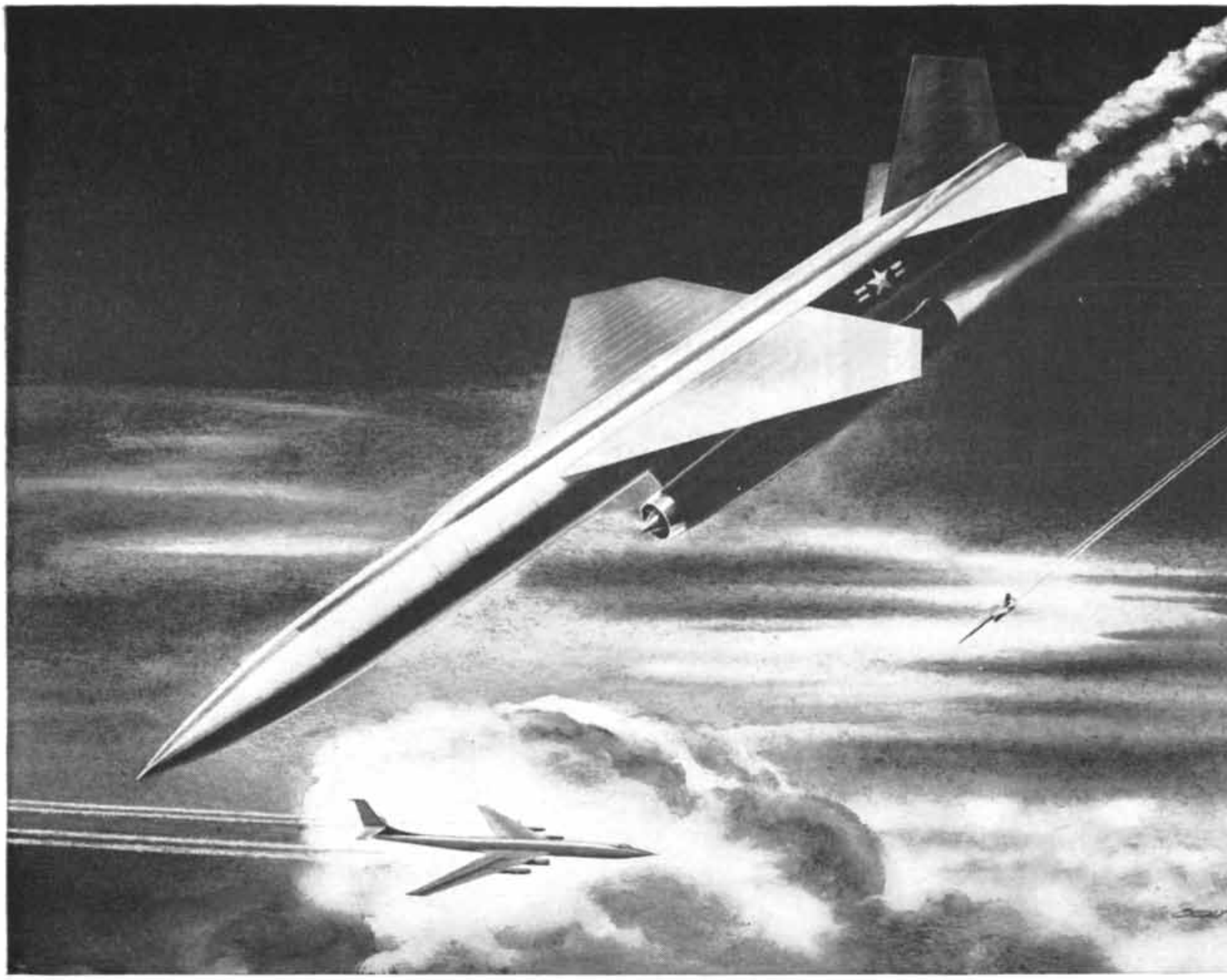
"Incidentally, the computer holds to arbitrary and stubborn opinions, as might be expected of a device with limited intelligence. Some authorities insist, for example, that an abbreviation should not be considered a word. Others disagree. The computer stoutly sides with the latter."

Among readers who requested the samples of radium offered last April in connection with the article on cloud chambers was Louie R. Hull, a physics teacher at South Side High School in Fort Wayne, Ind. He sends some photographs of alpha and beta tracks recorded in his homemade cloud chamber, one of which shows how a barrier of cellophane blocks the alpha particles [*see photographs on page 174*].

"These tracks," says Hull, "were photographed with the aid of a 'plumber's friend' cloud chamber—an arrangement assembled from odd parts from the junk box. Like the 'peanut-butter jar' chamber that you described, the plumber's friend can be constructed in a single evening. The basic idea stemmed from a chamber of the rubber-bulb compression type popular for classroom demonstrations. Although the rubber-bulb instrument is satisfactory for a visual demonstration, trouble was encountered when we attempted to photograph tracks with it. Compressions could not be reproduced uniformly, nor could we time the exposures correctly. Various alternate arrangements were tried until it occurred to us that the plumber's friend—a rubber plunger of the kind used for clearing drains—might work. In the cloud chamber it does not operate strictly as a piston does, of course, because the center of the plunger moves a greater distance than the edges. As a result the particle tracks are distorted somewhat;



The "plumber's friend" cloud chamber



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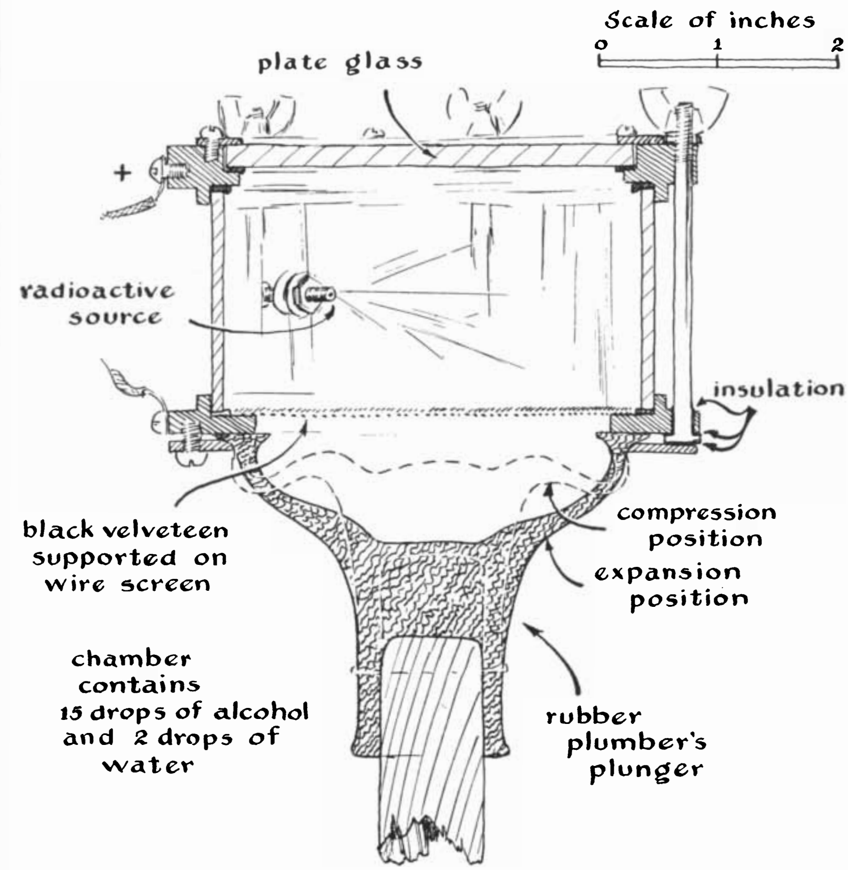
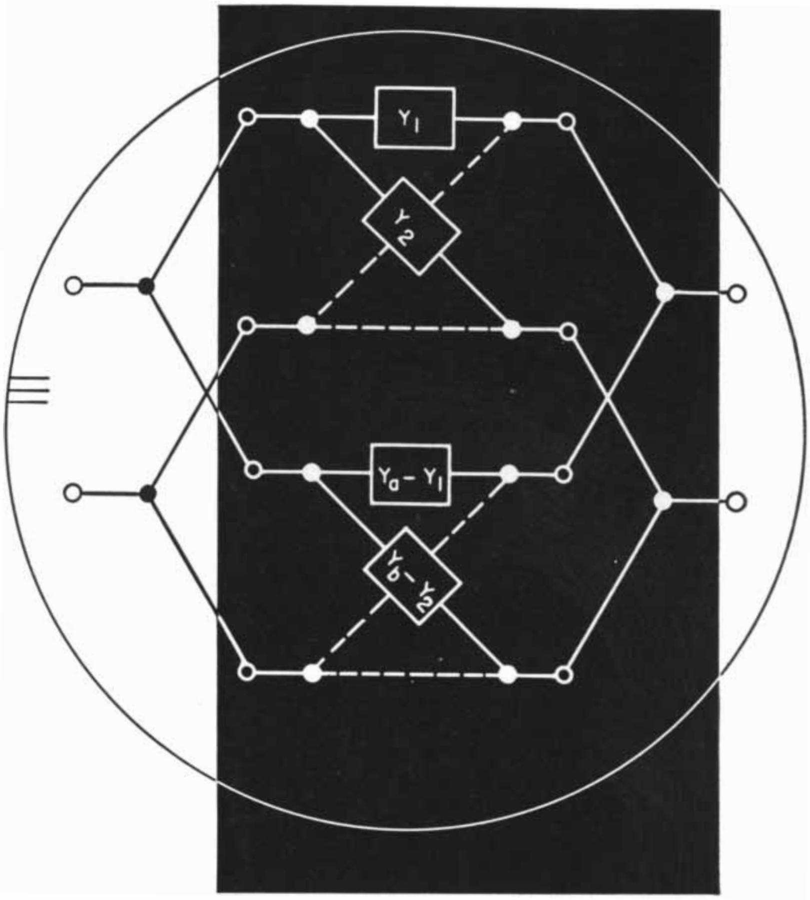


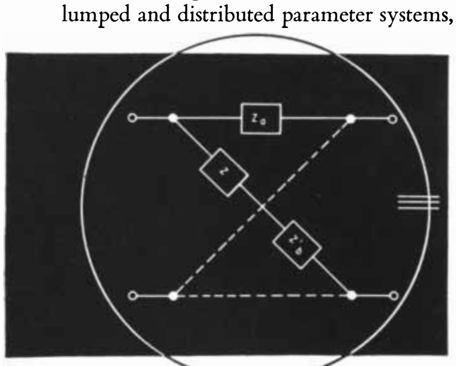
Construction details of the cloud chamber

nevertheless we are delighted with the performance of the arrangement and have made hundreds of excellent pictures.

"The side walls of the chamber are cut from a quart glass jar by the hot-wire method. You wrap a single turn of iron wire (such as that used for binding brooms) around the jar tightly at the place where the cut is desired, the ends being separated by a small sheet of asbestos insulation where they would otherwise make electrical contact. The loop becomes red hot when you connect it across the six-volt terminals of a transformer or storage battery. After about 30 seconds of heating you remove the wire. Plunge the jar into cold water immediately. The glass will break cleanly at the line where it was heated by the wire. The sharp edges are then rounded with abrasive such as emery or carborundum.

"The top of the chamber is closed by a plate-glass window [*see drawing on page 176*]. If you do not own a circular glass cutter, one can easily be rigged from a wheel-type cutter available in hardware stores. Fasten the wheel end of the cutter to one end of a short length of inch-square wood so that the wheel protrudes slightly beneath the lower edge of the wood. Next drive a wood screw through the wood vertically at a distance from the cutter wheel equal to the radius of the desired glass disk. The protruding tip of the wood screw serves as the center point of a compass, the wheel as the other point. Then make an indentation with a center punch in a small scrap of 16-gauge sheet metal. You place this punched piece of metal on the glass to be cut, backing the metal with friction tape to prevent it from slipping. The punched indentation is centered with respect to the glass. Now you put the protruding tip of the wood screw in the indentation and make a circular cut in the glass with a single, firm rotary stroke of the tool. After this, if you make 10 straight radial cuts from this disk to the edge of the glass sheet, you can break away the outer pieces, leaving a disk the same size as the circu-



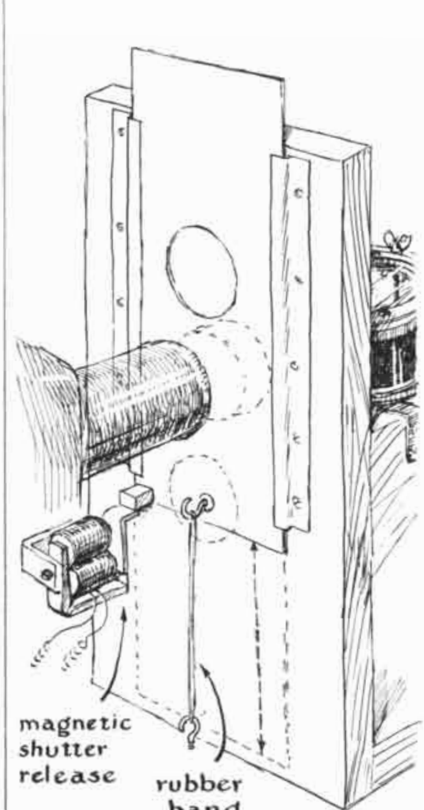


lar cut. You then smooth the edge of the disk with abrasive.

"The glass cylinder, window and plumber's friend are fastened together with metal rings [*see drawing on page 178*]. The ring fittings can be built of thin sections cut from sheet metal and soldered. If a metal cutting lathe is available, you can machine them from a thick slab of stock. Rubber gaskets must be inserted where the metal and glass come into contact. Turbulence in the chamber is minimized by inserting a disk of black velveteen, supported by wire screening, between the cavity of the rubber plunger and the chamber. The radioactive sample is supported inside the chamber by a machine screw inserted through the side wall.

"The assembled chamber is supported on a wooden bracket. Its expansion is actuated by a lever mechanism, which is tripped by a motor-driven cam. The chamber is illuminated by a 300-watt slide projector, the beam of which is controlled by a shutter released electromagnetically. The camera is positioned above.

"To make the compression stroke you lift the horizontal lever quickly and hook



Shutter details of the cloud chamber

it to the vertical lever [*see drawing on page 176*]. The compression should not exceed about one third of an atmosphere, or the chamber will fill with fog on expansion. After about 30 seconds you start the motor. The cam advances until the metal arm at the top of the vertical lever drops into a notch on the cam. A spring then pulls the vertical lever away from the chamber, unhooking the horizontal lever. The plumber's friend then springs to its original shape, accomplishing the expansion stroke.

"An electrostatic 'clearing' field is applied to the chamber automatically during the compression stroke by a microswitch actuated by the horizontal lever. The field is removed by the switch and the leads to the chamber are short-circuited automatically at the end of the expansion stroke. Similarly, the motor-driven cam is equipped with switches for operating the projector and shutter release in sequence. Exposure time is fixed by the tension of a rubber band hooked to the shutter [*drawing on page 180*].

"The proportion and amount of liquid in the chamber are not critical. Good tracks form with either 180-proof grain alcohol or rubbing alcohol as it comes from the bottle. Performance is influenced by room temperature, however. Above 70 degrees Fahrenheit results are improved by diluting the alcohol slightly with water—say 15 drops of alcohol to two drops of water. It should be kept in mind that fog results from too much liquid as well as from overexpansion. The chamber rarely requires more than 20 drops of liquid. Don't expect to see tracks during the first few expansions. The liquid must have time to evaporate.

"Beta tracks, being thin, are more difficult to see than alphas and appear best when the alphas have faded. It is interesting to investigate the penetrating power of particles through thin sheets of various materials. The chamber also enables you to experiment with various other atomic phenomena. If you substitute a freshly polished needle of zinc for the radium source, for example, you will see beta tracks shoot from the point. These are photoelectrons released by light shining on the metal. The number of photoelectrons ejected will increase immensely if the chamber is illuminated by an arc lamp shining through a window of sheet quartz or of a clear plastic that transmits ultraviolet light readily. Such modifications of the chamber enable you to investigate the photoelectric properties of many substances as well as other forces that disturb the atomic structure of matter."

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DECEMBER, 1956

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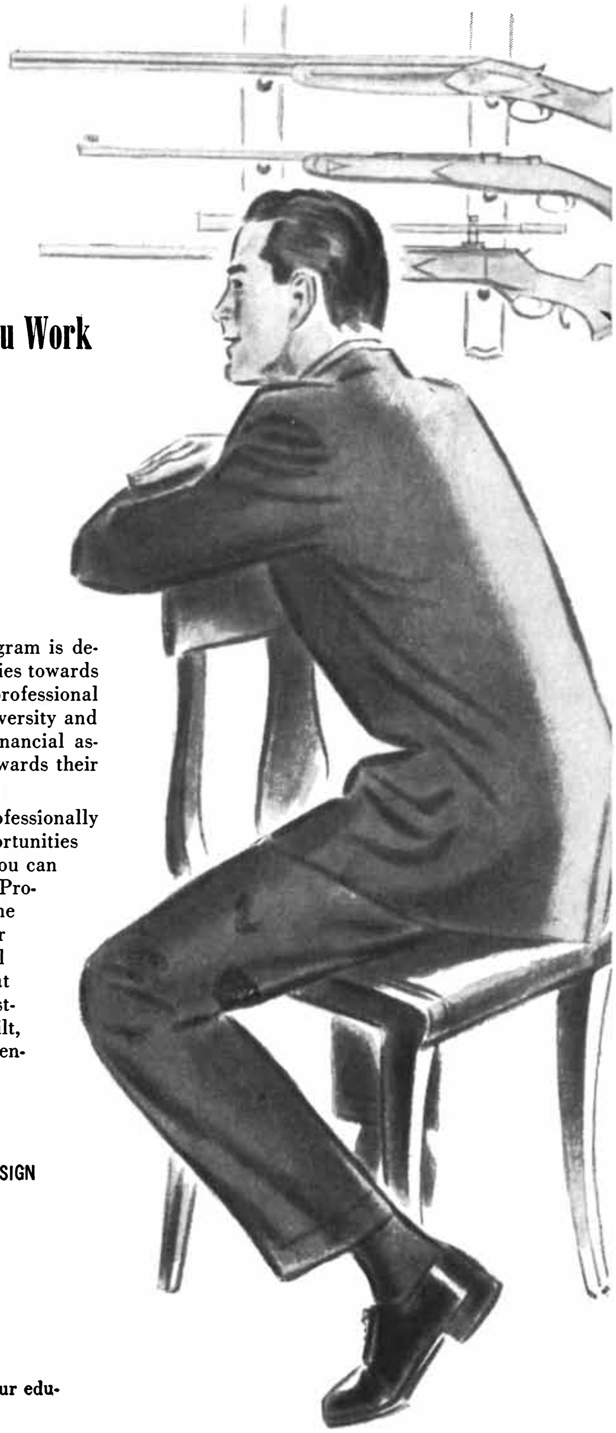

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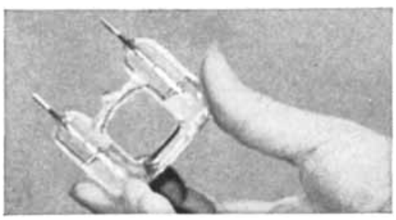
NORTHROP DUPLICATES HUMAN EAR

For use in its Guided Missile Programs

(HAWTHORNE, CALIF.) Scientists at Northrop Aircraft have duplicated the balance mechanism of the human ear in perfecting a highly effective "brain" unit for use in Northrop's advanced guided missile programs. Weighing little more



than an ounce, it resembles the convolutions of the inner ear in shape. Northrop engineers say the new instrument is so sensitive that if installed at the top of the Washington Monument it could detect the vibrations created by the footsteps of a small child entering the door at the base of the edifice.

The instrument consists of twin tubes of glass joined at the bottom by two smaller glass tubes. An electrolytic solution, precisely injected by a hypodermic needle, covers tungsten electrodes after they are fused into the glass. These are connected to an AC Wheatstone bridge circuit.

Scientists describe this sensitive device as a manometer accelerometer. In lay terms it is known as a "flying plumb bob," because it can continuously report to the complex automatic guidance "brain" of a missile even the slightest course deviation. It can also be used as an accurate vertical-sensing device in military weapons and for automatic precision leveling in survey operations. It also has potential use in preparing seismographs of earth movements.

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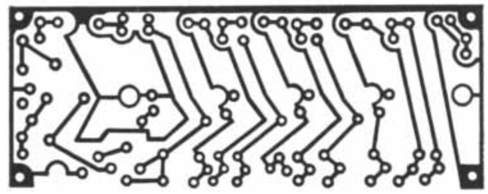

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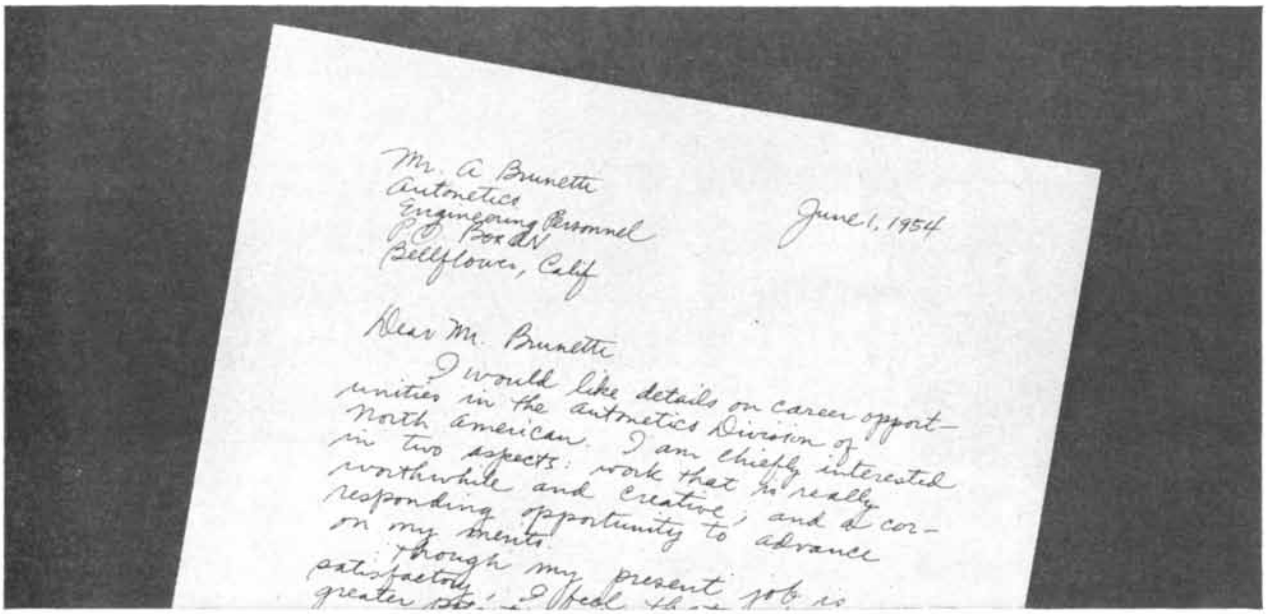
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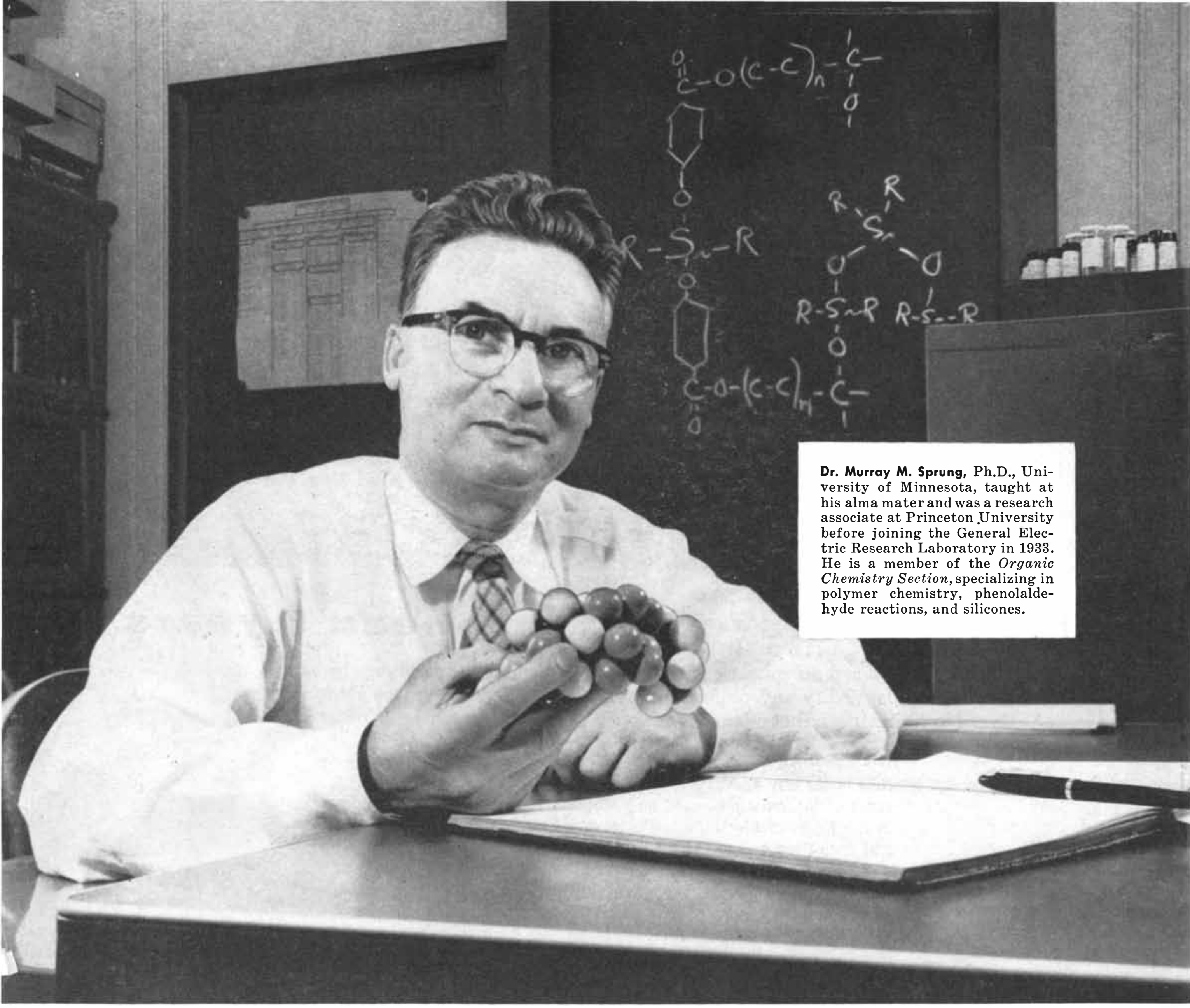

Dr. Murray M. Sprung, Ph.D., University of Minnesota, taught at his alma mater and was a research associate at Princeton University before joining the General Electric Research Laboratory in 1933. He is a member of the *Organic Chemistry Section,* specializing in polymer chemistry, phenolaldehyde reactions, and silicones.

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General Electric's Dr. Murray M. Sprung designs polymers

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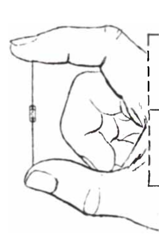

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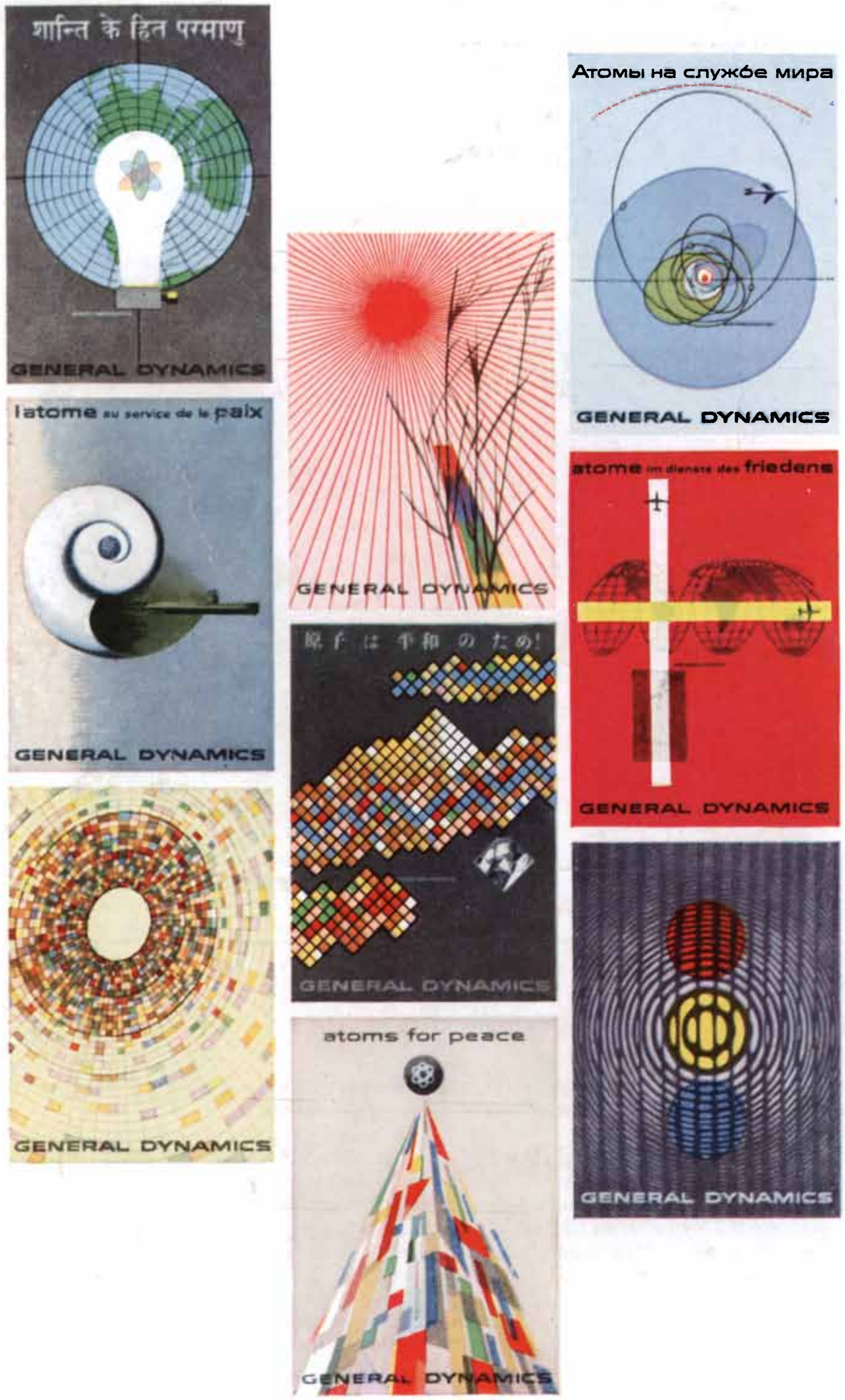

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