

SCIENTIFIC AMERICAN



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FIFTY CENTS

April 1959

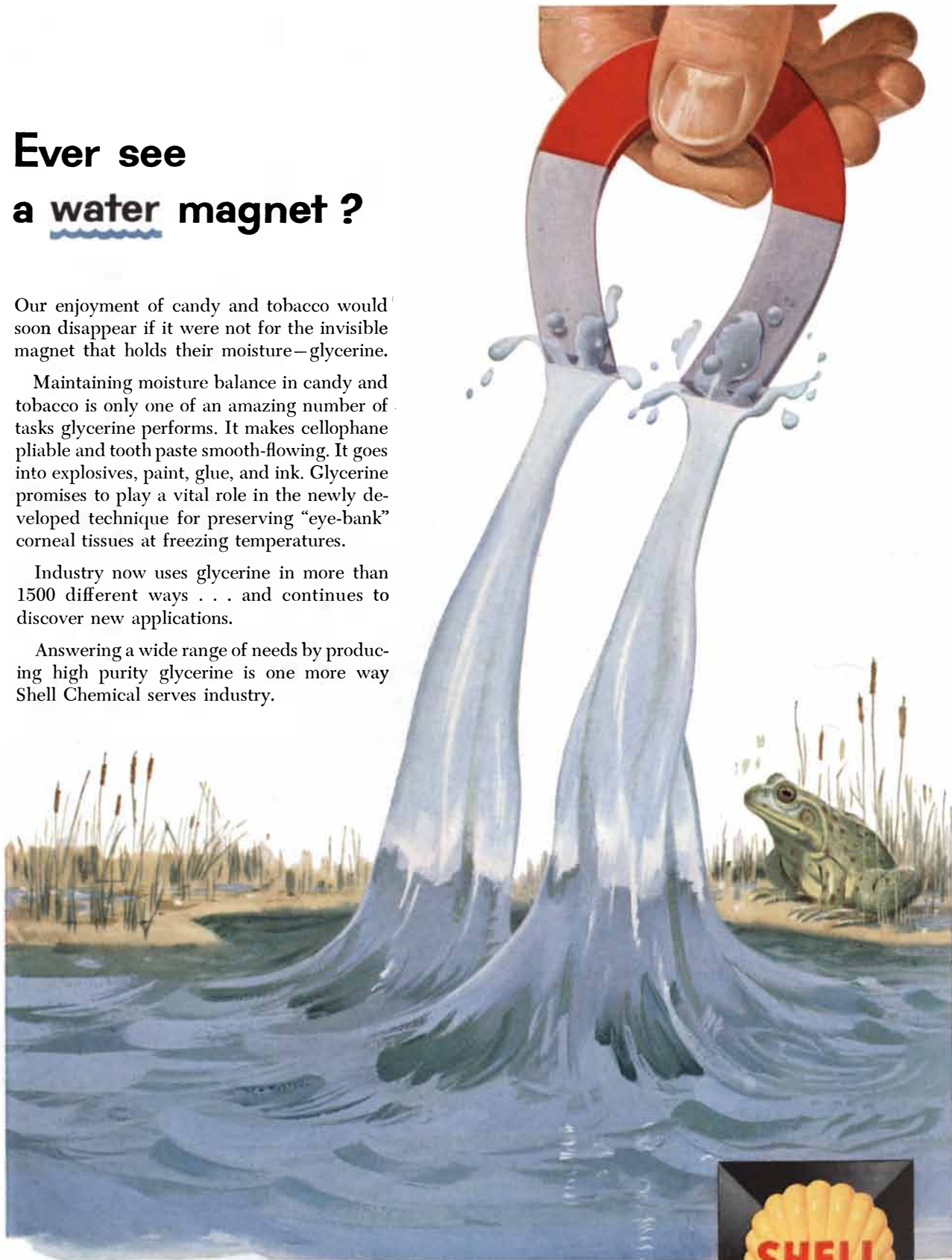
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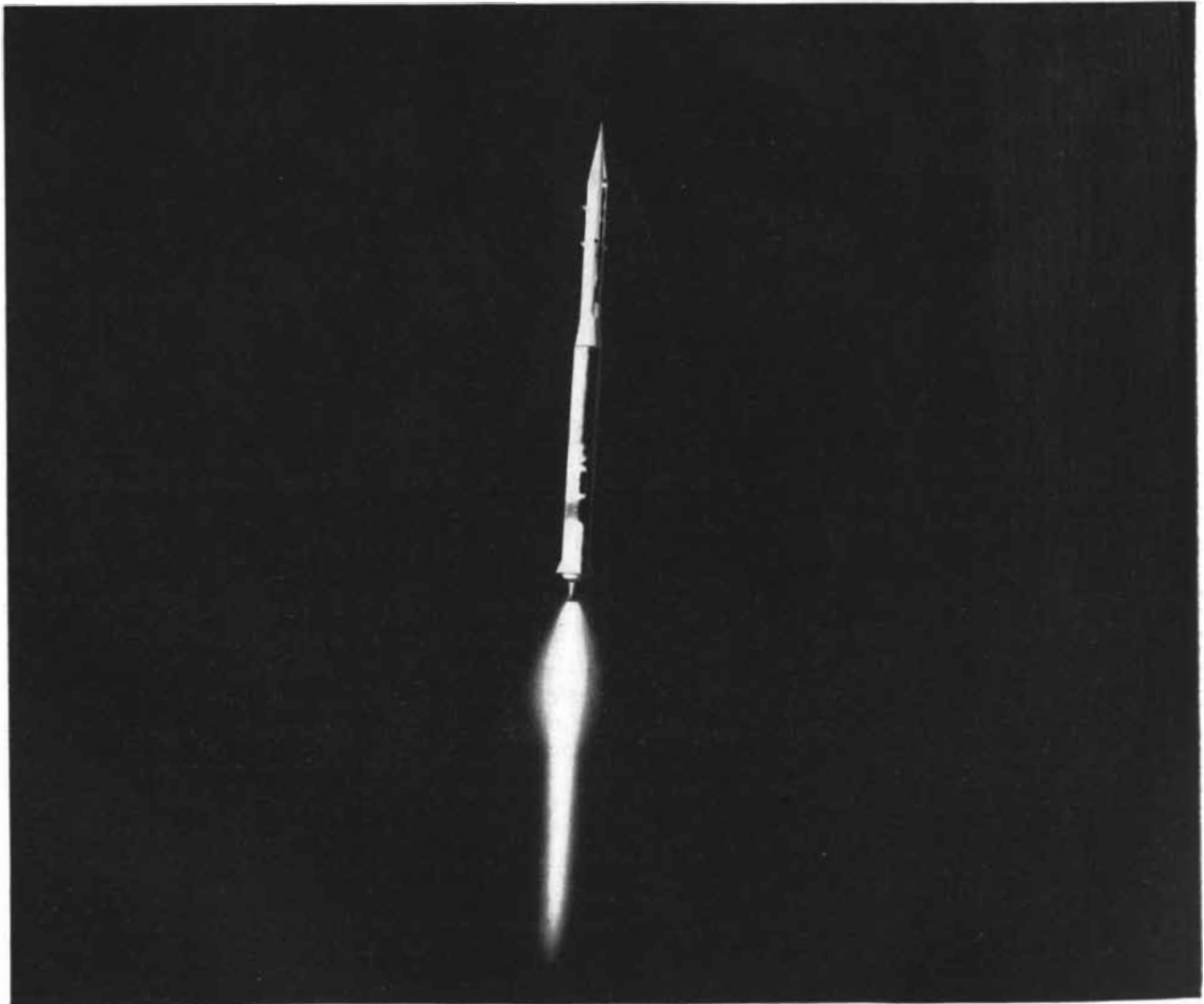


WHEN YOU'RE REACHING FOR THE MOON

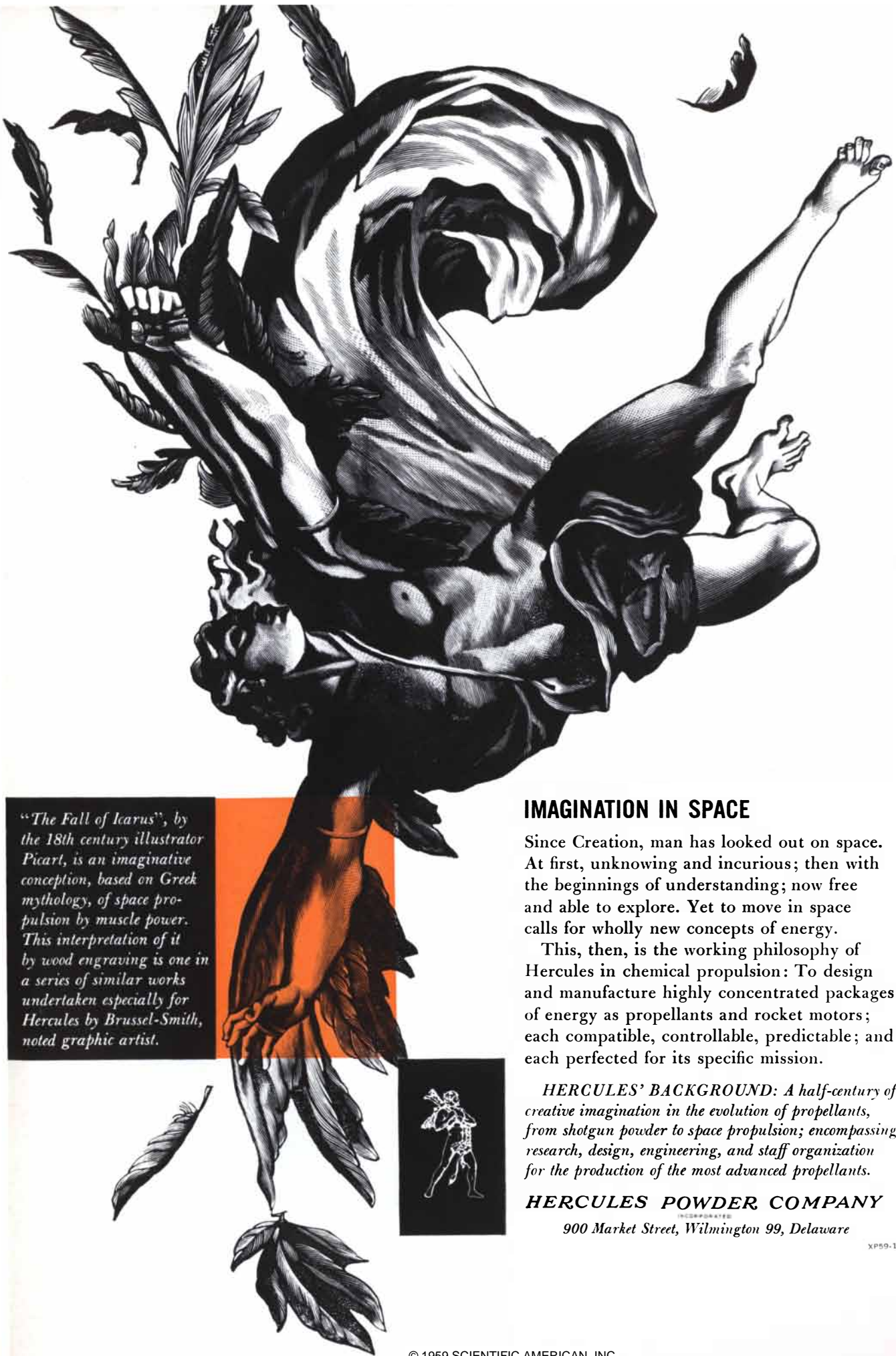
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"The Fall of Icarus", by the 18th century illustrator Picart, is an imaginative conception, based on Greek mythology, of space propulsion by muscle power. This interpretation of it by wood engraving is one in a series of similar works undertaken especially for Hercules by Brussel-Smith, noted graphic artist.

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Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

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How to get the tubing you need for fuel element cladding

In determining the practicability of materials under consideration for tubing used as fuel element cladding in nuclear reactors, the following factors must be considered and properly evaluated:

1. Type of fuel—ceramic or metallic matrix
2. Environment—temperature, pressure and corrosive conditions encountered
3. Neutron economy—whether materials like zirconium, columbium, vanadium or Zircalloy, which have the best nuclear characteristics, are to be used; or whether less effective substitutes must suffice as a cost consideration
4. Standard of reliability and integrity—what is wanted, what it is possible to produce, what is economically feasible
5. Dimensional requirements—OD, ID or wall thickness or any combination of these; straightness of tubing; and tolerances to be held

Only after these factors have been determined and given due relative weight by both the Metallurgical and Production Departments can a satisfactory recommendation be made. Let us take a composite inquiry to show what Superior does to give its customers the utmost satisfaction.

Analysis: Seamless 304, .002% max. cobalt limitation, chemistry restriction.

Sizes: .443 in. \pm .0005 in. OD x .423 in. \pm .0005 in. $-$.0000 in. ID. Cut lengths, tolerances, \pm $\frac{1}{64}$ in.

Tests: Ultrasonic nondestructive, to a 3% wall defect level; helium leak test; autoclave corrosion test; 2-hr. hydrostatic test.

Other Requirements: Dye penetrant inspection; no chlorinated lubricants or cleaning fluids permitted; identification of raw material through to finished tubing—top, middle and bottom of ingot.

Here is the tubing that was supplied by Superior and the requirements which it met after extensive discussions with the customer's engineers:

Analysis: 304L because of application temperature. The best reasonable available level of cobalt is .05% max. By special

melt we could get .01% max. By converting ingot we could get a .003% max.—but we aimed for .002%.

Sizes: Tolerances of \pm .001 in. OD and $+$.001, $-$.000 in. ID. Since ID was the prime limiting factor we air-gaged to insure these tolerances.

Ultrasonic Test: We agreed upon a defect level of 10% of the wall, since the wall thickness was less than .040 in. We also recommended Eddy current, since the tubing was below $\frac{1}{2}$ in. OD x .049 in. wall.

Helium Leak Test: Customer waived this test when told of its impracticability. More recently it has been dropped from Nuclear Military Specifications. Test is used on completed assemblies only.

Autoclave Corrosion Test: Customer indicated time and temperature of test. We performed it.

Hydrostatic Test: The impracticability and high cost of this 2-hr. test was discussed with customer. It was decided to limit it to the completed pressure vessel.

Dye Penetrant Inspection: Performed according to specifications.

Chlorinated Lubricants or Cleaning Fluids: We explained that chlorinated materials are used in redrawing stainless steels and many other metals. This is general procedure in all tube processing plants. Customer unhesitatingly withdrew restriction.

Identification: This specification can be readily met to the point where the material is extruded. Thereafter, while possible, it is extremely impracticable and costly.

Since there is no such thing as a standard fuel element and each new reactor suggests modifications and improvements in design, it is necessary to compromise to satisfy all requirements. Superior's experience in the nuclear and missile field can help you in developing fuel element cladding. Data Memorandum No. 20 gives a rundown of our background and some of the tubing available. Write for a copy today. Superior Tube Company, 2052 Germantown Ave., Norristown, Pa.



THE COVER

The painting on the cover shows three lettuce seeds as they would appear under a low-power microscope. (The seeds are enlarged some 50 times.) Attached to the seed at left is the feathery parachute by which the wind bears the lettuce seed away from the parent plant. The painting represents an experimental situation in the investigation of some influences which cause a seed to germinate (see "Germination," by Dov Koller; page 75). It is known that red light will stimulate the germination of a lettuce seed, and that "far red" light (between red light and infrared radiation on the electromagnetic spectrum) will inhibit this stimulation. Two of the seeds in the painting have been partly wrapped in metal foil to determine whether any particular part of the seed is involved in these responses. The "bottom" of the seed in center has been wrapped; the "top" of the seed at right. At far right the head of a pair of tweezers pinches the edge of the foil to make a close-fitting, light-tight cover.

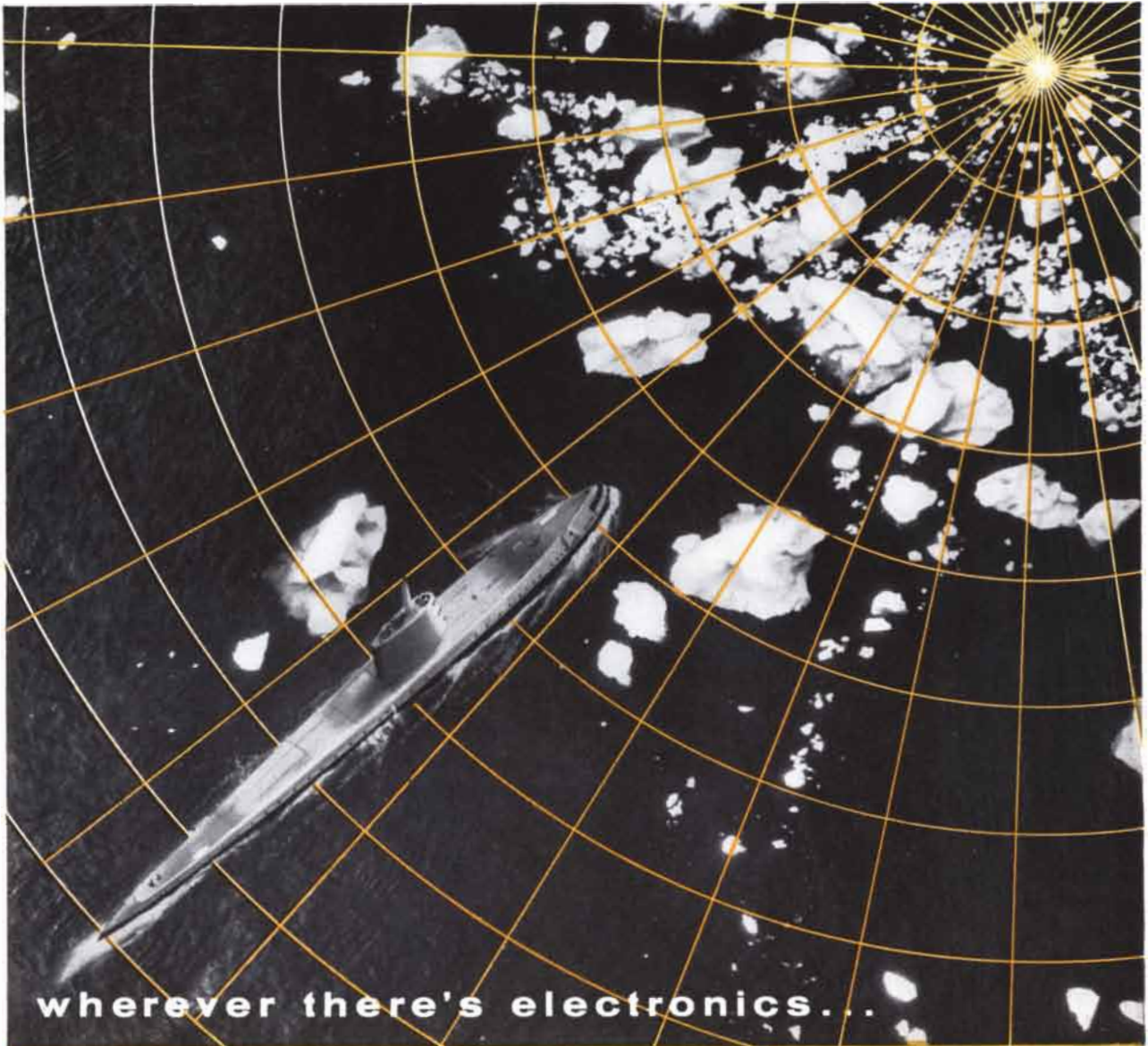
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by John Langley Howard

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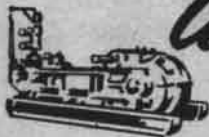


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AIRCRAFT

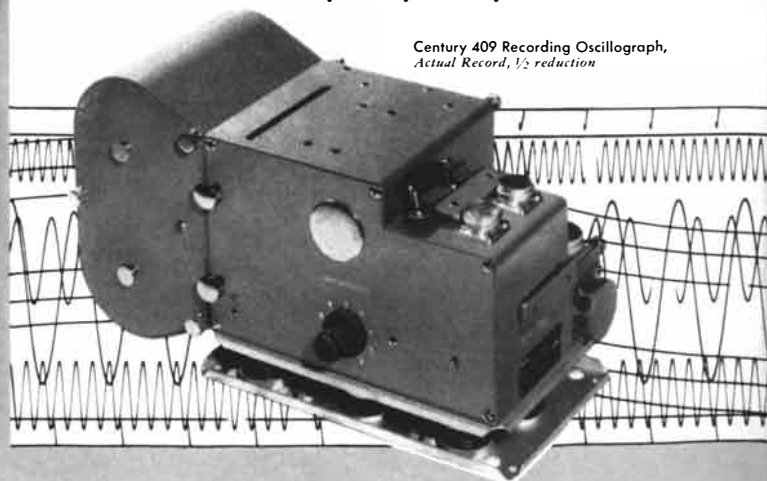
... The combination of compactness, thirteen pound weight, rugged dependability and simple design with uniform frequency response to 2,000 cps. makes the 409 Century oscillograph an ideal unit for airborne test recording in airplanes, rockets, missiles. It has had wide usage on an expendable basis in units being tested to destruction.

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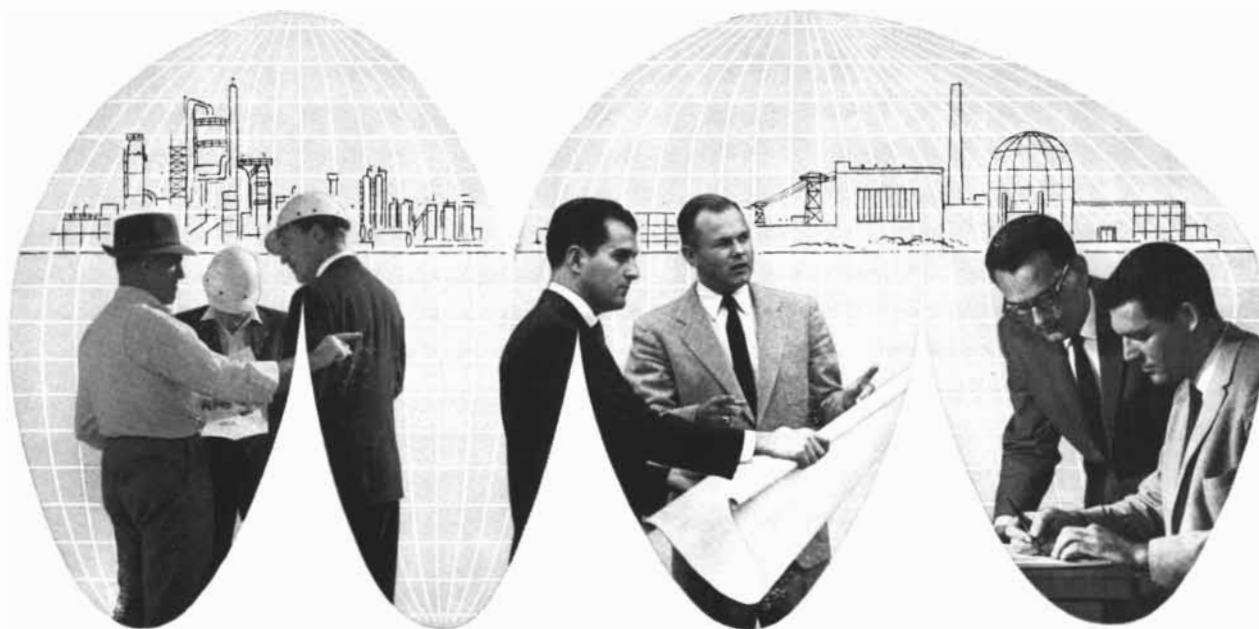


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Some of the world's largest companies have purchased the RW-300 Digital Control Computer for uses ranging

from the completely automatic control of an oil refinery unit in Texas to the monitoring of a nuclear reactor in France. Additional RW-300 installations are under way in such fields as chemical manufacturing, cement making, air traffic control, equipment testing, and data reduction.

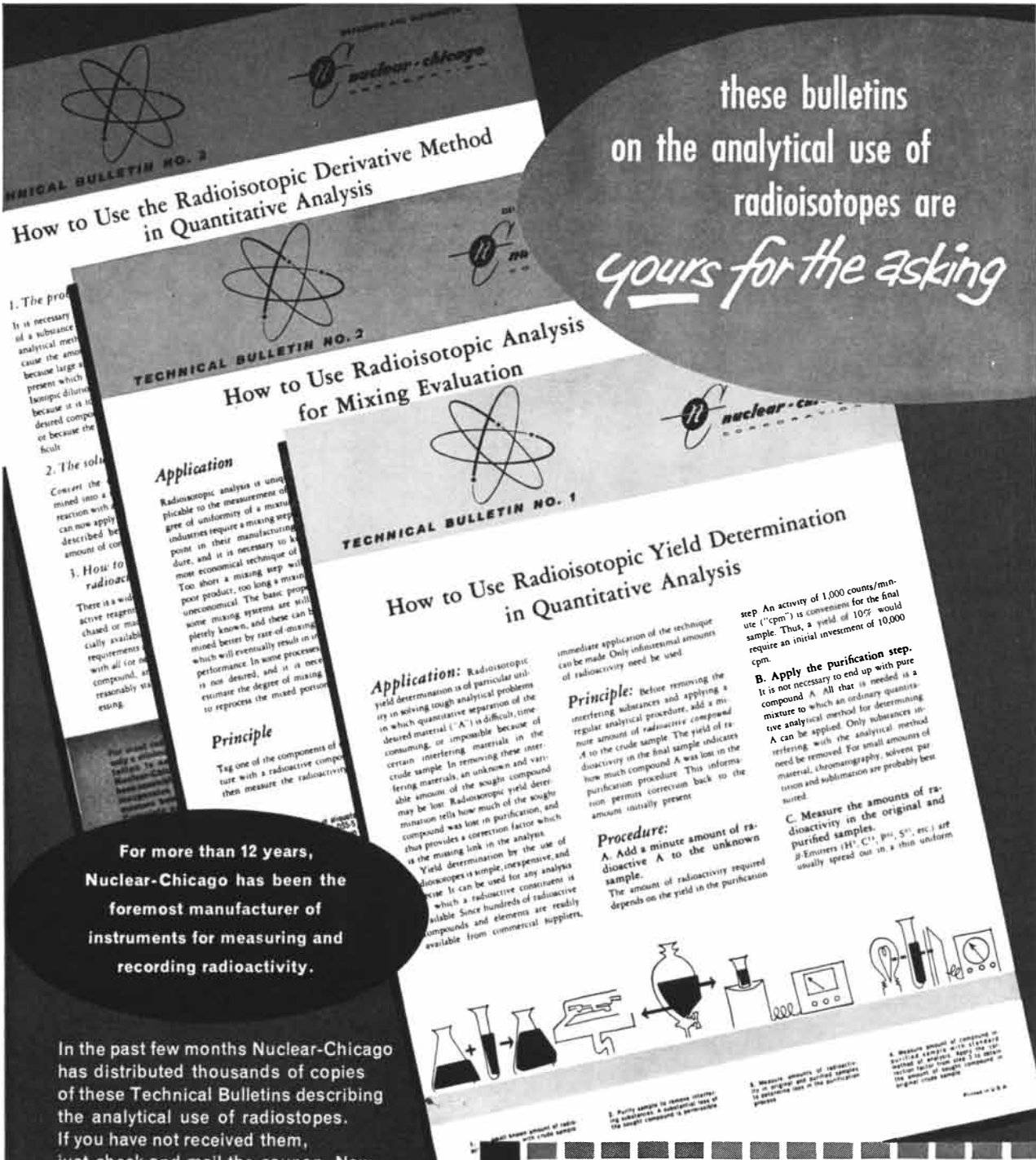
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TECHNICAL BULLETIN NO. 1

How to Use Radioisotopic Yield Determination in Quantitative Analysis

Application: Radioisotopic yield determination is of particular utility in solving tough analytical problems in which quantitative separation of the desired material ("A") is difficult, time-consuming, or impossible because of certain interfering materials in the crude sample. In removing these interfering materials, an unknown and variable amount of the sought compound may be lost. Radioisotopic yield determination tells how much of the sought compound was lost in purification, and provides a correction factor which is the missing link in the analysis.

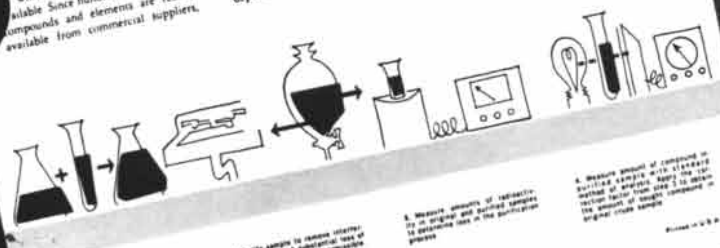
Principle: Before removing the interfering substances and applying a regular analytical procedure, add a known amount of radioactive compound A to the crude sample. The yield of A to the final sample indicates how much compound A was lost in the purification procedure. This information permits correction back to the amount initially present.

Procedure:
A. Add a minute amount of radioactive A to the unknown sample. The amount of radioactivity required depends on the yield in the purification process.

Step: An activity of 1,000 counts/minute ("cpm") is convenient for the final sample. Thus, a yield of 10% would require an initial investment of 10,000 cpm.

B. Apply the purification step. It is not necessary to end up with pure compound A. All that is needed is a mixture to which an ordinary quantitative analytical method for determining A can be applied. Only substances interfering with the analytical method need be removed. For small amounts of material, chromatography, solvent partition and sublimation are probably best suited.

C. Measure the amounts of radioactivity in the original and purified samples. β Emitters (H^3 , C^{14} , S^{35} , etc.) are usually spread out in a thin uniform sheet.



TO: Nuclear-Chicago Corporation
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Send Technical Bulletins 1, 2 & 3
 Send future Bulletins regularly

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METALGRAMS



. . . news about metals and metal chemicals

**Electromet ferroalloys,
pure metals and metal chemicals**

Slip-casting -- a method almost as old as the potter's wheel for shaping ceramics -- may help solve some modern metal fabricating problems. At UCM's Metals Research Laboratories, tungsten, molybdenum disilicide, and other intractable metals and intermetallics are being slip cast into intricate shapes with close tolerances. The ease with which powdered molybdenum disilicide can be slip cast, for instance, suggests its use as a structural material in missiles and rockets. High-temperature oxidation resistance and a high melting point (2030°C: 3686°F) qualify this refractory material for hypersonic vehicle applications. For more information, write for Bulletin MD 1-S.

* * *

The largest columbium ingot ever formed, made from UCM material, was recently melted by the Refractomet Division of Universal-Cyclops Steel Corporation. Weighing 345 pounds, the ingot measured 19 inches long and 9 1/2 inches in diameter. This has been successfully rolled into sheets as long as 170 inches, in widths from 16 to 36 inches, and in gauges from 0.02 to 0.06 inches. Thinner gauges are in prospect. This joint effort effectively demonstrates the feasibility of producing columbium on a commercial scale. Write for Bulletin CB 1-S.

* * *

Among UCM's new industrial metal chemicals are vanadium dichloride, vanadium trichloride, vanadium oxytrichloride, and vanadium tetrachloride. The polyolefin industry is evaluating these high purity compounds in producing new synthetic rubber products. The pharmaceutical industry, also, is studying them as reducing agents in organic reactions. Highly reactive, the vanadium chlorides can also be used to manufacture organometallic compounds. UCM's technical background and experience with vanadium metal -- over a ten-year period -- give investigators in this area a distinct advantage. Write for Bulletin MC 1-S.

* * *

Union Carbide Metals Company has begun production of titanium carbide on a semi-commercial scale. This high-melting-point compound has several known and potential applications. As an important additive in tungsten carbide cutting tools, titanium carbide improves resistance to oxidation and erosion. It is also being used for high-speed cutting tools as a base material in cermet compositions. Titanium carbide's resistance to corrosion by molten aluminum and cryolite recommend it as a potential cathode material in aluminum reduction cells. UCM also produces titanium metal and several other titanium compounds. Write for Bulletin TC 1-S.

* * *

Demand mounted during 1958 for vanadium metal with low content of oxygen, nitrogen, and carbon. The major contribution to the increased demand for vanadium were A. E. C. applications. Notable quantities, however, are also being used as melting stock in vacuum melting. Write for Bulletin VM 1-S.

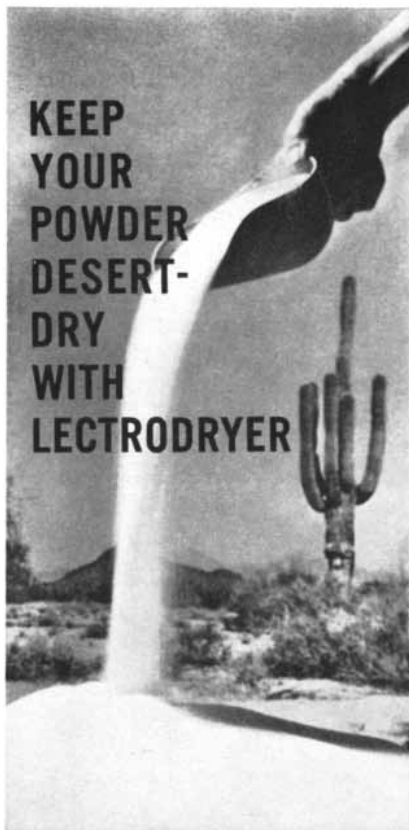
* * *

A large boule of transistor-grade silicon, produced by General Electric from UCM's purified silicon, was exhibited recently at the National Metal Exposition in Cleveland. This boule, measuring 4 in. long by 1 in. max. diam. and weighing 2 3/8 oz., contained enough silicon to make several thousand transistors. Write for Bulletin SM 1-S.

* * *

Union Carbide Metals Company, Division of Union Carbide Corporation,
P.O. Box 330, Niagara Falls, N. Y.

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LETTERS

Sirs:

James R. Newman reviewed Linus Pauling's book *No More War!* in your February issue and referred to a statement which I am said to have made.

Mr. Newman writes: "Merril Eisenbud, an Atomic Energy Commission official, wrote an article in 1955 which stated that 'the total fallout to date from all tests would have to be multiplied by a million to produce visible, deleterious effects except in areas close to the explosion itself.'" He then refers to certain Congressional testimony in which an earlier version of this statement was challenged by Ralph Lapp.

Newman's information, which comes in part from Professor Pauling's monograph, is incorrect. This statement did not come from an article I wrote. Instead, it appeared in the March 20, 1955, issue of the New York *Daily News* as a result of an interview I had with a reporter from that paper.

Although a newspaper account can certainly be considered no more than second-hand information, Dr. Lapp lifted the statement out of its original context and presented it as part of his testimony in the 1957 Congressional hearings on the nature of radioactive fallout and its effects on man. He reported it (third hand, mind you) to cite the irresponsibility of government officials. I thought this action quite unfair in view of the fact that I have published in scientific journals on this and allied subjects and that more reliable accounts of my official and professional views on the subject were thus readily available. I think it proper to question a man's judgment, or for that matter, his integrity, on the basis of things he writes or says, but I don't think it proper to do this on the basis of a newspaper account of what he is reported to have said in an interview.

I was disappointed to find that Professor Pauling extracted out of context not only the newspaper statement, but also the questions and answers from the published proceedings of the hearings. Please note at this point that Pauling's reference to the statement now becomes fourth hand since he based his material on Lapp's testimony. At least Professor Pauling was cautious to note that it was a quotation from the New York *Daily News*. Would that Mr. Newman had followed suit.

I have admired Mr. Newman's writing for many years and this review puts only the slightest nick in what I think is a fine record of scientific reporting. However, when even as reliable a writer as Mr. Newman will take confused fourth-hand information, and further confuse it in creating a fifth-hand version, one begins to wonder when to trust the "facts" he reads. Now that this fifth-hand version of "the statement" has appeared, to be read by people who may not read this letter, I wonder what the sixth-hand edition will say!

MERRIL EISENBUD

Manager

New York Operations Office
United States Atomic Energy
Commission
New York, N.Y.

Sirs:

The article "A Witness at the Scopes Trial," which appears in your January issue, was very interesting to me. It is probably impolite to call attention to the mythical nature of some of the material presented, when the facts have grown dim in the memory and so many of the principals are gone.

However, certain facts may be helpful in bringing the case into proper perspective. It was initiated in response to an advertisement in a Nashville paper by the American Civil Liberties Union calling attention to a little-known statute and urging a test case. This was seen by George Rappelyea, who correctly inter-

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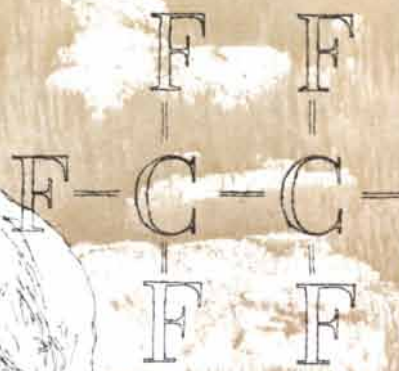
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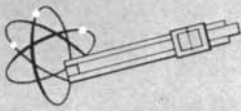
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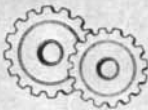
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preted it to mean that the A.C.L.U. would finance such a trial. He enlisted the cooperation of the other school-board members and of John Scopes and notified the A.C.L.U. The details of the coming show were then worked out at meetings with the A.C.L.U. in New York where the principals were guests of the A.C.L.U. Initial plans called for Rappelyea to act as the prosecutor but the veil proved to be too thin and he withdrew in favor of School Superintendent White.

The inducement for Scopes, a young science teacher, in his first year of teaching, was the promise of reappointment for another year at \$125 per month. This was small compensation for the badgering he received from reporters and others seeking to share his fame. So he was soon sorry that he had permitted them to persuade him to become the "guinea pig," and to his credit, refused to exploit the many offers, including a movie contract, lecture tour, etc., which were advanced by promoters and others, contenting himself with a scholarship to the University of Chicago where he could study geology. To picture or think of Scopes as a crusader or as a dedicated student of the Darwin theory is completely out of character. . . .

The interest of the populace of Dayton, then a marginal agricultural community, was based primarily on material rather than ideological considerations. Local lawyers were to conduct the case, but when it became apparent that it would command an international press, ambitious politicians and lawyers of prominence associated themselves with the case to share in the light of publicity, and the show was soon on the road.

While it is true that the churches generally took a stand against evolution, there were local dissenters, notably Reverend Byrd of the Methodist Church. To picture the local populace, which was primarily out for a quick buck, as hostile to visitors, or to defense counsel, or even to Scopes, adds color to an otherwise dull subject, but is mostly fictional. Instead, there was a clear working arrangement to promote and to continue the trial as long as possible for the maximum in publicity and for the financial benefit of the local merchants and those furnishing living accommodations and services for the visitors. Darrow was entertained by the Businessmen's Club at a standing-room-only banquet at the local hotel. Some joined the nightly poker game at the Darrow home on Second Avenue in Dayton. The father of the star witness for the prosecution vacated his home and rented it to Darrow. Dudley Field Malone's beautiful young wife was en-

tertained and amused by the young gallants of the town. Scopes helped to round up the student witnesses for the prosecution. . . .

This, of course, is not to imply that serious rivalry did not exist between Darrow and Bryan, but since Bryan had not tried a case in court for some 25 years, he was hardly a match for the able and experienced Darrow in a courtroom, and except for his testimony, which at times was quite comical, took relatively little active part in the proceedings. The case was conducted in a carnival atmosphere with only one- or two-hour morning and afternoon sessions devoted to the trial, and the balance of the time consumed in posing for pictures, making brief speeches on the radio, issuing statements and granting interviews to the press. . . .

However, all of this is not to imply that I question in any way the complete sincerity of the writer of the article in your January issue, as he seems very serious about the whole thing, much more so than the Supreme Court, which apparently recognized it for what it was.

How do I know these things? I was born and raised in Dayton, had intimate acquaintance with the local principals, was a pupil of Scopes at the local high school and was in the class that reported directly to him, lived just across the street from his residence, had constant and friendly association with him, had a ringside seat at the trial as an employee of radio station WGN of Chicago, observed many of the events and was invited by Scopes to testify.

CARMACK WATERHOUSE

Oak Ridge, Tenn.

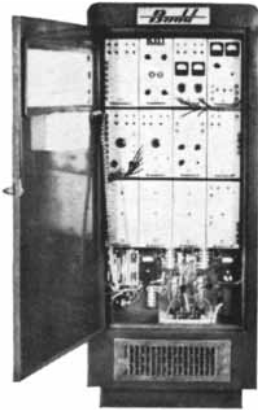
Sirs:

I have read Mr. Waterhouse's letter with much interest. It appears that he is drawing on his memory to bring "the case into proper perspective."

He mentions the agreement between the American Civil Liberties Union and Mr. Rappelyea to stage the case in Dayton. This is the first mention I have heard of such a plan. Whatever scheme they may have had for a court test, they could not have anticipated the appearance of Bryan, Darrow and other national legal and scientific figures which made it a "show."

It has been my habit through the years to keep very full notes on all important matters in which I have been involved. In this case I gave particular attention to intimate details which I might use in

“... why don't you do this type work yourself?”



Budd Monautronic Weld Control Unit, an electronic system which certifies each weld in high speed resistance welding.

Recently, after defending his stand on the use of outside companies for specialized metal fabrication, an engineer from a large aircraft company wrote us a letter. In it, he said, “The question has been asked by several people, ‘why don't you do this type work yourself?’ They, of course, do not realize the education, personnel, time, special equipment and expenditures that go into making up an organization such as you have developed for this special work . . .”



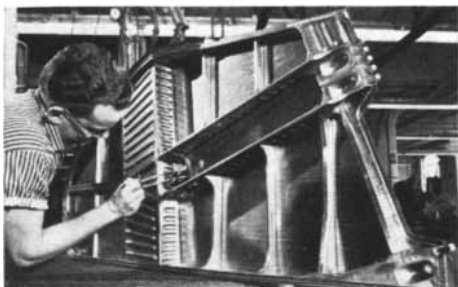
Resistance welding technique on a Budd-designed welding machine.

A detailed description of the development of Budd's symmetrical core stainless steel sandwich material was supplied to this engineer in answer to his further queries. It illustrates the value of the specialist in a weapons system—or any systems—product—development.



Fabrication feasibility studies of Budd integrated core panel.

Four years ago when it became evident that available materials would not be adequate for increasingly higher Mach vehicles, Budd began development of resistance welded stainless steel sandwich material. At the time, the industry was hoping to find its answers in brazed honeycomb.



Experimental aircraft speed brake of welded sandwich panelling.

By using the same combination of resources it has always used in the development and manufacture of all kinds of steel structures, Budd developed a resistance welded core material which requires no heat treating after fabrication. It is simply the product of a large engineering staff familiar with aircraft configuration requirements, 46 years of experience with every type of steel, over 30 years experience with the art of welding, and unique test facilities. Such progress is possible when a company has the skill and the resources to adapt itself to any industry's needs.

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a talk I had agreed to give on the trial and its implications, upon my return to Chicago. All materials used in my article were drawn from such notes and the very full record of the trial which I have before me. They are, I believe, correct in all cases. Mr. Waterhouse was probably too young to realize the depth of feeling which permeated most of the populace. I have cited some instances. He mentions the fact that the Reverend Howard Byrd of the Methodist Church (North) was a local dissenter. What he does not mention is the fact that after Reverend Byrd had invited Dr. Charles Francis Potter to speak at his church, he found it expedient to resign his pulpit. In most instances members of the Defense group received courteous treatment, for which Darrow thanked the Court in his closing remarks. Judge Raulston, in turn, paid a tribute to Scopes by saying "it takes courage for a man to stand for a sentiment that stands in contravention to public opinion about him. A man who is big enough to stand up for a principle is big indeed."

Despite such instances, those of us who made up the Defense were acutely aware of the fact that we were far from popular. In the courtroom—except for Malone's reply to Bryan—the Defense was met with silence while the Prosecution was lustily cheered.

All this is on the trivial side. Local merchants may have considered the trial a carnival and may have welcomed the publicity and financial gain it brought. The real meaning lay outside Dayton.

For months before the trial Bryan and his associates had been waging a nationwide crusade against the teaching of evolution. They had organized in 20 states, had presented bills in six and had secured legislation in two. Bryan had publicly stated their intention to introduce an amendment to the Constitution of the United States, and his associate—the Reverend Dr. Stratton—had proclaimed: "Better wipe out all schools than undermine belief in the Bible by permitting the teaching of evolution."

Here was a direct attack on fundamental American freedoms; an attack which if successful would allow an organized group to make its interpretations and beliefs mandatory—as the law of the land—by constitutional amendment and statute. It was this danger that led all members of the Defense to go, at their own expense, to Dayton to oppose Bryan and his plans.

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A USEFUL NEW TOOL IN GAS CHROMATOGRAPHY

The science of gas chromatography got new impetus some three years ago when Perkin-Elmer introduced one of the first commercially successful chromatographic instruments—the Model 154 Vapor Fractometer. Since then scores of industries have reported valuable, new uses for this low-cost, easy-to-operate analytical tool. Among the latest uses for the P-E Vapor Fractometer:

Tobacco researchers at Duke University recently devised a technique for identifying nonvolatile organic acid components of tobacco smoke. Using a modified Vapor Fractometer, they were able to identify 10 acids which had not been reported previously as smoke constituents.

At the Process Research Division of Esso, a battery of eight Model 154 instruments performs more than 700 types of analyses a month. Researchers here have gotten an especially high investment return in the analysis of light ends of olefin-free gasolines. Previously this work took an average of three hours per sample. Esso now does it with a Vapor Fractometer in 15 minutes with equal or greater accuracy.

Vapor Fractometers are taking to the air at Douglas Aircraft. Their ability to make fast, repetitive analyses is being used to check the safety and in-flight effectiveness of airplane fire extinguishing systems and to test cockpit air for contamination from gun gases when the plane's armament is fired. Douglas also uses its Vapor Fractometers to separate jet and rocket fuels into components for further analysis by infrared.



INFRARED EYES ORBIT EARTH IN FIRST WEATHER SATELLITE

The first satellite sent aloft to provide information which may help man in his age-old battle with weather contained two small infrared "Weather Eyes." These optically fast (f/0.7) devices were developed and built by Perkin-Elmer for the U.S. Army's Signal Research and Development Laboratory's Astro-Instrumentation Branch. Their purpose is to peer at the earth's cloud layer and measure its intensities.

Energy characteristics of the sunlit portions of the earth under the spinning satellite are focused by the weather eye's special parabolic mirror onto a tiny lead sulfide detector which converts the information into electric impulses. Data are stored on a tape recorder within the satellite for transmittal back to earth upon command. The eyes are mounted on opposite sides of the satellite, at a 45° angle from the satellite's axis of spin, so that one of them will always point at the sunlit portion of the earth.

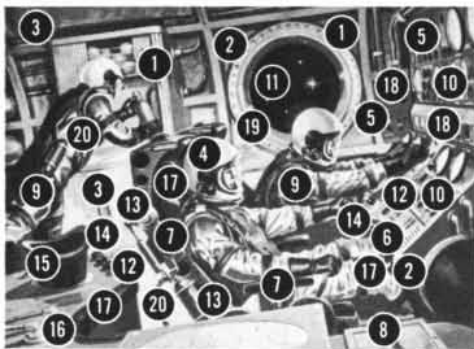
This first weather station in space is undoubtedly the forerunner of more advanced systems which will have a revolutionary effect upon the science of weather forecasting. The weather eyes are another example of "precision optics by Perkin-Elmer."

For information on Perkin-Elmer and the products it makes for a wide range of growing industrial, scientific and defense markets, write Perkin-Elmer Corporation, 915g Main Avenue, Norwalk, Connecticut.

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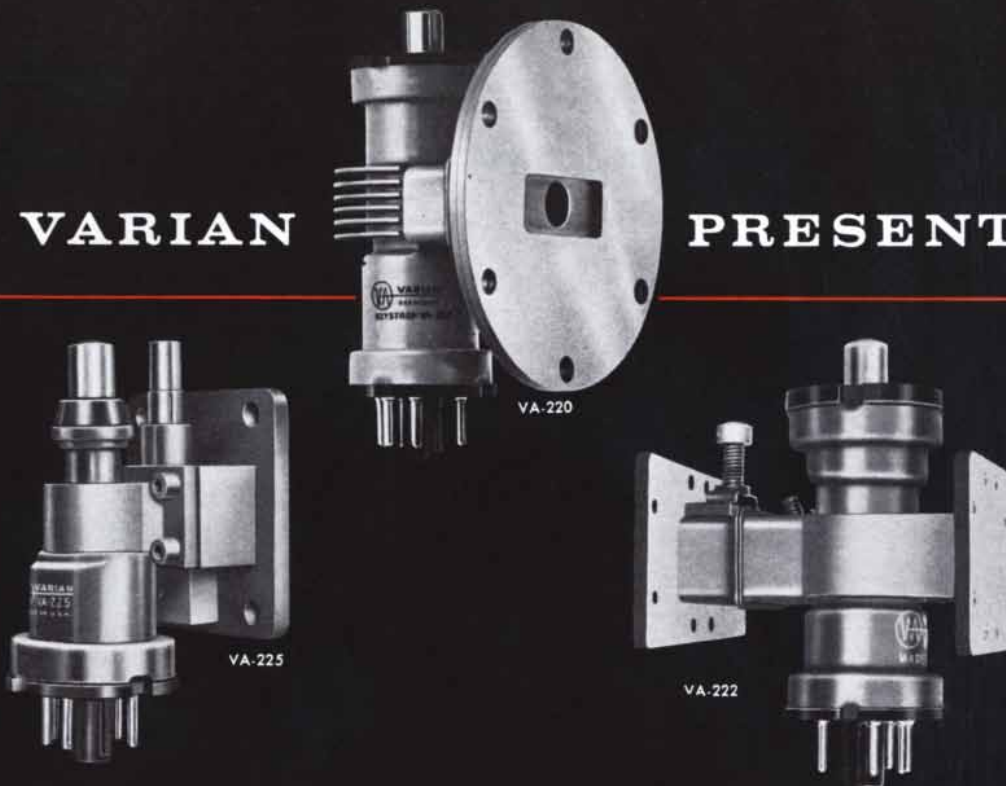
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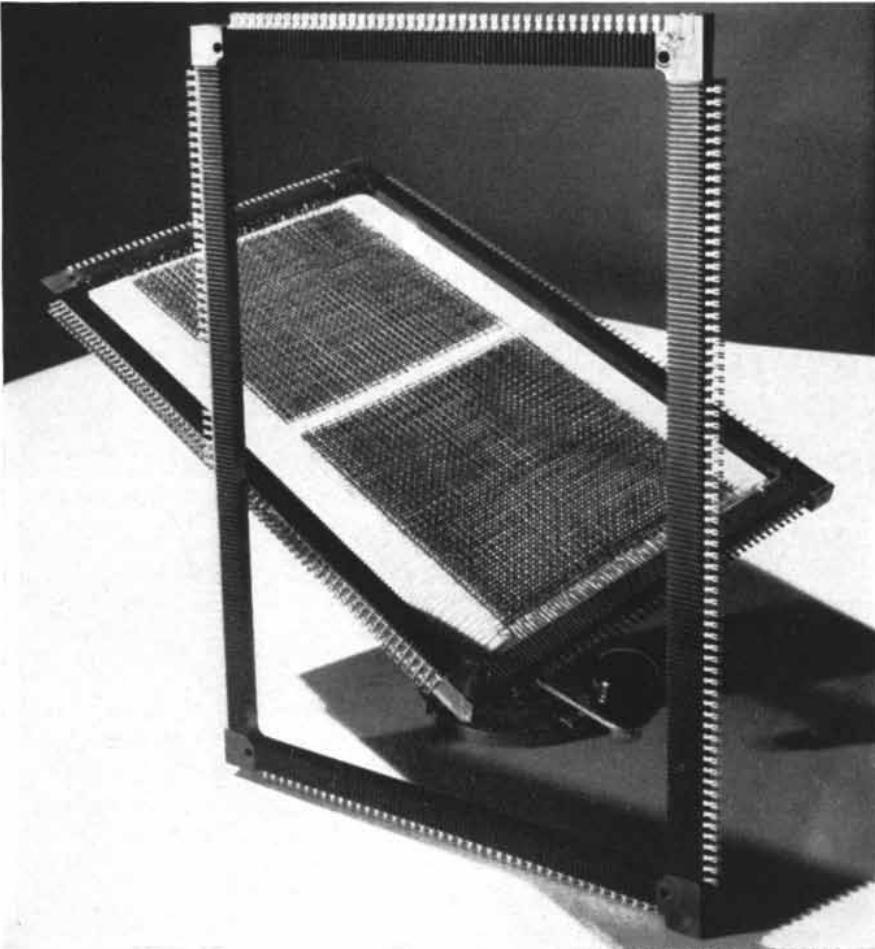
sponsored jointly by the Advanced Research Projects Agency, Department of Defense and the Army Ordnance Command. A scientific staff—most of them RCA personnel—will operate the equipment and report on missile performance from descent from space to final plunge, the data to be shared by all branches of the armed services.



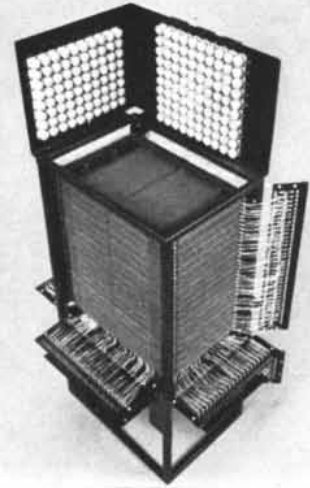
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MODERN ABACUS enables man to string words and numbers on wire like beads and pick them off again in millionths of a second. Durez phenolic is used to frame the thousands of ferrite cores in IBM magnetic data-storage unit. In an array of core planes stacked atop one another, electrical impulses alter the magnetic state of cores. A line of cores, some altered, some neutral, stands for a word or number, awaiting the impulse that releases it for calculation.

Material for a jet-age abacus

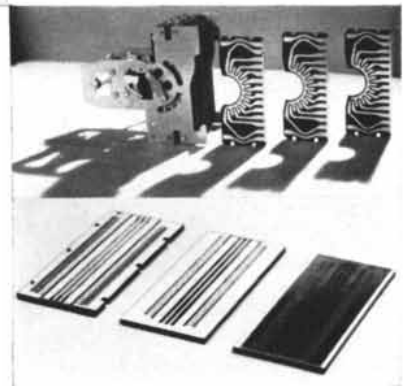
Engineers needed a non-warping material for the frame that supports thousands of tiny ferrite cores, heart of the magnetic "memory" in IBM data-processing systems.

Requirements were stiff. The frame must be an excellent insulator. It must be free of internal stress that would cause warping or cracking. During assembly it must withstand the blistering heat of dip soldering without losing its dimensions. Once assembled, it must not shrink or expand.

The material finally selected for this job is a Durez phenolic. Mineral-filled, it has a low molding shrinkage of 0.003 in./in. that minimizes stress and strain. Its water absorption is a low 0.2%. It stands temperature of 325°F under ASTM D648—easily survives the soldering operation. Its electrical properties, including arc

resistance, meet every requirement.

This is only one more example of a host of jet-age assignments handled with the new Durez phenolics. You can do more—meet today's needs better than ever before—with this wide-ranging family of materials. Thermal stability, electrical properties, impact strengths are up; costs are attractively low. To get an idea of the new latitude Durez phenolics give you, write for illustrated Bulletin D400.



IN OTHER IBM EQUIPMENT Durez phenolics prove their inborn versatility. Molded circuits employ a Durez mineral-filled compound in stepping switches and emitter for card-feed unit of an accounting machine.

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Heart of the system is the Bendix G-15 general purpose digital computer, which has proven its performance in well over 150 successful installations.

The CA-2 coupler, a newly developed G-15 accessory, enables the computer to operate in conjunction with

conventional punched card and tabulating equipment.

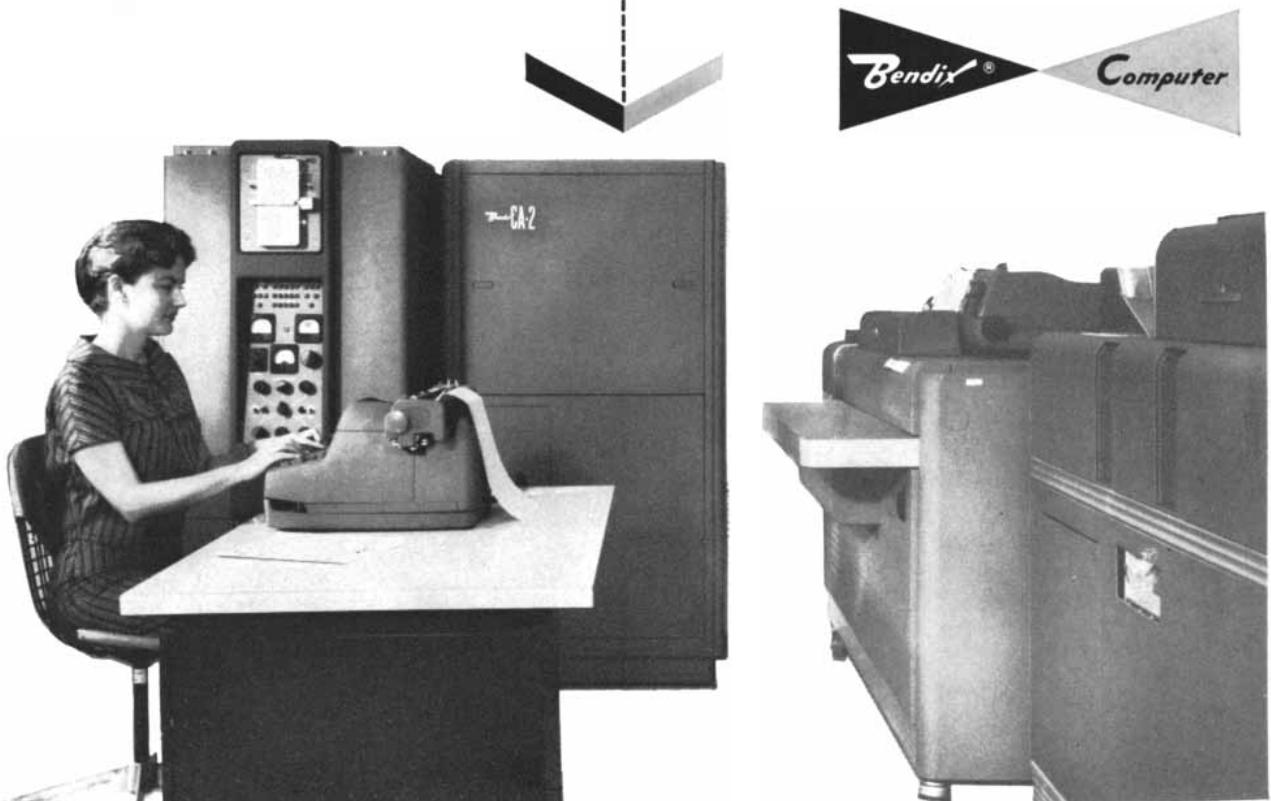
A full 80 columns of numeric, alphabetic, or special character information can be accommodated using only the CA-2 as a connecting link between the card equipment and the G-15. Any column of the card can contain any one of the three types of information.

Three input-output units may be connected simultaneously . . . one for input, one for output, and a third for input or output. Data may be read or punched by standard card units, or printed by standard tabulators. All input and output is under complete control of the computer. Computation can proceed during the input or output cycle, thus assuring maximum over-all computing speed.

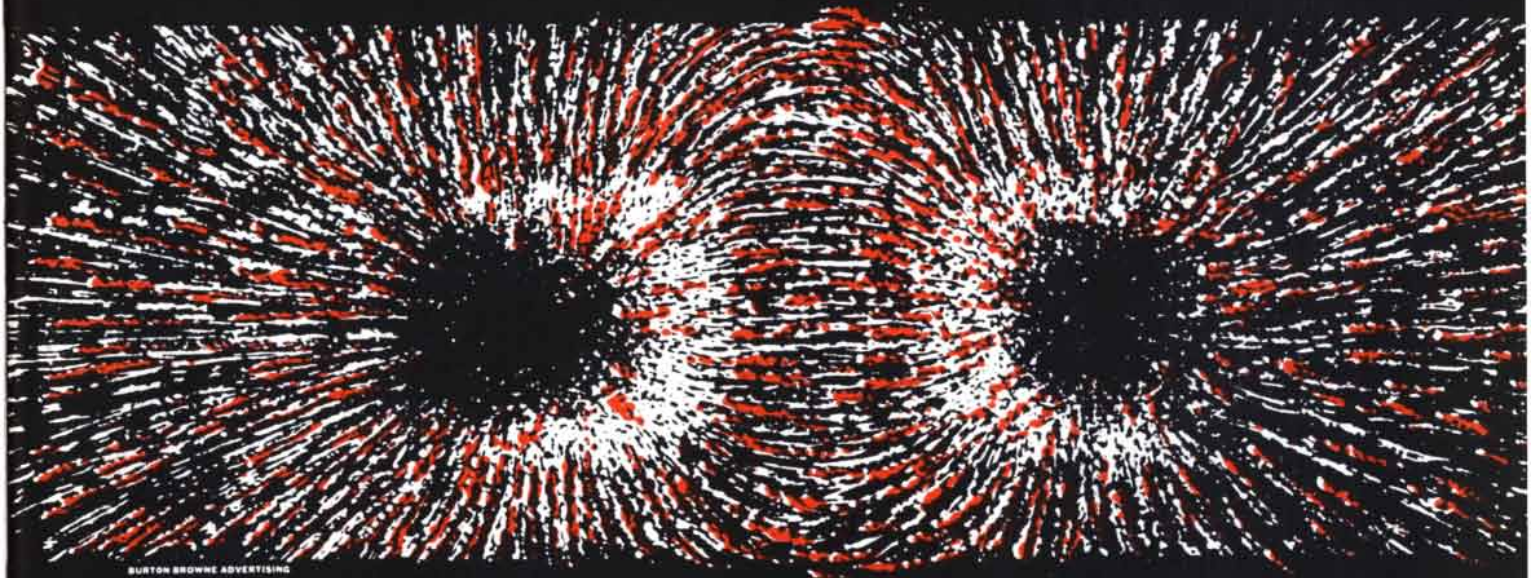
In addition to the CA-2, the computer's typewriter and paper tape equipment, and auxiliary magnetic tape storage units may be used for completely versatile input, output, and storage. Both power and space requirements of the complete punched card computer system are approximately half that of other systems of this type.

A system that includes the G-15 computer, the CA-2 coupler, two summary punches and a tabulator, leases for approximately half the price of a typical medium-priced system with similar capabilities.

Whether you are now using punched card or computing equipment, or if you are delaying such plans due to high costs, you will want to learn more about this inexpensive, efficient equipment. Detailed technical information on the G-15 and the CA-2 will be sent on request. Write to the Bendix Computer Division of Bendix Aviation Corporation, Los Angeles 45, California. Department C-11.



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50 AND 100 YEARS AGO



APRIL, 1909: "Lieut. Shackleton's feat in reaching latitude 88 deg. 23 min., only 111 miles from the South Pole, surpasses even Commander Peary's Arctic record for closeness of approach to a geographical pole. He took with him 15 hardy Manchurian ponies and 12 Esquimaux dogs, together with a motor sled, which could not cope with the huge upheavals of the Great Ice Barrier although it proved serviceable enough in laying depots on the ice. All told Shackleton covered 1,708 statute miles. He passed the very point reached by Scott in 1903, pushed on for 325 miles, and was eventually compelled to turn back by hunger, fatigue, scurvy and the loss of his dogs and ponies. He discovered eight new and distinct mountain ranges and more than 100 mountains. Of great scientific importance was his daring ascent of Mount Erebus, towering 13,120 feet above the sea level and ejecting vast volumes of steam and sulphurous gas in the midst of perpetual ice and snow. The south magnetic pole was reached at lat. 72 deg. 25 min. It is now brought out plainly that the south magnetic pole like the north magnetic pole shifts its position."

"Prof. W. H. Pickering recently announced that there might be a possible ultra-Neptunian planet in right ascension 7 h. 47 min., declination + 21 deg."

"The first real aeronautic exposition the world has ever seen will be held from July 10th to Oct. 10th at Frankfort on the Main, Germany. The Grand Exhibition Hall, with its gigantic dimensions of 426 feet long and 213 feet diameter of central dome, was erected at a cost of \$1,500,000. It is perhaps the most imposing exhibition hall in Germany, and countless numbers of inflated balloons will be able to float freely in it. Herr Mathis of Strasburg, who has bought the original Wright aeroplane, announces trial flights of this and also of a new Wright machine with a Fiat motor. Count Zeppelin is constructing a new airship to be stationed at Frankfort

during the exhibition, and used for carrying passengers on sight-seeing flights to different parts of Germany."

"R. J. Strutt has found in numerous rocks helium in quantities which bear definite relations to the proportion of radioactive ingredients. He inferred that helium, the final product of the radioactive transformation, must be present in quantity proportional to the age of the rock. This age was estimated as 225,000 years for the English Pliocene or late Tertiary, 3,080,000 years for the upper green sand of the Cretaceous period, 3,950,000 years for the lower green sand and 141,000,000 years for the hematite which covers the limestone of the carboniferous."

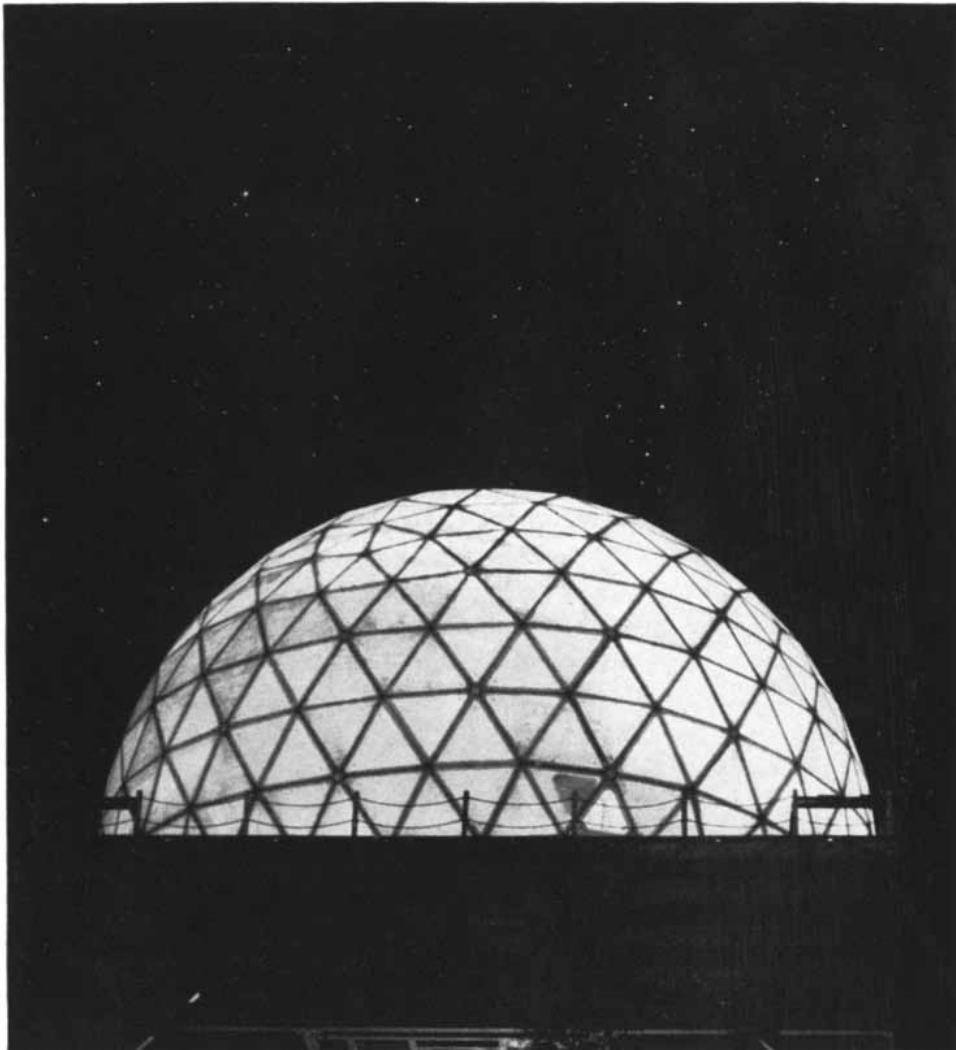
"Camille Flammarion has revived his old scheme of digging a geothermal well 200 meters in diameter to ascertain the internal constitution of the earth. The imaginative Flammarion proposes to find an economical and almost inexhaustible source of heat, to verify the rate of caloric increase, to find out if the materials constituting the terrestrial globe are in a state of fusion—in a word, to do rationally and directly what has been done slightly and a little by chance up to the present time in mines. To carry out the work the standing armies of the world are to be called into requisition."

"To the Editor of SCIENTIFIC AMERICAN: An airship is either a 'heavier-than-air machine' or a 'lighter-than-air machine.' But these are very clumsy names. Why not call the former a 'pondro,' and the latter a 'levitar'? These words, I think, are sufficiently 'regular' in derivation to justify themselves, and they are not awkward. Ambrose Bierce, Washington, D. C."



APRIL, 1859: "One of the most important murder trials which has ever come before our City Courts was terminated on the 26th ult. in the conviction of James Stephens for poisoning his wife. We allude to this case for the purpose of showing the power and subtlety of science in detecting arsenic, when used for criminal purposes. In this case the victim had been dead and buried for nearly a year before the matter was brought before the courts, the body was then exhumed and the intestines placed

**THE
ARCTIC EYE
THAT NEVER
SLEEPS**



This plastic radome houses a radar antenna constantly scanning the skies to detect the presence of aircraft. A line of these radars provides early warning of any threatening approach to the North American continent.

The Distant Early Warning Line is now on perpetual guard duty. Spanning the Arctic from Baffin Island to Alaska, this great system was conceived at the Lincoln Laboratory of M.I.T. and produced under the leadership of Western Electric.

But first the DEW Line had to be engineered into a workable system. This was done at Bell Telephone Laboratories.

The obstacles were formidable. Conventional means of communication—telephone poles, cables and even line-of-sight microwave radio—weren't feasible. A complicated system had to be made to operate reliably in a climate so cold that outdoor maintenance is impracticable farther than a few hundred feet from heated habitation.

Whenever possible, Bell Laboratories engineers utilized well-proven art. But as it became necessary, they innovated. For example, they designed and directed the development of a new and superior radar which automatically scans the skies, pinpoints a plane and alerts the operator.

To reach around the horizon from one radar station to another, they applied on a massive scale a development which they pioneered—transmission by tropospheric scatter. Result: at a DEW Line Station you can dial directly a station more than a thousand miles away and converse as clearly as with your home telephone.

Bell Laboratories' contribution to the DEW Line demonstrates again how telephone science works for the defense of America.

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- "Cryopumping for High Vacuum With Low Power," Bruce M. Bailey & Raymond L. Chuan, Fifth National Vacuum Symposium.
- "What Top Management Must Know About R & D," Warren C. Lothrop, *American Business*.
- "Automation, Yes or No"
- "High-Temperature Research in Space Vehicle Design," P. E. Glaser.
- "Atmospheric Heat-Transfer to Vertical Tanks Filled With Liquid Oxygen," F. E. Ruccia & C. M. Mohr; "Methods of Gaging Liquid Oxygen," R. C. Reid et

al; "Pressurized Transfer of Cryogenic Fluids," D. C. Bowersock et al; "Pressurized Cooldown of Cryogenic Transfer Lines," J. C. Burke et al, 1958 Cryogenic Engineering Conference.

"Atomic Orientation by Optical Pumping," W. Franzen & A. G. Emslie, *The Physical Review*.

"Superconductive Switching Circuits," A. E. Slade & H. O. McMahon, *Proceedings of the National Electronics Conference*.

"Group Invention—Antidote to Organizational Inertia," D. A. Schon, *Chemical Processing*.

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in the charge of Dr. Doremus for chemical analysis. He found from four to six grains of arsenic in the remains of the deceased woman."


"Professor Morse has received intelligence that the Queen of Spain has created him Commander of the Order of Isabella the Catholic. The Swedish Royal Academy of Science at Stockholm has also elected him a foreign member of the academy. Our distinguished countryman enjoys these honors with an additional grace when it is remembered that he has a handsome fortune to couple with them."

"Our reflections turn to Volume I of the *SCIENTIFIC AMERICAN*. On the 28th day of August, 1845, there issued from a little '7 by 9' office in New York the first number of what was destined to be an important feature in American literature, namely, a popular and enduring scientific journal. The editor, in his first public address, sets forth in plain terms the intention and purpose of the journal. He says:—'We have made arrangements to furnish the intelligent and liberal working men, and those who delight in those beauties of nature which consist in laws of mechanics, chemistry and other branches of Natural Philosophy, with a paper that will instruct while it diverts or amuses them, and which will retain its excellence and value when political and ordinary newspapers are thrown aside and forgotten. In conducting this publication we shall endeavor to avoid all expressions of sentiment, on any sectional, sectarian or political party subject; but we shall exercise a full share of independence in the occasional exposure of ignorance and knavery.' What has been the influence of the *SCIENTIFIC AMERICAN* upon the arts and sciences? In 1846 Mr. Elias Howe, Jr., obtained the patent for his combined needle and shuttle machine, but the public were generally oblivious of the fact until the subsequent year, when one of the editors of this paper hunted up the invention, described it and directed attention to the extended field opened for its application. This was the means of awakening a general interest in regard to its importance (for Mr. Howe did little to bring it into notice), and the consequence was, the minds of inventors were excited with the subject, and the latent genius of Wilson, Singer and others was thus stimulated and developed to the splendid results which have since been accomplished. We could particularize other important inventions which have had a history nearly similar."



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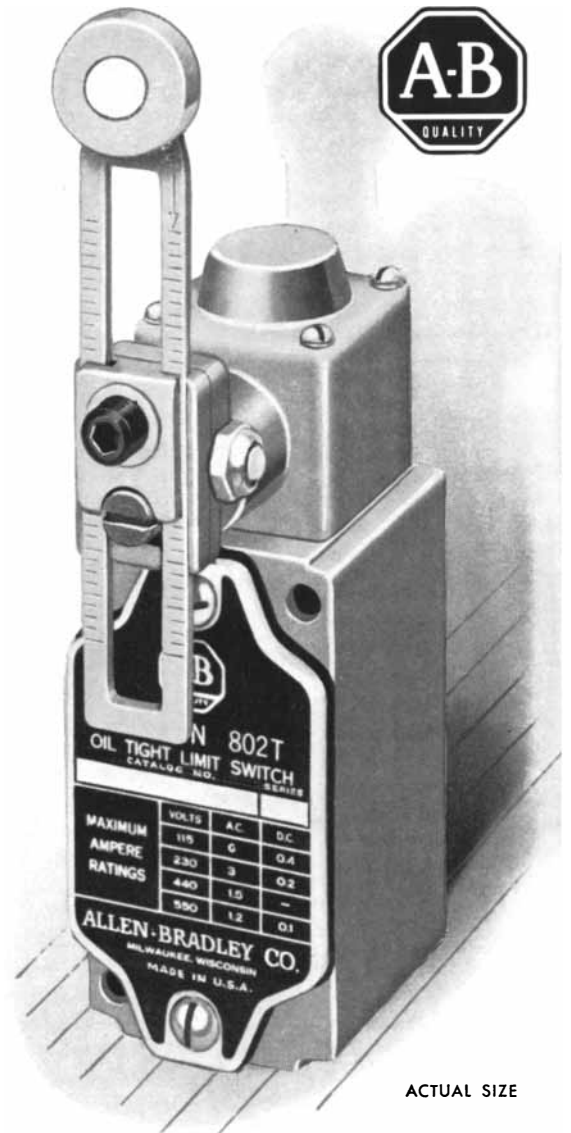
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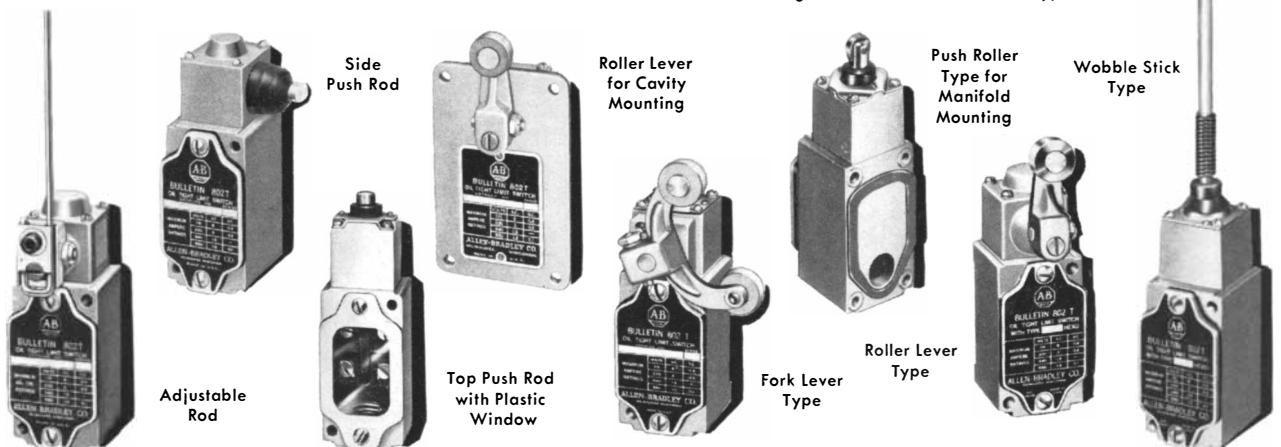
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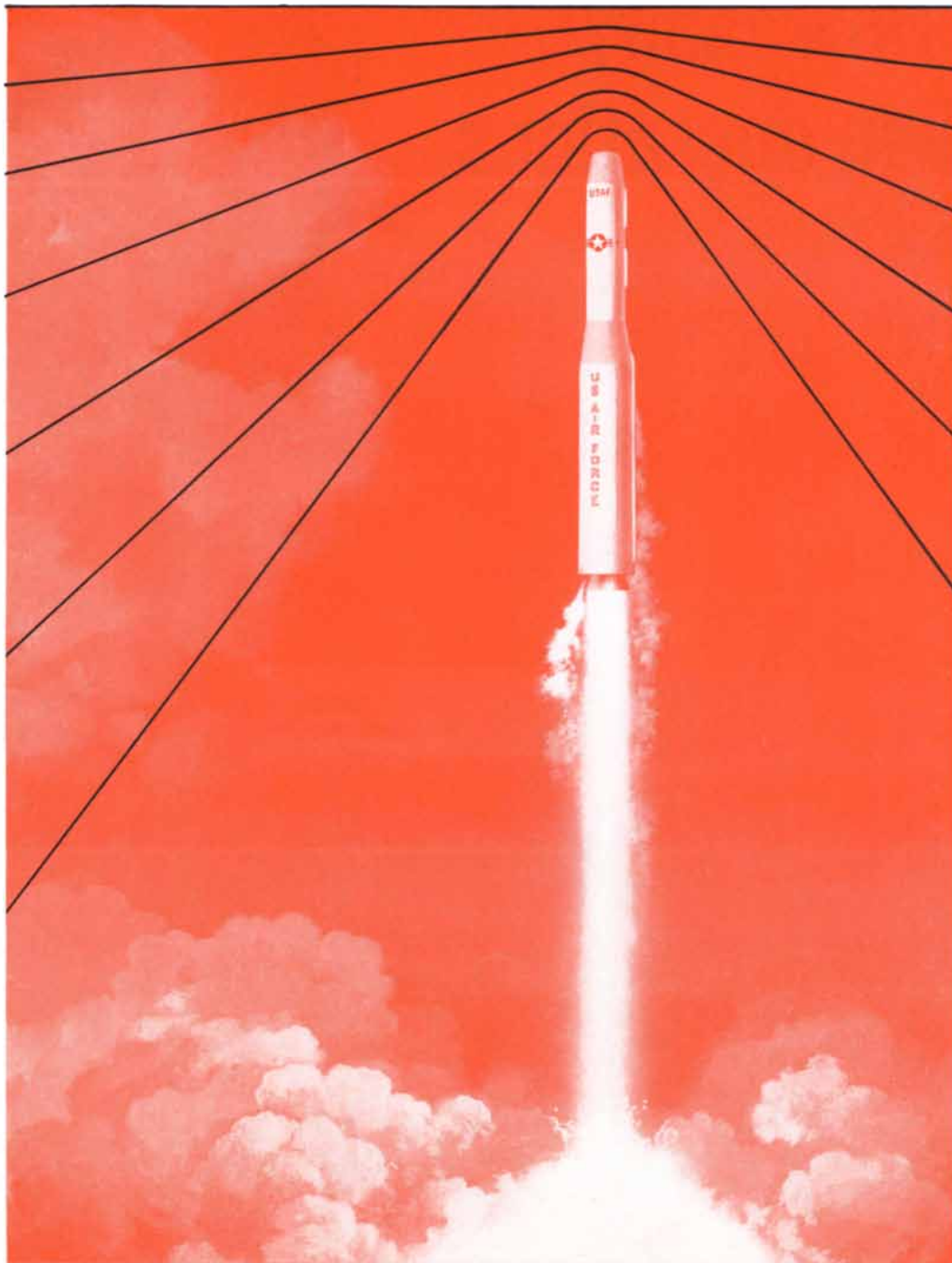
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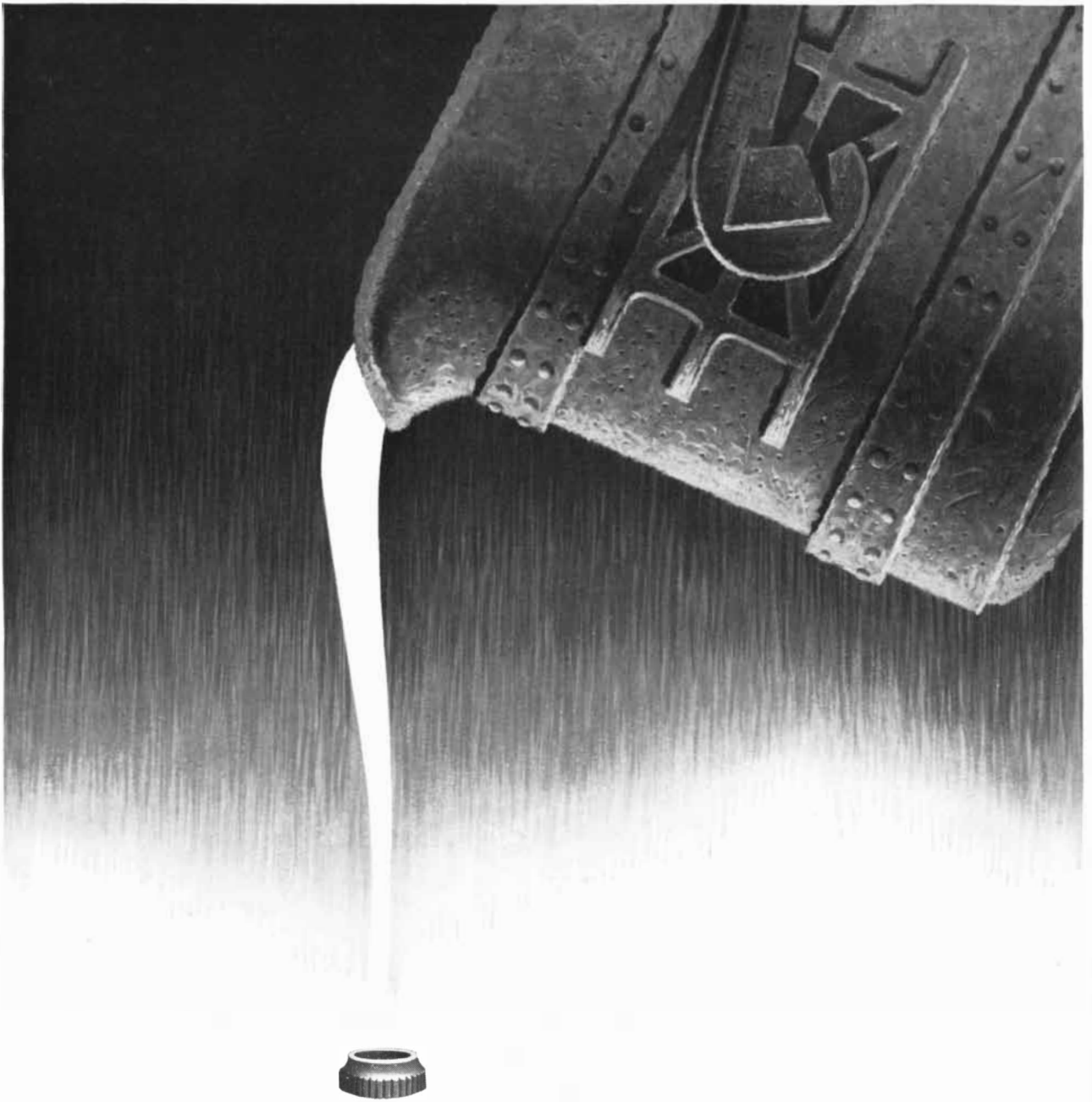


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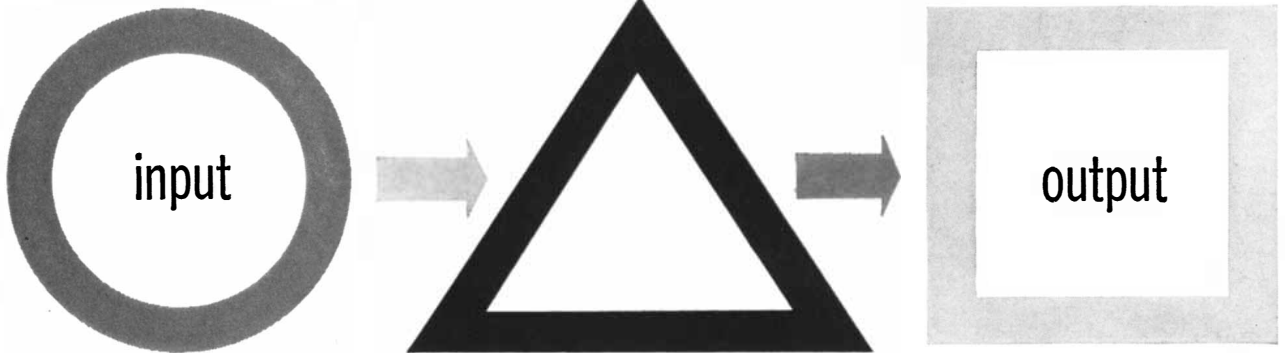
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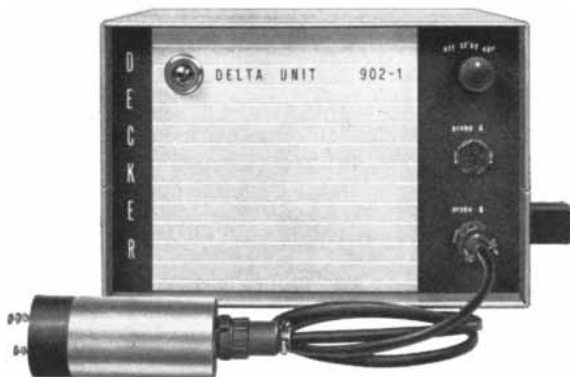
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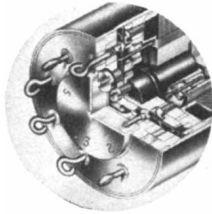


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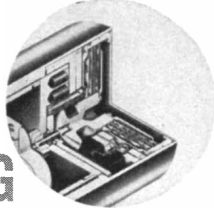
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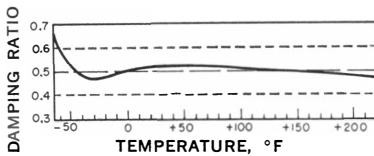
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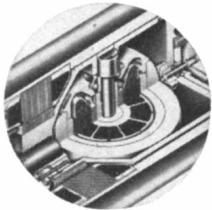


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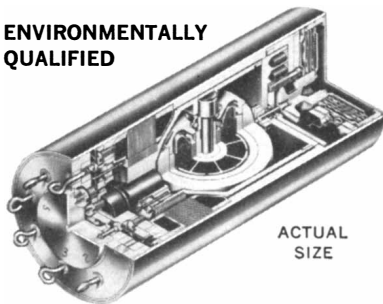
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THE AUTHORS

WILLARD BASCOM ("The Mohole") serves on the staff of the National Academy of Sciences as executive secretary of the Maritime Research Advisory Committee and (lately) of the AMSOC Committee, which, as he relates in his article, first nurtured the project of drilling a "Mohole" through the earth's sub-crustal Mohorovicic discontinuity. Bascom is a native New Yorker who in the years before World War II learned geology during alternate periods of work as a miner and as a student at the Colorado School of Mines, which he left a few months short of his degree in order to become a mining engineer in Arizona, Idaho, Colorado and New York. In 1945 he joined the University of California, first as a research engineer to make studies of waves and beaches. Later he moved to the University's Scripps Institution of Oceanography at La Jolla to work on the instrumentation of nuclear-bomb tests at the Pacific Proving Grounds. Bascom joined the National Academy staff in 1954. Since then he has served as executive secretary of the Academy's Committee on Meteorology; traveled to Sweden and the Netherlands as a U. S. delegate to International Geophysical Year conferences; spent nine months in Tahiti installing I. G. Y. wave-measuring instruments and writing on Polynesian history; and advised the producers of the Columbia Broadcasting System Sunday evening television series "Conquest," which popularizes science.

RONALD F. FREEDMAN, PASCAL K. WHELPTON and ARTHUR A. CAMPBELL ("Family Planning in the U. S.") report in this issue on the first large-scale study of U. S. family planning, financed by the Rockefeller Foundation and carried out by the University of Michigan's Survey Research Center and the Scripps Foundation for Research in Population Problems at Miami University in Ohio. Freedman is professor of sociology at Michigan. Born in Canada, he graduated from Michigan in 1939 and received his Ph.D. from the University of Chicago. He has been a Guggenheim Fellow and (during 1957 and 1958) a Fulbright Professor at the University of Amsterdam, his base of operations for an extensive family-planning survey of West Germany. Whelpton and Campbell are statisticians at the Scripps Foundation, of which Whelpton is director. A Cor-

nell graduate, Whelpton has been associated with the Scripps Foundation since 1924. He is president of the Population Association of America and formerly directed the Population Division of the United Nations. Campbell is an assistant professor at the Scripps Foundation and co-author of *The Population of Yugoslavia*. He comes from Brooklyn, graduated from Antioch College and has been an analyst for the Metropolitan Life Insurance Company and the U. S. Bureau of the Census.

WARREN J. WITTEICH ("Visual Perception and Personality") is manager of consumer research for the Armstrong Cork Company. In addition he conducts his own management-consulting business and private practice as a clinical psychologist. Now just 29 years old, Wittreich describes himself as a "psychological rarity"—a clinician with an experimental background. Upon graduating *summa cum laude* from Princeton University in 1951 he planned to enter clinical work, but then decided to remain at the University, where "the hard facts of experimental perceptual research were pounded into an initially reluctant but now exceedingly grateful subject." Wittreich received his M.A. while he was a National Science Foundation Fellow at Princeton in 1953. The following year, while a Guest Scientist at the Naval Medical Research Institute in Bethesda, Md., he acquired his Ph.D.

DOV KOLLER ("Germination") teaches plant physiology at Hebrew University in Israel. He was born in Israel (then Palestine) in 1925 and matriculated at Hebrew University in 1941, only to interrupt his academic career for six years of military service, three as a Royal Air Force volunteer and three as an infantryman in the Israeli army during that nation's war of independence. "The ability of plants to exist in the desert has fascinated me ever since my intimate contact with the deserts of North Africa and the Middle East in wartime," he says. "Germination is a crucial phase in the life cycle of the desert plant, since it is at this time that the plant commits itself, so to speak, to try weathering the hazards of its extreme environment." Koller came to the California Institute of Technology in 1957 as a Rockefeller Research Fellow. Now, as an Earhart Foundation Fellow, he is completing a second year at Cal Tech, where he studies desert plants in the celebrated "phytotron" [see "Climate and Agriculture," by Frits W. Went; SCIENTIFIC AMERICAN, June,

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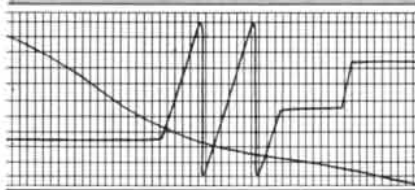


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Write for Bulletin 359

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1957]. Koller was co-author (with Michael Evenari) of the article entitled "Ancient Masters of the Desert," which appeared in *SCIENTIFIC AMERICAN* for April, 1956.

OWEN GINGERICH ("The Solar System beyond Neptune") is teaching astronomy at Wellesley College while completing research for a doctoral dissertation in astrophysics at Harvard University. "I have been in love with the stars as long as I can remember," he says. Born in Iowa in 1930, he was a life member of the American Association of Variable Star Observers by the time he was 15. Gingerich's observations with a borrowed six-inch telescope led to a long correspondence with the late Albert G. Ingalls, who conducted "The Amateur Scientist" department of *SCIENTIFIC AMERICAN* for many years; while he was an undergraduate at Goshen College in Indiana Gingerich contributed an article on spectrograph adjustment to the third volume of Ingalls's *Amateur Telescope Making*, the bible of the lens-grinding fraternity. "In college I completed my own eight-inch telescope, with which I independently found Honda's comet many weeks after it was known to the rest of the astronomical world!" says Gingerich. "One summer I worked for Harlow Shapley at the Harvard College Observatory; this experience led me to professional astronomy. In 1955 I was a member of the Harvard eclipse expedition to Ceylon, and for three years following I was director of the American University Observatory in Beirut."

CHARLES M. BOGERT ("How Reptiles Regulate Their Body Temperature") is chairman and curator of the Department of Amphibians and Reptiles at the American Museum of Natural History in New York. He was born on a ranch at Mesa, Colo. "The reptiles my elder brother—a trapper—brought in, particularly such rarities as a gaudily banded red, yellowish and black king snake (*Lampropeltis dolia*) left a lasting impression on me," he reports. "There were eight offspring in our family when the mortgage was foreclosed in 1913. Our departure from Mesa must have decreased the population by at least 8 per cent. We moved to Los Angeles and I took a few horned lizards with me on the train, hidden in my luggage. By the time I was in high school I had managed to trade a rawhide rope for a Model-T Ford. This enabled me to make trips to the Mojave desert, collecting tortoises, lizards and snakes, which I kept under observation in a large cage

in the back yard." Bogert did undergraduate and graduate work at the University of California at Los Angeles, where he began a long collaboration with Raymond B. Cowles on thermo-regulation in reptiles.

B. D. CULLITY ("Aligned Crystals in Metals") is associate professor of metallurgy at the University of Notre Dame. A Montanan, he studied at McGill University, the University of Minnesota and the Massachusetts Institute of Technology, where he was a group leader in the Manhattan project during World War II. A fuller notice of Cullity's career appeared in the May, 1957, issue of *SCIENTIFIC AMERICAN*, which contained his article "Diffusion in Metals."


W. F. LOOMIS ("The Sex Gas of Hydra") is professor of biochemistry at Brandeis University and founder of the Loomis Laboratory in Greenwich, Conn., where he studies cellular changes in normal differentiation and in cancer. "I have aimed at this kind of research since I was 17," he says. After acquiring his B.S. and M.D. degrees at Harvard University, Loomis joined the Office of Strategic Services to organize World War II medical work behind Japanese lines in China. On his return he held research fellowships at Columbia University and the Massachusetts General Hospital, taught biology at the Massachusetts Institute of Technology, then became assistant director of the Division of Natural Sciences in the Rockefeller Foundation. "In 1952 I built my own lab in Greenwich, where I work Arrowsmith style, doing all my own glass washing, for example. I have no technicians or secretary. I believe in what I call the modern kitchen theory of research. No one has maids any more—they have automatic dishwashers. I have some nice automatic equipment! I believe strongly that a worker should handle the phenomena personally—not through someone else's notebook." Private laboratories are a custom in Loomis's family, this being the fourth since his great-grandfather's time. An ardent skier and mountain climber, Loomis was a member of the team that ascended the 26,000-foot peak of Nanda Devi in 1936. At the time this was the highest climb that had been made.

ERNEST NAGEL, who reviews two new volumes of the works of Charles Sanders Peirce in this issue, is John Dewey Professor of Philosophy at Columbia University and a frequent contributor to *SCIENTIFIC AMERICAN*.

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SUMMARY OF ENGINEERING LABORATORY REPORT No. 8158


SUBJECT: Fatigue Life and Endurance Limit testing of; "DURAFLEX" Superfine-Grain Phosphor Bronze and Commercial Quality Phosphor Bronze, 5% (A) spring quality strip material.

SPRINGS: Flat spring strip was made into the usual type of contact springs used in switches, relays and instruments. These springs were deflected at about 1 cycle per second in a specially built fatigue testing machine and the deflections recorded.

STRESSES: The springs were deflected from the initial free position of zero stress to a final position having a bending stress of 77,000 p.s.i. This stress, for phosphor bronze strip is unusually high and is higher than stresses ordinarily recommended for Beryllium-Copper or Stainless Steel for such severe service.

RESULTS: Commercial Quality Phosphor Bronze, 5% (A) springs acquired a permanent set quite early and broke at an average number of deflections of 453,374. "DURAFLEX" springs were still satisfactory, showed no permanent set, no loss of load and no breakage at 4,000,000 deflections.

CONCLUSION: Design stresses for "DURAFLEX" can be at least 50% higher than the stresses for Commercial Quality Phosphor Bronze, 5% (A) as shown in the TOOL ENGINEERS HANDBOOK.



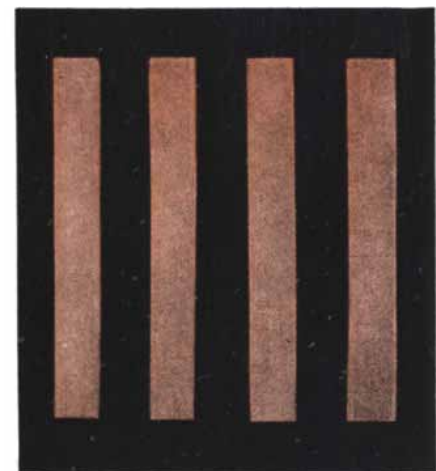
HC:R

Respectfully submitted,
THE CARLSON COMPANY

Harold Carlson
Harold C. R. Carlson, P.E.
Licensed Professional Engineer



THREE SPRINGS of regular Phosphor Bronze, 5% (A), actual size, took a permanent set at about 200,000 deflections and fractured at an average of 453,374 deflections.



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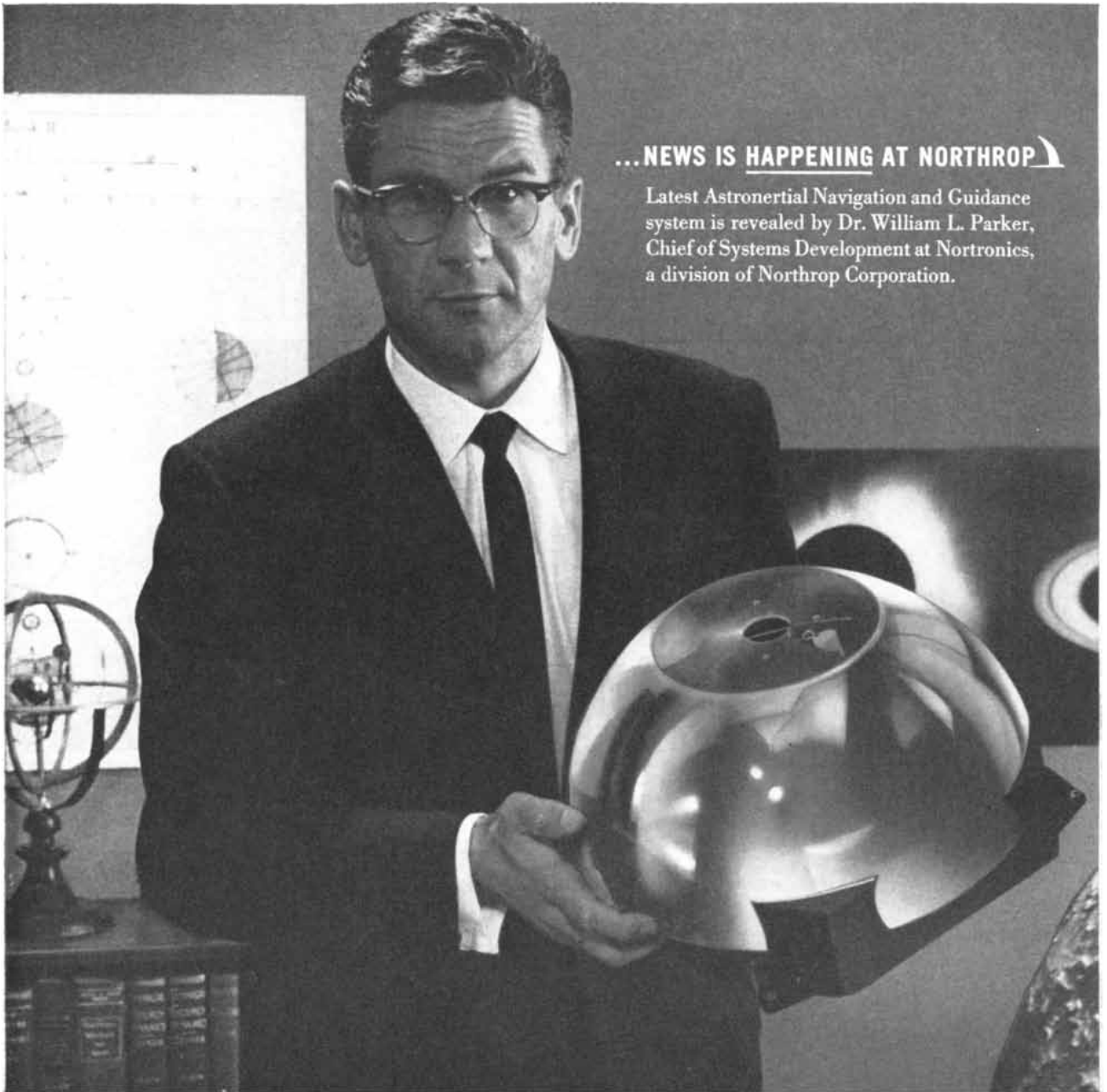
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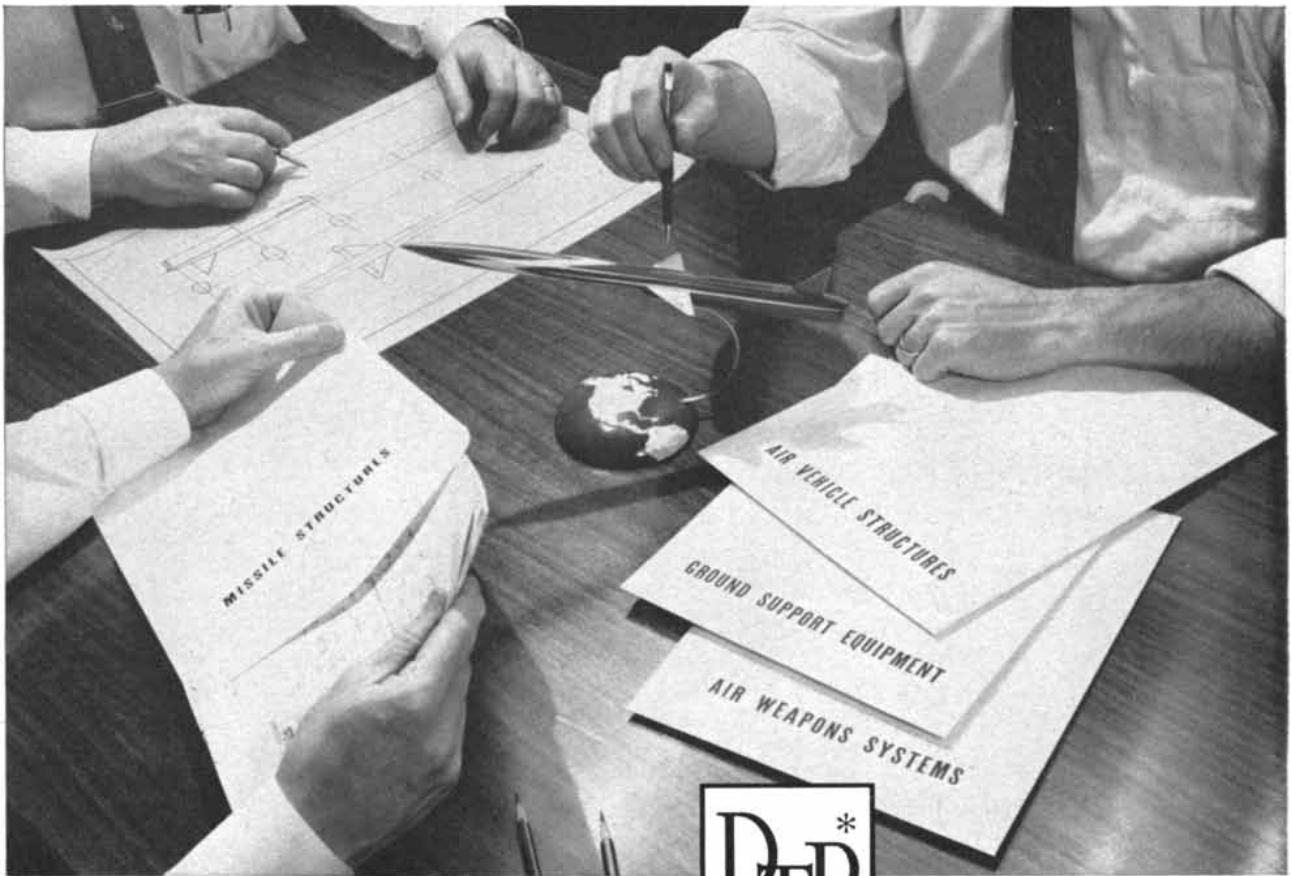


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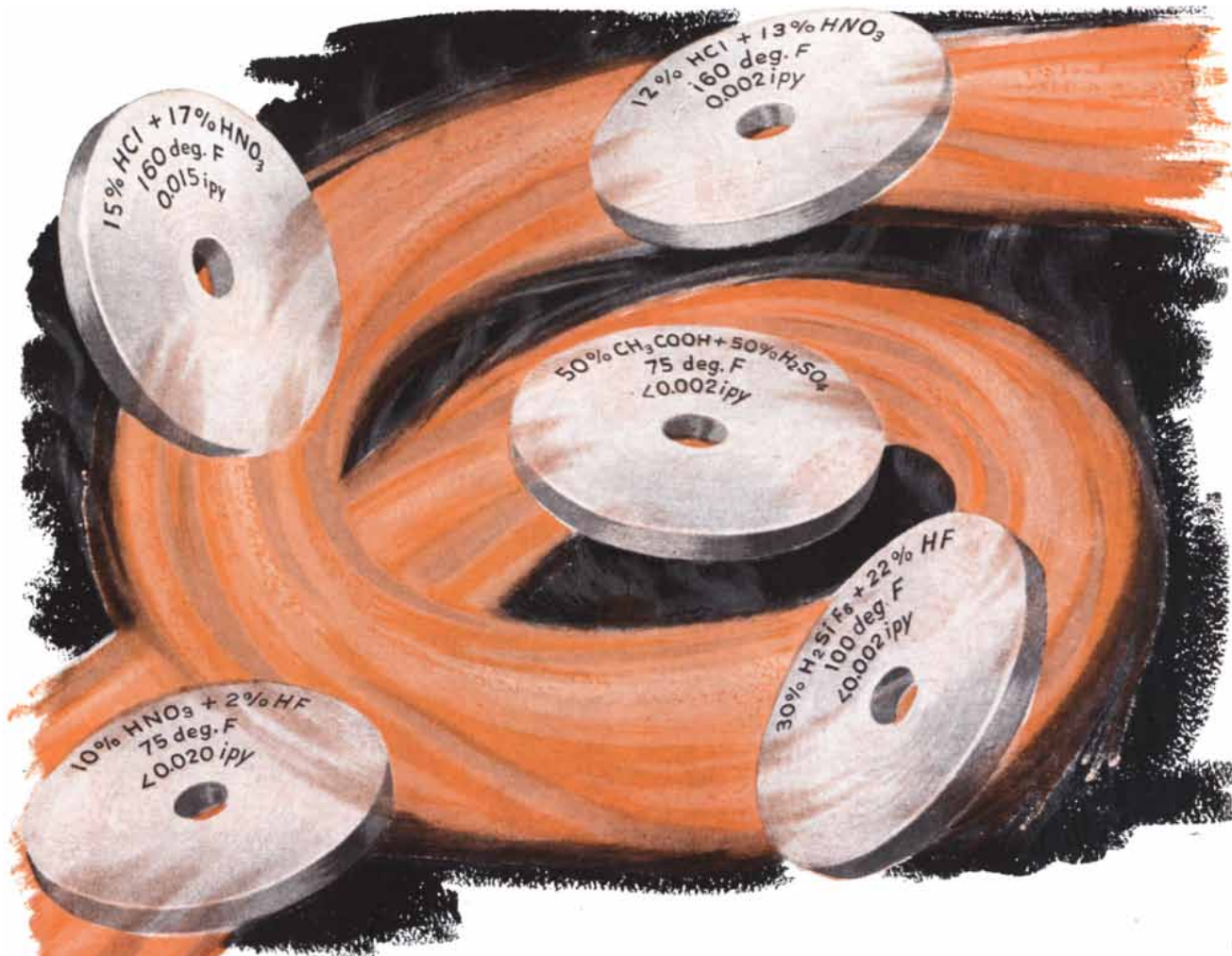
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Michael Faraday...on self-criticism

“The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a

respector of persons but of things. Truth should be his primary object. If to these qualities be added industry he may indeed go and hope to walk within the veil of the temple of Nature.”

— Quoted in Sir Richard Gregory, *Discovery*

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The Mohole

The U. S. may drill a hole to the Mohorovicic discontinuity between the earth's crust and the underlying mantle. The hole would provide priceless evidence on the earth's history and internal constitution

by Willard Bascom

The 1950s may well be remembered as the decade in which man made his most heroic efforts to explore the extremities of his environment. He has at last climbed Everest, traversed the surface of Antarctica and descended to the ocean floor in bathyscaphs. He has reached beyond the atmosphere with instrumented rockets and into the deepest ocean trenches with instrumented cables.

Now there is a proposal to drill a hole through the earth's crust beneath the floor of the ocean to reach the interior of the earth. A floating drilling station anchored in water three miles deep and capable of drilling into the bottom another 18,000 feet may do the job. The total reach of the drill pipe must be two miles longer than that used in the deepest hole yet drilled. But the hole will return such valuable direct evidence about the composition of the earth and its geological and biological history that it seems well worth the effort.

The crust of the earth is a relatively thin film over the earth's interior. Its average thickness is some 10 miles, a mere 400th of the earth's radius. Beneath the crust lies the mantle, thought to be composed of a rock called peridotite, and beneath the mantle lies the core, probably composed of nickel-iron. Although the mantle accounts for more than 80 per cent of the earth's volume, important details of its composition and character are uncertain. These can only be determined by direct examination. The boundary between crust and mantle

is the Mohorovicic discontinuity, known to earth scientists as the Moho. To obtain a sample of the mantle we must drill a hole through the Moho. A Mohole.

The Mohole was originally proposed by Harry Hess (professor of geology at Princeton University) and Walter Munk (professor of oceanography at the University of California), mainly as a means of resolving some of the major uncertainties in theories of the earth but perhaps partly as a rebellion against the deluge of routine scientific proposals they were called upon to review. It became an AMSOC project at a wine breakfast in Munk's home in La Jolla, Calif., in March of 1957. Gordon Lill of the Geophysics Branch of the Office of Naval Research, who was present on that happy occasion, was made chairman of the project by acclamation.

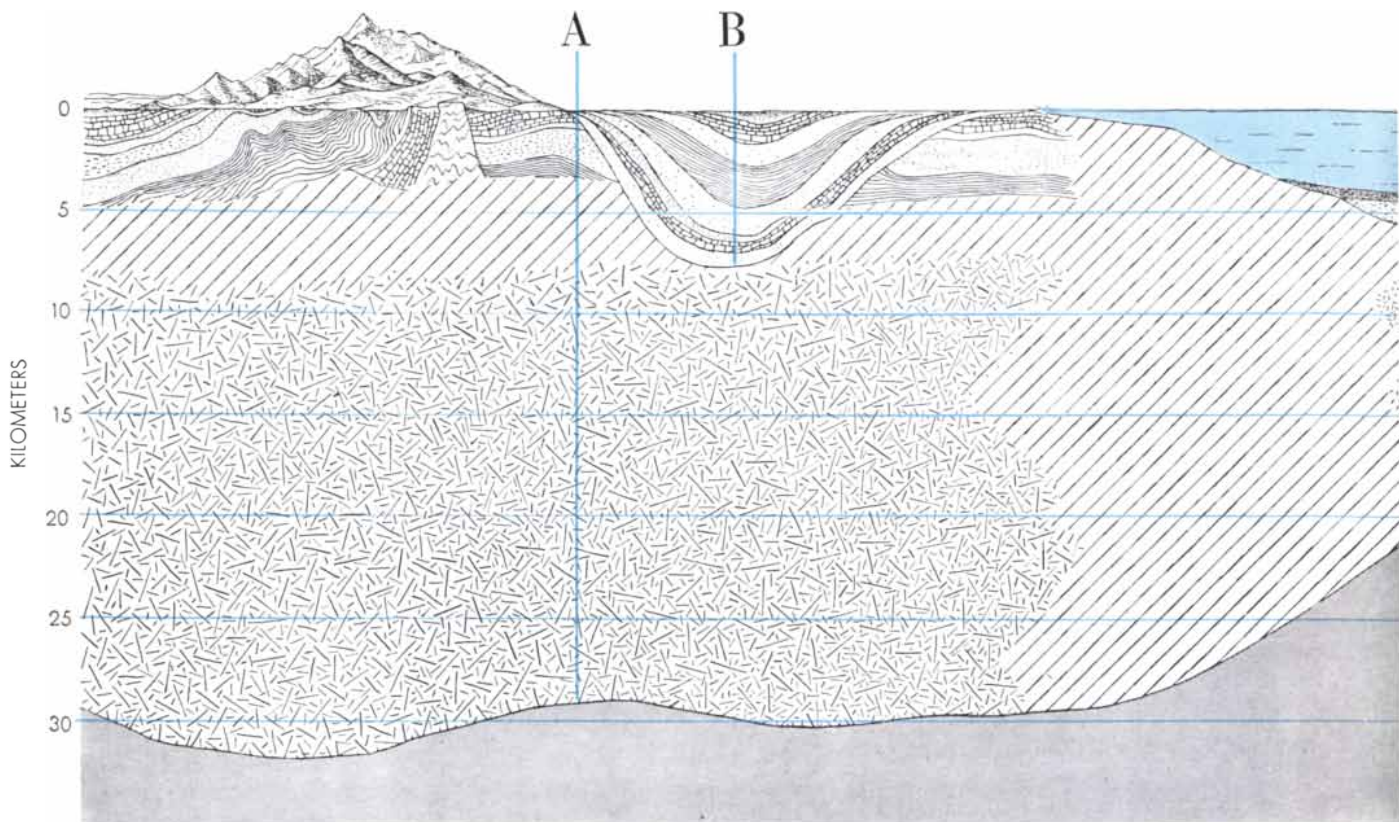
Despite the impressive ring of its abbreviation, AMSOC began as a mild satire on alphabetical scientific organizations. The letters stand for American Miscellaneous Society. AMSOC has no officers, no constitution, no bylaws, no publications and no formal roll of members. Meetings have been held at cocktail time in Washington's Cosmos Club with a two-member quorum. Thus AMSOC can act expeditiously and without red tape when action is required. It was clearly the Society's duty to form a special Mohole committee.







The idea of probing deep into the earth goes back at least to the 1920s, when Arthur Conan Doyle's fictional

Professor Challenger dug a hole eight miles through the shell of the earth (which, he claimed, was a living animal resembling a sea urchin). Having gingerly bottomed the shaft in a slimy gray pulsating material, the Professor by remote control thrust a long drill point into the bottom to get a reaction. He did, and the story is called "When the World Screamed." Long before that Jules Verne's heroes had descended to the "central sea" via a volcano, and the Rover Boys had explored the interior of the earth with a mechanical mole.

AMSOC's La Jolla planning group decided to enlist international support by making the first public proposal at the 1957 meeting of the International Union of Geodesy and Geophysics in Toronto. There Hess, T. F. Gaskell (a British geophysicist) and Roger Revelle (director of the Scripps Institution of Oceanography) jointly sponsored a resolution that concluded: "The IUGG . . . urges the nations of the world and especially those experienced in deep drilling to study the feasibility and cost of an attempt to drill to the Mohorovicic discontinuity at a place where it approaches the surface." The resolution was adopted by the IUGG on September 14, 1957.

In order for AMSOC to be able to accept the funds necessary to carry out the project, it was necessary for the organization to acquire formal status. Five of the original nine members of the AMSOC planning group were also members of the National Academy of Sciences, so it was easily arranged for



-  GRANITIC MATERIAL
-  BASALTIC MATERIAL
-  MANTLE MATERIAL
-  SEDIMENTS
-  "SECOND LAYER"
-  SEDIMENTARY ROCK

SCHEMATIC SECTION of the earth's crust and upper mantle shows why a hole to the boundary between the crust and the mantle (the Mohorovicic discontinuity) will be drilled from a barge moored in the deep ocean. To reach the discontinuity from the surface of a continent the hole (A) would have to go some 100,000 feet (roughly 30 kilometers or 20 miles). To reach the discontinuity from an oceanic island the hole (D) would have to go

the group to become a formal committee of the National Academy. When the National Science Foundation supplied the initial funds for a feasibility study, the AMSOC-Mohole Committee was launched, with the writer as executive secretary.

During the discussion of the Toronto resolution a Soviet scientist arose and said: "We already have the equipment to drill such a hole; we are now looking for the place." By September, 1958, the Soviet Academy of Sciences had appointed its equivalent of the Mohole committee. Perhaps there will be a race to the mantle.

In order to appreciate why we require more information about the interior of the earth; why a hole in the ocean bottom will be both shorter and more valuable than one on land; and why direct measurements and samples of deep rocks are needed, one needs to know

something of theories of the earth and the reasoning that supports them.

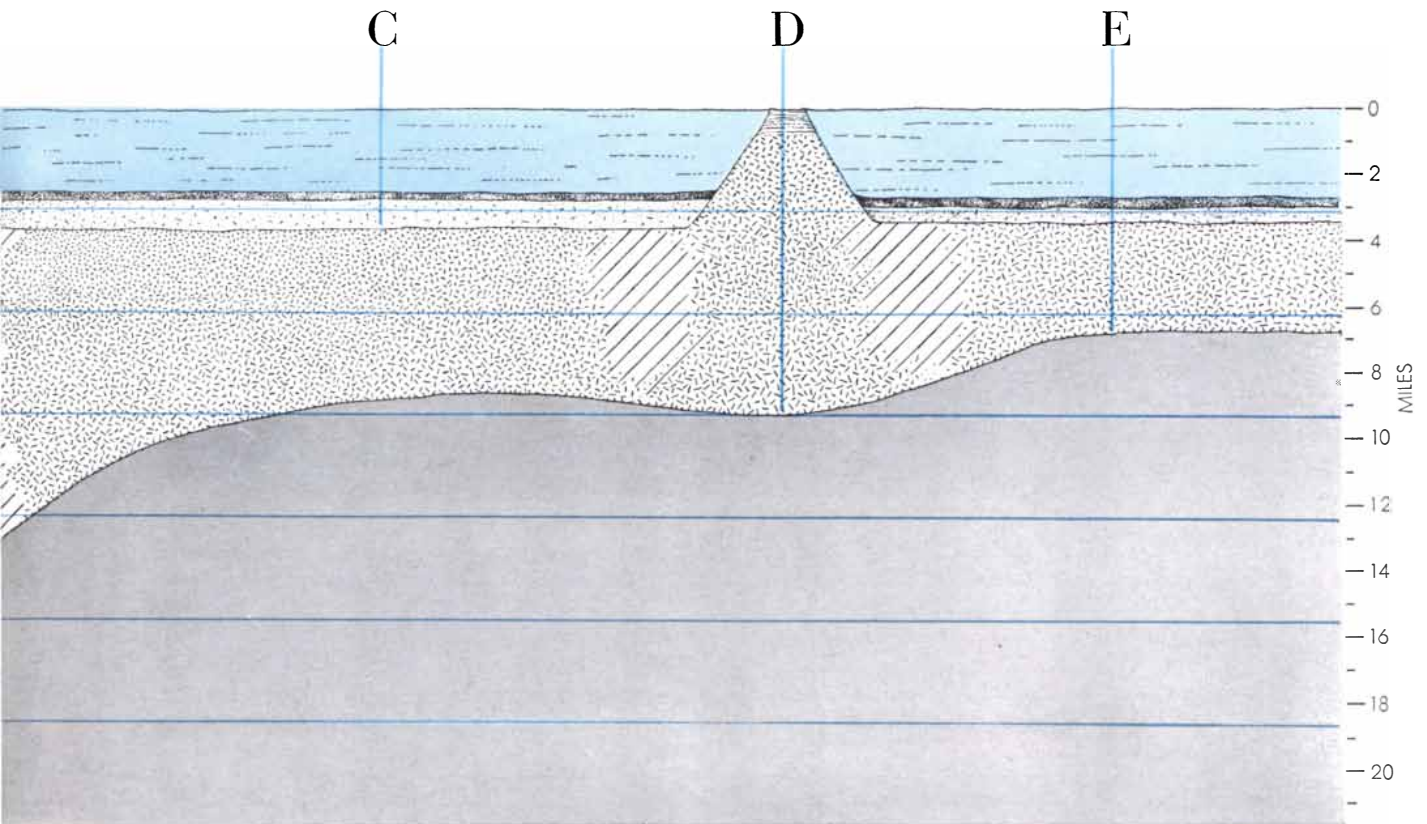
We can look into the earth through a series of scientific windows, each with a filter that permits but one form of evidence to pass. From astronomy comes information about the mass, density and moment of inertia of the earth; the composition of our fellow travelers in space; and ideas about the origin of the earth. From geology comes knowledge of the distribution, composition and movements of crustal rock as well as of the nature of volcanic activity. The history of the earth is revealed by radiochemistry and paleontology. Physics contributes concepts of the strength, conductivity and plasticity of rocks. Seismic, magnetic, gravity and heat-flow studies provide even more explicit clues.

The problem of the geophysicist is to fit this mass of evidence into a working hypothesis. At present he sees the crust of the earth as consisting of vast sheets of relatively thick, light granitic (the continents) separated by large areas of thinner, denser basalt (the

ocean basins). Both kinds of rock act as if they are floating on the even denser rock of the mantle. Floating does not mean that the continents move about on the earth's surface; the basalt is much too rigid to permit that. Rather it is a loose description of isostasy, a concept that regards the continents as being something like icebergs, which in order to rise a little above the surface of the sea must extend much farther below it. In the crust of the earth a similar vertical adjustment takes place, but its rate is very slow because the material of the mantle is enormously viscous.

If a mass of rock stands high, whether it be a mountain chain, a large island or an entire continent, it is compensated by an extra thickness of the crust below. As erosion removes some of the raised mass, the bottom of the crust will tend to rise. Conversely, if an eruption adds to the weight of a large volcanic mountain, the crust in that area will sink.

Thus it appears that the continents and ocean basins have always maintained a relationship something like the present one. Although the continental



some 50,000 feet (roughly 15 kilometers or nine miles). To reach the discontinuity from the surface of the deep ocean the hole (E) would have to go only some 32,000 feet (roughly 10 kilometers or six miles), the upper 14,000 feet of which would be water. A hole (C) might also be drilled in somewhat shallower water to obtain a

cross section of oceanic sediments. The depth of the deepest well yet drilled on dry land (B) is 25,000 feet. The crust beneath the soft oceanic sediments is divided into two layers, the upper of which is called the second layer. The diagonal lines in the diagram indicate the regions in crust of least certain composition.

crust has an average thickness of about 20 miles, the suboceanic crust may in some places be as thin as $2\frac{1}{2}$ miles. In most oceanic areas, however, the crust seems to be overlain with half a mile of sediment and some $2\frac{1}{2}$ miles of water. Even so, the mantle is much closer to the surface of the sea than to the surface of the land.

Man's first ideas about the nature of rocks beneath the earth's surface were derived from volcanoes, which obviously spewed out molten rock from the depths. It was concluded that except for the crust the earth was liquid. This seemed to be substantiated by measurements in mines and drill holes, that showed that the rise in temperature with depth would be sufficient to melt any known rock less than 60 miles below the surface.

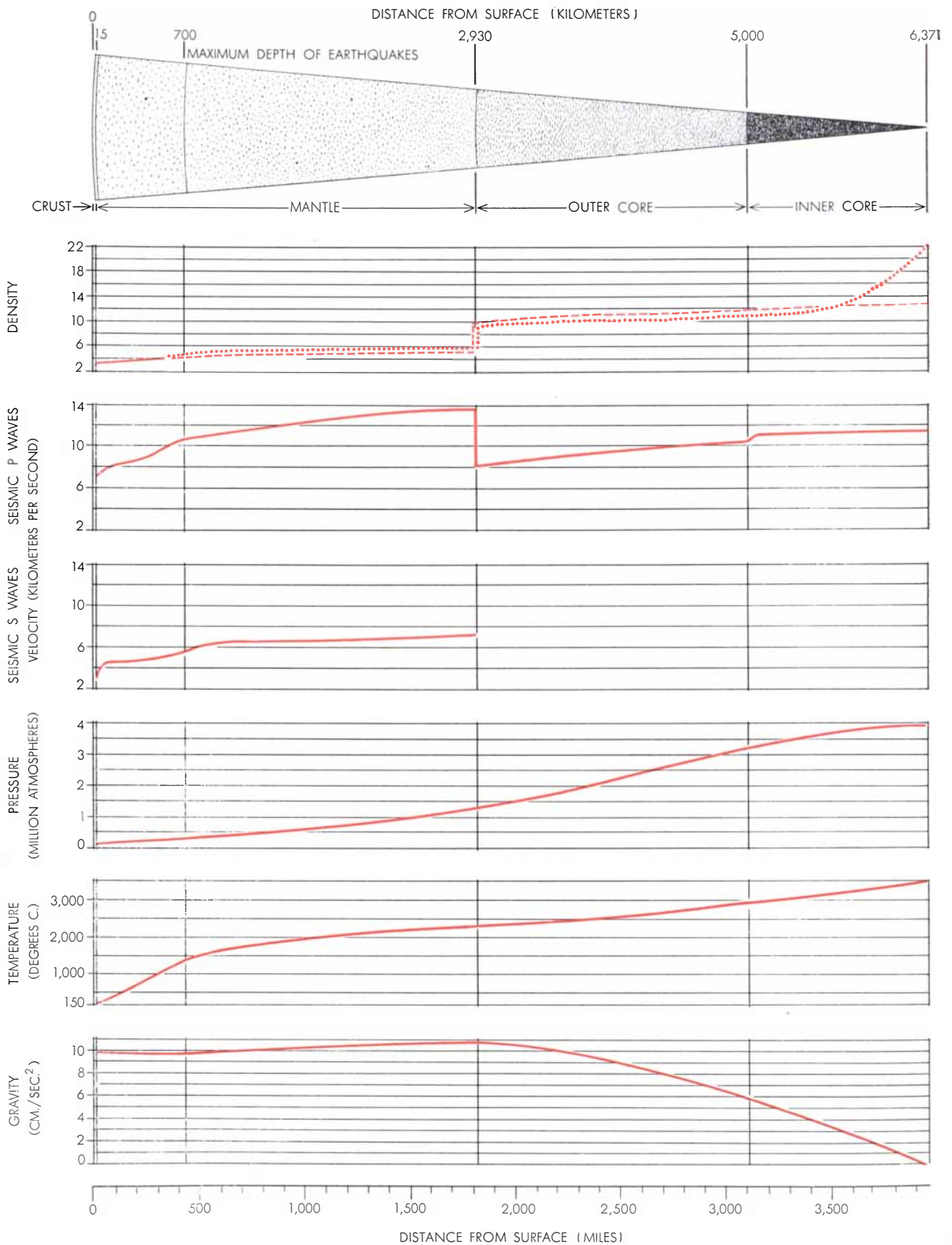
The concept was generally accepted until Lord Kelvin's theoretical studies of tides in the solid earth led him to the conclusion that the earth's interior could not be liquid, and that in fact the interior was more rigid than steel. He proposed that the interior was solid, but that it had cooled from a molten state.

His theory was borne out by later evidence that the density of the earth increases with depth and that the earth has a heavy metallic core, as though gravity had segregated the original liquid materials according to their weight. Kelvin's theory is challenged in turn by recent measurements of the earth's radioactivity and of the amount of heat that flows from the earth's surface. It is possible that radioactivity gives rise to more heat than is radiated from the surface; if so, this could mean that the earth has been heating up rather than cooling.

The question of the origin of the earth is far from settled, mainly because there is no information about the materials of the interior, and about the distribution of radioactivity with depth. A logical place to begin to seek such information is to examine the rock that comes up in volcanoes. The lava from volcanoes in the Hawaiian Islands is basalt containing occasional lumps of a rock called dunite. At the surface dunite has a melting point of about 1,200 degrees centigrade; at a depth of a few

miles, however, the pressure would keep it solid at higher temperatures. This is significant because seismological studies indicate that the earthquakes that precede a Hawaiian volcanic eruption start at a depth of as much as 20 miles. Over a period of several days these disturbances approach the surface, releasing the pressure that keeps the rock solid and opening fissures that the lava can follow upward. Since independent seismic evidence indicates that the thickness of the crust in the Hawaiian Islands is only about 10 miles, this suggests that the lavas actually come from the mantle. However, they probably are not representative of it. The basalt of the lava is not dense enough to account for the velocity of earthquake waves in the mantle, and although the dunite meets the density requirement, it seems most likely to represent some kind of chemical segregation.

There are other clues to the nature of the mantle. The heights of mountain ranges reflect the strength and rigidity of the underlying rock, which must sup-



STRUCTURE OF THE EARTH is indicated in the pie-shaped segment at the top of this chart. The structure is deduced from such phenomena as earthquake waves and gravity variations, which in

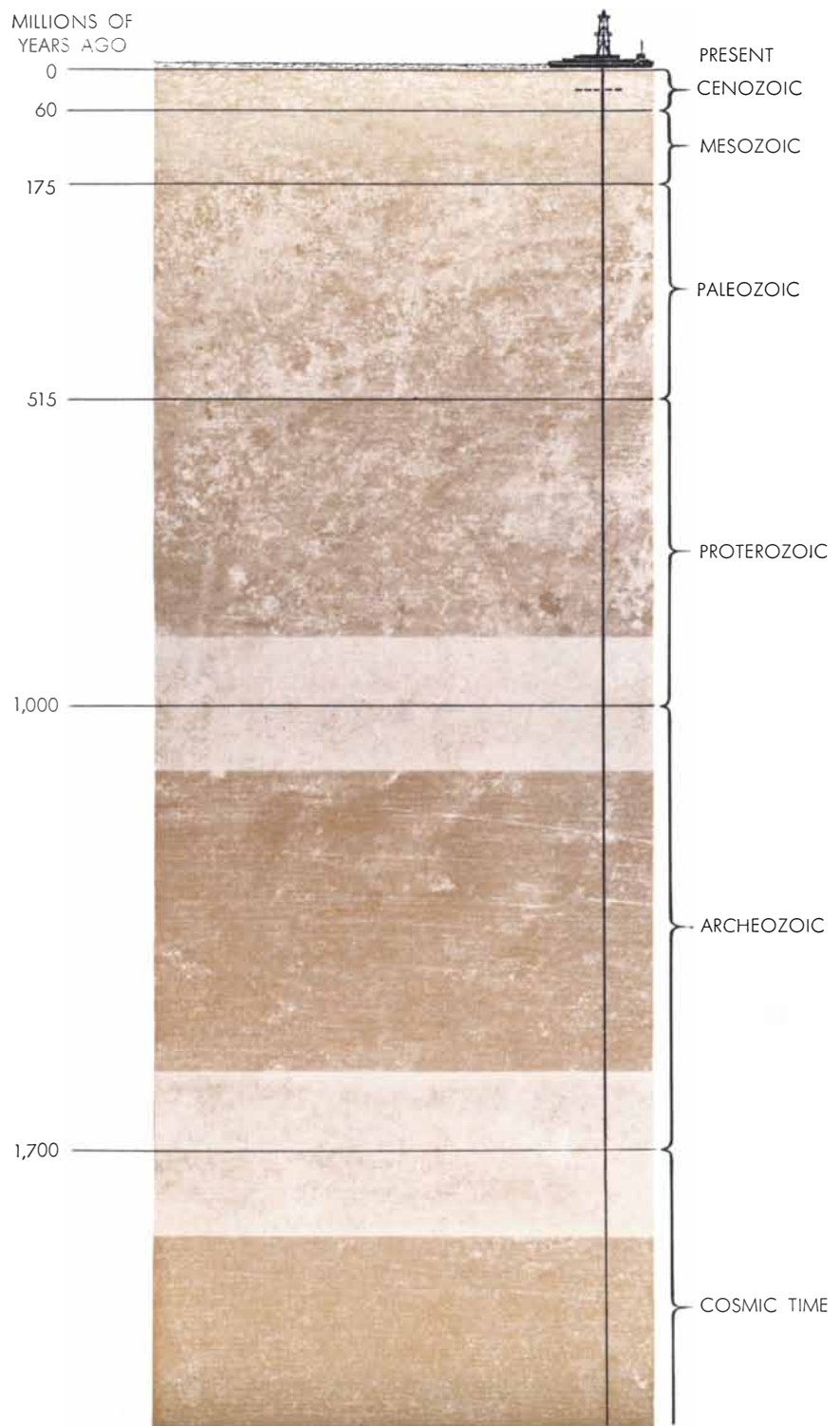
turn suggest the properties of each region of the interior. The 15-kilometer thickness indicated for the crust is a worldwide average. The two curves for density reflect two different hypotheses.

port the mountains and transmit the stresses that raised them. The age of the rocks in the mountains indicates how long it took these stresses to accumulate. Seismic exploration for oil has revealed that in some continental areas rocks that originated with sediments in shallow inland seas go down more than 30,000 feet below sea level. The granitic material beneath the sediments has been warped downward into the mantle in response to the sedimentary load.

The composition of meteorites is also an indicator of the internal composition of the earth. These objects from interplanetary space probably represent a sample of material similar to that from which the earth and the other inner planets were formed. Meteorites vary in composition from stony aerolites to nickel-iron siderites, and include every gradation between the two. However, an analysis of a considerable number of specimens, representing an over-all average of those reaching the earth, indicates a composition of something like 87 per cent peridotite (essentially an impure dunite) and 13 per cent nickel-iron; in other words, about the same components and in the same ratio as proposed for the earth by reasoning from other kinds of evidence.

The moon and the nearby planets have densities that suggest that they too are composed of these materials, but with considerable variation in the relative size of their metallic cores. The moon, which is the smallest of these bodies, apparently has no core at all; its density being the same as that of the earth's outer mantle. It may well be that the best place to get a sample of the moon is beneath the earth's crust.

A good deal of information about the character of the crust has been obtained by measuring the small variation in gravitational force from place to place on the earth's surface. It would seem reasonable to expect that the great visible mass of a mountain range would be responsible for an increased value of gravity. Curiously this is not the case; instead the gravitational attraction is less in mountain areas than in lowlands where the rocks have a similar density. The explanation of this gravity deficiency is that the high crustal material is balanced by a rough mirror-image of itself in similarly light rock which extends far down to displace the denser rock of the mantle. The opposite holds for the ocean basins. Measurements made at the ocean surface (where a couple of miles of rock are in effect replaced by much less dense water) give



HISTORY OF THE EARTH may be continuously recorded in the deep ocean by sediments lying atop the primordial crust. One hole drilled through these sediments might sample material from every era of geologic time (*right*). Dinosaurs first appeared at the beginning of the Mesozoic Era. The earliest substantial fossils of living organisms are from the beginning of the Paleozoic Era. Life is assumed to have originated at the beginning of the Proterozoic Era. The first deposition of sediments on the primordial crust occurred at the beginning of the Archeozoic Era. Beneath these sediments may lie meteoritic material and a surface similar to that of the moon. Lighter bands in the colored area represent uncertainties in the lengths of the ancient era. Cosmic time continues backward beyond the Archeozoic Era to the time of the origin of the earth, estimated as three to five billion years ago.

gravity values that are apparently too high. The high values result from the fact that the oceanic crust is relatively thin and the dense mantle comes closer to the surface. It is these measurements that led to the theory of isostasy. But it is necessary to confirm such theories of the structure of the earth's crust by still another independent means: the study of seismic waves in rock.

Earthquakes are the result of rocks fracturing under stress. When the rock gives way, seismic waves of several kinds radiate outward in all directions through the earth. Their velocity increases with density, so that by measuring the time required for these waves to travel to distant seismographs it is possible to work out their pathways and the densities of the rocks through which they traveled.

The two main kinds of seismic waves are designated P (primary or compression waves) and S (secondary or transverse waves). The P waves travel through both the solid and liquid parts of the earth; the S waves travel only in the solid part and at about two thirds the speed of the P waves. Since the S waves do not pass through the center of the earth it has been reasoned that most of the earth is solid but that there is a liquid core of nickel-iron that in effect casts a seismic shadow on the side of the earth opposite an earthquake. For comparatively shallow crustal exploration explosives are used to produce the seismic waves, and portable geophones or hydrophones are used as receivers. Such methods bear out the evidence from gravity measurements that under the ocean bottom the Moho is much closer to the surface than it is anywhere else.

The earth's magnetic field provides still other clues to the nature of the interior. Electrically conducting materials moving in the interior doubtless account for the magnetic effects we observe at the surface. Convection currents in a liquid nickel-iron core could act as a dynamo, which would explain both the magnetic field and its local variations. The steady westward drift of the field (1,600 years per revolution) suggests that the core rotates more slowly than the mantle.

The last major piece of evidence to be fitted into the puzzle is that of heat flow. As indicated above, the earth's internal heat evidently is a combination of the original heat of formation plus heat that is continually being added by radioactivity. In order to explain the neat segregation of materials by density

it is customary, though not necessary, to assume that the entire earth was once liquid and that by a combination of convection and surface radiation it cooled until it mostly solidified. From then on cooling could only take place by conduction, and since rock is a very poor conductor the process is very slow.

The increase in pressure caused by the weight of the overlying materials raises the melting point of rock at a rate of some five degrees C. per mile of depth. Since rock occupies less space as a solid, in order to become molten it must expand against the pressure of the rock above. Thus once a rock has solidified it cannot become liquid again unless there is a considerable rise in temperature, or unless the pressure is relieved by an earthquake.

The mantle material, even though it is rigid enough to permit earthquakes down to 400 miles, must also be able to deform plastically if isostasy is to be satisfied. Careful measurement has detected patterns in the heat flow through the ocean bottom. This evidence suggests that there are slow convection currents in the mantle which speed up the movement of heat to the surface—more support for the concept of a plastic mantle.

From all this interlocking evidence investigators in many disciplines have constructed a grand-scale hypothesis of the nature of the earth's interior. But it is obvious that this hypothesis relies almost entirely on indirect evidence. A direct examination of the interior material would greatly enhance the validity of the existing evidence and relieve some great uncertainties. The principal objectives of drilling to the mantle are as follows:

The Mohole will make it possible to obtain samples of the various rocks of the mantle and the deep crust for chemical and physical analysis, including mineral composition, radioactive content, density and conductivity (both electrical and thermal). With actual specimens instead of supposed mineral combinations, the laboratory work on rock at high temperatures and pressures would become much more meaningful. The validity of the meteorite analogy can be tested, and when the density of the outer rock is accurately known, the estimates of density all the way to the center of the earth can be improved. When the radioactivity of a sample of the mantle is known, it may be possible to say whether the earth is cooling and to explain the high flow of heat through the ocean floor. It may also be possible to determine the age of both crust and

mantle by the analysis of their content of radioactive isotopes.

Exact depths, thicknesses and characteristics of the boundaries between the various materials down to and including the Moho will be obtained. The depths and thicknesses will serve to check determinations made on the basis of earthquake waves. It is not even certain that the Moho will be immediately recognized when it is reached.

Direct measurements will be made at various depths of temperature, earthquake-wave velocity, electrical conductivity, heat flow and the earth's magnetic field. The properties of the rock will be measured by methods similar to those used for oil-well logging. These should give us a much better understanding of all the data obtained by indirect geophysical methods.

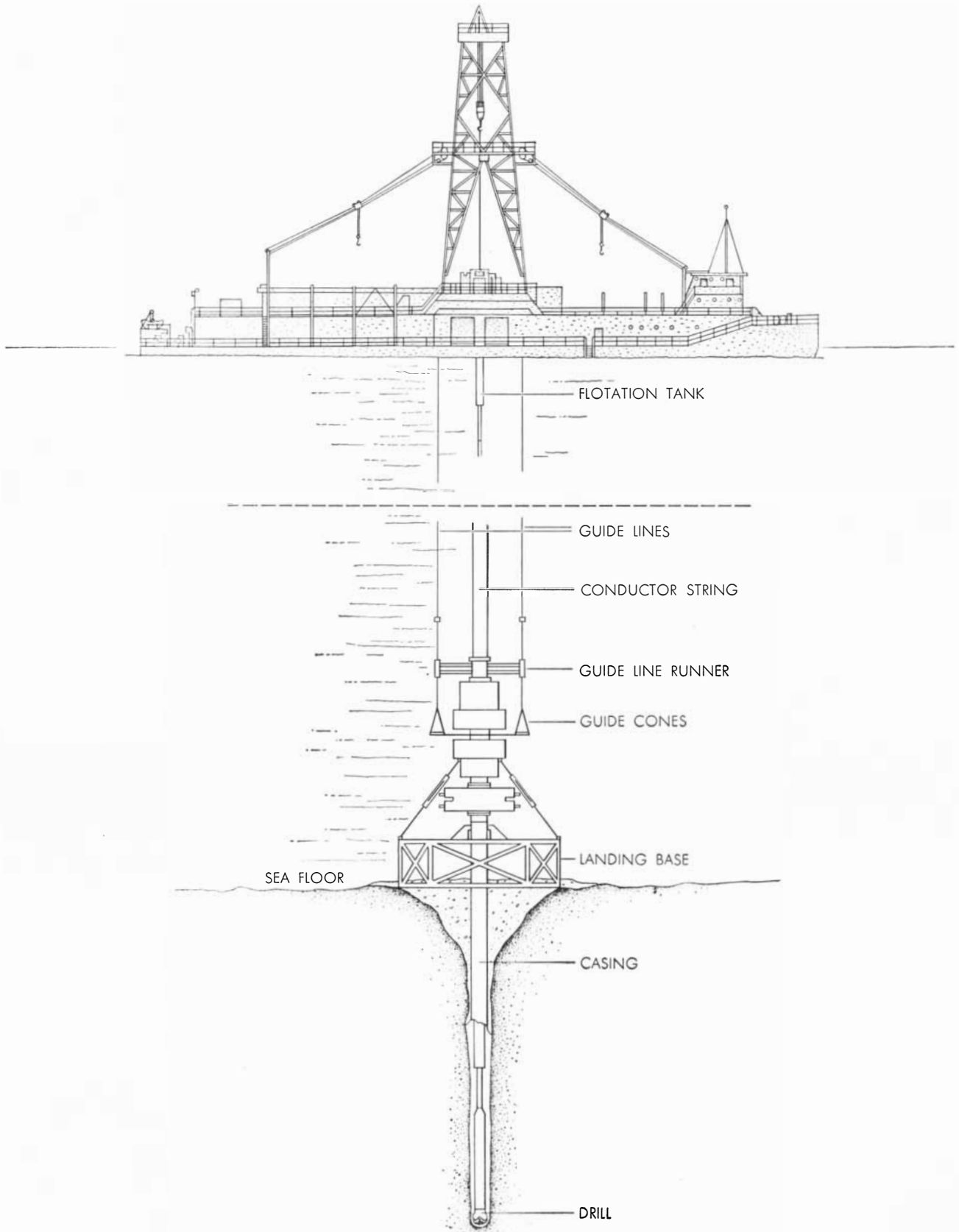
Perhaps the most important objective is to look for the unexpected. The history of science has repeatedly demonstrated that unpredicted discoveries which upset accepted theories are the most valuable result of new work.

Although reaching the mantle is the ultimate objective of the Mohole project, an intermediate step is likely to yield equally valuable and interesting information. This is the taking of a continuous cylindrical sample, or "core," through the sediments of the ocean floor. These sediments may be the most fabulous history book of all time; they could contain an uninterrupted record of the earth's development for two billion years.

The oceanic sediments are quite different from the sedimentary rocks found on land. They are softer, unconsolidated to a considerable depth and show little variation over huge areas. Some areas of ocean bottom show little evidence of ever having been disturbed by crustal movements and there may be places where there has been continuous sedimentation since the process first began on earth. It is likely that part of the record will be missing at the first site selected. If so, additional holes may be required to bridge the gaps in time.

The earth's magnetic history may have been recorded in the deep-sea sediments. As tiny particles of magnetic minerals settle to the bottom they tend to align themselves with the earth's magnetic field. By examining the orientation of these particles in the sediment, it may be possible to determine changes in the positions of the magnetic poles.

The earth's climatic history will be similarly reflected. Because the solubility of calcium carbonate is related to temperature, the amount of calcium car-



“CUSS” SYSTEM, used to drill exploratory holes in shallow water off the coast of California, might be modified to drill to the Moho in deep water. In this system a rotary drill is lowered to the bottom

to make a relatively shallow hole. The drill is then pulled partly out of the hole and a landing base and casing are lowered and cemented into place. Then the drilling proceeds through the casing.

bonate in a sediment indicates the temperature at the time the sediment was deposited. Ancient temperatures will also be recorded in the ratio of the isotopes of oxygen in shells.

The fossils in known sedimentary strata have given the paleontologist a fairly complete picture of the evolution of life since the Cambrian period [see illustration on page 45]. However, there are essentially no fossil-bearing rocks found on land that record what happened before that time. Since all animal phyla with the exception of the vertebrates are present in early Cambrian rocks, it is evident that much of the evolutionary sequence has not yet been examined. The record of these millions of years in the development of life may exist in the deep-sea sediments. Since the drill will pass through the time and place of the first life on earth, there is a chance of finding evidence of this life. As it proceeds backwards through time, the hole will enter the age when the first atmosphere and water caused the first erosion and sedimentation on the newly solidified face of the earth. Beneath the soft sediments is the "second layer," which may be compacted sediment, massive dolomite or basalt, according to which theory you prefer. And somewhere down there is the primordial surface of the earth—perhaps similar to the face of the moon; perhaps cov-

ered with a layer of ancient meteorites.

No one site or hole will satisfy all the requirements of the Mohole project. The hole to the mantle itself will be drilled where the geologic situation is uncomplicated and where the Moho is closest to the surface. To locate such a place, seismic, gravity and heat-flow surveys are already under way. One possible Atlantic location is on the abyssal plain some 200 miles north of Puerto Rico, where the water is some 14,000 feet deep and the Moho is about 18,000 feet farther down. There are promising locations in the Pacific near the Equator due south of San Diego and northeast of Clipperton Island.

The criteria for locating the best place to obtain a sedimentary record are quite different and in some ways more difficult to meet than those for the mantle, but obviously drilling through the sediments will be a less demanding task. In fact, experimental drilling to test equipment can be conducted at sites that will return valuable geologic as well as engineering information.

The ideal site would be the lowest spot on the original earth surface, into which the earliest waters drained and brought sediment. Here continuous layers of sediment would represent the entire history of the earth and of the evolution of life. Probably no such site exists. However, if paleontologists can

obtain cores of fossil-bearing strata considerably older than Cambrian sediments, one of their fondest dreams will be realized.

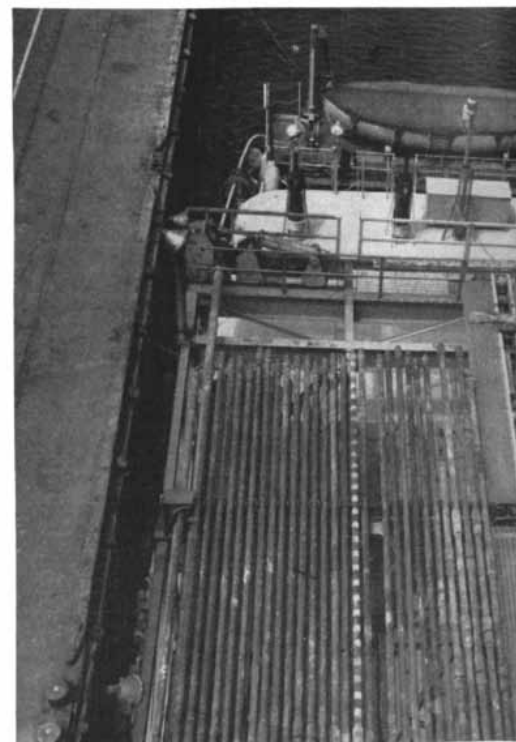
In addition to the requirements imposed by the study and by the reach of a drill, there are two other matters to be considered in selecting a site. One is weather; obviously hurricane areas, freezing weather, rough seas and strong currents should be avoided. The other is that the main drilling sites should be as close as possible to a port that can support the operation.

Even under the best of circumstances drilling an 18,000-foot hole in the deep ocean floor will be a formidable undertaking. It might be possible to invent a completely new way to do the job, but it seems best to rely as much as possible on the methods that have been developed and thoroughly tested in drilling for oil. The search for oil in the shallow waters off the California coast has led several major oil companies to develop floating platforms for drilling with conventional rotary equipment. Techniques have been worked out for re-entering a hole after changing bits, for setting casing, for coring and for circulating the mud that lubricates the bit and carries its cuttings away.

One vessel that has compiled a valuable experience record is the 260-foot converted Navy freight barge *Cuss I*,



"CUSS I" (left) is an experimental vessel which has been used to drill holes in the bottom off the California coast. The vessel, which is a converted Navy freight barge, is 260 feet



long and displaces 3,000 tons. At right is a view of its top deck, on which 8,500 feet of

named for the four companies that jointly sponsored it: Continental, Union, Shell and Superior. By the beginning of 1959 this 3,000-ton craft had drilled a total of more than 100,000 feet of hole in depths of water ranging up to 360 feet. With *Cuss I* procedures were developed for automatically handling and horizontally racking drill pipe, for buoying and relocating a temporarily abandoned hole and for inspecting bottom operations by means of closed-circuit television. After the crew had become experienced, this rig could anchor in several hundred feet of water, drill, log and seal off a 5,000-foot hole in 11 days.

The *Cuss* method is as follows. The ship is firmly anchored by a six-point mooring. Beneath it is suspended a pre-fabricated "landing base" bearing a short length of casing. The drill pipe is lowered through the casing to the bottom, where it freely drills several hundred feet of hole using sea water as a drilling fluid. The drill string is then raised but left in the hole to serve as a guide. The landing base and the initial casing are lowered down the drill pipe on guide cables and cemented into place at the top of the hole.

A "conductor" that slides on the guide cables and is exactly centered on the landing base by conical sockets is used to direct the riser-pipe (the casing above

the sea bottom) to the hole mouth. Some of the weight of this riser-pipe is taken up by underwater flotation tanks, which also help compensate for the relative movement of the barge and the conductor. A flexible pipe from the riser-pipe to the barge permits the drilling mud to be circulated in a conventional manner.

Cuss's operators claim that they have never been seriously hindered by rough water or weather, and that their costs are less than for nearby holes of similar depth on land. So far so good. However, the fact that these techniques work well in the shallow, comparatively sheltered waters and hard bottom of Santa Barbara Channel does not prove that they can be easily transplanted to open ocean with water more than 15,000 feet deep and a bottom consisting of soft sediments. In order to make this next step feasible a lot of hard engineering must be done to work out means of deep-sea mooring, of bringing casing from the sea bottom to the surface, of circulating the drilling mud and of coring.

To reach such extreme depths, pipes and cables may have to be tapered in steps so that their weight will not exceed their tensile strength at the surface. We can take some encouragement from the fact that the depth of the Mohole will be about the same as that of deep Pacific trenches whose bottoms have already been reached with tapered cables from oceanographic survey ships. A heavy six-inch drill pipe equally long will be only slightly more rigid than these cables; it can be expected to sway, bend and even form loops in response to the forces of the moving water.

High temperature is not expected to be a problem; at the Mohole itself the temperature should be less than 200 degrees C. Some engineers think that a promising method for drilling the hard rock in the deep part of the hole would be to use a diamond-coring bit on a turbodrill driven by sea water pumped from the surface at high pressure. If a wire-line core-retrieving method can be developed to use with this to avoid having to pull out all the pipe to get a core, a great deal of time and money can be saved. It seems possible that the research effort to make the improvements necessary for a hole this deep would undoubtedly be repaid by the speeding up of normal oil-well drilling.

The first attempt at deep-sea drilling cannot be expected to solve all the drilling problems; we will have to feel our way along. First, thorough engineering studies must be made that will essen-

tially modify the best existing techniques so that they will work in this new environment of waves, currents and high corrosion. Specially light, strong and corrosion-resistant metals may have to be used; new logging and coring techniques will have to be devised; instruments small enough to lower inside a drill pipe must be invented.

Second, the new array must be tried out at sea. The rig will be anchored in true oceanic depths (more than 10,000 feet) and a hole drilled in a sediment bottom. By hard trial, and perhaps error, it will be found out how to set up and drill without getting the pipes and lines into a hopeless snarl. The questions of whether sea water is an acceptable drilling fluid, of how much of the hole has to be cased, of whether the sampling system returns cores that are scientifically satisfactory, of how much surface excursion can be permitted for the drilling barge, of how far the bit will go before becoming dull—all these questions need to be settled by test.

Third, when the results of the first tests are in, modifications will have to be made in the drilling methods; this in turn may require a practical readjustment of scientific requirements. Then the first major hole will be attempted. This will be mainly a sediment-coring job, but it will penetrate the second layer. Its depth from the surface will be of the order of 16,000 feet. Such a hole may be so rewarding that a series of similar holes will be the most reasonable next step. After the first hole is finished, however, we will have definite knowledge of how difficult and how rewarding it is to drill in the deep rocks. At that time it will be possible to make a sound reappraisal of the kind of equipment needed to go on to the Moho.

Fourth, the hole to the mantle will be drilled. It will be very difficult; there are no illusions about that. But it will remain the ultimate objective of the Moho project.

Obviously this program will cost several millions of dollars and will extend over a period of years. However, the outlay of money and time cannot be fairly estimated until engineering studies are completed. Suffice it to say that the Mohole project appears to be scientifically sound; technically feasible and economically reasonable.

A group of holes through the oceanic rocks to the mantle will not answer all our questions about the earth. On the contrary, they can be expected to pose new and more difficult ones that will tax our ingenuity even more. That is the nature of nature.



drill pipe can be automatically racked during a single round trip to the bottom.

Family Planning in the U.S.

Where the birth rate of the U. S. was once fairly stable, practices of contraception have now made it a variable. How these practices affect population trends has been examined by a large-scale study

by Ronald F. Freedman, Pascal K. Whelpton and Arthur A. Campbell

Birth, migration and death are the key factors in the growth of a nation's population. Until about a century ago the birth rate in most countries was fairly stable at a high level; death and international migration were the changing variables, oscillating with economic conditions and the fortunes of peace and war. Today in Western nations the situation is reversed. For example, international migration now plays a minor role in U. S. population trends, and the death rate is stabilized at a low level. Successful techniques of contraception, on the other hand, have made the birth rate the dynamic force in population growth. Moreover, the recent swings in the U. S. birth rate show that it is now acutely sensitive to economic and social conditions.

This vital revolution has had great impact on many aspects of the life of our society. Yet we have had little reliable information on a national scale about the extent and success of family planning. Some important facts on the whole population and on major subgroups of it are now available as a result of a national survey conducted in 1955 by the Scripps Foundation for Research in Population Problems (at Miami University in Ohio) and the Survey Research Center of the University of Michigan. Some major results of this first comprehensive study, presented in our book *Family Planning, Sterility and Population Growth* (to be published in May by the McGraw-Hill Book Company) will be reviewed in this article.

In the perspective of history it is only recently that family planning has become so widespread that it could have a major influence on population trends. In the past the number of births for the average family varied little; it tended to approach the number that the average

woman was biologically capable of having. Crude methods of contraception, supplemented in some societies by infanticide and abortion, were never sufficiently widespread, effective and flexible to cause rapid changes in the average of family size. Change in the rate of population growth thus had to be caused by other influences. Epidemic disease, famine and war would increase the death rate; population growth would be slowed and at times reversed. In times of peace and well-being the death rate would fall to relatively low normal levels, and the population would grow accordingly. From time to time massive migrations produced large population gains in some areas at the expense of others.

Today advances in medicine, public health, nutrition and other fields have dramatically cut the death rate. The great 19th-century tides of international migration have been generally reduced to trickles. At the same time married couples have available to them techniques that, for the first time in history, let them make effective decisions as to the number of children they will have. During the past 75 years the widespread use of these birth-control methods has begun to cause rapid changes in population trends in almost all of the Western nations.

During the depression decade, for example, the U. S. birth rate fell to an all-time low. Many population experts thought that our population would cease growing and might even decline, since the practice of family limitation was spreading to rural areas and lower-income groups. Almost no one foresaw the prolonged postwar baby boom and the accompanying population jump. Now we realize that a population that post-

pones marriage and childbearing in an unfavorable period may very well marry younger and start childbearing earlier when conditions improve. In addition, since planned families need not be small families, the size of the average family can increase in prosperous times.

The fluctuations in the birth rate have affected capital investment, housing, recreation, education, manpower recruitment and many other aspects of society that depend not only on the size of the population but also on the relative number of people in each age group. This in turn depends on the number of births in successive years. Our current school crisis is one painful result of the effect of postwar prosperity on the age of marriage, the size of families and the spacing of children. The population bulge resulting from the baby boom is creating successive crises in many other social institutions as well. Starting in the crowded maternity wards, the population bulge moves inexorably up the age pyramid to the elementary schools, high schools and colleges, then to the labor market and housing, until it finally reaches the old-age-pension system. Moreover, when one population bulge moves into the reproductive years of life, it starts another bulge that moves along 25 or 30 years later.

Clearly the impact of family planning requires that we learn much more about it. In the present survey our group set out to discover how couples feel about family planning and how extensively they practice it, how various groups in the population differ in their practice and how successful they are as measured by whether they have the number of children they want. To develop quantitative data on these questions 2,713 white wives in the principal childbearing years (18 to 39) were interviewed

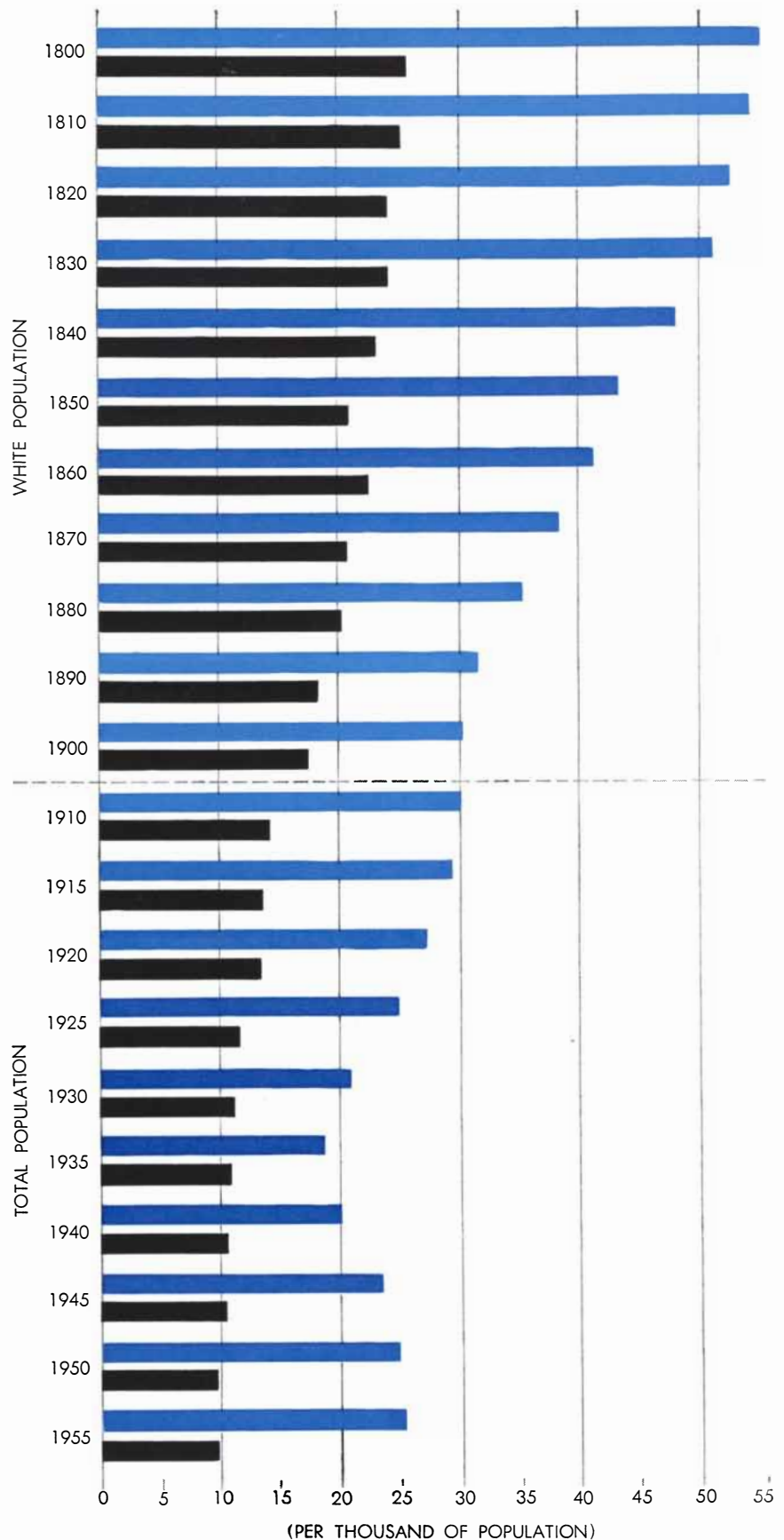
at length. They gave detailed information on their pregnancy histories, contraception practices and their plans for future childbearing. The wives were selected on a probability basis to give a good representation of the approximately 17 million white married couples in our population with wives 18 to 39 years old in the spring of 1955.

We secured complete interviews from 91 per cent of the sample, indicating that family planning is now accepted by young married people as a topic for discussion and investigation. In most surveys on political and economic subjects the completion of interviews from 85 per cent of the sample is considered satisfactory. Fewer than four wives in 1,000 declined to answer questions about the methods of contraception they practiced. In contrast, a larger number refused to answer questions about family income as being "too personal."

We should say a word at this point about terminology. Partly because some methods of preventing conception are morally unacceptable to certain groups, there is no general agreement on a term that applies to all methods. Here we use "family limitation" and "contraception" interchangeably and with no moral connotation for all methods (except sterilization) for avoiding conception. Included are periodic continence (the "rhythm method"), abstinence for long periods and withdrawal (coitus interruptus), as well as appliance or chemical techniques, such as diaphragm, condom, douche, jelly and the "birth-control pills" now being tested.

The survey showed that in general all population groups accept the idea of couples deliberately regulating the number and spacing of their children in relation to their needs and resources. All the women were asked: "Many couples do something to limit the size of their families and to control when the children come. How do you feel about that?" Less than 5 per cent expressed unqualified disapproval of family limitation. Even among Roman Catholic wives only 13 per cent avowed such sentiments. Catholics as well as Protestants in overwhelming majorities approved family limitation in some circumstances. At the other extreme 73 per cent of the Protestants, but only 33 per cent of the Catholics, approved limitation without qualification.

These differences reflect the doctrines of the Roman Catholic Church that forbid the use of certain methods of family limitation and restrict the extent to which other methods may be used. But



POPULATION TRENDS in the U. S. are toward a stable and low death rate and a varying birth rate. Family planning accounts for the new variability in births. Data before 1910 are for white population only. The length of each bar is based on an average for each five-year period.

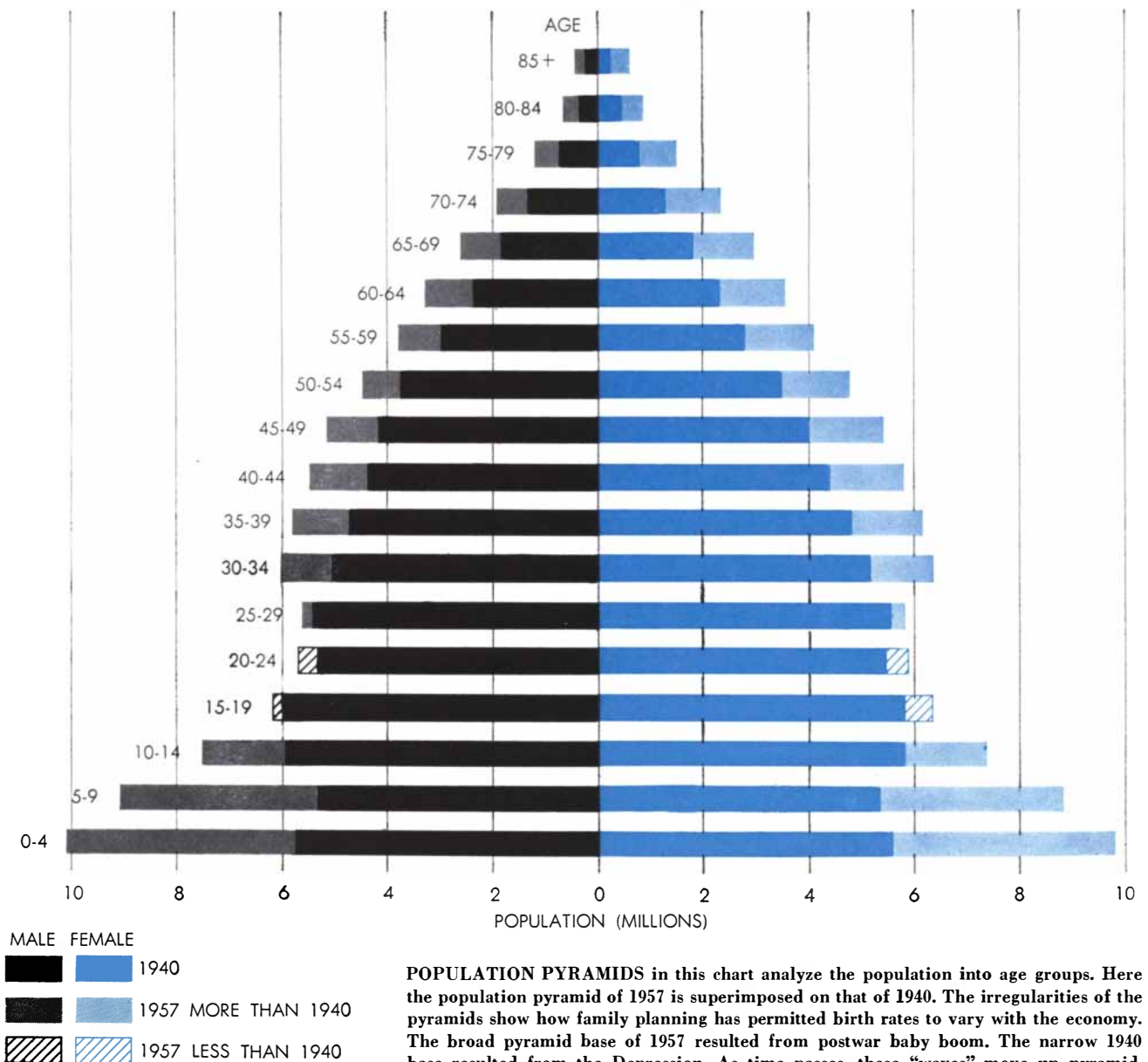
there is no categorical prohibition of all methods. The late Pope Pius XII said in a 1951 address that the use of periodic continence (the rhythm method) or long-continued continence for "serious motives" is morally acceptable. One such motive is the avoidance of more children than the family can adequately care for. Catholics sometimes refer to methods forbidden by the Church as "artificial birth control." This includes coitus interruptus and the use of any chemical or mechanical agent. Since about a fourth of U. S. adults are identified with the Roman Catholic Church, its doctrines are important to national fertility trends.

As might be expected, the attitudes expressed by the wives in the sample

were reflected in their accounts of their family limitation practices. The great majority of U. S. couples use some method of contraception. In our sample 83 per cent of the fecund couples (those who find that they can have children easily) had adopted contraception; 7 per cent more planned to do so after having the one or more children they still wanted. We think that the proportion may actually exceed 90 per cent, because many couples who are indifferent or opposed to contraception in early married life adopt some method when confronted with the problems of a rapidly growing family. In fact, 92 per cent of the fecund couples married more than 10 years reported efforts to control family growth.

Many couples do not practice contraception until they have had one or more children. Approximately half the couples using some method had at least one pregnancy before beginning to do so, often because they wanted to start having children soon after marriage. However, since most couples want a relatively small family, the delay before adopting control measures is usually brief. Unless in the meantime they had discovered a fecundity impairment, 89 per cent of all couples with two children had already used contraception in order to space pregnancies or restrict family size.

The majority of couples who never take control measures are those who suffer some type of physical impairment that limits their ability to bear children.

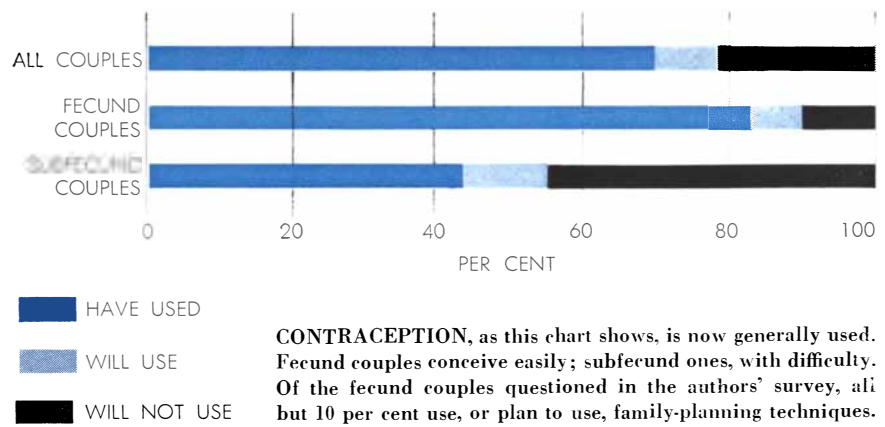


Whether such impairments are discovered depends in part on whether couples dispense with contraception for extended periods. Therefore couples who do not begin contraception until they have had one or two pregnancies are more likely than others to discover physical impairments that make voluntary control unnecessary. There is evidence that poorly educated couples are more likely than others to delay taking control measures until pressed by necessity. Relatively more of them "test" their child-bearing ability in this way and discover fecundity impairments that they would not otherwise know about.

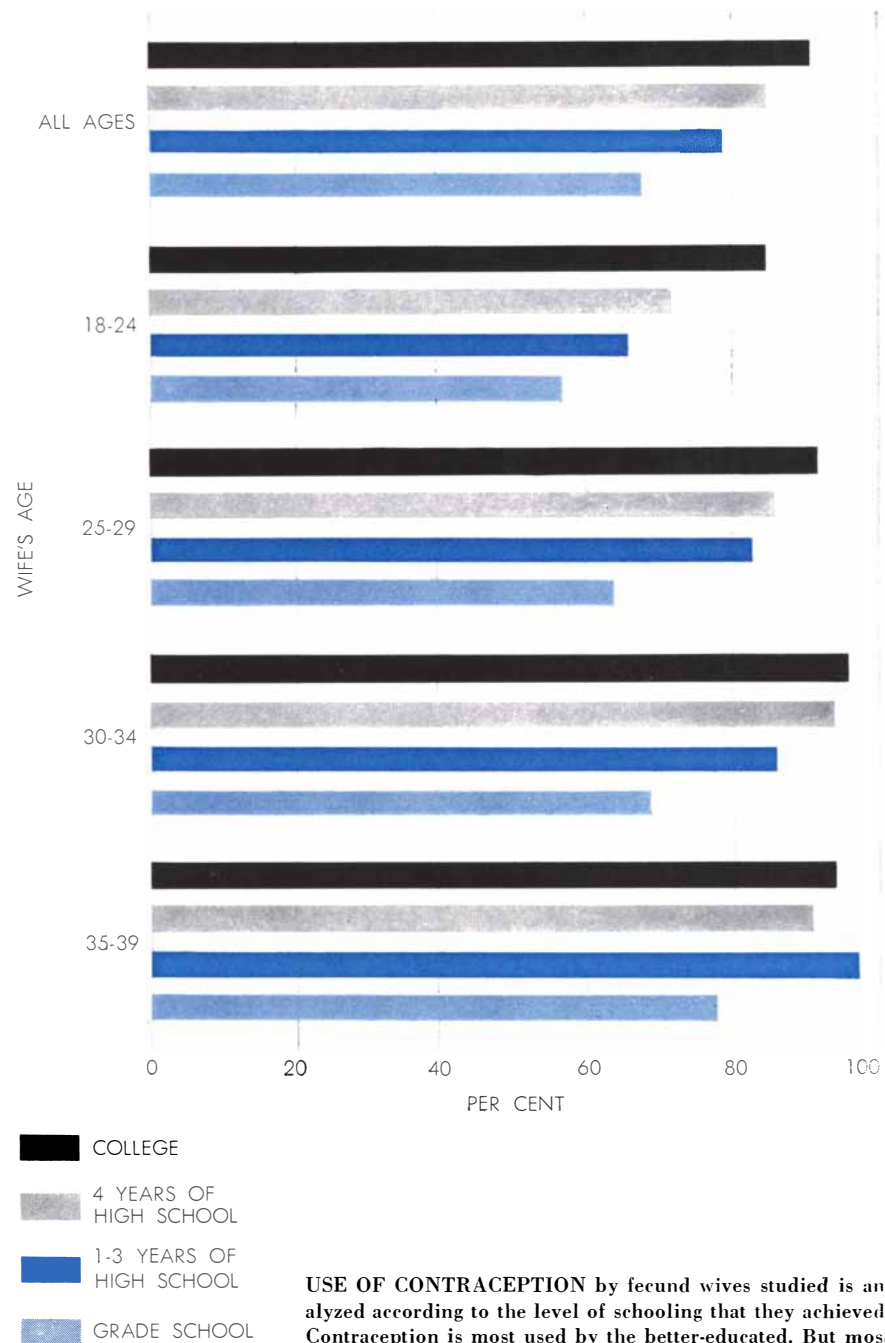
Another major finding of the survey is that a majority of the fecund couples in all the major strata of the white population now practice contraception. For the purposes of the survey, strata were defined by education, income, occupation, religion, region and type of community. The widespread practice of family limitation that we found is definitely a new development. Contraception was undoubtedly taken up first by the higher-status groups: the well-educated, the professional and white-collar people and those in upper-income brackets. As a result family size declined more rapidly in higher-status than in lower-status groups. This led a generation or two ago to fears that the quality of the population would deteriorate as more of the nation's children came from supposedly inferior social and biological backgrounds.

Now there are signs that eventually the historical differences among the birth rates of various population groups may be reversed. Among the wives in our survey who had been married less than five years, those with a college education expect to have more children than those with less education. Similarly, recent census figures show a lessening of birth-rate differences among socioeconomic groups, probably indicating that various segments of the population want about the same number of children. A 1940 study of Indianapolis, Ind., found that among couples who planned the number and spacing of their pregnancies, those with higher incomes were having the larger families. Such couples can afford more children without sacrificing the other things Americans value as part of their standard of living, including the ability "to give the children what they should have."

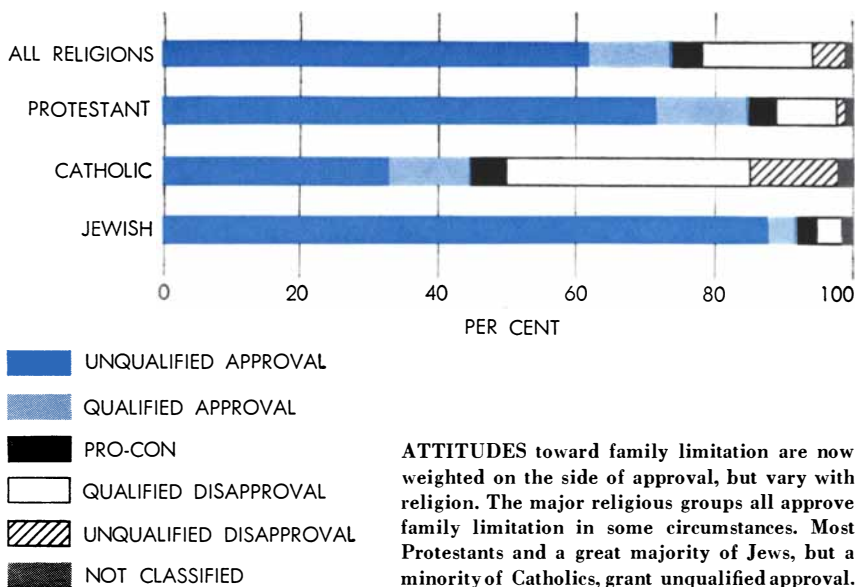
Though contraception is a general practice in all strata of society, there are still significant differences among groups, particularly with respect to religion and



CONTRACEPTION, as this chart shows, is now generally used. Fecund couples conceive easily; subfecund ones, with difficulty. Of the fecund couples questioned in the authors' survey, all but 10 per cent use, or plan to use, family-planning techniques.



USE OF CONTRACEPTION by fecund wives studied is analyzed according to the level of schooling that they achieved. Contraception is most used by the better-educated. But most fecund women use it in later years, regardless of education.



ATTITUDES toward family limitation are now weighted on the side of approval, but vary with religion. The major religious groups all approve family limitation in some circumstances. Most Protestants and a great majority of Jews, but a minority of Catholics, grant unqualified approval.

education. Among fecund couples 88 per cent of the Protestants but only 70 per cent of the Catholics reported using control measures. This divergence is not related to other nonreligious differences between members of religious groups, such as education, income, occupation or place of residence. When Catholics and Protestants who are similar in these respects are compared, the Catholics remain less likely to practice family limitation. The Catholic pattern of family limitation is also different from the Protestant. Far fewer Catholics plan their families by always practicing contraception except at the times when they want to have a child.

Interestingly enough, one factor that reduces the differences between Catholics and Protestants is whether the wife works. The differences based on religion are smallest among wives who have worked at least five years since marriage and therefore have had extensive contacts outside the home. In these cases religion appears to have less influence on family-planning practices.

While the differences by religion are important, they should not be exaggerated. The great majority of Catholics do practice some form of family limitation. This is not necessarily a deviation from the Church's precepts, since many use only the rhythm method and for "serious motives."

Along with religion, education plays an important role in determining whether or not a couple adopts some

family-limitation method. Presumably higher education gives a couple the wider range of contacts and information likely to make them analyze their family situation more self-consciously. It may cause them to want a style of life that requires careful planning, including the planning of family growth. In any case the more education couples have, the more likely they are to use contraception and to avoid unwanted pregnancies.

Education is also important in explaining the relationships of other characteristics, such as income, to family-limitation practices. For example, lower-income couples are less likely than others to practice contraception. But when couples with similar educational backgrounds are considered, differences by income become much smaller. In the same way, farm-city differences almost vanish when couples with similar educational backgrounds are compared. The fact that farm couples in general are somewhat less likely than urban couples to try to restrict family size reflects their lesser educational attainments.

So far as we know, contraception was formerly less widely practiced in the country and the small town than in the metropolis. Our study shows, however, that the distinction has been disappearing. This represents a marked change in a generation or two, and is probably the result of a double process. On the one hand, the tremendous mobility of Americans has thoroughly mixed people of very different backgrounds in communities of different sizes and types.

On the other hand, the influence of the metropolis has been reaching out to every section of the country, spreading common standards and aspirations that affect not only what people consume and produce, but also how many children couples want and how couples plan family growth. The educational attainments of farm and small-town couples are becoming more like those of urban couples, and so are their family-planning practices.

Just as the family-planning practices are becoming more uniform, so are the goals. Most couples, the survey revealed, want a small or moderate-sized family. Each woman in the sample was asked a variety of questions to discover what family size was her objective. At various points in the course of the interview she was asked how many children she expected, how many she wanted and how many she considered ideal. These questions elicited slightly different answers, but there was a remarkable consensus on no less than two and no more than four children. If all couples have the number of births they are expecting, the average will be about three. Catholics expect an average of 3.4 births per couple and Protestants expect 2.9. While it is probably biologically possible for U. S. couples to have an average of eight births, most of them are likely to come close to achieving their more moderate plans because they will use family-limitation methods fairly successfully.

Although a large majority of couples will come close to their goals, many will not be so successful. About one family in six may be "underplanned" because physiological conditions prevent the bearing of as many children as are wanted. For some couples inability to have any children is a major tragedy, and for others their failure to have an additional child or children causes serious distress.

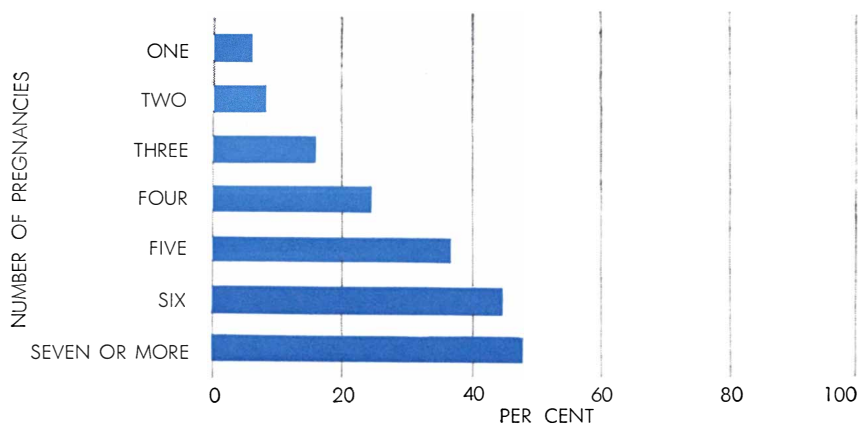
At the other extreme are those who have more children than they want. In the case of approximately one couple out of seven in our sample the last pregnancy was not wanted by one or both parents. This is a common situation among larger families. More than half the wives who had borne more than four children said they or their husbands did not want the last pregnancy. Such unwanted pregnancies are much more frequent among couples with little education than among the better educated; in fact, they are about four times as frequent among those with a grade-school education as among those with a college education. Here is another indication that family planning is more

extensive and effective among the better-educated couples. It is also likely that unwanted pregnancies are relatively frequent among Negro families, not included in this study. Negroes are presently concentrated in the lower educational and income groups in which accidental and unwanted pregnancies are most prevalent.

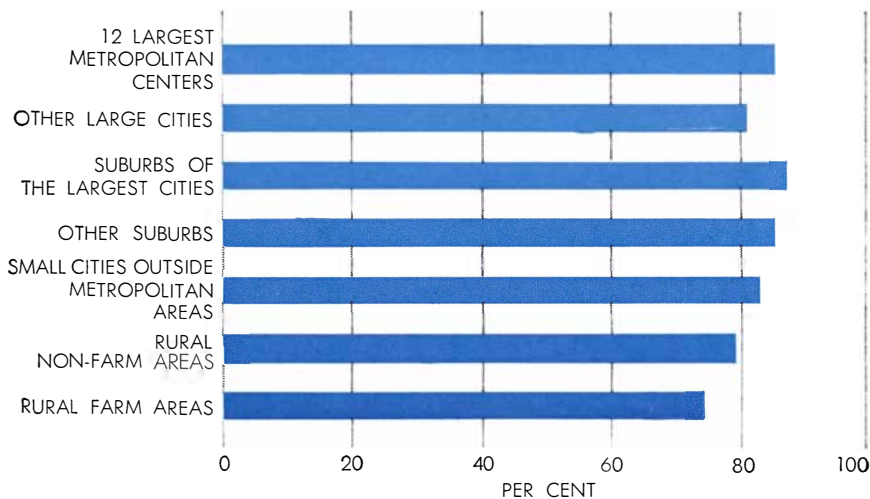
Another measure of success in family planning is the incidence of "accidental" pregnancies—those that begin when the couple is using some method to try to avoid conception. The wives in the sample reported that about 12 per cent of all their pregnancies were "accidents." However, a more meaningful "accident" rate is based on pregnancies that occur after use of contraception is begun. On this basis about one pregnancy in four occurred when the couples were using some method of contraception. Accidental pregnancies do not necessarily result in unwanted children, because in many cases the couples have merely been seeking to postpone a child they had planned to have later. Only about 24 per cent of all pregnancies begin after the deliberate discontinuance of contraception in order to have a child. Nevertheless, most couples are successful in having the small number of children they want. Even the significant minority of couples who miss their goal do so by no more than one or two children in most cases.

Since Americans have adopted reasonably effective means to control the size of their families, an understanding of the goals of their planning is of great importance in predicting population trends. Because the goals are likely to change with social and economic conditions, they should be studied from time to time along with changes in the effectiveness of family planning. The Office of Population Research at Princeton University is now following a sample of couples who had a second child in 1956, in order to learn what factors will determine which of them will have a third child. Such studies of particular stages in the family life-cycle are important because many families do not grow according to a plan envisioned at marriage. There is interaction between the plans of the parents and their changing situation in the 10 to 20 years most of them have for childbearing.

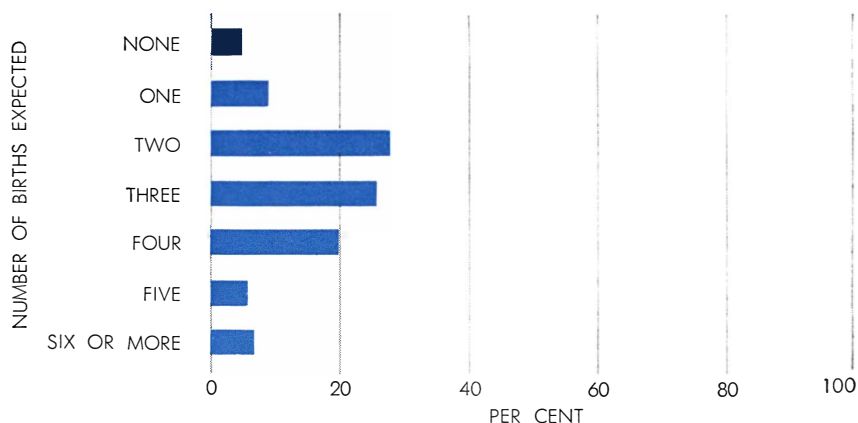
This first study of a representative national sample of young married couples can only serve as an introduction to a complex subject. It shows that family planning of the U. S. population can be investigated with significant results.



UNWANTED PREGNANCIES are most characteristic of large families, according to this chart. The vertical coordinate indicates the number of pregnancies in the history of the family; the horizontal coordinate, the percentage of instances in which the last of these pregnancies was unwanted. In almost half of the families with seven or more pregnancies the last was unwanted. Successful family planning is thus most typical of small families.



DISTRIBUTION OF FAMILY PLANNING is nearly even among all types of community. This chart shows the per cent of fecund couples using contraception in each of seven environments. The low rate for farm couples results from a low level of education.



EXPECTED FAMILY SIZE, as reported by the couples interviewed, usually calls for two, three or four children. Of those couples expecting no children, almost all were subfecund.

Visual Perception and Personality

Experiments with specially distorted rooms reveal that the way in which we perceive the size and even the shape of others is powerfully influenced by our emotional relationship with them

by Warren J. Wittreich

When we watch a person walk away from us, his image shrinks in size. But since we know for a fact that he is not shrinking, we make an unconscious correction and "see" him as retaining his full stature. Past experience tells us what his true stature is with respect to our own. Any sane and dependable expectation of the future requires that he have the same true stature when we next encounter him. Our perception is thus a prediction; it embraces the past and the future as well as the present.

From such considerations psychology has taught us all by now that perception is not a simple act. We do not merely see what is "out there" in the here and now. Perception is an ongoing process that involves our image of our own self, our needs, values and purposes, as fully as it involves the image of the object perceived. In this "transaction" between the viewer and the viewed it seems evident that emotional relationships between people must also condition how they see each other. Would anyone deny that beauty is in the eye of the beholder?

Six years ago we began a series of experiments designed to measure the degree to which the emotional feeling of one person toward another may modify that person's image of the other. At Princeton University and subsequently at the Naval Medical Research Institute at Bethesda, Md., we studied how one person's perception of another is influenced by emotions arising out of the marriage relationship, out of one person's subordination to another and out of perceiving that the other person is disfigured or mutilated. We have found that the emotions do not only involve such intangible qualities as beauty; they may also significantly affect a person's perception of such "objective" attributes

as the stature of the person perceived.

For the experimental devices and procedures employed in our study we are indebted to the late Adelbert Ames, Jr., of Hanover, N. H., whose work has inspired so many other lines of investigation in psychology during the past 25 years. This gifted investigator (who before he turned to psychology had been a lawyer, then a painter, then a physiologist) developed a number of powerful demonstrations of the transactions involving the perceiver and the perceived [see "Experiments in Perception," by W. H. Ittelson and F. P. Kilpatrick; SCIENTIFIC AMERICAN, August, 1951]. For one series of experiments we employed one of Ames's famous distorted rooms. The floor of this room slopes upward to the right of the viewer, the rear wall recedes from right to left, the windows in the rear wall are different sizes and trapezoidal in shape. When the room is viewed from one vantage point, however, it looks like an ordinary room: the floor appears level, the rear wall is at right angles to the line of sight and the windows are rectangular and of the same size. Out of his past experience with the cues provided by perspective, the viewer has assembled a set of assumptions that he brings to the occasion and applies to the immediate experience.

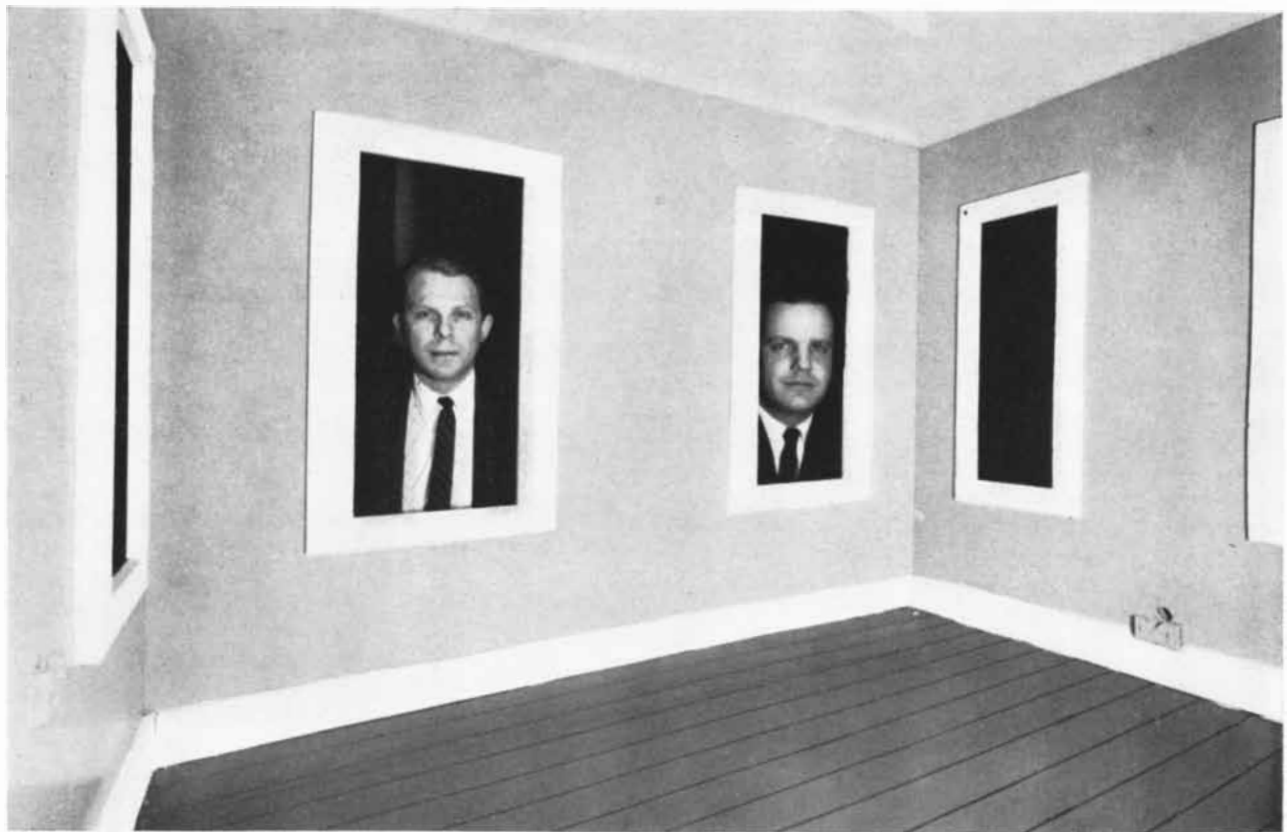
Ames built one of these rooms large enough for people to walk about in it. A surprising thing now happens. When the viewer sees another person walk across the room, he typically observes an extraordinary alteration in that person's size. Depending on which way the person walks, he appears to grow or shrink. A smaller model of this room permits hands or faces to be seen at the rear windows. As with the larger room, the hands or faces appear to be abnormally large or small, depending upon

whether they are framed in the window to the viewer's right or to his left. Thus in the typical experience the viewer sticks to his assumptions about the shape of the room, even to the extreme of accepting distortion in the appearance of another person.

On one occasion a decade ago, however, Hadley Cantril and his associates at Princeton University observed a striking departure from the usual pattern of response to the Ames room. A viewer, observing the faces of her husband and another man at the windows of the small room, reported that her husband's face remained unchanged though she observed the expected distortion in the face of the other man. Similarly, the other man appeared to grow or shrink as he walked to and fro in the larger room, while her husband underwent no change in size whatever. Cantril called this reaction the "Honi" phenomenon, after the woman's nickname.

Suspecting that the emotional relationship of this woman to her husband might in some way underlie the Honi reaction, a group of us at Princeton set out to repeat the experiment with other married couples. Of the 10 couples we enlisted, it happened, most had been married for a brief time, several for less than a year. The majority of these individuals saw their partner grow and shrink in the usual manner and to the same apparent degree as a stranger who acted as the "control" in each experiment. Six viewers, however, reported that their partners altered less than the stranger or did not change at all.

All six turned out to be recently married. Indeed, at least one member of every couple married less than a year reported the Honi reaction. Only one subject married more than a year dis-



SMALL "AMES ROOM" is built in a distorted shape. Viewed through one eye (or photographed) from a particular point (*top*) the room appears normal and faces in the rear windows appear un-

equal in size. Some married people, however, see their partner's face as the same size in either window. From another angle (*bottom*) the faces appear to be the same size and the room distorted.

played it, and he had been married only two years. We also noted with interest that the "Honi" subjects tended to see the room as distorted when their partners entered it. Faced with the choice of seeing their partner or the room distorted, they chose the latter.

Our tape recordings of the subjects' spontaneous comments support the authenticity of the response recorded in each case; several expressed surprise when they observed that their partners did not change size. In search for a more objective standard of determining the subject's response, however, we enlisted six new couples, all married less than 15 months. This time we asked each subject to tell us at what point the partner and the stranger appeared to assume normal size as they walked from wall to wall in the larger room. The location of this point varied considerably in each trial, but in every case the marital partner was required to walk a shorter distance than the stranger to be judged of normal size. We also asked each subject for detailed "before and after" descriptions of the room's appearance. When we totaled the number of distorted items in each description, we found that the "distortion score" increased sharply after the partner's entrance. As one would expect, the subjects with the

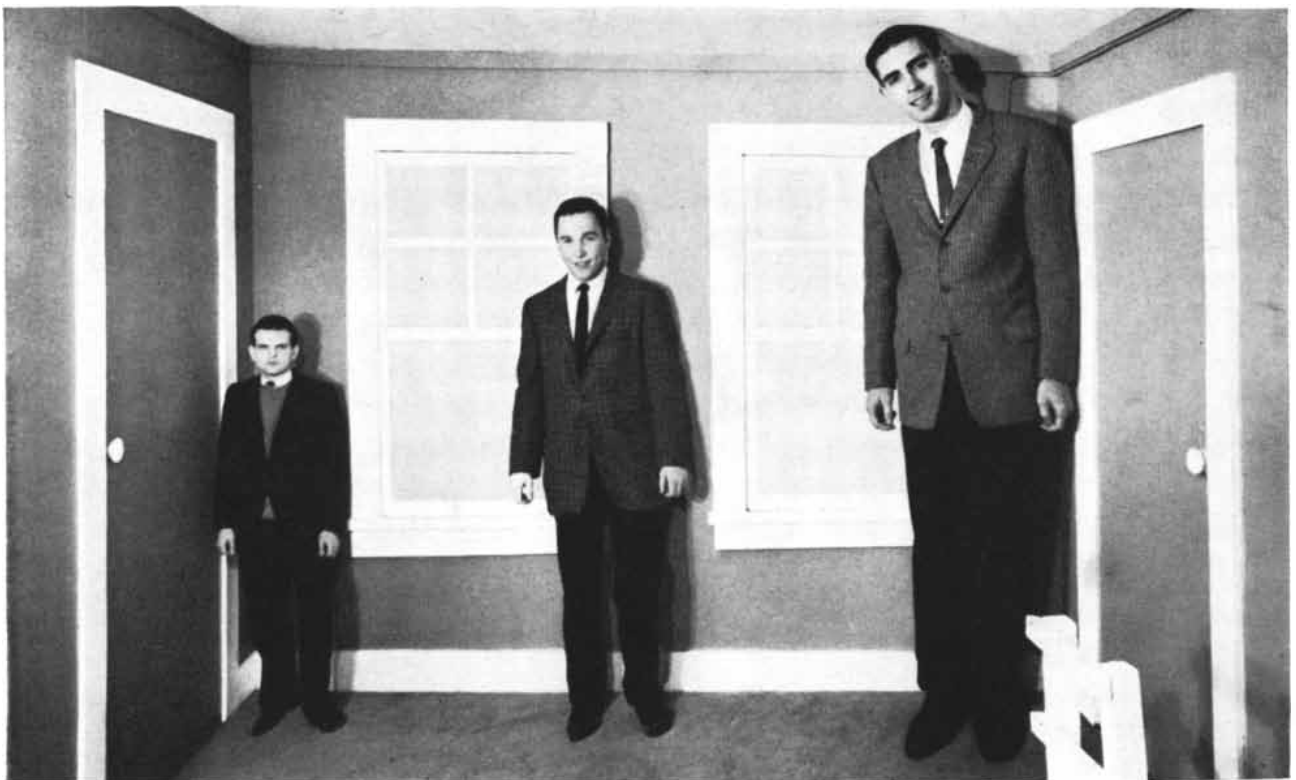
strongest tendency to perceive their partners unchanged showed the highest scores with the partner in the room.

The completion of this experiment left us in something of a quandary. We had demonstrated differences in perception that seemed somehow related to marriage, but were hard put to explain the differences. It could not be ascribed to mere familiarity with the person perceived, since the effect was most marked among newlyweds. On the other hand, the "Honi" couple had been married for more than 25 years. This troublesome fact pointed up an almost self-evident truth: Marriage, though it has a very clear legal meaning, has diffuse meaning in psychological terms. The relationship between marriage partners obviously differs from that between unmarried people. But specifically and precisely in what way does it differ that is relevant to our finding? Indeed, the marriage relationship itself changes with the years. To explain our results we obviously needed to experiment with a simpler and more clear-cut relationship, subject to more precise definition.

An opportunity to conduct such experiments presented itself in 1953 at the Naval Medical Research Unit in connection with the psychiatric adjustment of

patients who had been seriously mutilated or disfigured. In this investigation we employed another Ames technique that involves the use of "aniseikonic" lenses. These lenses had originally been devised to correct a defect in the mechanism of stereoscopic vision (aniseikonia), which has been found to affect about 2 per cent of the population. When a person with normal vision looks through the corrective lenses, his vision is distorted as if he were troubled with aniseikonia. Another person viewed through aniseikonic lenses of one type appears to lean forward; the lower portion of his body seems to broaden to give him almost a pyramidal shape. Individual parts of his body may also suffer corresponding distortion. The kind and degree of distortion depend partly on the distortion power of the lenses, but lenses of a given power still produce different degrees of distortion for different people.

When we fitted amputees with these lenses and asked them to view other persons, including other amputees, we at once made a significant finding. Each amputee reported that he saw considerably less distortion in the appearance of other amputees than he did in normal, whole persons. By way of experimental control, we fitted normal persons with



THREE STUDENTS of about the same height seem to be of radically different sizes in a larger Ames room. The student on the left

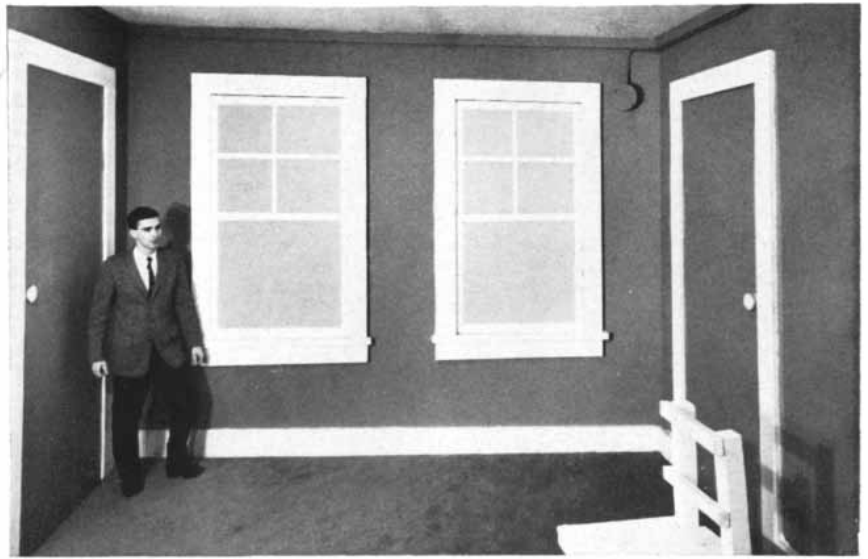
is actually nearly twice as far from the camera as the one on the right, but the distorted perspective of the room conceals this fact.

the lenses and got the same report from them. They too saw amputees and even simulated amputees as less distorted than other people.

Since each type of aniseikonic lens is available in graded degrees of distortion power, we were able to reduce these differences in the perception of each subject to a quantitative expression. We had each of 12 enlisted men, selected at random from the staff, view a normal person and a simulated amputee through a succession of lenses of increasing power. For 11 of our 12 subjects it took a lens of higher power to cause him to see the "mutilated" figure as distorted. The average difference was about 25 per cent; in one case it was 150 per cent.

As compared to our first series of experiments with married couples, the finding of this study was susceptible to somewhat more precise and reliable interpretation. It is not too difficult to specify the one overriding emotion involved when one person views another who is, or appears to be, mutilated and disfigured. Almost invariably it is a feeling of uncertainty and anxiety. Few of us have had enough experience with mutilated people to be sure of ourselves in dealing with them. Thus, it may reasonably be supposed, the subjects of our experiment were moved to reject the distortion of the mutilated figures conveyed to them by the distorting lenses. One might think that the amputees who had taken part in our preliminary studies would not have reacted in this way, because they had presumably become used to seeing other mutilated men. All these men, however, were receiving psychiatric help in adjusting to their own mutilation, and the sight of another amputee still set off their more intense anxieties.

To test our hypothesis that an anxiety-inducing figure would be less easily distorted than a "neutral" one, we devised a third experiment. We had noted quite by accident that when one of our assistants, an enlisted man, looked through aniseikonic lenses, his immediate superior, an officer, appeared less distorted than other enlisted men. Intrigued by this observation, we conducted a series of interviews to assess the feelings of enlisted men toward their officers. We were not surprised to find that most of them reported some feeling of anxiety and that the feeling was most marked among recruits. We therefore selected at random 24 Navy recruits, or "boots," and had each of them view two different men through the lenses. One man wore the insignia of the recruits'



APPARENT GROWTH IN SIZE occurs when a person walks from one side to the other in the large Ames room; he usually appears "normal" about halfway across (*middle*). Newly married people who watched first their partner and then a stranger cross the room reported that the partner looked normal after walking a shorter distance than the stranger.



NORMAL AND "MUTILATED" FIGURES provided further evidence of the influence of emotion on perception. Aniseikonic lenses, which alter the way in which we see three-dimensionally,

caused both figures to appear distorted. However, lenses of a given strength almost invariably produced less distortion in the anxiety-producing mutilated figure than in the normal one.

immediate petty-officer superiors; the other, the insignia and canvas leggings ("boots") of a recruit. All but two of our subjects required lenses of higher distortion power to perceive the "officer" as distorted. The increase in lens power averaged about 50 per cent.

Apparently anxiety and an intensified need for reliable guides to action explained both the "mutilation" and the "authority" results. Did they also explain the findings of our experiments with married couples? At first glance there certainly seemed little connection between the emotions associated with the sight of a marital partner, an amputee and a person in authority. Newlyweds, however, may be regarded in one sense as "recruits," uncertain and anxious about their relationship to their spouse. In the case of Honi, a veteran of 25 years of marriage, one may surmise that her husband had the role of an "authority figure." On the other hand, marriage re-

mains a complex relationship, and some entirely different process may have been at work. Further studies will doubtless reveal many emotional factors other than anxiety that may influence perception just as powerfully.

A number of experiments at the Naval Medical Research Institute and elsewhere suggest the unexplored possibilities. Some of the most interesting studies concern the way in which we perceive ourselves. Children who view themselves in a mirror through aniseikonic lenses report different kinds of distortion at different ages. Girls, who are typically more anxious about their appearance than boys, consistently report less distortion than boys of the same age. Both children and adults report that their own mirror image is distorted in different ways from that of another person. One's own image changes mainly in detail; the other person's, in over-all size and shape.

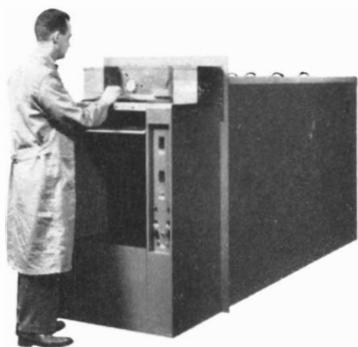
Most intriguing of all, some "mirror" experiments with psychotics indicate that they see the over-all distortion in their own image that a normal person sees in a stranger. Although the exact meaning of these experiments is not clear, one is tempted to say that the psychotic is a stranger to himself. Such measurement of perception may eventually prove useful in diagnosing mental disease. In any case, a knowledge of how the psychotic "sees" himself and other people should help us to understand his peculiar behavior.

Though I have spoken here of reacting to people and perceiving them as two distinct processes, these processes should not be regarded as being so separable as this wording suggests. In using such terms we are simply abstracting two aspects of a single process. The evidence points to the fusion of feeling and perceiving in a deeper understanding of the process of living.

Kodak reports on:

cutting waiting time for radiographs from 1½ hours to 13 minutes . . . the circumstances of our entry into the field of rare earth organic compounds . . . how what's good for the missileers is good for the chromatographers

The one-hoss-shay principle



One end of this thing extends 22 inches into the darkroom. Into a slot at this end a human being feeds miscellaneous sizes, shapes, and lengths of x-ray film. All he does is unwrap them from the light-tight holders in which they have been exposed to the various ¼-, 1-, and 2-megavolt x-ray machines, betatrons, and gamma-ray sources around the plant, through the various castings and weldments that have to be tested. Each piece of film emerges dry and ready to read 13 minutes later in time and 10' 10" away in space. There another human being picks it up and conveys it to an inspector who is now only 13 minutes short of the ability to look at will through solid metal and know what he is seeing.

X-ray film is a delicate proposition. It has emulsion on both sides. Processing artifacts in industrial radiographs are intolerable. You have to take the sizes as they come, in any order. You can't hook them together like a train. You can't put them in carriers. You have to move them on rollers like a printing press. The rollers have nothing to grip but wet gelatin, and they mustn't leave a mark on it. You have to build in foolproof guarantees that at each point in the system the film will be in an exactly specified physical and chemical condition. Breach these tolerances and you're manufacturing silver-flavored gelatin pudding. And because the human beings might lose count or be wasteful, the machine should automatically meter the replenishment solutions to the length of film processed.

Kodak chemists and mechanical engineers, knowing film intimately, solve

such problems for each other in return for their paychecks.

Who needs it? Remember Oliver Wendell Holmes' poem about the deacon's one-hoss shay that lasted 100 years to the day because no part was first to give way. Radiographs show inhomogeneities, places where trouble gets its first foothold. With proof in hand that there aren't any such, one needs little shay insurance, less extra weight as security against hidden weakness. Today, in the more advanced fields of endeavor, extra weight is intolerable for technical reasons. By reducing the waiting time for radiographs from 1½ hours to 13 minutes, the X-Omat System ought to make extra weight economically intolerable too, in a pleasing number of instances.

The Kodak Industrial X-Omat Processor lists for \$37,450. If you think you might buy one, write Eastman Kodak Company, X-ray Division, Rochester 4, N. Y.

The Brazilian trick

There was this pair of Brazilians, and they had an idea. They knew that chloranilic acid has a vivid reddish-purple ion. But its silver salt is colorless and not very soluble. Silver chloranilate, however, is not nearly so insoluble as silver chloride.

This is where the Brazilians got their idea. Add silver chloranilate to a solution containing chloride ions, and the latter will steal all the silver. Releasing free chloranilate ions! Which are reddish-purple! And easy to measure colorimetrically!

Being proper scientists, the Brazilians published their idea. A fad started. Other chloranilate salts worked for other hard-to-measure colorless ions.

When the clan gathered at last year's Pittsburgh Conference on Analytical Chemistry, conversations on the chloranilate method were easy to start. In the interests of barium chloranilate (Eastman 7508, for sulfate) and mercury chloranilate (Eastman 7504, for chloride), we had an animated one going at our booth. Someone mentioned fluoride ion. All present agreed that for fluoride you'd want strontium chloranilate—all except one chap. Everybody knows, he maintained, that for immobilizing fluoride ions the rare earth lanthanum is tops. At having

overlooked such an apparently obvious fact of nature, we were forced to conceal our embarrassment. In our fluster we failed to note the name on his badge before losing sight of him in the crowd.

This account explains the circumstances of our entry into the field of rare earth organic compounds with the offering of 2,5-Dichloro-3,6-dihydroxy-p-benzoquinone Lanthanum Salt as Eastman 7629 at \$2 for 5 grams. If you want the salt (or any of some 3700 Eastman Organic Chemicals in our latest catalog, List No. 41) you order from Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

See the steroid?

When we brought out Kodak Linagraph Direct Print Paper we never dreamed of steroids. We were dreaming of the long, long miles of galvanometer data traces that the missileers would be happy to make on a photographic paper requiring no wet processing.

These dreams having come true, correspondence on the product is handled by gentlemen who don't even know what a steroid is. Of the inconvenience in locating on a paper chromatogram a substance readily discernible only by its ultraviolet absorption, they know even less. They have never read pp. 255-305 in Volume 7 of "Recent Progress in Hormone Research" (Academic Press, New York, 1952).

Fortunately, a short paper in *Analytical Chemistry* (12, 2068) describes how a piece of Kodak Linagraph Direct Print Paper, briefly exposed to an ultraviolet lamp while kept in good contact under a dried chromatogram, will upon subsequent exposure to a 30-watt fluorescent lamp show light gray areas against a dark background at the sites of u-v absorbers in the chromatogram. The method is reported successful in routine use where 5γ or more is present of the absorber per square centimeter of paper.

To find out where to order Kodak Linagraph Direct Print Paper, write Eastman Kodak Company, Photo Recording Methods Division, Rochester 4, N. Y. That much they know.

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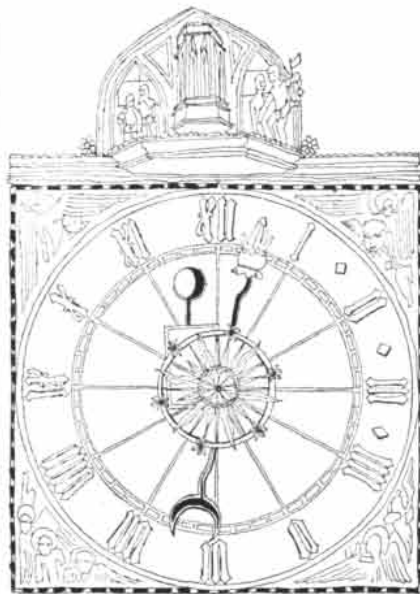
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Ancient Computer

Recent studies of the decomposed fragments of a bronze object in the Greek National Museum suggest that ancient technology must be radically reassessed. Reliably dated from the first century B.C., the fragments are nothing less than the remains of a complex mechanical computer.

The object was found in 1901 by Greek sponge divers. Working in 200 feet of water off the tiny Greek island of Antikythera, the divers came upon the wreck of a ship laden with bronze and marble statues. Among the objects they brought up was a mass of corroded bronze. Archaeologists who examined the object some months afterward were excited to perceive in it numerous geared wheels and ancient Greek inscriptions in which astronomical words could be deciphered. The object was so heavily corroded, however, that they could do little more than publish detailed descriptions of it and speculate on its function.

Over the years technicians of the National Museum have slowly disentangled from the object the fragments not only of gears but of inscribed plates and of multiple graduated dials. Last summer the fragments were intensively examined by Derek J. de Solla Price, a University of Cambridge expert on the history of scientific instruments who is now at the Institute for Advanced Study in Princeton, N. J. Working with archaeologists and specialists in ancient inscriptions, Price has been able to show that the mechanism was designed to calculate the dates and times of astro-

SCIENCE AND

nomical events and to exhibit this information on three complicated dials. Among the events displayed were the rising and setting of stars, the phases of the moon, eclipses of the sun and the motions of the planets. All this was accomplished solely by trains of gears.

It is well known that the Greeks could predict these astronomical events, but not that they could build such fine instruments. The Antikythera mechanism is far more sophisticated than any described in classical scientific texts. Scientific instruments did not regain this level until comparatively modern times. Price points out, however, that this Greek mechanical tradition was kept alive by the Arabs; they passed it on to Europe, where it gave rise to the medieval mechanical clock.

The Exploration of Space

There are now eight man-made objects on orbit in the solar system, two of them circling the sun itself. The total includes three new U. S. ventures into space launched in a period of four weeks:

The Navy's *Vanguard II* is traveling on an orbit inclined at 45 degrees to the Equator.

The Air Force's *Discoverer I*, launched from Vandenberg Air Force Base in California, represents the first successful attempt to put a satellite on a pole-to-pole orbit. Faulty communications, however, have left its orbit in some doubt.

The Army's 14.5-pound satellite *Pioneer IV* is in orbit around the sun. Its perihelion is established at 92 million miles and its aphelion at 106 million miles, giving it a 392-day "year." With instruments and transmitter in good working order, *Pioneer IV* provided data on radiation levels out to 400,000 miles. It passed through the two rings of intense radiation that had been detected by earth satellites and lunar probes, but encountered no other such regions before its radio gave out. The vehicle passed the moon at too great a distance to yield any information on that object's magnetic field.

Meanwhile the National Aeronautics and Space Administration launched its own active existence with the announcement of a 10-year program of space exploration. Starting in the middle of this

THE CITIZEN

year, the U. S. will launch at least one earth satellite or long-range space probe each month. In addition, 100 sounding rockets with vertical ranges up to 4,000 miles will be fired each year.

The program is directed at five scientific areas: atmospheres, ionospheres, energetic particles, astronomy, and magnetic, electric and gravitational fields. Some specific objectives are as follows:

Determine the relationships between the earth's atmosphere above 50 miles and weather patterns on the ground. A major portion of this work will be conducted by weather-scanning satellites on the model of the new *Vanguard*.

Discover whether the sun's atmosphere extends to the far reaches of the solar system and whether this atmosphere contributes to the heating of the earth.

Analyze the atmospheres of other planets.

Correlate variations of the ionosphere layers with outbursts of X-rays and ultraviolet rays from the sun.

Locate the source of charged particles that cause auroras and determine the origin of cosmic rays.

Measure the magnetic field of the moon.

Determine whether the law of gravity operates in the same way throughout space.

Find out whether a clock in a satellite actually runs slightly faster than a clock on earth, as predicted by the theory of relativity.

Observe stellar X-rays, ultraviolet radiation and radio waves that are ordinarily absorbed by the earth's atmosphere.

The Exploration of the Oceans

A warning that the U. S. is in danger of falling behind the other nations of the world in exploring the sea and exploiting its resources has been issued by the National Academy of Sciences—National Research Council. The report of the Committee on Oceanography pointed out that scientists know more about the surface of the moon than about many regions of the oceans. In arguing that the exploration of the oceans deserves equal footing with the exploration of space, one member of the Committee is said to have asked: "Is not the

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Turnkey alkylation plants represent only one phase of TRECO's service to the oil and related petrochemical and chemical industries. TRECO is a sign of quality engineering and construction throughout these vital American industries.

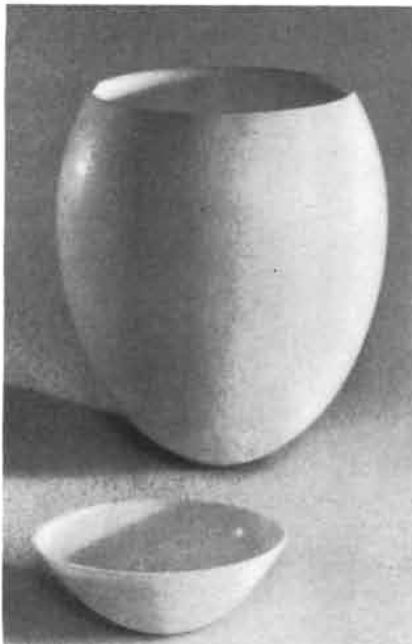
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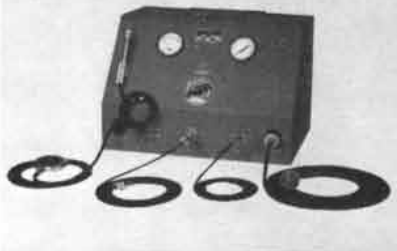


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ocean's bottom as interesting as the moon's behind?"

The report urged the Government to increase support for oceanography by \$650 million during the next decade. More than \$200 million would be spent for a fleet of 70 new research vessels, ranging from 500 to 2,200 tons displacement. Another \$100 million would be allotted to the development of new devices, such as stable midocean research platforms, ice-breaking submarines and manned submersibles capable of operating down to and on the bottom of most of the oceans.

Libby Resigns

Willard F. Libby has resigned as commissioner of the Atomic Energy Commission effective June 30, 1959. The only scientific member of the Commission, he will return to research and teaching. Prior to joining the Commission in 1954 Libby was professor of chemistry at the University of Chicago's Institute for Nuclear Studies.

The four remaining commissioners are: John A. McCone, chairman, Harold S. Vance, John F. Floberg and John S. Graham.

The Feasibility of Inspection

A Panel on Seismic Improvement last month submitted to the White House recommendations for increasing the efficiency of detecting underground nuclear explosions. The group, under the chairmanship of Lloyd V. Berkner, president of Associated Universities, Inc., held its deliberations in secret, and its conclusions were not made public. This left as a matter of conjecture the feasibility of the inspection system recommended by an international conference of experts in Geneva last summer.

The Geneva experts had based their study on data from a single underground atomic explosion in the U. S. They concluded that a world-wide network of 180 seismographic stations would be sufficient to detect any major atomic blast. After two further test explosions last fall the U. S. announced that such detonations are much harder to distinguish from earthquakes than had been thought. According to the announcement, there would be about 10 times as many doubtful cases, requiring on-the-spot inspection, as the Geneva committee had contemplated. The reappraisal has helped to stall the current Geneva discussions of a ban on nuclear-weapon tests.

From the information made public

the chief problem seemed to concern the use of "first motion" to distinguish earthquakes from explosions. The first waves that an earthquake sends through the body of the earth are compressions in certain directions and rarefactions in others. An explosion sends out compressions in all directions. Any disturbance that results in rarefactions at some of the stations can therefore be written off as an earthquake. If the source of the waves is too weak or too far from the observing station, however, extraneous vibrations will mask the nature of the first motion. Since the latest results on underground explosions indicate that they send out less energy than had been estimated, more of them will apparently fall into the uncertain category.

Some possible measures to reduce the uncertainty were discussed by Hans A. Bethe, a member of the Panel and of its parent body, the President's Science Advisory Committee, before the Senate Disarmament Subcommittee. Placing the detecting instruments in deep holes such as dry oil wells would reduce the background of random vibrations, he pointed out. Also, increasing the number of seismographs at each station to 100 would help average out this "noise." Instruments to detect surface as well as body waves would increase the amount of useful information.

Furthermore, Bethe said, the network of manned stations might be supplemented by automatic stations spaced 100 miles apart. At least one unmanned station is already operating. The U. S. Coast and Geodetic Survey office in Tucson, Ariz., has been getting regular radio reports from a seismograph sunk in bedrock 15 miles away.

Whether such an expansion of the detecting network will actually be necessary is not clear. A statement by the State Department has said that the data from the two most recent test explosions "did not invalidate the system agreed upon at Geneva last summer." According to the Federation of American Scientists, testimony before the Disarmament Subcommittee "makes it clear that the same detection capability envisioned by the Experts' Conference can be obtained with the original number of stations proposed, with some improvements in the techniques used."

The Sociology of Polio

The eradication of paralytic poliomyelitis in the U. S. population is now a task for applied sociology. From an average of 40,000 cases annually,



Glass adds a new dimension

This is the New York City office of the famed industrial design firm Raymond Loewy Associates.

Note how men who work with color, shape, and space have deftly combined these elements to create the right kind of atmosphere.

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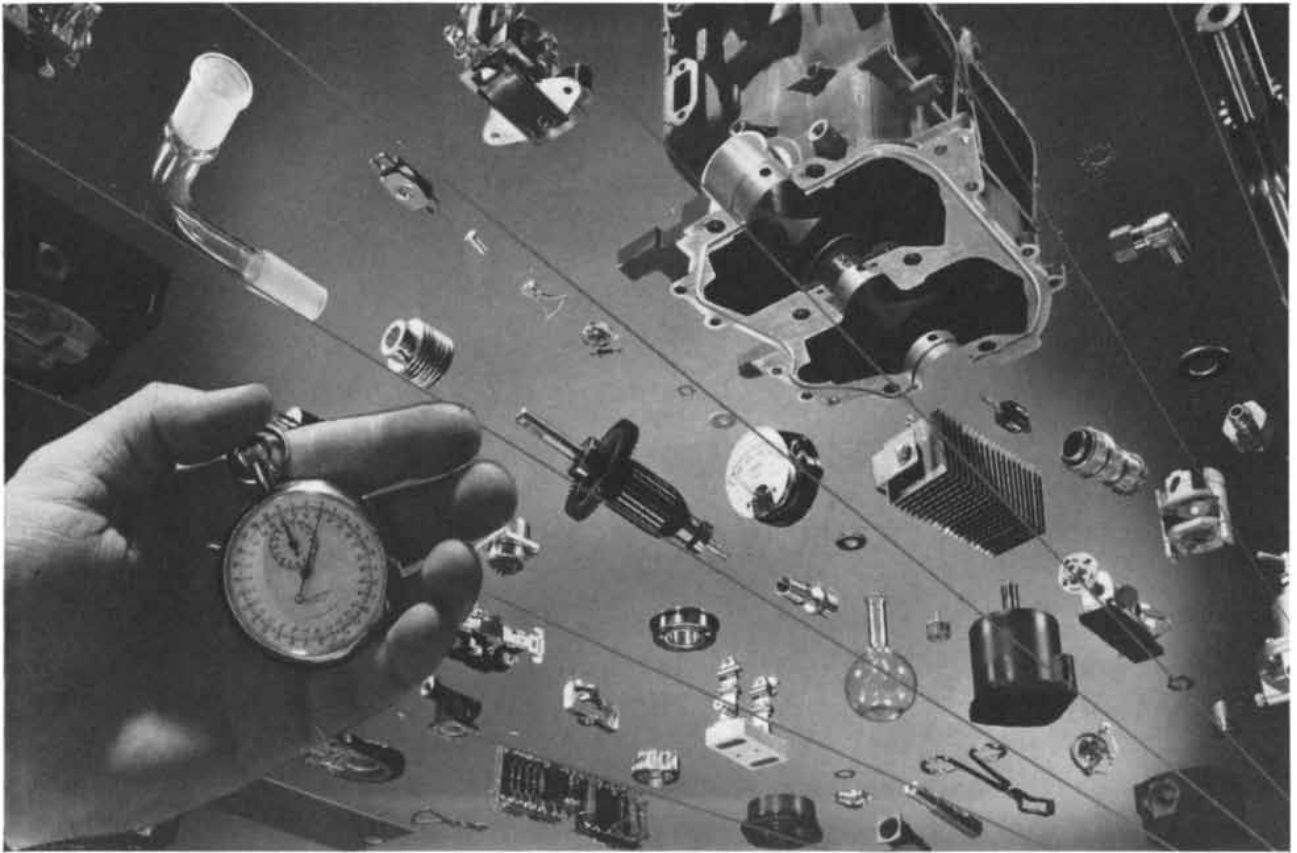
laboratory glassware to eyeglass lens blanks, from radiation shielding windows to corrosion-resistant piping.

For a look at the many ways glass is solving problems in every industry and business, write for "This Is Glass." Or for specific information on lighting glassware, send for "Commercial Lighting Application Guide." Write to 49 Crystal Street, Corning, N. Y.

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a million ideas

Salk vaccination reduced the incidence of the disease to 7,000 in 1957. But last year the number of cases increased again to 10,000, with more than half reported in children under five years old and the highest rate in one-year-olds. "Despite high susceptibility of preschool children," writes Surgeon General Leroy E. Burney, "about a third have had no poliomyelitis vaccine. The total unvaccinated population under 40 years of age is more than 40 million."

To find out why people fail to have themselves and their children vaccinated, the Public Health Service asked various State health departments and universities to conduct public-attitude surveys. The results are summarized in *Public Health Reports* by Irwin M. Rosenstock, Mayhew Derryberry and Barbara K. Carriger.

As a major conclusion of the surveys, it appears that the media of mass communication which helped to persuade 50 million people to get themselves vaccinated do not reach the still-unvaccinated portion of the population with the same effectiveness. A major percentage of these people are in the lower socioeconomic groups. Many of them have the impression that polio has been eliminated, that the disease affects only children and that it is a relatively mild infection in the adult.

Experience in a number of communities, however, has shown that apathy in these groups may be overcome by personal contact. In two cities in Georgia a higher proportion of Negroes than whites reported for vaccination as the result of vigorous "selling" by teachers, ministers, professional people and other leaders of the Negro community. The Surgeon General urges that each community survey "the current vaccination status in the various geographic sections . . . and tailor its vaccination program to fit the local situation."

The Ultimate Particle?

Another strange fundamental particle, called the neutral xi particle, has made its debut on the subatomic stage. This one has a special distinction: It may be the last of the long, puzzling procession. At least it brings theory and experiment into balance for the first time in more than 25 years. All the particles predicted theoretically have now been found (except for a few anti-particles, whose existence no one doubts). And all the known particles fit into a theoretical scheme (with one exception, of which more below).

The uncharged xi was made with the

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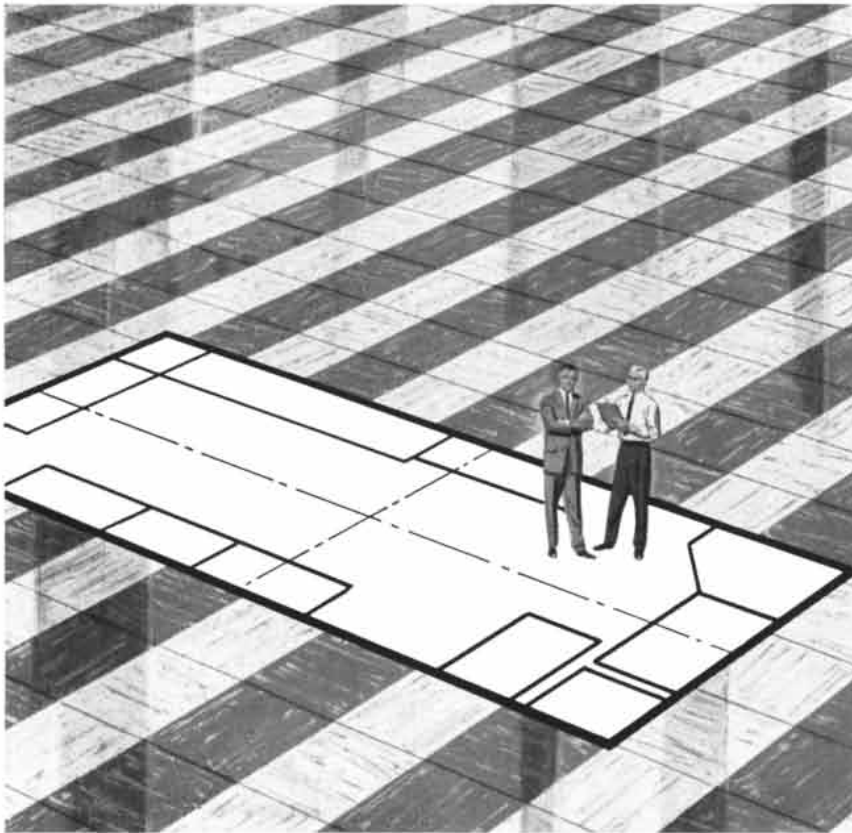


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63 Second Avenue, Waltham, Mass.

aid of the Bevatron, the giant accelerator at the University of California. A negative K meson produced by the machine collided with a proton in a liquid hydrogen bubble chamber, creating a neutral K and the neutral xi. Neither of these particles left a track in the chamber, but the neutral K subsequently decayed into a pair of charged particles, producing a V-shaped track, and the neutral xi decayed into a neutral lambda particle and a neutral pi meson. Then the lambda particle decayed into a proton and a negative pi meson, these charged particles also making a V. From the angle between the V's, physicists were able to deduce the invisible chain of events leading up to them.

Creation of the neutral xi is a very unlikely process. A team of experimenters, headed by Luis W. Alvarez of the Lawrence Radiation Laboratory at the University of California, photographed 70,000 collisions between negative K mesons and protons, and was able to find just a single xi.

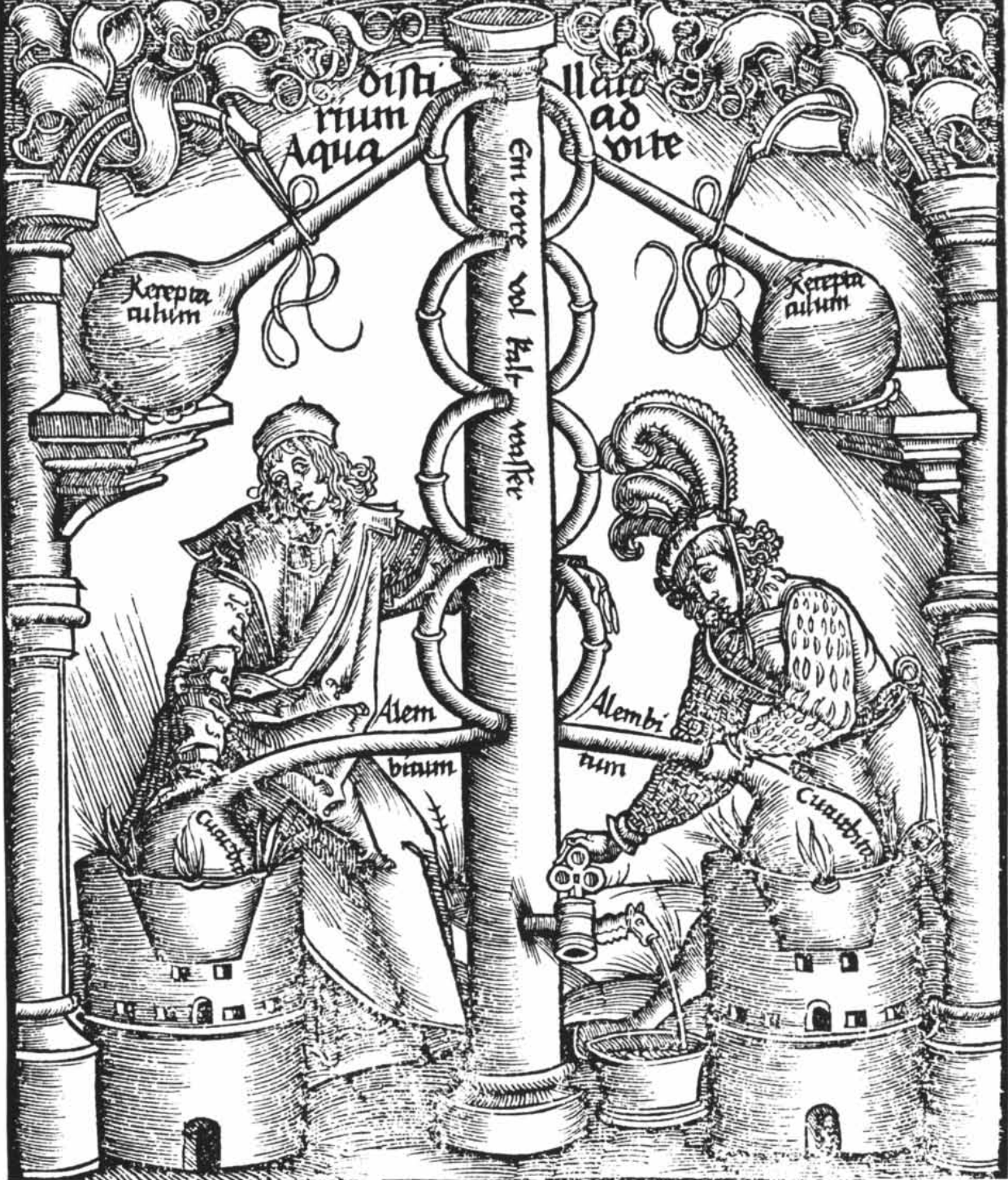
A sister particle to the neutral xi, the negative xi, has been known for some years. According to the scheme of classification devised independently by theoreticians Murray Gell-Mann and Kazuhiko Nishijima the negative xi was believed to be one of a pair of particles, the other one being neutral. The present discovery constitutes a final triumph for their "strangeness" theory [see "Elementary Particles," by Murray Gell-Mann and E. P. Rosenbaum; SCIENTIFIC AMERICAN, July, 1957]. The mass of the neutral xi has not yet been determined, but it is probably about the same as that of the negative xi: 2,570 times as heavy as an electron.

Although their periodic table of fundamental particles is now neatly filled, physicists are still casting nervous glances at one of the members: the mu meson. There is no place for this particle in their scheme of things, but it is undeniably there. Until they figure out why, they can have no confidence that a horde of further particles is not lurking in the wings, waiting for higher-energy machines to bring them out into the open.

Gravity Particles

One of the major tasks confronting physicists today is to draft a modern law of gravitation. The noted British theoretician P. A. M. Dirac has now made a significant start on the job.

A change is long overdue. For a couple of centuries after Isaac Newton the



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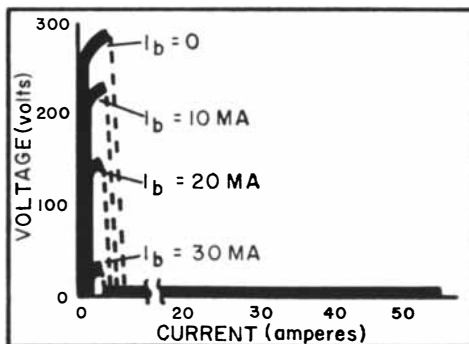
The "Trinistor," semiconductor successor to the thyatron, is a highly efficient three-terminal switching device which overcomes the thyatron's limited power handling capacity, low switching speed, and relatively high forward drop. With recent developments at Westinghouse, Trinistors of various high-power capacities will soon be commercial realities.

The Silicon Trinistor will find a host of new applications. It can be used wherever today's thyratrons, relays, magnetic amplifiers, power trans-

sistors and standard rectifiers find use. Applications include the high-speed switching of AC and DC, full-wave phase controlled DC power supplies, circuit breakers, inverters, motor control, and many others.

The switching characteristic of the Silicon Trinistor from the "OFF" to the "ON" condition, and the control function of the base current I_b , are illustrated below.

Watch for the announcement of commercial availability of the new Westinghouse Silicon Trinistor.



YOU CAN BE SURE... IF IT'S **Westinghouse**
Westinghouse Electric Corp., Semiconductor Department, Youngwood, Pa.

subject lay just where he had left it when he framed the inverse-square law. Then Albert Einstein showed that the force of gravity arises out of the geometrical structure of space-time. But all physicists feel certain there is more to the story than that. A deeper insight, they believe, would show that gravity obeys laws similar to those governing electromagnetism: that the force is carried from one place to another by waves of finite velocity and that the gravitational field is actually composed of indivisible quanta of energy.

No experimenter has yet detected gravity waves, much less gravity quanta. Nor has any theoretical physicist written down equations that demonstrate their existence. In a talk before the recent New York meeting of the American Physical Society, Dirac described a powerful new mathematical approach to the theoretical problem. Starting with Einstein's general theory of relativity Dirac has succeeded in showing that for very weak forces the field equations can be made to yield both waves and quanta. In itself the achievement is not unique. Other workers have also demonstrated waves and quanta in the case of unrealistically weak fields. Dirac's approach, however, is the first one that promises to be effective with stronger, realistic forces.

Radio Sextant

A new navigational aid that tracks the sun and moon by the weak radio signals they emit has been developed by the Collins Radio Company. In addition to giving the positions of these bodies the instrument indicates true north 10 times more accurately than present marine compasses, according to Collins engineers. Operating in all weather, the radio sextant provides continuous fixes as long as the sun or moon is in the visible portion of the sky.

The sextant proper consists of a steerable five-foot parabolic antenna, which is stabilized against pitch and roll, and an ultrasensitive radio receiver. (The sun's radio emission is faint and noisy, and the moon's 50 times fainter still.) As the antenna moves automatically, following the sun or moon across the sky, information about its direction is fed into a computer that turns out navigational data on punch cards.

Since the instrument sends out no signals, it cannot be detected. Ships equipped with the sextant could rendezvous at any point without breaking radio silence. The Navy has installed the sextant on the *Compass Island*.

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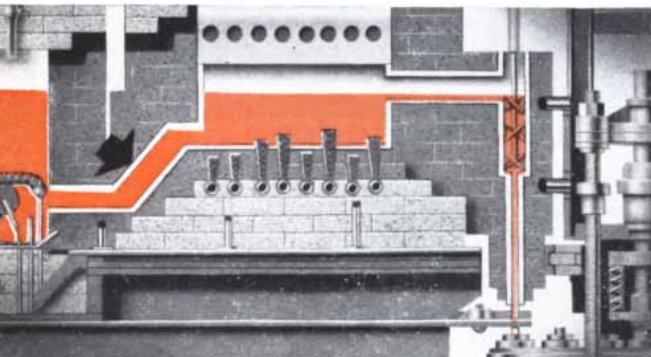
Gifts of the Firebird: compounds of silicon • zirconium • boron • aluminum • magnesium • titanium • chromium . . . including many borides • carbides • nitrides • oxides

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ductive surfaces, as in the production of printed electrical circuits; and many other products, the platinum metals have proved to be most economical.

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GERMINATION

Many plants have evolved natural mechanisms that keep their seeds “dormant” until the optimal time for sprouting. These mechanisms include chemical responses to light and rainfall

by Dov Koller

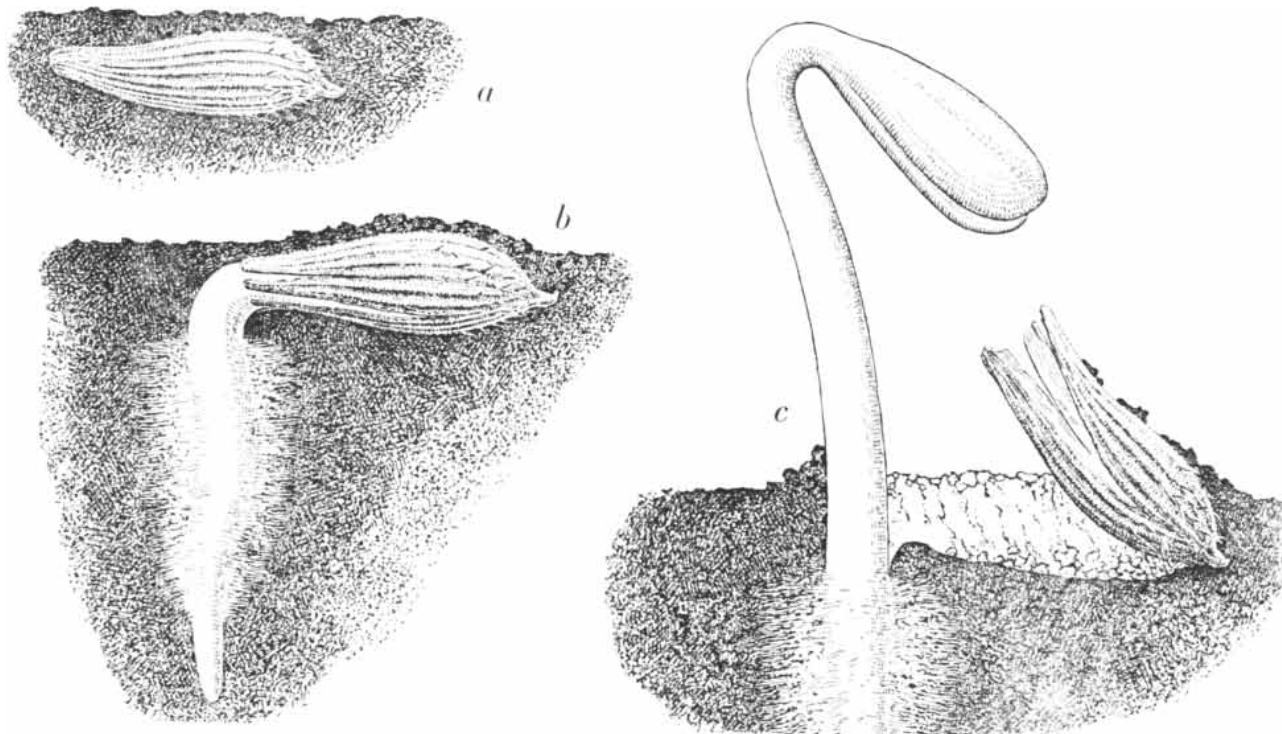
In parts of the world where one season is sharply contrasted with the next, the transition from the harshest season to the mildest is heralded by a tinge of green on hill, valley and plain. Not even the humblest roadside, back yard or refuse dump escapes the gentle arrival of new plant growth. Some of this growth is represented by the sprouting buds of established plants, but by far the greater part of it is due to the shoots of newborn seedlings, sprouting from seeds that earlier in the year might have passed for inanimate crumbs of soil. It is this transformation of seed to seedling that we call germination.

To the farmer or the gardener germination seems as inevitable as the progression of the seasons. He expects every seed in his planting to sprout, or else! Meanwhile, beyond his field or garden, the seeds of wild plants also sprout in profusion. But were he to try to cultivate some of these wild plants in a similar manner, the odds are that only a pitifully small proportion of his seeds would germinate.

People who have tried and failed to grow wild plants from seed often conclude that the seeds that do not germinate are dead. Yet it would surely be paradoxical if a plant expended energy,

time and material in making dead seeds. Such a plant would be a poor evolutionary prospect indeed. Investigations spurred by this paradox have shown that practically any seed can be made to sprout under the right conditions and at the right time. We could say that when we cannot cause a seed to germinate, the fault is not the seed's but ours. A few species do produce sterile seeds, but these are exceptions.

If we take for granted the dependable germination of a commercial seed, that is a tribute to the talents and perseverance of the generations of farmers, gardeners and seedsmen who have bred it



GERMINATION OF A LETTUCE SEED is depicted in these drawings. At first the seed lies “dormant” in the soil (a). Then,

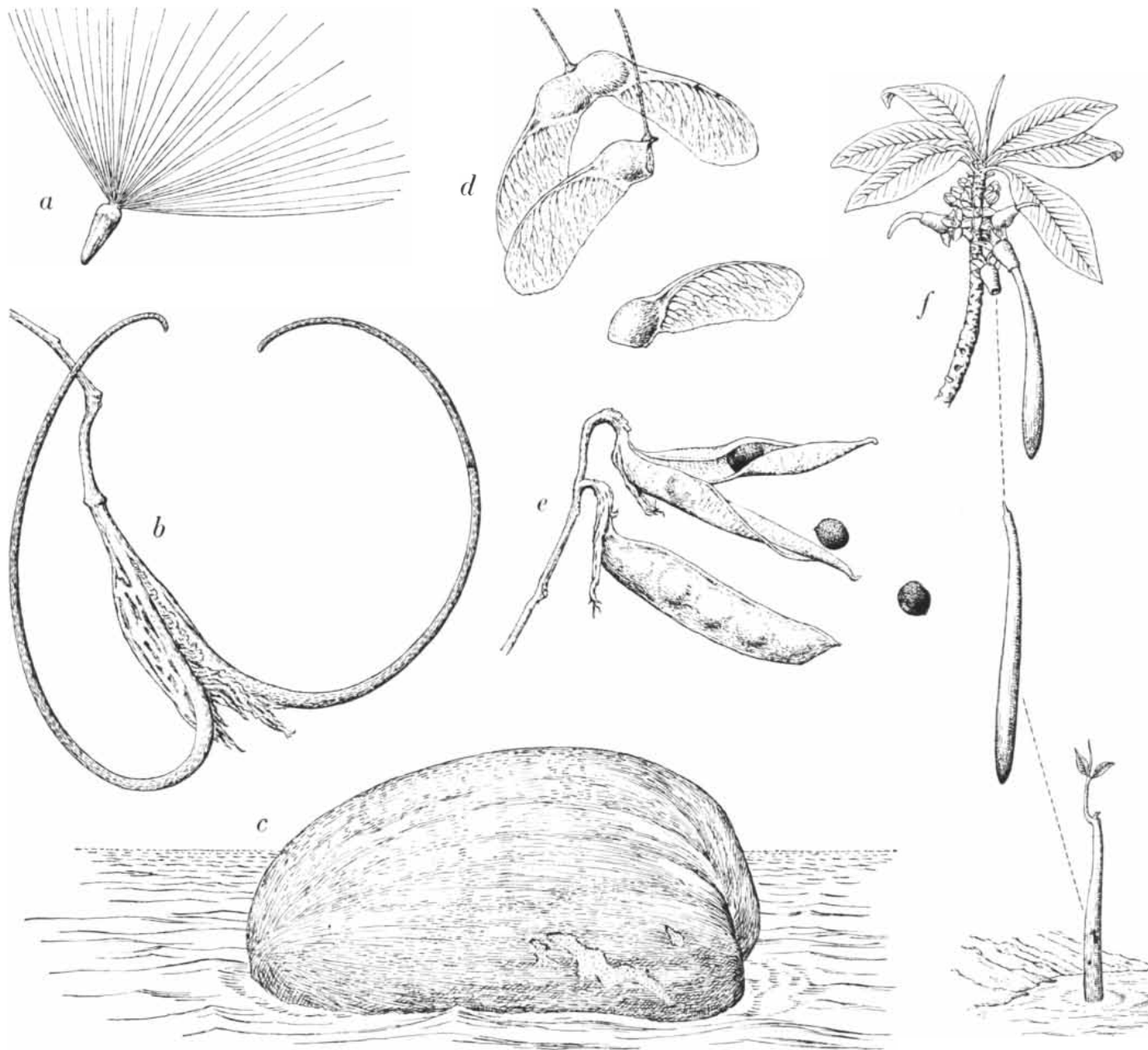
in response to environmental stimuli, a root sprouts (b). Finally the shoot sprouts, leaving behind the outer covering of the seed (c).

not only for beauty or utility, but also for full, prompt and uniform germination. For the farmer and gardener such readiness to germinate is an advantage, but for the wild plant it is a hazard. A readily germinable wild plant would literally put all its eggs in one basket; total germination, if followed by drought or disease, might lead to the total destruction of the species.

Consider what would happen in the desert if a drought followed an early shower. If all seeds germinated during the shower, all the annual species in the area would become extinct. Thus for most wild species a reluctance to germinate is a condition for survival, since it ensures the maintenance of seed reserves for later germinations. The seeds of cultivated plants germinate readily, and untold numbers of them are inadvertently scattered, yet how often do we see such plants growing in the wild? The inability of domesticated plants to live under such conditions stems from their very readiness to germinate indiscriminately. If domesticated species have survived the vagaries of the environment throughout the ages, it is only because man has substituted for nature in conserving their seed.

The essential part of the seed is the embryo it encloses. The embryo starts out as a single cell—the fertilized egg—and ends up by becoming a tiny plant consisting of a miniature root and shoot. In the usual course of development the growth of the embryo stops completely when the seed ripens. Plants that are viviparous, that is, plants in which the embryo continues to grow on the mother plant, are either genetical freaks or very specialized. The embryos of the swamp-dwelling mangrove tree, for example, grow into foot-long, javelin-like seedlings while they are still attached to the mother plant; then they plunge from the tree to embed themselves in the

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“DISPERSAL UNIT” of a plant is its seed plus other equipment, some of which is responsible for the dispersal of the seed by wind, water or other agencies. The fruit of the thistle (a) is airborne. The devil’s-claw (b) and the cocklebur (g) are dispersed when they

catch in the fur of animals. The coconut (c) travels by water. The samara of the maple (d) glides on the wind. Vetch pods (e) pop when they dry, expelling their seeds. The mangrove fruit (f) is atypical in that it sprouts on the parent plant and then falls. The

bottom of the swamp. In most plants, however, the ripe seed becomes detached from the mother plant some time after the embryo has stopped growing.

The embryo thus takes the first step toward an independent existence, but it rarely takes that step unequipped. Accompanying the embryo on its journey into the unknown are several tissues and organs: a food supply, a seed coat and sometimes certain tissues of the fruit, flower, specialized leaves or other organs. The entire structure is known as the dispersal unit. Many parts of the dispersal unit serve fairly obvious functions. Thus the stored food nourishes

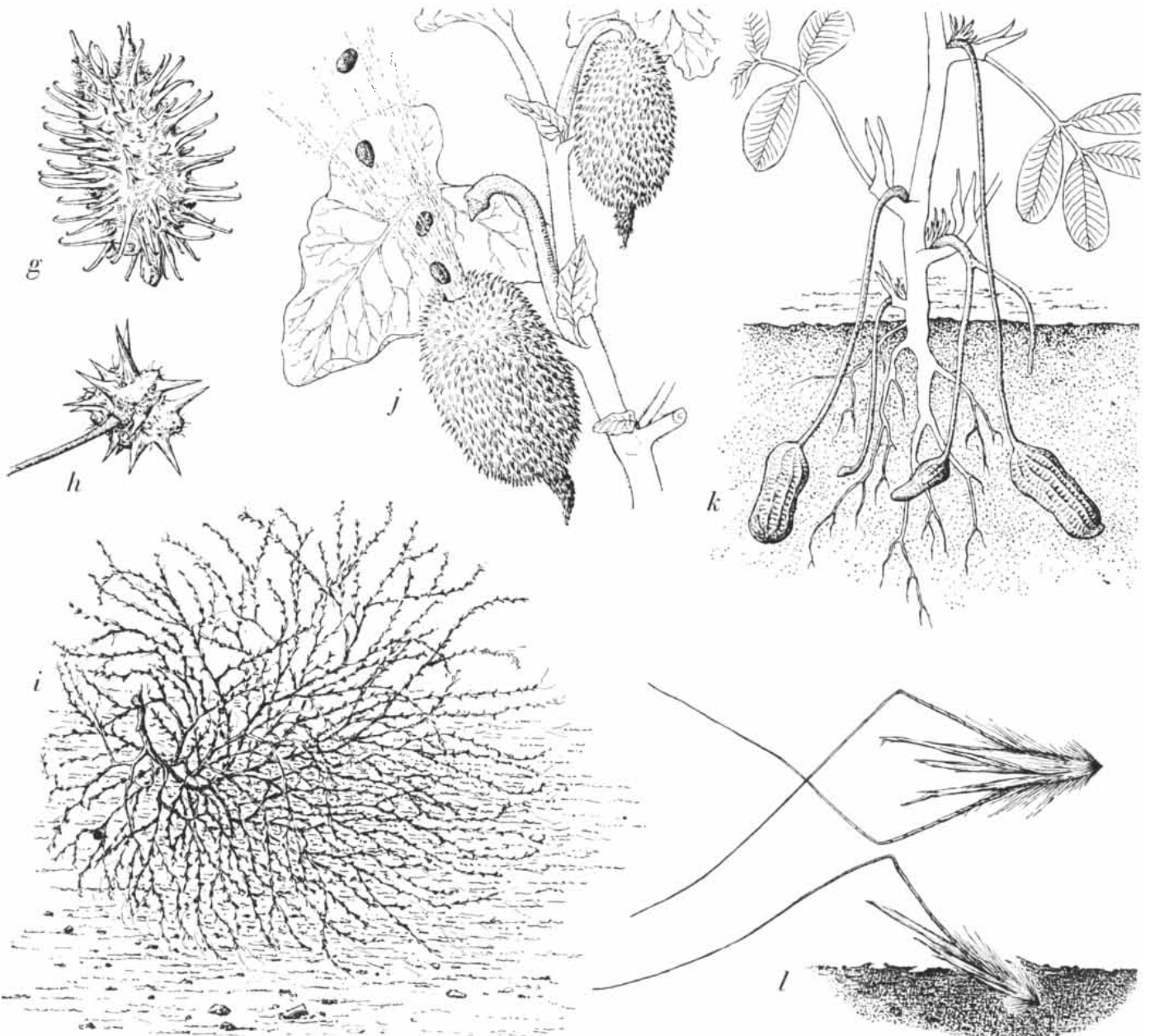
the embryo until it becomes a self-sustaining seedling, the enveloping seed coat protects the delicate body of the embryo and its food supply, and so on. Other functions are less obvious, but a close scrutiny reveals that many things in the make-up of the dispersal unit serve to determine the fate of the embryo it accompanies, and to some extent the fate of the plant which will grow from it.

One such function is the control of the distribution in space of the progeny in relation to the parent plant. Another function inherent to the dispersal unit is the avoidance of prompt, uniform and

indiscriminate germination. Both functions operate in the preservation of the species by decreasing the probability of chance annihilation.

Distribution in Space

Many dispersal units are adapted to make use of some special environmental agency for the control of dispersal. Wind is a typical agency. It can move dispersal units equipped with parachutes (*e.g.*, lettuce, thistle) or wings (*e.g.*, maple) over great distances. The same agency, but a different method, transports the various tumbleweeds (*e.g.*,



puncture vine (*h*) is dispersed by spikes which puncture the paw of an animal. The entire shoot of the tumbleweed (*i*) is a dispersal unit which scatters seed as it rolls before the wind. The squirting cucumber (*j*) ejects its seed in a sticky jet when it is touched. The

peanut plant (*k*) is an example of "anti-dispersal"; instead of dispersing its seeds, it keeps them on a leash. The barbed dispersal unit of the wild oat (*l*) is propelled into the ground by the humidity-driven coiling and uncoiling of its two long "tails."

Russian thistle). Here, after seed ripening, the entire shoot breaks off at the base and rolls before the wind, scattering seed as it goes. Water is a second agency, carrying buoyant dispersal units such as coconuts to distant shores.

A third agency is aerial humidity, which operates in a variety of ways. In some species (vetch, weaver's broom, *Impatiens*, geranium) the fruit comprises strips of tissue joined edge to edge. As the fruit dries, tension between the strips increases until they part explosively, dispersing the seed. In other species the dispersal unit is equipped with humidity-operated devices for self-burial. The wedge-shaped dispersal units of the wild oat and stork's-bill have a long, humidity-sensitive tail that coils into a tight spring when it is dry and uncoils when it is moist. Barbs projecting from the wedge allow it to move only in the direction of its point. With daily variations in humidity the tail coils and uncoils repeatedly, driving the barbed wedge forward until it meets an obstacle or reaches a depth where humidity is constant.

Animals are a fourth agency of seed dispersal. The dispersal units of some plants (cocklebur, devil's-claw) carry hooks that catch and tangle in animal fur. Others (the puncture vine) have sharp, strong barbs that pierce horny paws. Nonpoisonous dispersal units with a tasty or nutritive fruit attract animals which propagate the seed in a variety of ways. Many small-seeded berries, such as grapes, are eaten whole; the seeds of such plants are carried off in the animal's stomach and excreted without loss of viability. Other dispersal units are

harvested as food by ants, mice or squirrels. Some fruits (e.g., bitter brush) are collected for their pulp, and the inedible seeds are left to germinate in the nest. Some seed-eating animals are too prudent, collecting more than they can consume; others cannot keep track of their numerous caches, thus leaving many seeds to germinate. The juicy, sticky fruit of the parasitic mistletoe is well adapted to dispersal by birds because it adheres to their beaks and is wiped off upon a new host branch. A remarkable dispersal unit is the fruit of the squirting cucumber, which contains a sticky fluid under great hydrostatic pressure. When it is disturbed by a passing animal, this fruit bursts, squirting its seeds in a powerful jet of fluid that glues them to the animal's skin or fur.

While many plants have evolved methods of dispersing their seed over great distances, a few species have achieved the opposite extreme: deliberate prevention of dispersal. "Anti-dispersal" of seed can be observed in the peanut and subterranean clover, the fruit of which develops at the end of a long stalk. The stalk actively grows down into the ground, thus burying the seeds in the immediate vicinity of the parent plant.

Regulated Germination

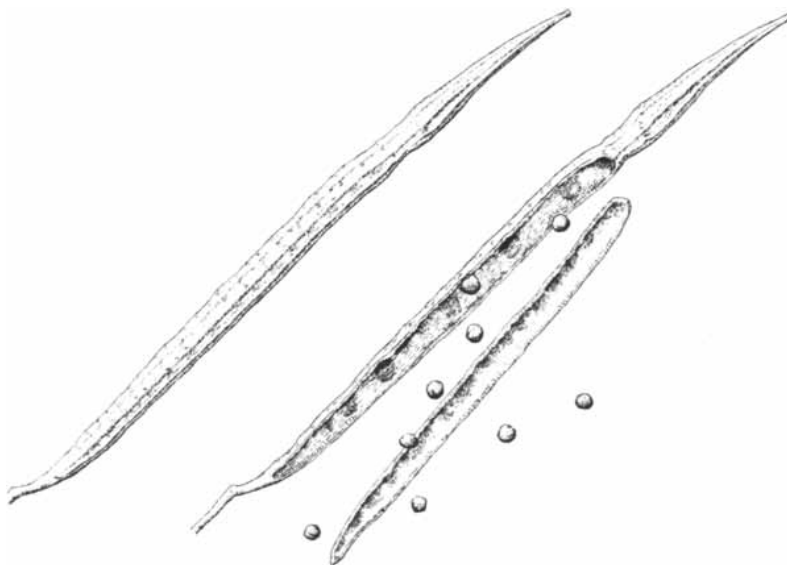
Plants can control not only their distribution in space but also their distribution in time. In many species few, if any, of the seeds will exhibit readiness to germinate soon after ripening, but over the years more and more will do so. One example is provided by some spe-

cies of mustard plant, in which only a part of each fruit opens after ripening. The seeds that are released from the fruit germinate readily, while the rest remain enclosed in the "beak" of the fruit. Their germination is thus delayed considerably. Another example is provided by many species, notably legumes, in which the embryo is denied access to soil moisture by being enclosed in a waterproof seed coat or fruit coat, thus effectively preventing its germination. The gradual relaxation of impermeability makes a small fraction of the seed population ready to germinate at any given time. Many years may thus pass before all the seeds of a given crop are germinable. In some of these "hard" seeds the impermeable coat must actually disintegrate. The more elaborate seeds of this type have ingenious valves operated by such environmental factors as atmospheric humidity.

The events that trigger germination sometimes suggest a highly specific adaptation to the environment. In California sumac proliferates after a forest fire because the fire causes a waterproof layer of the dispersal unit to become permeable. The localization of certain plant species in pastures is traceable to the fact that their hard seeds are made water-permeable by bacterial action as they pass through the digestive tract of ruminants. Far from damaging the seeds, this process enhances their prospects for germination, and moreover deposits them in a moist, manured environment. The open range is thus kept well stocked with pasture plants. This arrangement sometimes backfires, however, allowing undesirable plants such as mesquite to overrun the range and oust more desirable species.

Today botanists are exploring a new realm of mechanisms that regulate germination more specifically than by mere dispersal in time. These mechanisms help to determine the timing and locality of germination by restraining it in environments and seasons that do not afford a reasonable chance for the plant to complete a life cycle "from seed to seed." Typical of these newly discovered mechanisms is that of chemical regulation, now under investigation in the Earhart Plant Research Laboratory of the California Institute of Technology and in the Department of Botany of the Hebrew University in Israel.

Clearly there is no worse place for a tomato or melon seed to germinate than inside the growing parent fruit; such vivipary would be highly disadvantageous. The warm, moist flesh of the fruit provides just the sort of environment in

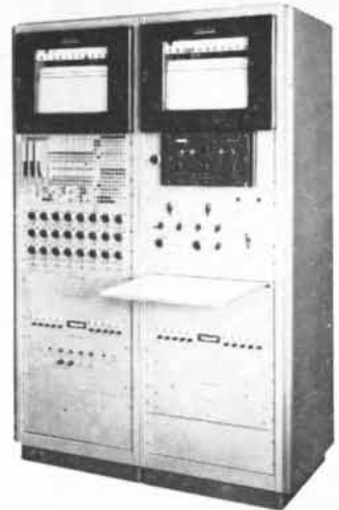


SEEDS OF MUSTARD PLANT are scattered when pod bursts. However, some seeds are retained in the "beak" of the pod (upper right), which disperses them later when it bursts.

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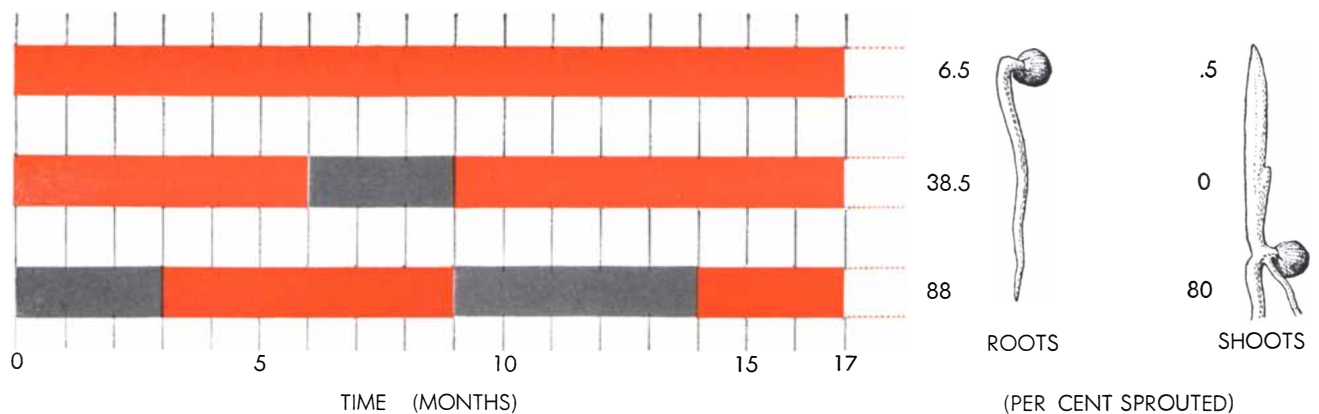
Bucknell University, Syracuse University, and University of Maryland join Wayne State University and the Universities of Oklahoma, Toronto, and West Virginia in the growing list of institutions using Honeywell's Nuclear Reactor Simulator.

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Honeywell



First in Control



TEMPERATURE triggers germination in the snow trillium, as shown in an experiment by Lela V. Barton. In this plant, root growth follows one winter; shoot growth, the second winter. In

the experiment few plants germinated at a steady warm temperature (*top bar*). With one "winter" plants grew only roots (*middle bar*). Two winters produced roots and shoots (*bottom bar*).

which the seeds might be expected to sprout, yet they rarely do. How is germination delayed until the fruit has fallen and decayed? The prevention of vivipary in most fleshy fruits is due to the presence in them of substances that specifically inhibit germination. Only when the seeds are free of the pulp and juice will they germinate.

More dramatic are the "chemical rain gauges" found in many dispersal units. These are inhibitory substances that are water-soluble, and are therefore readily leached out by rainfall. The amount of inhibitor in the dispersal unit is apparently adjusted so that the amount of rainfall needed to leach it out sufficiently to permit germination will at the same time moisten the soil sufficiently to ensure the plant's subsequent growth. In the dispersal units of wild smilgrass (*Oryzopsis miliacea*), local varieties are "gauged" to the rainfall pattern of their habitat. The importance of such rainfall-dependent germination control for the survival of plants in arid or semiarid zones, where rainfall is limited and erratic, will be self-evident.

Another regulatory mechanism found in many dispersal units is the "temperature gauge." In its simplest form the temperature gauge restricts germination of a species to a specific temperature range that is often very narrow and precise. This then distinguishes plants that start their lives in cool climates and seasons from those that do so in warm ones. More highly developed regulation by temperature is found in plants that will germinate only when they are submitted to a specific change in temperature. Most common are the "cold-requiring" seeds, the subject of extensive research at the Boyce Thompson Institute for Plant Research in Yonkers, N. Y. In order to germinate, these seeds require either one or two prolonged exposures

(each of several weeks) to near-freezing temperatures, alternating with one or two exposures to higher temperatures. The apple, the peach and other plants that exhibit such mechanisms are invariably denizens of temperate climates; their ability to avoid germination before prolonged exposure to cold is of high survival value, since it minimizes the danger that seeds may germinate before the hazard has passed.

Moreover, like most other plants, temperate-zone plants are habitat-specific; their entire developmental pattern (growth, flowering and fruiting) is synchronized with the climatic cycle to such an extent that they could not grow normally elsewhere. Their requirement for such "seasonal thermoperiodicity" for germination is thus an important factor in assuring them a start in life in a suitable environment, that is, one that includes a cold season. Unfortunately we have no more than fragmentary knowledge of the physiological nature of this mechanism. But its complexity can be judged from the case of the snow trillium, the root growth of which is induced by a cold period, is carried forward in a following warm period and is not followed by shoot growth unless a second cold period intervenes.

Low Temperature and Light

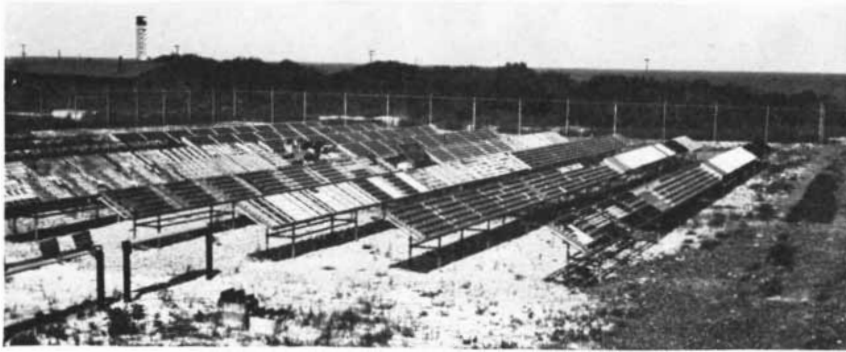
Especially mystifying are the workings of the temperature gauge close to the freezing point. As yet we have been unable to perceive any of the low-temperature processes at the time they take place. Our only indication that something has indeed been going on is the subsequent growth at higher temperatures. We have as yet no means of distinguishing between a cold-treated seed and an untreated one, except by germination. Under certain conditions the

naked embryos of cold-requiring seeds can be coaxed to grow without cold, but these embryos invariably give rise to plants with dwarfed, unextended shoots. The dwarfism is maintained as long as cold is denied. When the seedling is exposed to cold, it starts to grow normally. Recently it was shown that the plant-growth substance gibberellin will substitute for the cold treatment of dwarfs. Gibberellin also substitutes for cold in the so-called rosette plants, such as *enclave*, where cold treatment causes elongation of stem and flowering. It is interesting to note that the same substance may "cure" hereditary dwarfism in the pea, in corn and in other plants [see "Plant Growth Substances," by Frank B. Salisbury; *SCIENTIFIC AMERICAN*, April, 1957]. Here, however, the gibberellin is not substituting for cold. The nature of the relationship between gibberellin and the cold processes has been the subject of intensive research, but it is as yet unclear.

Another common, though even less understood, response to temperature variation is "diurnal thermoperiodicity," a characteristic of plants that germinate far better under daily alternations of warmth and cold than they do at any constant temperature. Ecologically, such a mechanism can prevent germination in climates, seasons or soil depths where proper temperature alternations do not occur. Physiologically, we have almost no clue to the operation of the mechanism. Rhythmical (or cyclical) phenomena have been observed in many forms of living things: plants, mammals, birds, insects and microorganisms. Many of these phenomena follow a 24-hour periodicity quite independent of the environmental, or astronomical, 24-hour cycle, but capable of being synchronized with it. It is quite likely that the study of this general phenomenon will lead to

THE FACTS ABOUT MAGNESIUM AND CORROSION

Once this basic law of nature is recognized, proper design and protective measures permit excellent service life.



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in mind, almost any corrosion problem can be "designed out" from the beginning when working with magnesium.

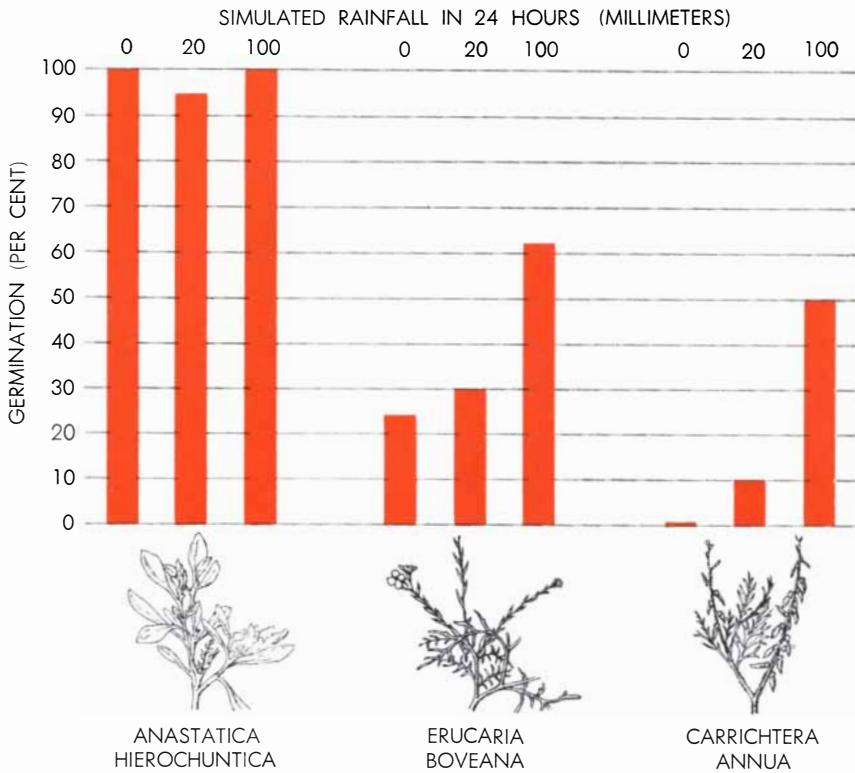
Whenever the corrosion characteristics of magnesium are acknowledged, and preventative measures are incorporated into designs, magnesium gives outstanding performance in service. Proof of this statement is evident by the growing use of magnesium alloys for such applications as: aircraft skins, wheels and engines; missile frames, fins and skins; radar antennas; military vehicle platforms and wheels; chain saws, hand trucks and dock boards.



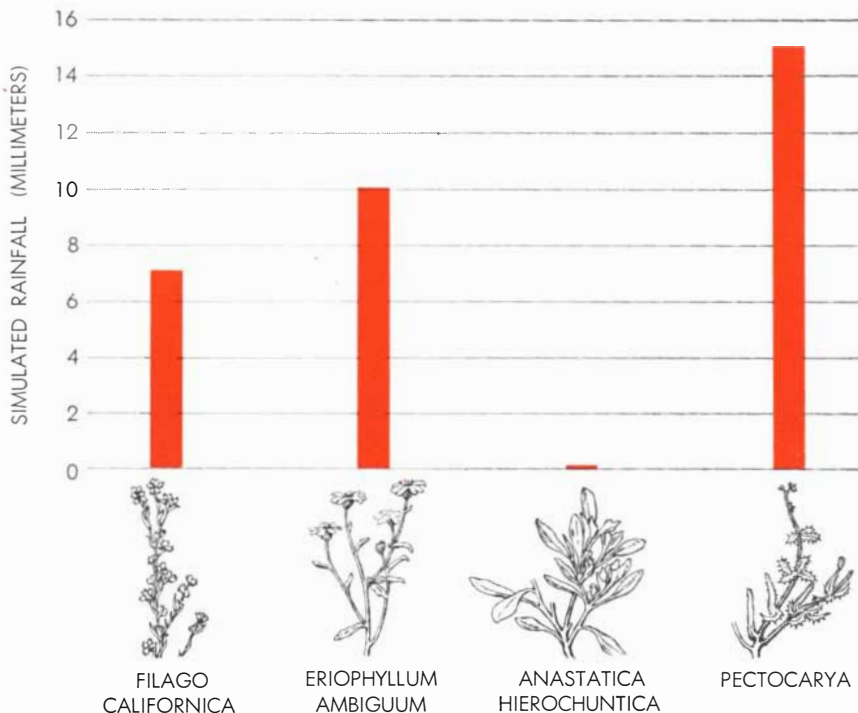
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RAINFALL triggers the germination of many desert plants. This chart illustrates the results of experiments by A. Soriano, who subjected desert plants to artificial rainfall. The seeds of all three species shown here were kept in moist soil. Only *Anastatica hierochuntica* did not require considerable extra rainfall to leach out a chemical that inhibited germination.



OPTIMAL RAINFALL for the germination of four desert plants was also determined by Soriano at the California Institute of Technology's Earhart Plant Research Laboratory.

an understanding of diurnal thermo-periodicity in germination.

Dispersal units incorporate not only rainfall and temperature gauges, but also sensitive mechanisms that respond to light. Such a mechanism in the humble lettuce plant is the subject of research at three research institutions (the U. S. Department of Agriculture laboratories at Beltsville, Md., the Hebrew University in Israel and the University of California at Los Angeles). In darkness lettuce seeds germinate tolerably well only within a narrow temperature range. Given light they germinate promptly and uniformly over a very wide range, and under a variety of conditions that would absolutely inhibit germination in the dark. Dry lettuce seed is insensitive to light, but a few minutes after the seed is moistened it becomes light-sensitive, so sensitive that exposure for a few seconds to light with an intensity of a few foot-candles suffices to produce the full effect. The obvious analogy to photographic exposure extends further: If a soaked seed is exposed to light and then dried, it will retain the "message" it received and, when it is subsequently remoistened, it will germinate in darkness.

A search of the light spectrum for the most effective wavelengths has shown that only the red portion of the visible spectrum stimulates germination. At the same time it was found that far red light (on the boundary between the visible red and the infrared) is capable of reversing the stimulation by red light, thereby inhibiting germination. A flash of red stimulates germination. A flash of far red, following closely, completely reverses the stimulation. This reversal is itself reversed when followed closely by another flash of red, and so on repeatedly. It is always the color of the final light-flash that is decisive. Our understanding of this mechanism is fragmentary. As in the case of the near-freezing of seeds, the results of the process are not immediately visible. We only perceive their end products, namely subsequent germination or nongermination in darkness.

Sensitivity to light implies the presence of a pigment that absorbs the light. The effects of the red and far red indicate some properties of this pigment, but it has yet to be extracted, purified, identified and studied—a process that may take some time, since the pigment doubtless occurs in minute amounts. Luckily for the investigator, light-sensitive mechanisms of this kind are not restricted to seeds; an identical mecha-

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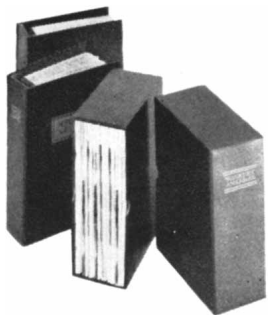


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nism has been observed in many developmental processes of plants, and may also occur in animals. Thus etiolated plants (plants grown in darkness) will be pale, tall and spindly and will bear unexpanded leaves; upon exposure to light they begin to grow normally. Similarly the study of the relationship between flowering and the relative length of day and night has shown that, in order for the dark period to stimulate flowering in short-day plants or inhibit it in long-day plants, the darkness must not be interrupted by light. If the plant is exposed even briefly to low-intensity light near the middle of the dark period, the effect of the darkness on flowering may be wiped out. It turns out that in both etiolation and flowering the sensitivity to light responds to the same red and far red stimuli as germination.

It may be significant that gibberellin and another plant-growth substance, kinetin, simulate the red-light stimulus that triggers germination, but to complicate matters several substances (e.g., potassium nitrate and thiourea) which are not known as plant-growth regulators, also do so. Another complication is the fact that germination apparently loses its sensitivity to light when the embryos are decoated. It remains to be seen whether light acts on the embryo, somehow making it grow with vigor sufficient to overcome the resistance of the coat, or whether it works on an extra-embryonic entity, perhaps by activating an inhibitor in the coat.

Like a photographic plate, seeds can be over- and under-exposed. The brief flash of light that stimulates germination in lettuce and tobacco plants would be insufficient for the rush *Juncus maritimus*; on the other hand, although continuous illumination works as well as a flash in the case of lettuce, it would inhibit wild smilgrass or the Negev salt-bush, plants fully stimulated by a brief exposure. The finding that some seeds are as sensitive as fully mature plants to relative length of day and night does not, therefore, come as a surprise, in view of the fact that both have the same responses to the red and far red.

We can deduce some implications of this mechanism for the ecology of plants. Sensitivity to the period of light and dark may determine the season of germination just as it determines flower initiation and the onset or end of dormancy in the buds of trees and shrubs. Inhibition by overexposure to light may be of value in preventing germination from occurring on an exposed soil surface, where treacherous conditions such as rapid drying or high temperature are

common. This may be why the germination of many desert plants is inhibited by overexposure. Conversely, inhibition by underexposure may be of value in preventing germination from taking place in poorly illuminated or overpopulated localities. This may explain why many aquatic and marsh plants require light for germination.

It should be said that this account has described only a few of the better known germination-regulating mechanisms. Moreover, it must be understood that several mechanisms are often found in a single seed. A well-known example of interdependent mechanisms occurs in the ordinary garden cress, which germinates only in response to a combination of light and temperature stimuli. *Trigonella arabica*, on the other hand, is a desert annual that has a dispersal unit equipped with at least four independently operating controls: a water-soluble inhibitor, a "hard" seed coat and sensitivity to both temperature and light.

Germination and Evolution

The life of every plant includes critical phases at which it is more than usually susceptible to the vicissitudes of the environment. Apparently it is at these phases—the change from seed to seedling, from the active to the dormant bud and vice versa, from the vegetative to the flowering plant—that regulatory mechanisms, operated by environmental signals, are particularly important. Taken together, they serve to maintain the harmony of the plant and its environment. The regulation of germination does more than this: it also acts to preserve the species by conserving embryonic material and by helping to select a favorable environment for further development of the offspring.

In evolutionary terms the origin and spread of these regulatory mechanisms may be easily imagined. Once created, whether by mutation or the reassortment of genes, the higher survival value that they imparted to their bearers provided the latter with distinct advantages over their kin that lacked these advantages. Selection and breeding by man have in many cases reversed this process, producing plants that germinate at man's will rather than in response to natural signals. These tame plants have minimal germination control. On the other hand, nature's own selection and hybridization have been, and apparently still are, tending toward more efficient control and regulation of germination, as a means for the preservation of plant species.

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The Solar System beyond Neptune

Pluto, our sun's most remote and mysterious planet, may once have been a satellite of Neptune. Current theories about its origin provide new clues to the genesis of the solar system

by Owen Gingerich

Early in 1979 the planet Pluto, having crossed inside the orbit of Neptune, will be proceeding on its orbit toward a perihelion that will bring it 16 million miles nearer to the sun than Neptune ever comes. Thus for two decades Neptune will resume the position it held, before the discovery of Pluto, as the outermost planet. Many astronomers think that Neptune should be reinstated now, in advance of the event; in their relatively brief acquaintance with Pluto they have begun to doubt that this object is a planet at all. Pluto's eccentric orbit is tilted at a considerable angle to the plane of the ecliptic, in which the orbits of the other planets lie. Even on its closest approach to our region of the solar system, it will shine no brighter than Triton, one of Neptune's two satellites, suggesting that it is no larger. There is suspicion that Pluto is an illegitimate offspring of Neptune, a satellite that escaped, as two man-made satellites recently did, to ply its own orbit around the sun.

The discovery of Pluto in 1930 had seemed a triumph of classical celestial mechanics. Computation from perturbations in the orbits of Neptune and Uranus had shown where it might appear in the sky. Astronomers had looked there and found it, in apparent fulfillment of the Newtonian vision of the solar system as a perpetual clockwork whose totality might ultimately be inferred from the motions of its nearer parts. What we know about Pluto now, however, leads some astronomers to declare that its discovery was an accident. Certainly its dubious status as a planet must dash the expectation that we might go on discovering new planets at ever greater distances from the sun. But as it brings one era of astronomy to a close, Pluto opens a new period of exploration at the outer

edge of our solar system. It tells us to look not for planets but for other objects, including errant bodies like itself. Trans-Neptunian space holds increasing interest for what it may disclose about the origin and evolution of our no longer unchanging solar system.

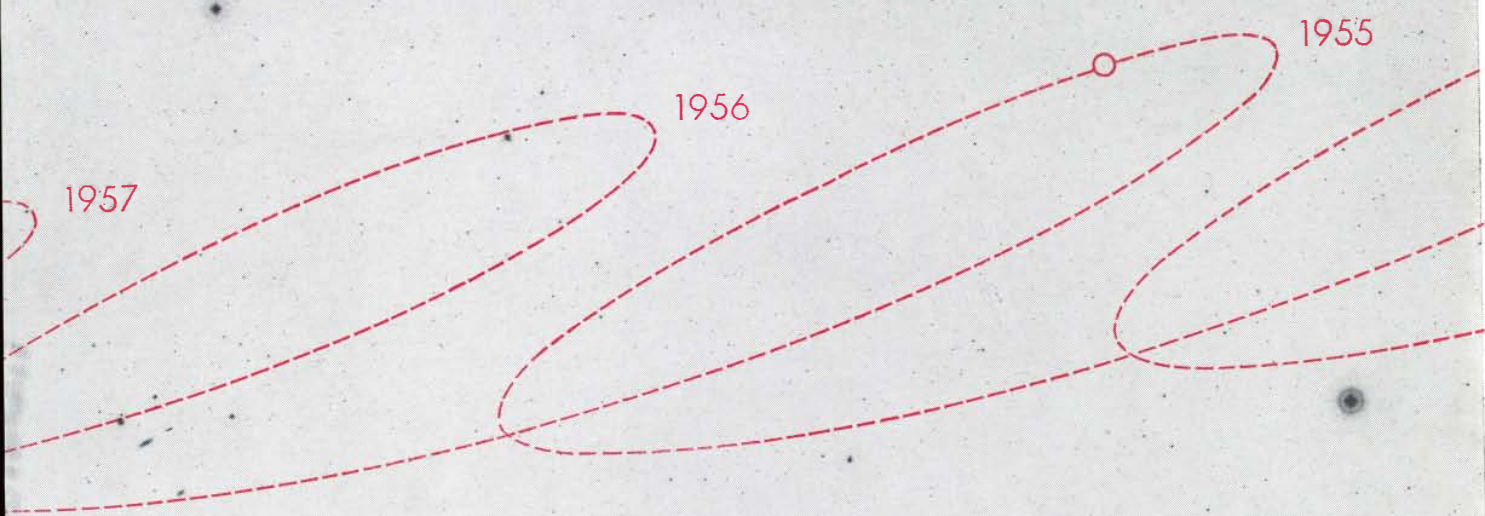
It has taken a little more than a century to complete this revolution in astronomy. The civilized world was electrified in September, 1846, by the announcement from Berlin of the discovery of a new planet circling the sun in the remote space beyond Saturn and Uranus. Its existence had been predicted by the young French celestial mechanician Urbain Jean Joseph Leverrier from his study of small irregularities in the orbit of Uranus. His computations, communicated to observers in Berlin, pinpointed the new planet's location within a degree of where it was found in the constellation Aquarius. Meanwhile a parallel investigation in England had led John Couch Adams to essentially the same, but unpublished, prediction. The coincidence served to heighten the celebration of the discovery of the new planet, which was named Neptune, and encouraged astronomers to hope for a repeat performance. Leverrier, addressing the French Academy of Science, declared: "This success allows us to hope that, after 30 or 40 years of observation of the new planet, we should be able to use it in its turn for discovering the planet next in order of distance from the sun. Continuing this process, we should eventually arrive at planets which, unfortunately, because of their immense distance from the sun, would be invisible, but whose orbits may be worked out in ensuing centuries and traced with great accuracy. . . ."

By the end of the 19th century celestial mechanicians had gathered enough

data to make a fresh attack on the motions of the outermost planets. W. H. Pickering of the Harvard College Observatory, working from historical and contemporary records of the orbits of Neptune and Uranus, predicted in 1919 the location of a trans-Neptunian planet near the foot of the constellation Gemini. A search of photographs made at the Mount Wilson Observatory, however, failed to show the hypothetical planet. Meanwhile, Percival Lowell of the Lowell Observatory in Flagstaff, Ariz., was launched on a parallel effort. Though a trans-Neptunian planet would necessarily disturb Neptune more than Uranus, the planet next closer to the sun, Neptune had not yet been observed for a complete revolution around the sun. Lowell accordingly based his computations on Uranus, which had been observed for two full revolutions. The disturbances in the orbit of Uranus did not, however, lead to a strong solution for the place of the unknown body. Lowell found two possible regions on opposite sides of the sky. He believed that one of these areas—an area near Pickering's predicted position—was the more likely.

Recognizing that the hypothetical planet would be faint and thus hard to find among the myriad of zodiacal stars, Lowell undertook a systematic photo-

PLUTO appears as the tiny black speck within the colored circle on this photograph made in 1955 with the 48-Schmidt telescope on Palomar Mountain. The earth's own rotation about the sun makes Pluto appear to spiral slowly through the heavens (*broken line*). The picture is reproduced from a negative print. Such a print increases the contrast and visibility of objects on the plate.



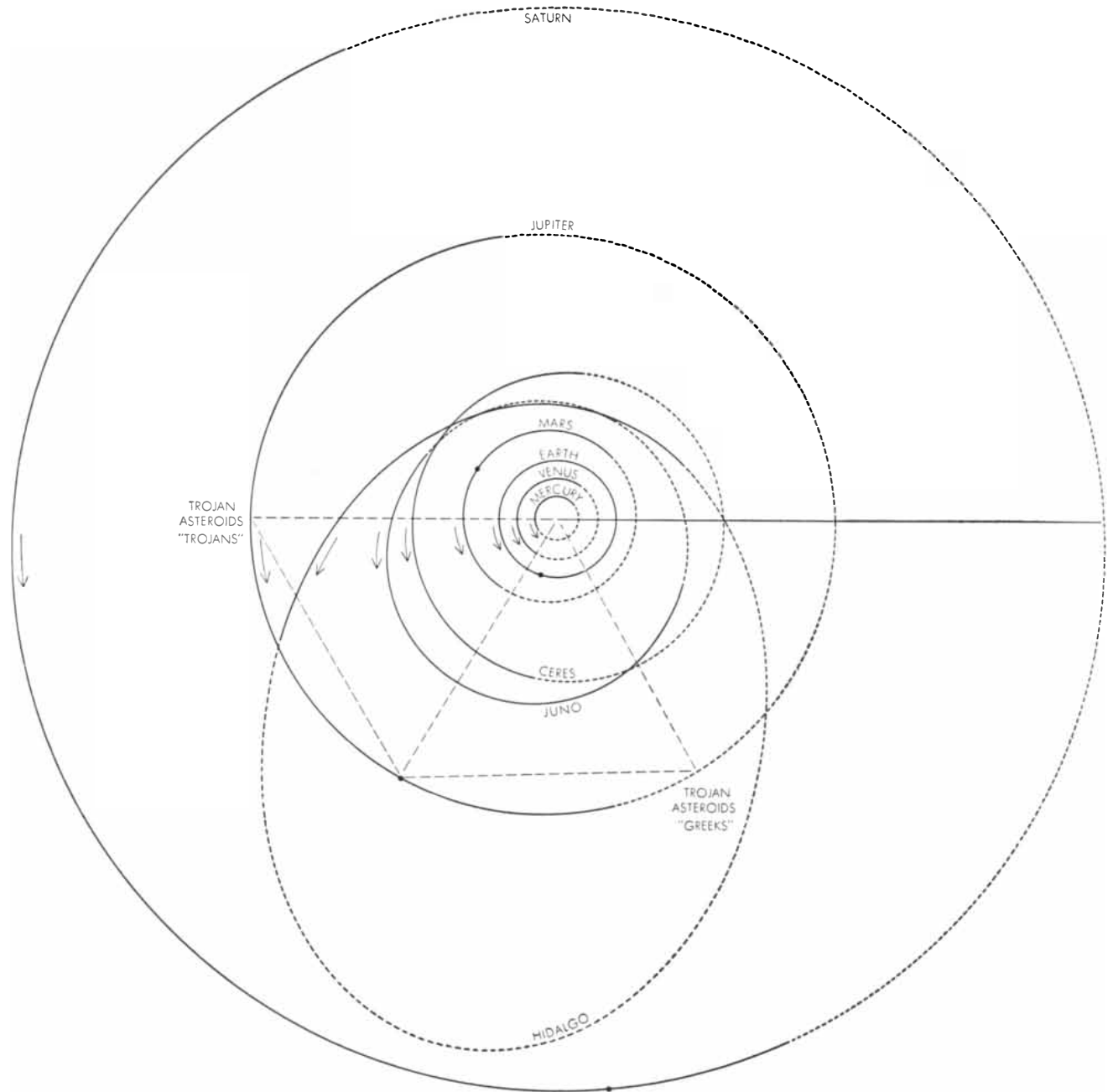
graphic search of the indicated region of the sky. But the cameras available during his lifetime proved inadequate. Not until 1929 did the Lowell Observatory secure the necessary equipment. A young assistant, Clyde Tombaugh, then took on the task of making pairs of matched plates covering the region of the sky staked out by Lowell. The plates in each pair were taken several days apart and recorded the same 170 square degrees of sky. If the hypothetical planet were in the area covered by a pair of plates, the movement of the earth on its

orbit would cause the image of the planet to appear in a different position in the second plate. Tombaugh then compared the matched plates in a "blink comparator," an instrument in which the two plates are precisely aligned and presented alternately to the observer's eye by means of a hinged mirror. Star by star Tombaugh searched the plates, looking for a pinpoint of light that would appear to jump to a new position on the second plate when he flopped the mirror.

After a year he located a pair of 15th-

magnitude images that showed the motion required of a trans-Neptunian object. On March 13, 1930, the anniversary of Lowell's birth, the discovery of the ninth planet was announced to the world. Pluto revolves about the sun at a mean distance of 3,670,000,000 miles from the sun, 40 times farther out than the earth and nearly 900 million miles beyond the mean orbit of Neptune.

A reinvestigation of the Mount Wilson plates which had been made in 1919 revealed that Pluto had actually registered its existence then. It had been



INNER SOLAR SYSTEM comprises the orderly orbits of six planets and a population of many hundreds of asteroids. Typical asteroids, such as Ceres and Juno, lie between Mars and Jupiter. The peculiar orbits of Hidalgo and the two Trojan groups suggest

that these bodies are former satellites of Jupiter. The two groups of Trojan asteroids are locked by Jupiter's gravitational field in relative positions indicated by the adjacent equilateral triangles. The broken portions of orbits lie below the earth's orbital plane.

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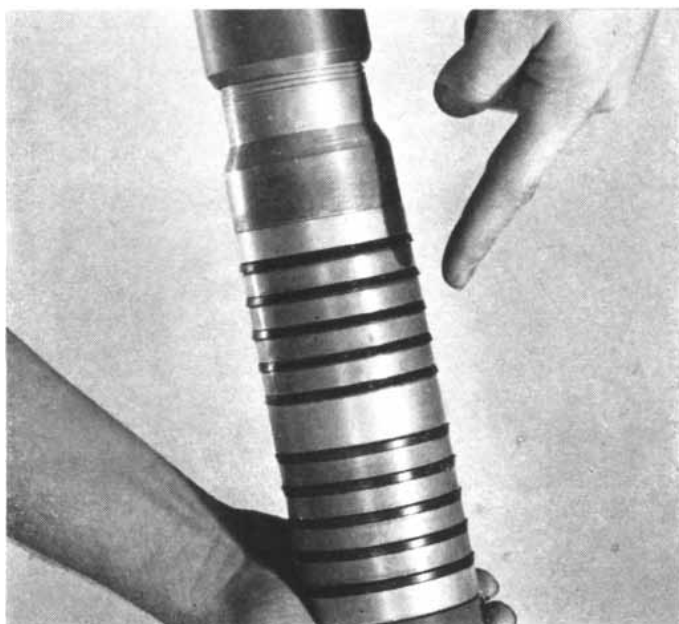
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	Carbon tetrachloride	75° F.	85	1.3	+ 2
	JP-5 petroleum aircraft fuel	75° F.	100	0.4	+ 1
	Sulfuric acid, fuming	75° F.	58	4.8	- 4
	Dichlorobenzene	158° F.	81	10.5	-11
	Sodium hydroxide, 50%	158° F.	89	5.1	- 8
	Phosphoric acid, 60%	212° F.	93	0.5	0
	Water	212° F.	98	2.7	+ 3
	Sulfuric acid, 60%	250° F.	102	5.2	- 3
	Petroleum oil, crude	300° F.	91	1.4	- 9
	Oronite 8200 silicate ester	300° F.	93	1.8	0
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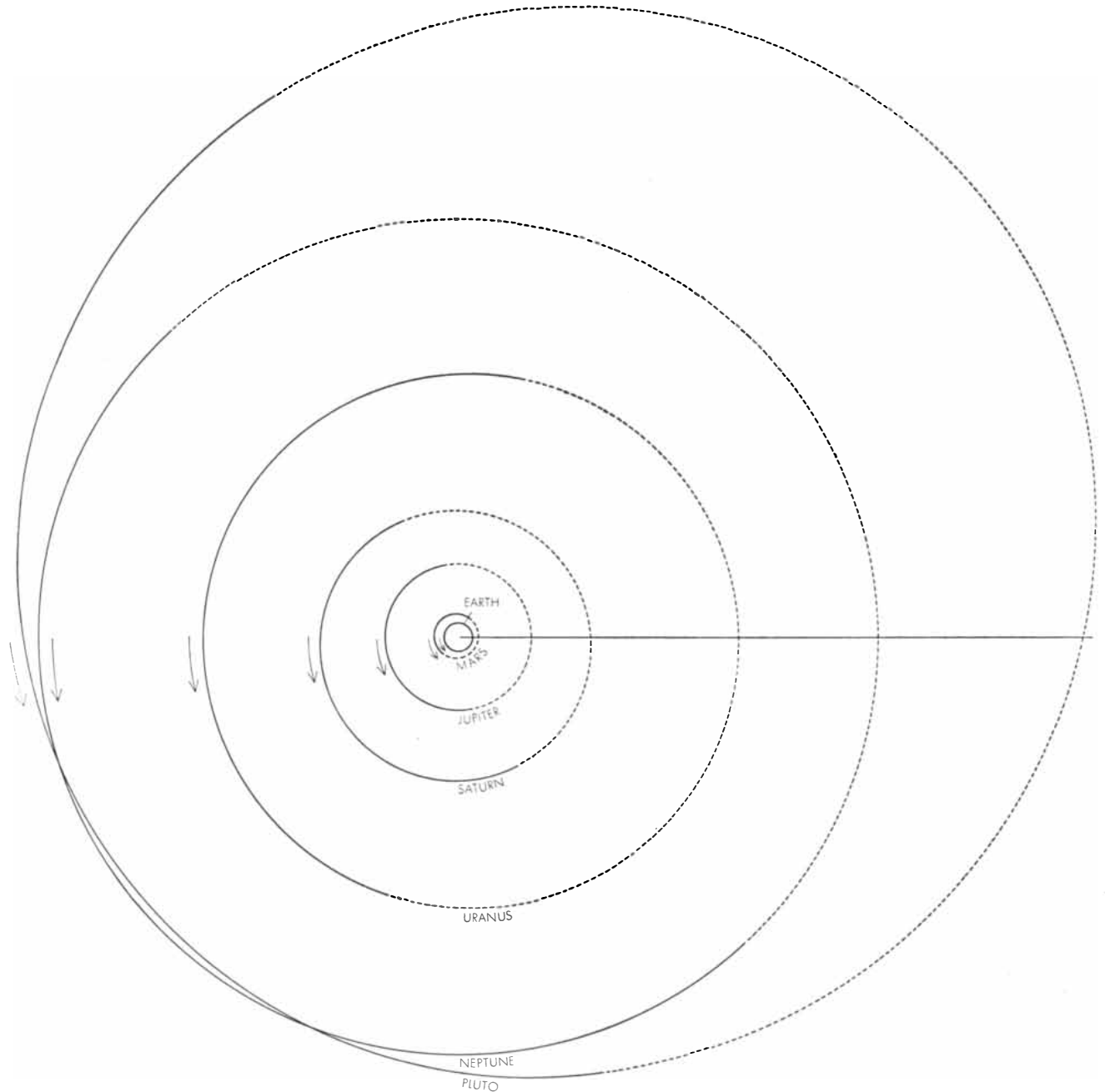
overlooked partly because it was unexpectedly faint. It was nearly 1,000 times fainter than Neptune, which itself would have to be about five times brighter to be just visible to the naked eye. Astronomers were perplexed. If Pluto were faint because it was small in diameter, then it would probably not be very massive. But if it had small mass, Pluto could not have perturbed Uranus or Neptune enough for its place to be found theoretically. On the other hand, if Pluto were small but massive, its density would be unreasonably high. And if

Pluto were large in diameter yet faint, then its reflectivity would be unexpectedly low.

The first task was to determine Pluto's mass. In the case of Uranus and Neptune the motions of their satellites accurately reveal the masses of the mother planets. But Pluto had no apparent satellites; its mass could be determined only indirectly by its perturbations of Uranus or Neptune. In the nearly two centuries since Uranus was found and the century since the discov-

ery of Neptune, Pluto has caused such tiny displacements in their positions that the mass of Pluto cannot be satisfactorily established from them alone. Lowell and Pickering had depended upon observations of Uranus and Neptune that had been recorded before the two objects were recognized as planets.

The French astronomer Joseph Jérôme Lefrançois de Lalande had recorded a pair of fixes on Neptune in 1795. He thought it was a star, because of its pointlike appearance, and overlooked its snail-like pace across the



OUTER SOLAR SYSTEM comprises the three planets discovered in modern times: Uranus, Neptune and Pluto. Pluto's abnormal orbit crosses Neptune's at lower left. As in the diagram on page

88, the broken portions of orbits lie below the earth's orbital plane. However, only Pluto's orbit is significantly inclined to the orbital plane of the earth; its orbital "tilt" is about 18 degrees.

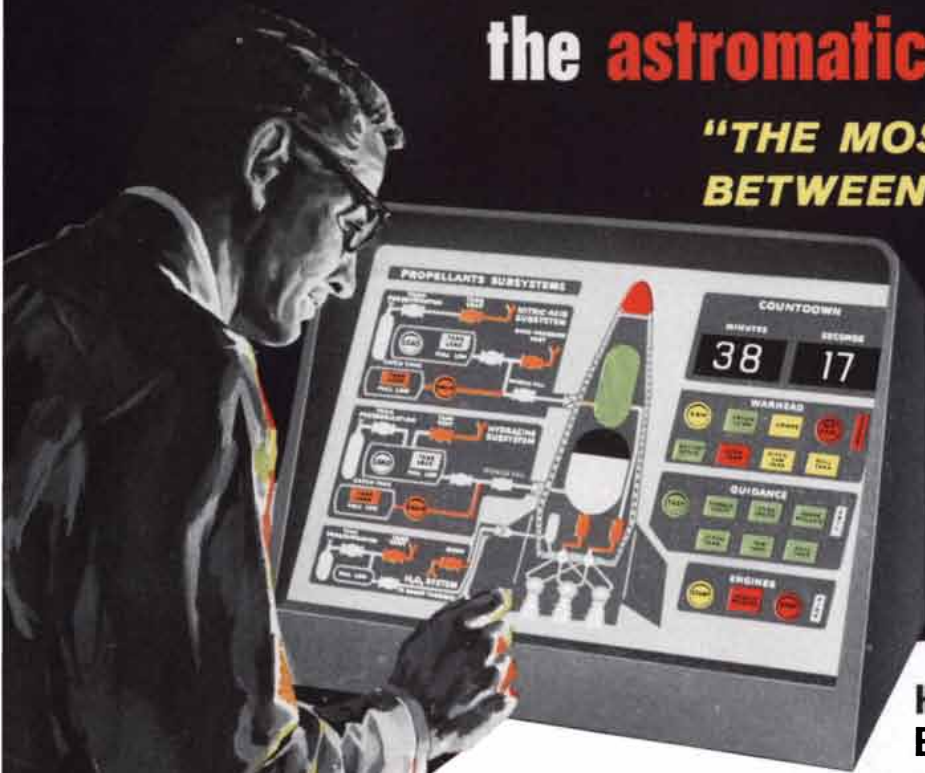


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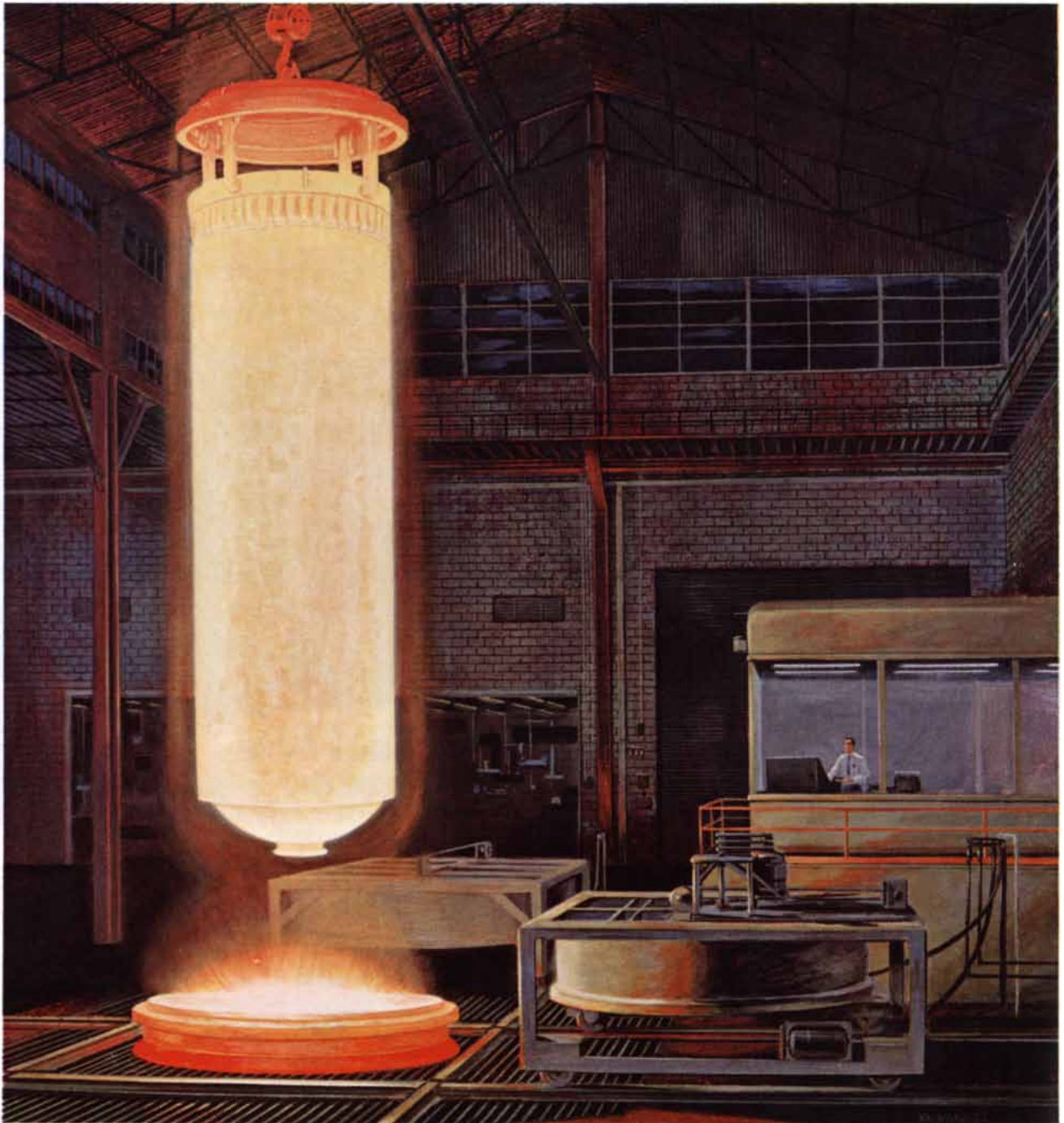


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sky. His observations, compared with modern positions, would indicate that Pluto had produced a displacement of at least six seconds of an arc in Neptune's celestial longitude. To cause such an effect the mass of Pluto would have to be nearly equal to that of the earth. Allowance for reasonable error in Lalande's observations would make Pluto only half as massive as the earth. By comparison Uranus has a mass of 14.5 earth masses, and Neptune a mass of 17.2.

It was the small indicated mass of the new planet that prompted several astronomers to pronounce its discovery a lucky accident. The perturbations caused by such a small body would be concealed by the random errors of observation. How, then, did the two independent calculations of Lowell and Pickering converge on the same general area of the sky?

Vladimir Kourganoff, a French astrophysicist, provided one explanation after a careful re-examination of Lowell's and Pickering's work. He found that both had relied on the 18 observations that had been made of Uranus before its discovery in 1781. These prediscovery measurements show an unfortunate amount of statistical scatter. But they had indicated a seemingly extraordinary displacement of Uranus around 1710 as the result of a particular juxtaposition with Pluto, and had apparently defined the time well enough to permit the predictions by Lowell and Pickering. The 18th-century observations do not, however, yield any reliable determination of Pluto's mass.

Unfortunately the calculation of Pluto's mass from the observed positions of the other two outer planets cannot be more exact than the observations themselves. Recently W. J. Eckert of the Watson Computing Laboratory, Dirk Brouwer of Yale University and G. M. Clemence of the U. S. Naval Observatory programmed an electronic computer to calculate the positions of the outer planets throughout the four centuries from 1653 to 2060. For this definitive study they assigned to Pluto a mass that had been derived in an earlier investigation by L. R. Wylie at the Naval Observatory. They found that this mass, slightly less than that of the earth, made possible a satisfactory agreement between the computed and observed positions of both Neptune and Uranus.

Astronomers would probably accept this value if it were not for a set of quite different observations made in March, 1950, by Gerard P. Kuiper of the Yerkes Observatory. At Palomar

Mountain, with the help of Milton Humason, Kuiper used the 200-inch reflector (in one of the rare visual observations made with that instrument) to compare the size of Pluto's image with a standard set of disks. Kuiper and Humason agreed that the image had a diameter of only .23 second, corresponding to 3,600 miles, or less than half the diameter of the earth.


Now if Pluto's mass were equal to that of the earth, this determination of its diameter would give it a density 10 times that of the earth! Such an enormous density, five times greater than that of lead, is highly unlikely in a member of our solar system. Could something be wrong with the measurement of Pluto's diameter? Dinsmore Alter of the Griffith Observatory in Los Angeles pointed out that if Pluto reflected light like a polished ball bearing, Kuiper would have observed not the disk of Pluto but the reflected image of the sun. But there is no reason to believe that Pluto's surface is abnormally smooth. An icy surface would be quickly eroded by evaporation, temperature changes and bombardment from cometary material.

Since the Kuiper measurement cannot be controverted, astronomers feel compelled to reject the rather weak determination of Pluto's mass from celestial mechanics. Granting the planet an acceptable density, the 3,600-mile diameter yields a calculated mass about .03 that of the earth. Such a tiny mass could not have produced the apparent perturbation of Uranus in 1710 on which Pickering and Lowell had relied so strongly. Whether Pluto was discovered by chance or prediction remains a major mystery. Brouwer writes off the prediction as "a fantastic coincidence."

Pluto's status as a planet is further weakened by the eccentricity of its orbit. When Pluto swings inside Neptune's orbit to perihelion, it comes more than 1.8 billion miles closer to the sun than at aphelion. Moreover, the inclination of the orbit to the plane of the ecliptic exceeds 17 degrees. All of these considerations led Issei Yamamoto of the Kyoto Observatory to speculate in 1933 that Pluto was not a true planet but an escaped Neptunian satellite. Shortly afterward calculations by R. A. Lyttleton of the University of Cambridge showed how a close encounter between Pluto and the Neptunian satellite Triton might have ejected Pluto from the gravitational system of the planet.

Kuiper agrees that Pluto began its existence as a satellite of Neptune but has proposed that it escaped to a planetary orbit under entirely different cir-

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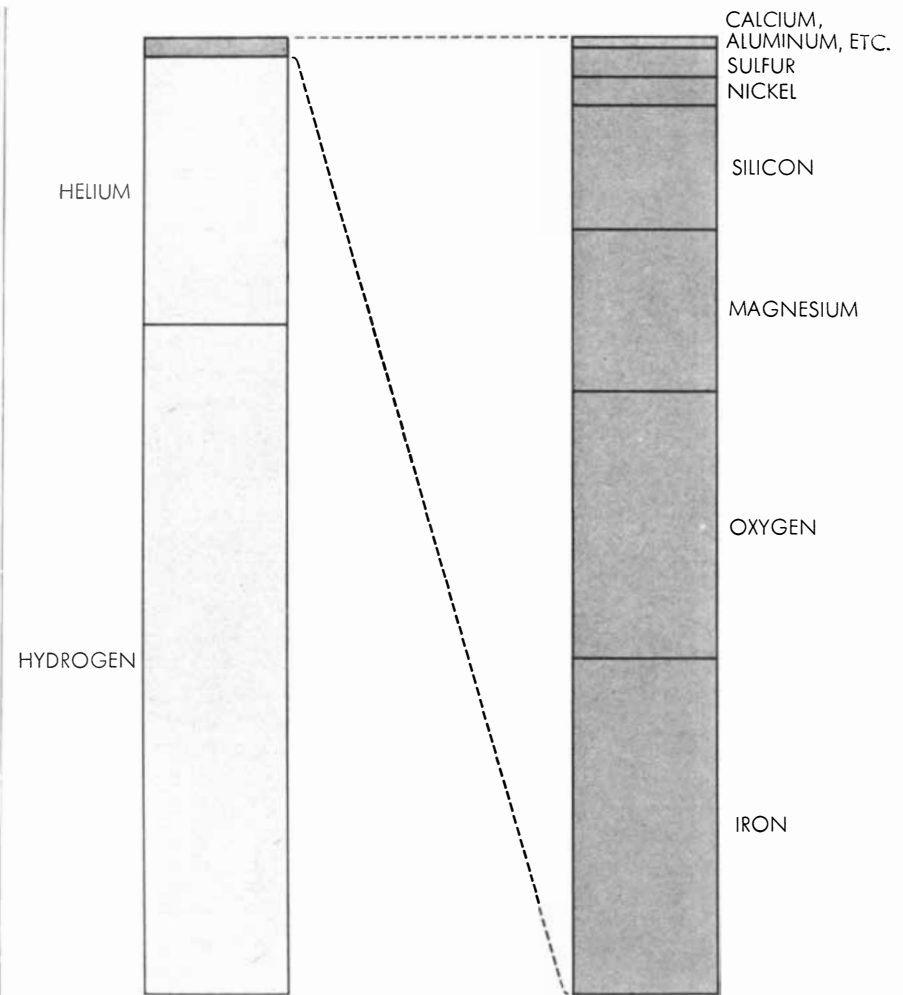
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COMPOSITION OF PROTO-EARTH probably resembled the present composition of the sun (left): 98 per cent hydrogen and helium with heavier elements (dark shading) making up the remainder. Present composition of earth (right) includes 35 per cent iron, 28 per cent oxygen. The lighter elements have evaporated almost completely except for oxygen, most of which is bound into heavy mineral oxides. The larger planets such as Jupiter, being more massive than the earth, have retained a higher proportion of light elements.

cumstances. In this account of its genesis, Pluto figures as a major item of evidence for an explanation of the origin of the solar system which is gaining increasing acceptance in modern astronomy. According to this view the planets and the sun began by condensing from an extended mass of dust and gas. Numerous investigators have contributed to the current revival of this nebular hypothesis, now also called the "dust-cloud" theory; Kuiper has given his protoplanet theory the fullest development.

The birth of the solar system begins with the contraction, under its own gravitation, of a cold cloud of dust and gas. Rotation of the cloud sets up centrifugal force that works against the gravitational collapse and flattens the cloud into a wheeling disk. As the cloud contracts and grows more dense, local instabilities break it up into individual

self-gravitating units, with a protostar at the center and a series of protoplanets out toward the periphery.

The protoplanets formed in such a cloud do not necessarily condense into planets. Tidal attractions from the protostar may disrupt these individual clouds so they cannot contract into spheres. The ring system of Saturn gives us a scale model of what happens in this circumstance. The disruptive action of Saturn apparently prevents the material in the rings from forming an inner satellite. Saturn's rings thus represent the vestiges of a discoidal protoplanet.

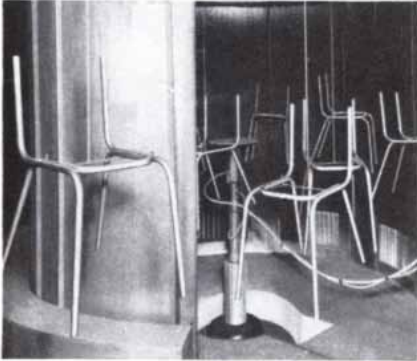
Condensation can occur, however, in those protoplanets whose density exceeds a certain critical limit. Here the dust-cloud theory requires a certain elaboration in order to reconcile it with observed facts. If the present mass of the planets and their satellites in our solar system were smeared out into a dusty

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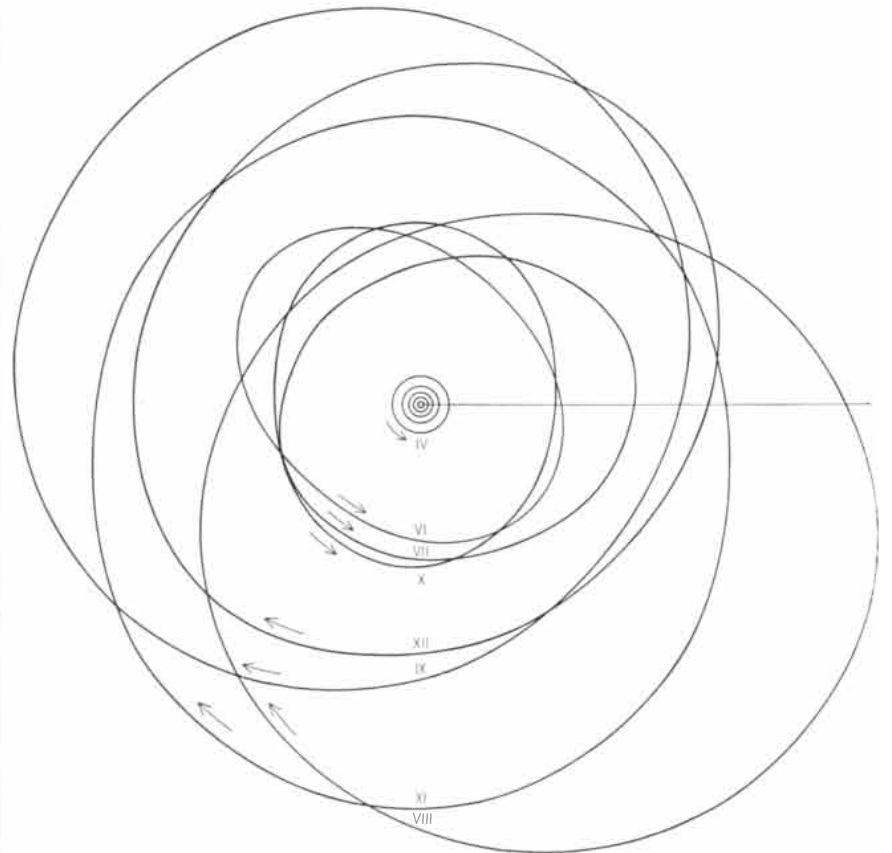
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disk around the sun, the density of the cloud would not attain the critical condensation limit. Modern theories ingeniously avoid this difficulty by postulating that the mass of the protoplanets must have greatly exceeded the present planetary mass. As condensation proceeded, radiation from the protosun, already glowing from the release of gravitational energy, caused the surplus material (approximately 99 per cent of the original mass) to evaporate from the protoplanets and swept it out into space. This argument is supported by the observation that such dissipation of material from the atmospheres of the planets is still going on, though at a greatly reduced rate. The lightest elements, hydrogen and helium, which must have constituted the major bulk of the solar nebula and therefore of the protoplanets, have almost entirely escaped from the earth, leaving behind the tiny residue of heavier elements which now constitute our planet. The higher escape velocities of the more massive Jupiter, Saturn, Uranus and Neptune have allowed them to retain a larger propor-

tion of light elements, giving them a lower average present density.

To assist us in visualizing the further evolution of the solar system we have another scale model at hand in Jupiter and its dozen satellites. Proto-Jupiter, the largest and most massive cloud to have broken from the solar nebula, must itself have broken down into a central body and a retinue of protosatellites. In the evaporation stage proto-Jupiter would have continually lost mass. Its outer satellites, bound more and more tenuously to the system, must eventually have slipped away. Only the five innermost satellites remained. They still resemble a miniature solar system, these "planets" being spaced at regular intervals in a common plane of revolution. In contrast, the seven tiny outer satellites of Jupiter present a scene of great irregularity. Their highly inclined orbits interloop one another, and the outer four revolve in a direction opposite that of the rest. We may deduce that these satellites once took up independent orbits around the sun. Upon later encounter with the extended gaseous atmos-



SATELLITES OF JUPITER fall into three groups. The inner satellites, V, I, II, III and IV, all revolve in the same plane and from west to east; they have presumably always been satellites. The next three, VI, VII and X, revolve in the same direction but in three different planes; VIII, IX, XI and XII also revolve in different planes, but from east to west. These two groups apparently represent "escaped" satellites that were recaptured at two different times. These Jovian satellites are numbered in the order of their discovery.

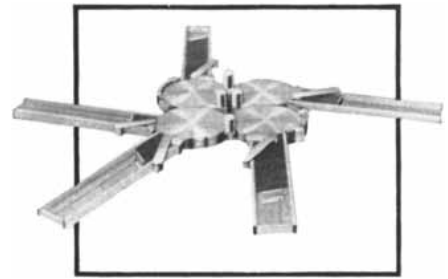
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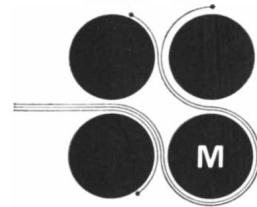
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phere surrounding proto-Jupiter, they were captured in irregular orbits bearing little resemblance to their original paths. Other proto-Jovian satellites may have been lost completely, to become asteroids orbiting around the sun with unusual inclinations and eccentricities.

The parallel process of evolution in the case of proto-Neptune fully accounts for Pluto's remarkable orbit. Both of Neptune's present satellites represent recaptures; Triton's orbit is retrograde and Nereid's is highly eccentric. Any remaining original protosatellites would have been removed by massive proto-Triton as it spiraled in through proto-Neptune's gaseous envelope on its return journey. The inclination of Pluto's orbit suggests that it too escaped from orbit around Neptune but did not return. It is otherwise difficult to explain the interlooping of its ellipse with Neptune's orbit.

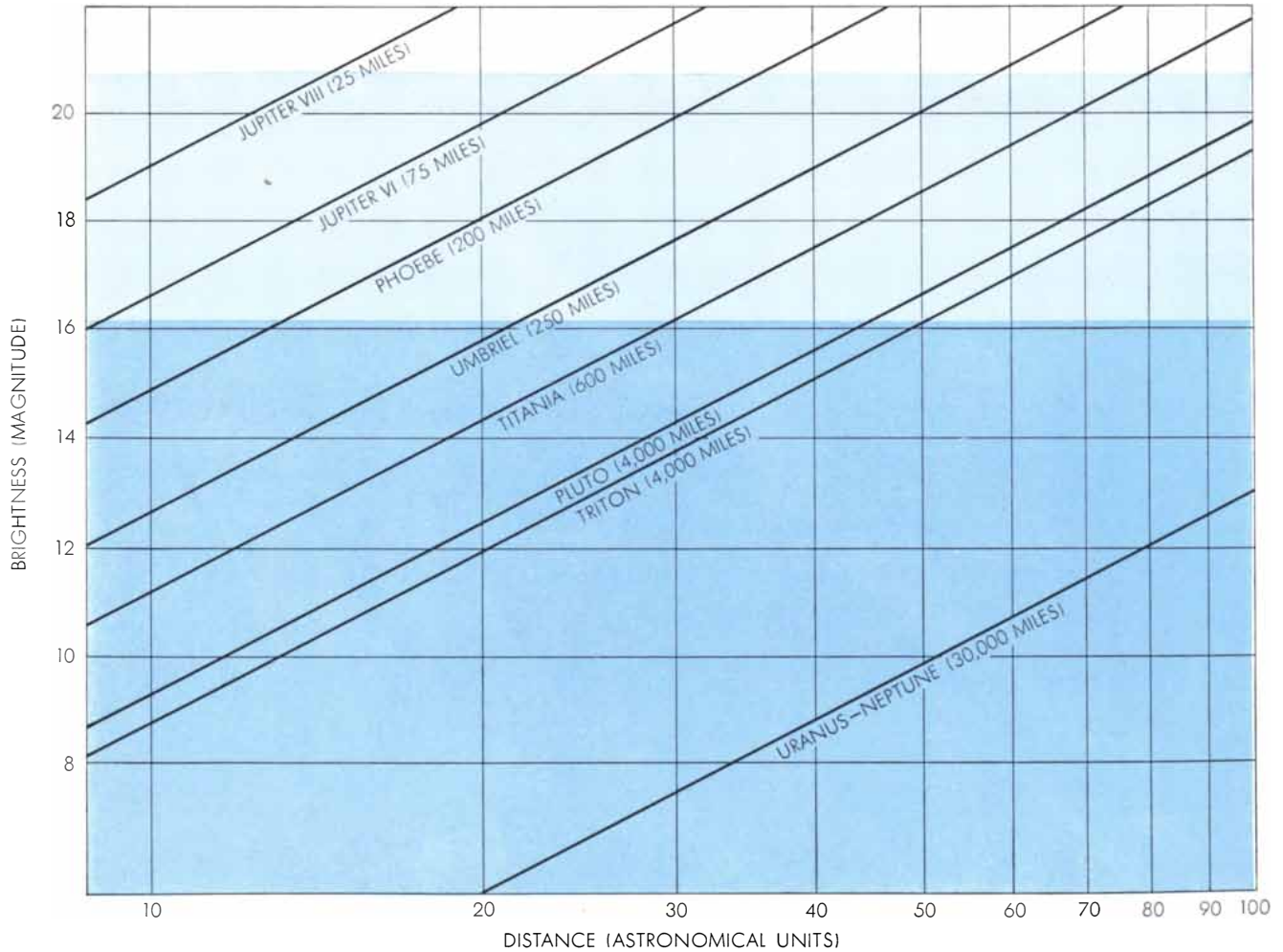
Convincing evidence for this recon-

struction of Pluto's origin came in 1956, when Merle Walker and Robert Hardie at the Lowell Observatory measured variations in the light reflected by the planet. The small fluctuations in brightness repeated themselves regularly, as if dark markings were passing across the planet's disk. This cycle indicated that Pluto rotates in 6.39 days, much more slowly than any of the massive outer planets, which rotate in 10 to 15 hours. Kuiper suggests that Pluto originally revolved around Neptune once in 6.39 days, rotating on its own axis in the same period. Now, on its lonely orbit around the sun, Pluto rotates just as slowly as when it was attached to Neptune.

Has Leverrier's dream of extending the solar system step by step by means of celestial mechanics been shattered? The answer is yes. Pluto lies just at the threshold of gravitational detection. From now on we must look to accidental photographic discovery rather than ce-

lestial mechanics if we hope to add any remote members to our solar system.

Following the discovery of Pluto the Lowell Observatory continued a systematic search of a wide belt, covering three quarters of the sky, on either side of the ecliptic. Altogether 90 million star images passed under Tombaugh's examination. The survey turned up about 3,000 asteroids but found no trans-Plutonian object. The limiting magnitude of this investigation is represented by the edge of the darker colored area in the brightness-distance diagram reproduced on this page. Any planet as bright as Neptune would have been discovered out to 180 astronomical units (an astronomical unit is equal to the distance from the earth to the sun). Pluto itself lies close to the threshold; a planet the size of Pluto would have escaped the net beyond 50 astronomical units. Trans-Neptunian objects intrinsically fainter than Uranus's moon Titania, and therefore presumably smaller than 600 miles



LIMITS OF OBSERVATION for objects of different sizes are shown on this brightness-distance diagram. Numbers in parentheses give approximate diameters of nine known objects; one astronomical unit equals about 93 million miles. The Lowell Observatory sky survey (*dark color*) extends to slightly beyond the 16th mag-

nitude (increasing magnitude means decreasing brightness). The Palomar survey with the 48-inch Schmidt telescope (*light color*) reaches the 20th magnitude. Thus a planet the size of Pluto would be invisible beyond 100 astronomical units even with the Schmidt. Other considerations make it unlikely that such a planet exists.

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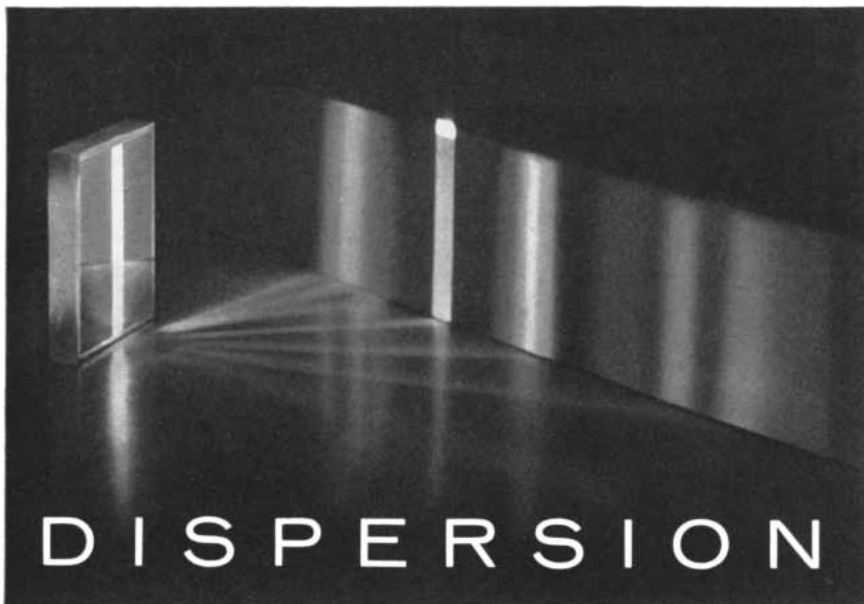
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in diameter, would not have been caught.

The 48-inch Schmidt telescope on Palomar Mountain casts a considerably finer net. It could show Pluto at a distance of 150 astronomical units or a planet 200 miles in diameter at Pluto's present distance. But a search down to magnitude 20.5 with the Palomar Schmidt would be a fantastic undertaking; the number of faint star images on some individual plates exceeds two million. The colored area for the Palomar Schmidt on the brightness-distance diagram represents the practical limit for the accidental discovery of a trans-Plutonian object.

What members of the solar system might be found in the unsearched range, fainter than magnitude 16 but brighter than magnitude 20? Probably no major planet, according to the protoplanet theory. Examination of the mass distribution of the outer planets supports the idea that beyond Neptune the density of the primordial dust cloud must have been too low for a protoplanet to form. But at such vast distances the gravitational force of the protosun would also have been much attenuated, reducing in turn the critical density of condensation. Smaller, less massive bodies might therefore have formed from the cloud in this region. Comets appear to have just the right size and composition, being made up of light elements and their compounds, frozen with a sprinkling of heavier stony or metallic particles. When occasional comets come out of their cosmic deep-freeze into the central regions of the solar system, they evaporate, forming gaseous atmospheres that are dissipated into space via their long and often spectacular tails. The comets appear to come from a tremendously distant swarm, suggesting that Pluto might have scattered them into their remote orbits. Other cometary bodies may still circle the sun on less eccentric orbits just beyond Neptune. But all known comets are much too small to be visible at these distances.

The escape of Pluto from Neptune, however, raises the possibility that we may yet find objects larger and more interesting than comets out on the fringes of the solar system. Three or four additional Neptunian satellites may have escaped to travel even more highly elliptical orbits around the sun. The accidental discovery of one or more such objects is no less improbable than the discovery of Pluto itself. They would add considerable substance to speculation about the origin of our solar system.

Jungle missionary straightens out shaft problem



Hazardous passage. Drifting debris, submerged rocks and ever-shifting shoals pose constant threats to this missionary. He is Brother Dismas of the Maryknoll Fathers, whose frequent missions take him up and down uncharted, unpredictable waters deep in the jungles of Bolivia.

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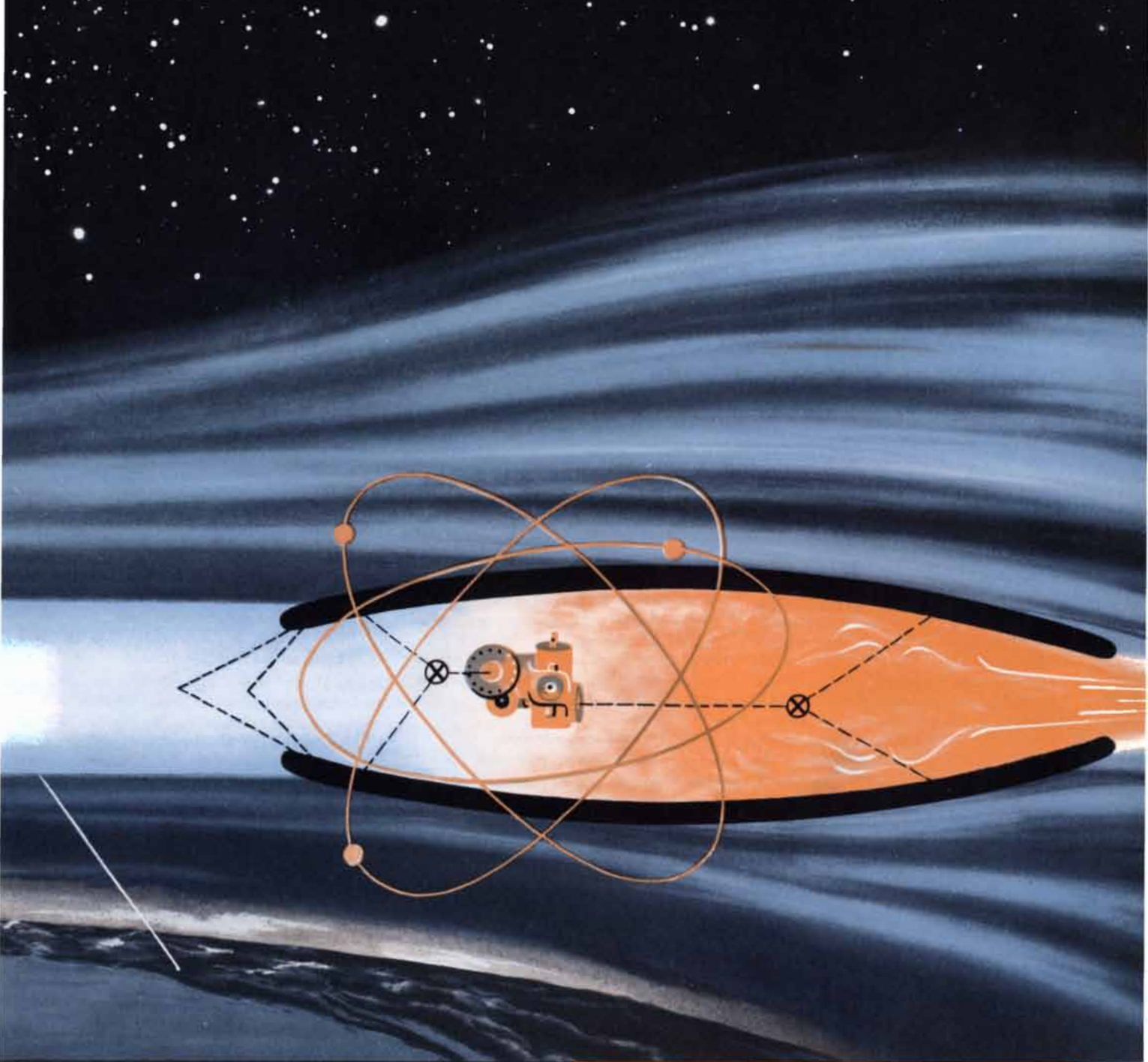
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A camera, projector, three types of viewers, and all necessary printing accessories are available with the Micro-Master system, and all equipment can be obtained through your local K&E distributor. He can also furnish 105mm reductions and enlargements of your drawings as a service. For complete information, call your K&E dealer, or write to Keuffel & Esser Co., Dept. SA-4, 300 Adams St., Hoboken, N. J.



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How Reptiles Regulate Their Body Temperature

Although they lack internal controls, they can maintain a high temperature by their behavior. A lizard, for example, can raise its temperature by changing the position of its body in the sun

by Charles M. Bogert

More than 50 years ago Sir Charles Martin, a distinguished British physiologist, compared the regulation of body temperature in a number of mammals with that of a lizard. He showed that the mammals were able to maintain their temperatures within a fairly narrow range during wide variations in the temperature of the laboratory environment. The temperature of the lizard, on the other hand, rose and fell almost as rapidly as that of the environment. Observations of this sort long ago established the textbook aphorism to the effect that "reptiles have the temperature of the surrounding atmosphere."

It is true that reptiles are "cold-blooded" animals and have no mechanism of temperature regulation such as that of

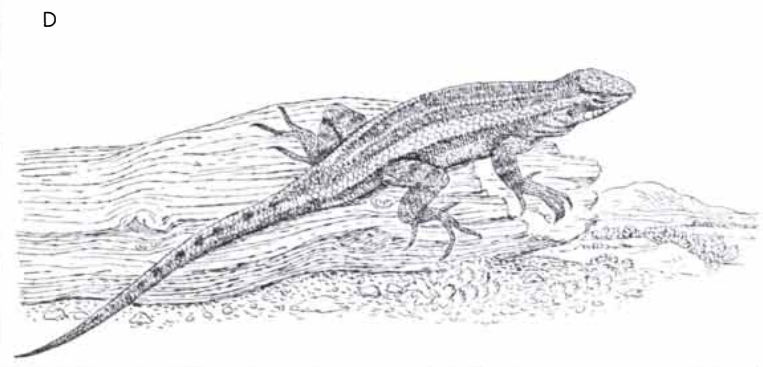
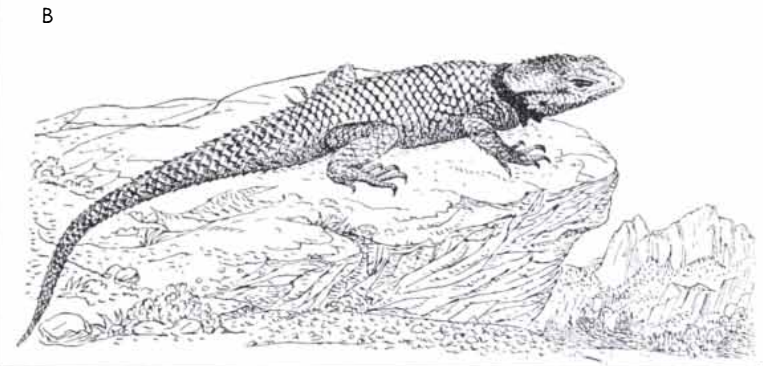
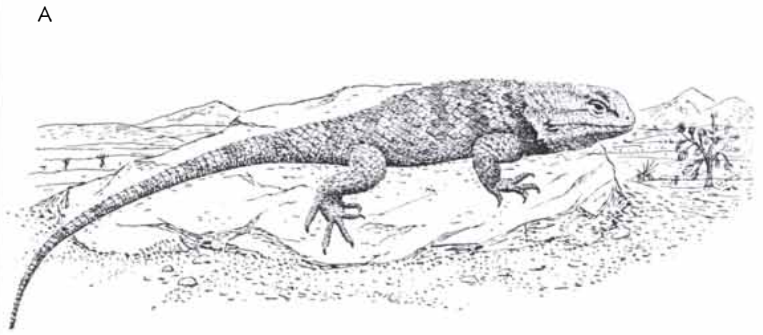
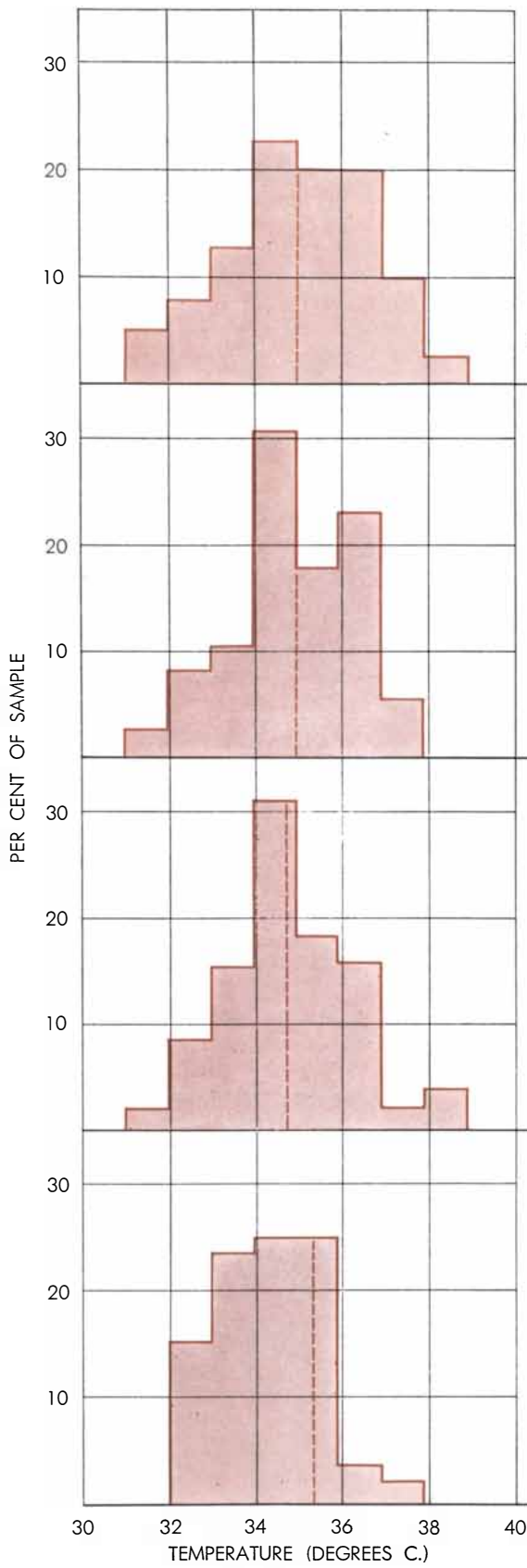
mammals. The laboratory observations correctly reflect what happens to a lizard's body temperature when the laboratory temperature is changed. But the conclusion drawn from these observations holds true only for the lizard in the laboratory. In their natural habitats during the day, lizards forage, mate, defend territories and flee at body temperatures that may be even higher than our own, and they maintain their temperatures within narrow limits despite wide variation in air temperature. The greater earless lizard (*Holbrookia texana*), an inhabitant of the foothills of the U. S. Southwest, has a mean temperature of 101.3 degrees Fahrenheit (38.5 degrees centigrade), slightly above our own, and while the lizard is active its temperature is within 3.3 de-

grees of this level 75 per cent of the time. At 14,600 feet in the Peruvian Andes, with the temperature of the thin air at the freezing point, Oliver P. Pearson of the University of California found that the lizard *Liolaemus multi-formis* had a body temperature of 87.8 degrees F. (31 degrees C.); at temperatures as much as eight degrees below freezing he found other lizards abroad, a trifle sluggish, with body temperatures of 58 degrees (14.4 degrees C.), or 34 degrees above the temperature of the air. In my own studies over the past 14 years I have measured the temperatures of lizards of many different North American species. I have found that members of the same or closely related species show the same high and constant temperature in widely different



CHUCKWALLA (*Sauromalus obesus*) is found in deserts of the southwestern states. When this lizard cannot take shelter from the sun, it pants to cool itself by the evaporation of moisture from its

lungs and places itself parallel to the sun's rays in order to expose a minimum of body surface to the radiant heat. This animal was photographed at three o'clock in the afternoon on a clear day.



TEMPERATURES OF SPINY LIZARDS of four species were tested by the author, who sampled 39 or more active animals of each kind in their native habitats. In each species the average tem-

perature (broken line) fell close to 35 degrees C. (95 degrees F.). The lizards tested were *Sceloporus magister* (A), *Sceloporus jarrovi* (B), *Sceloporus undulatus* (C), *Sceloporus variabilis* (D).

environments, although members of distantly related species maintain distinctly different mean temperatures in the same environment.

Why were the laboratory observations so misleading? For much the same reason that a man with a heavy iron ball chained to one leg cannot demonstrate how fast he can run! The analogy is to the point, because lizards regulate their temperatures to a large degree by their behavior. Many of these creatures are "heliotherms," deriving the heat they need to energize their body chemistry directly from the sun. In consequence of this dependence they have developed basking to a fine art. Lizards do not merely crawl out of their nocturnal shelter and rest in the sunlight. When their temperatures are below the threshold for normal activity, they orient their bodies at right angles to the sun's rays in order to maximize their exposure and even seek inclined surfaces to achieve such orientation with respect to the slanting rays of the morning sun. In the desert, where the ground becomes warmer than the air, lizards often press their bodies close to the surface, shifting slowly from side to side in the loose sand to secure better conduction of heat. On a rocky mountainside that warms up more slowly, they do their basking on mats of dead grass that insulate them from the cold ground. When a lizard's temperature approaches the upper limit of tolerance, on the other hand, it faces the sun, exposing the least possible surface, or returns to cooler temperatures in the shade or underground.

The size and shape of their bodies and the pigmentation of their skins play a part in determining and regulating the rate at which lizards absorb heat from their surroundings. But the decisive factor is behavior. In the artificial situation of the laboratory the lizard could not show what it can do.

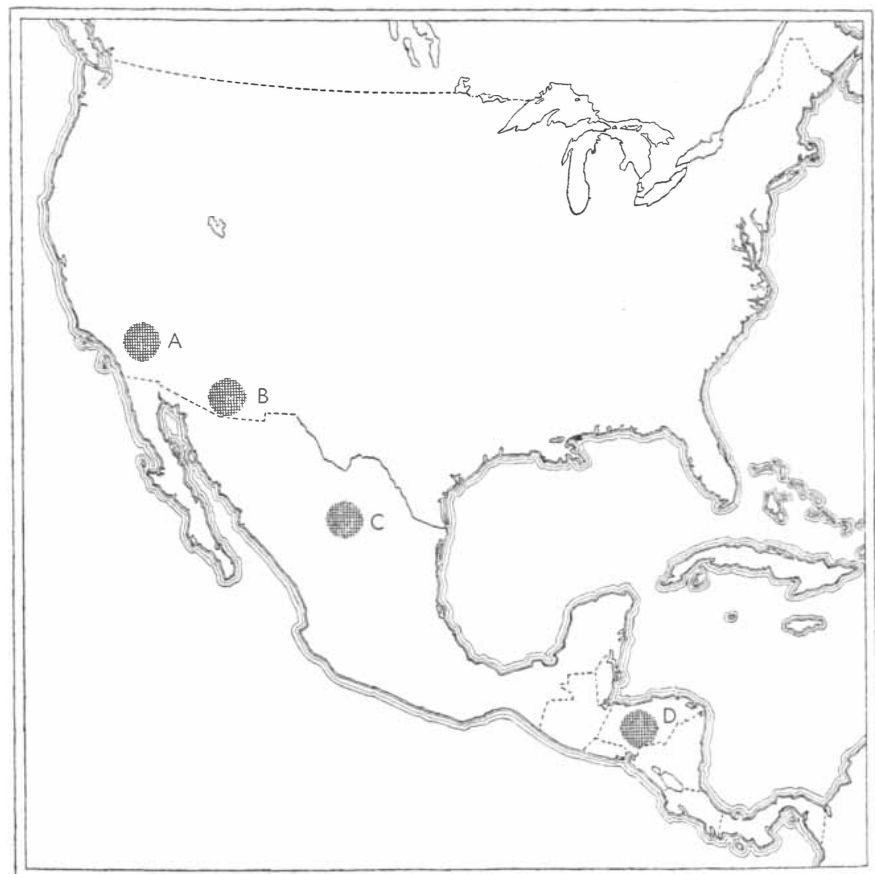
When our department at the American Museum of Natural History and R. B. Cowles of the University of California at Los Angeles undertook to study heat regulation in reptiles, we had a general understanding of the factors involved. We expected to find, however, that temperature tolerances played an important part in determining the distribution of species and that the various species would show different optimal body temperatures in their various environments. In framing these assumptions, it turned out, we underestimated the efficiency of our subjects' heat-regulating behavior and equipment.

We chose the spiny lizards as our subjects, because their 50 species are abundant all over North America, from coast to coast and from southern Canada to Panama. Few groups of lizards have penetrated more environments. As many as five species may occur in a single locality, each in its own ecological niche. Some live on the ground, others on trees or shrubs; they variously frequent rocky hillsides, canyon walls, sand dunes, grassy plains and even human habitations. We sought them out in coastal areas, foothills, plateaus and mountains; in arid regions with little vegetation; in pine barrens, short-tree forests, pine forests and high-altitude cloud forests. We made our measurements in habitats ranging from sea level to near the timber line at 12,500 feet on the Nevado de Toluca in Mexico.

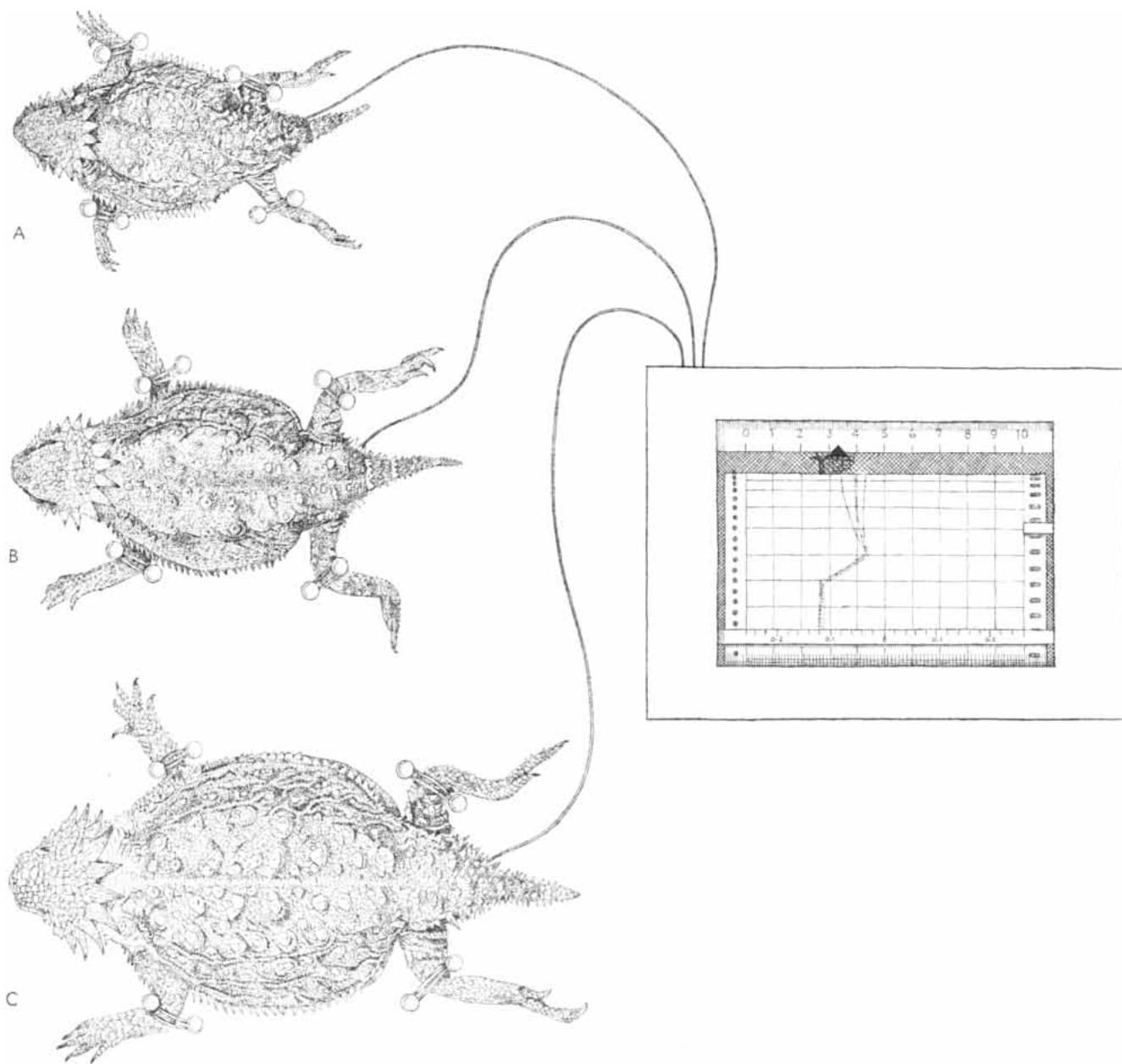
In all of this diversity of habitat, to our surprise, measurements indicate that spiny lizards go about their active lives at a mean body temperature of about 93 degrees (34 degrees C.). This approximates the average for all species, but does not imply that spiny lizards

have no leeway in temperature. They function at apparently full efficiency with body temperatures between 86 and 104 degrees (30 and 40 degrees C.). In their natural environments, however, these extremes are exceptional. Once their basking has brought them to the temperature threshold at which activity begins, spiny lizards maintain their body temperatures within 4.5 degrees of the 93-degree mean for about 80 per cent of the time and over the entire range of environmental temperature to which they voluntarily subject themselves during their daily routine.

These lizards regulate their heat intake largely by exposing themselves to direct sunlight, prolonging their forays by suitably orienting their bodies to the sun much as they do when basking, or by retreating from the sunlight when their temperatures run high. Comparisons of the temperature curves of various spiny lizards reveal only minor differences between species. Most of the peaks fall near the 93-degree average for the group. For species living in the tropical lowlands of Mexico and Honduras,



HABITATS of the lizards shown on the opposite page are marked with the corresponding letters on this map. They are (A) the Mojave Desert of California, elevation 3,000 to 4,000 feet; (B) the Chiricahua Mountains of Arizona, elevation 5,000 to 9,000 feet; (C) La Goma, Durango, Mexico, elevation 4,000 feet; (D) El Zamorano, Honduras, 2,600 to 3,000 feet.



REGAL HORNED LIZARDS (*Phrynosoma solare*) weighing respectively 12.4 grams (A), 29.4 grams (B) and 85.5 grams (C) were exposed to the midday sun while their body temperatures were

continuously measured by means of wires from the cloaca of each to a recording potentiometer. The colors of the lizards were nearly the same at start but then changed, smallest lizard becoming palest.

the curves shift scarcely three or four degrees toward the warmer end of the scale. For those in higher mountains, the shift is two or three degrees toward the lower end of the scale.

We do not know whether such slight differences result from variations in the physiological adaptation of the animals or from the limitations of behavioral regulation. We sometimes lose sight of the fact that temperature refers to the amount of heat per unit of mass, or the degree of heat concentration, as measured on one scale or another. Optimum heat concentrations for biological processes, however, lie not at points but

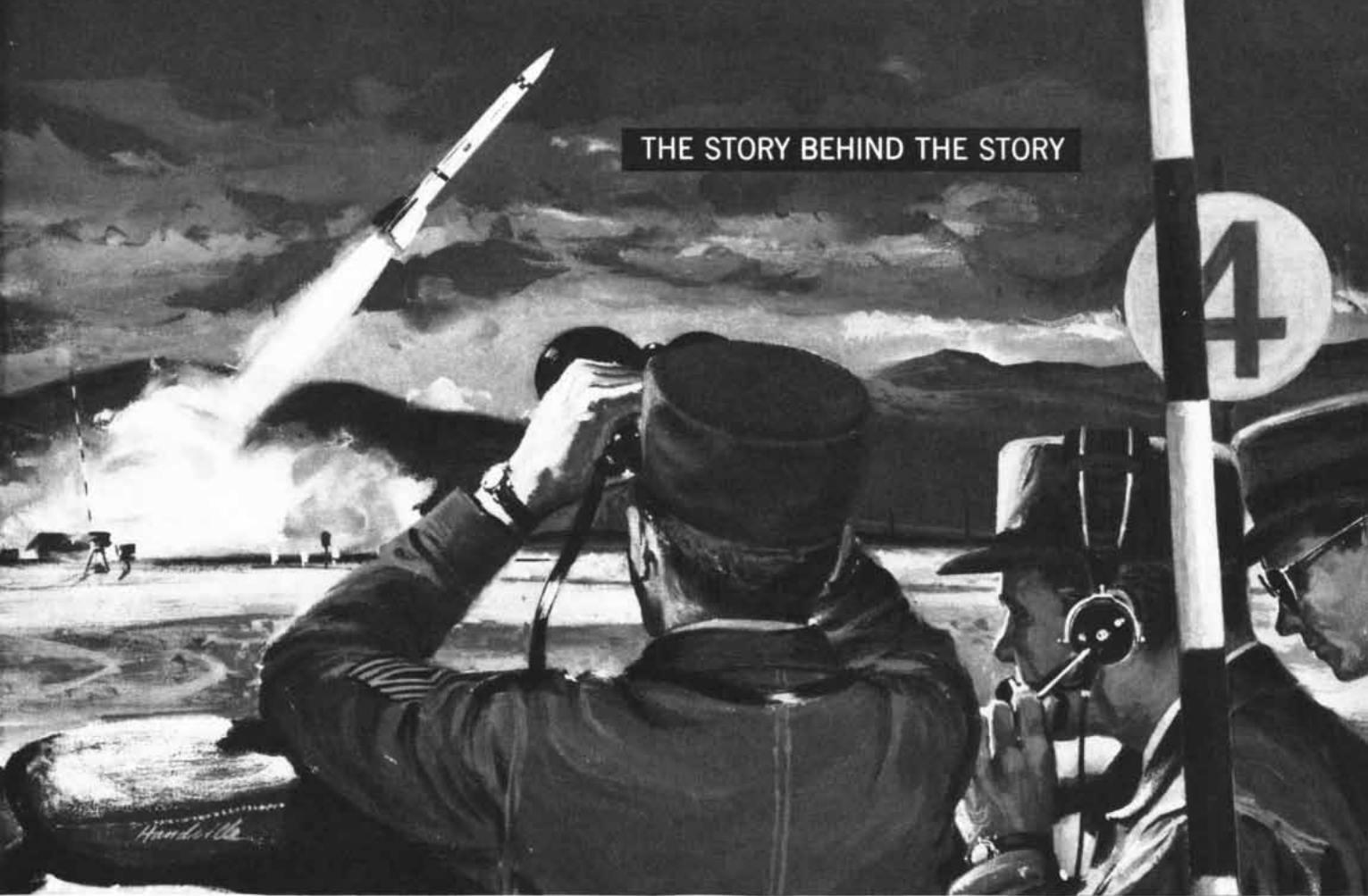
within zones on the scale. The "normal temperature" of human beings is actually an average for a zone between limits set roughly at 98 to 99.5 degrees (37 to 37.5 degrees C.). Hence the differences observed between the mean temperatures of the spiny lizard in different environments may still lie within the zone of optimum temperature for their biological activity.

In the Arizona desert the air temperatures recorded at sites of capture averaged 90 degrees (32.2 degrees C.); the temperature of the spiny lizards averaged 95 degrees (35 degrees C.). In contrast, the average body temperature of cloud-forest lizards is 91 degrees

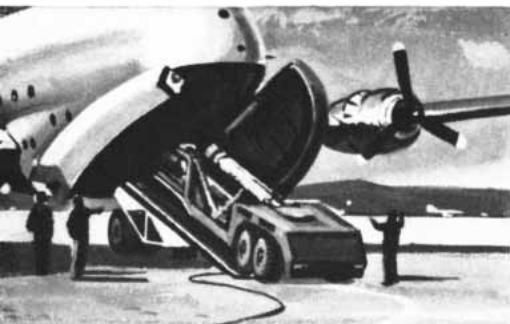
(32.8 degrees C.) when the air around them averages 66 degrees. The greater differential between air and body temperature in the case of the cloud-forest lizard should accelerate the loss of heat to the air. Nevertheless the lizards absorb enough solar heat to compensate for these losses and thus keep their body temperature within the zone permitting them to be active.

So, we learned, spiny lizards do not have different body temperatures reflecting different physiological adaptation to different environmental temperatures. Instead these reptiles restrict the fluctuation of their body temperature to a relatively narrow zone suitable to the

THE STORY BEHIND THE STORY



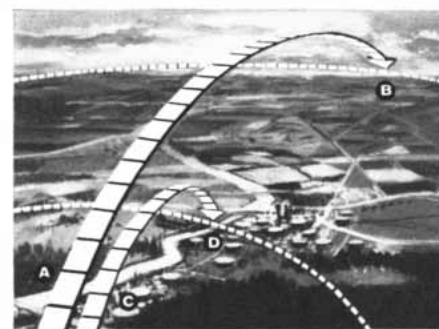
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SPERRY

NO MONDAY

MORNING

QUARTERBACK



: * * * * *

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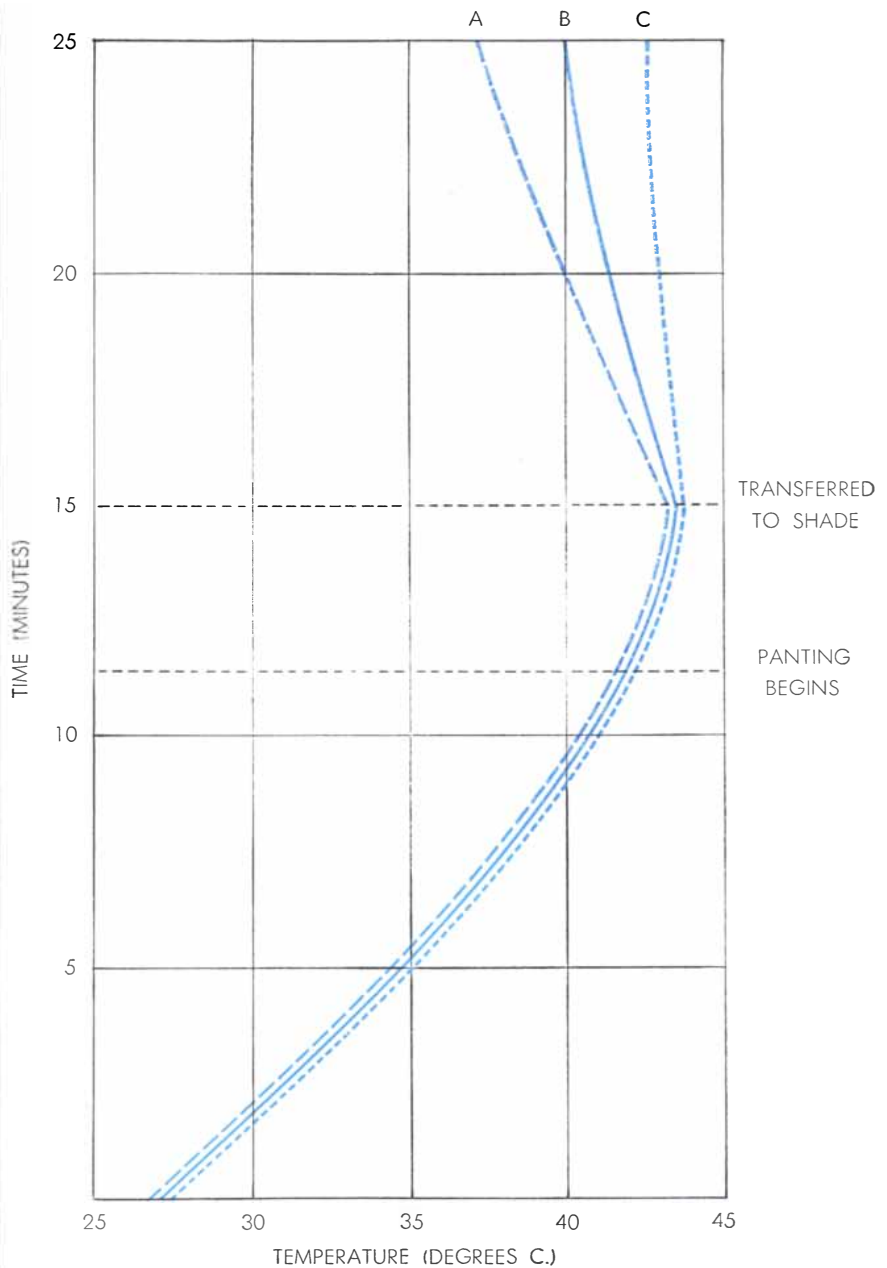
At Grumman, the signals that were called years ago have won design competitions: the A2F, a carrier-based attack fighter; the Mohawk, a twin turboprop higher-performance observation airplane for the Army; and the Eagle, an air-to-air and air-to-ground missile.

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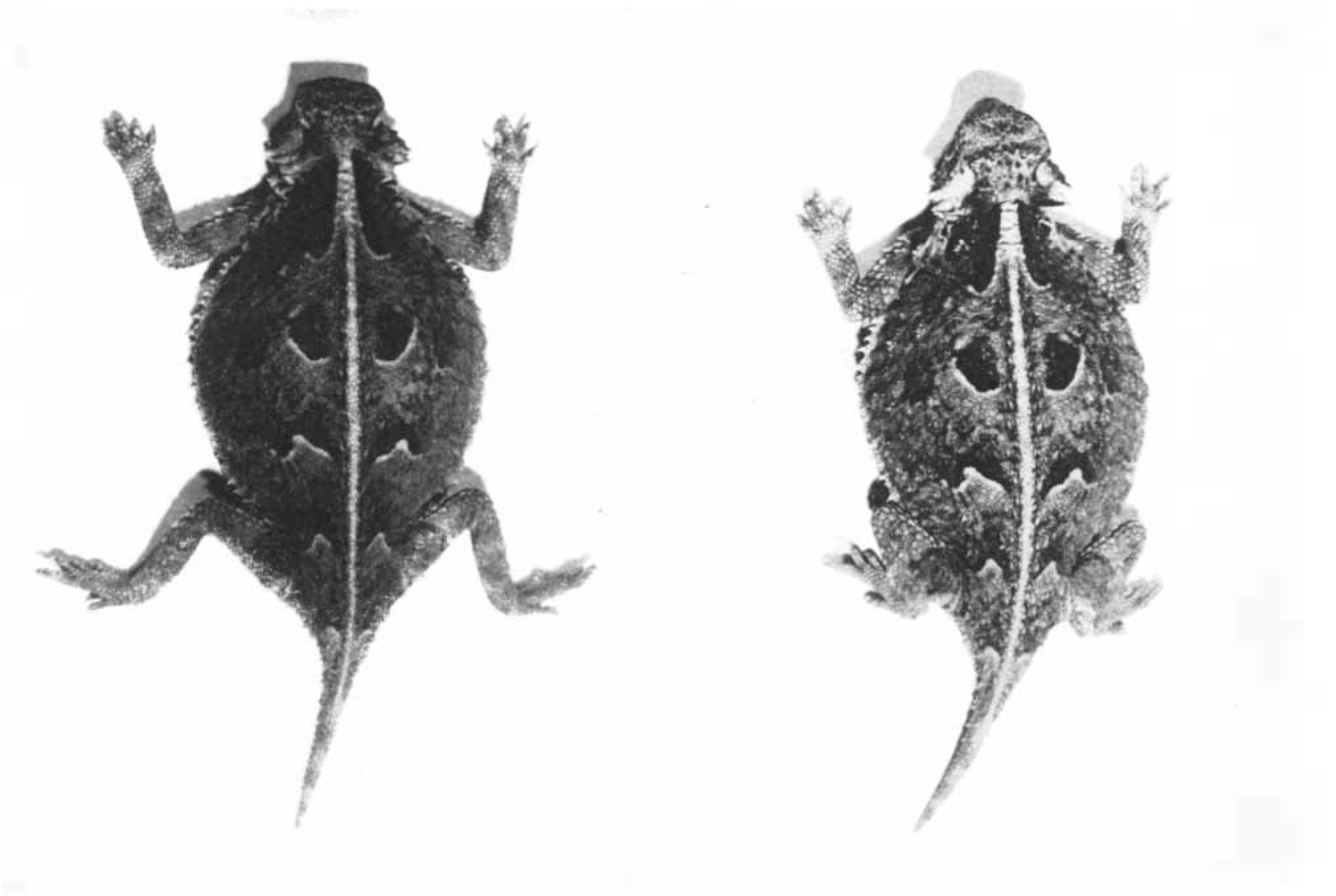
In current production: F11F-1 Tiger, supersonic jet fighter; F9F-8T Jet Trainer; S2F, carrier-based anti-submarine aircraft; WF-2, carrier-based early-warning aircraft; SA-16 Albatross, rescue amphibian; Gulfstream, turboprop executive transport; AO-1AF Mohawk for the Army; Ag-Cat duster-sprayer.



TEMPERATURE CURVES of the three lizards in the experiment depicted on page 108 were virtually identical as the animals absorbed heat. The smaller animals lightened in color, which aided the absorption of heat and compensated for their smaller ratio of surface to mass. Actually the lines on the chart were nearly superimposed. They were separated by transferring the smallest lizard (A) to the shade, while the next largest lizard (B) had only its head in the sun and the largest lizard (C) had its head and half its body in the sun.

similar physiological needs of all species. Probably the optimum zone for activity in spiny lizards is an ancestral trait. If so, their physiological adaptation became stabilized for a narrow zone centering around 93 degrees early in the evolution of the stock. The subsequent diversification and dispersal of the stock is largely a history of changes in such characteristics as size, shape, pigmentation and basking behavior, as species after species became adapted for survival under various combinations of environmental conditions.

From one standpoint the evolution of the spiny lizard, as a minor current in the broad stream of evolution, followed the course of least resistance. Once the delicate equilibrium of its physiological processes had been established in a particular zone of temperature, any adaptation to lower internal temperatures would have entailed revision of the whole complex system. The lizard's behavior, on the other hand, provided the necessary leeway to permit it to invade different environments successfully. There, under the pressure of selection,



TEXAS HORNED LIZARD, like the regal horned lizard, has the ability to change the color of its skin. When its body temperature

is low, the animal is quite dark (left), but the same animal becomes paler (right) after it has been exposed to higher temperatures.

the various species developed adaptations in pigmentation and other physical characteristics associated with the regulation of body heat.

Spiny lizards are not the only lizards whose normal physiological activity is restricted to a narrow zone of temperature characteristic of the group as a whole. Other groups exhibit a similar identity. The whip-tailed lizards (*Cnemidophorus*), with species widely distributed in North, Central and South America, are active at body temperatures in a zone higher on the scale. They maintain a mean temperature close to 104 or 106 degrees (40 or 41 degrees C.), with no significant difference between the temperatures of populations in climates and landscapes as widely different as Arizona, Florida and Honduras.

Whip-tailed and spiny lizards often occur side by side in the same habitat. Invariably they show an average difference of 10 or 12 degrees between the means of their respective ranges in temperature, even though the identical sources of external heat are available to both. This alone is evidence of the effectiveness of behavioral control of

heat intake and dissipation, augmented by pigmentation and enhanced by adaptation in structure.

This interaction of structure and behavior makes it difficult to design experiments testing one or another of the reptile's temperature-regulating attributes. Unquestionably size is subject to adaptive changes. Whenever we compare adequate samples from various portions of the range of a widely distributed reptile, we nearly always find that the average size of adults in one area is larger than that of adults in another area. Often the trend in size parallels the trend in climate, with the larger animals restricted to warmer areas or to regions with longer growing-seasons. Such correlations are suggestive, but without experimental evidence we cannot be certain that heat and size are directly related. The length or bulk of a reptile may be governed by such other variables as the food supply or gene combinations.

The problem of evaluating the adaptive significance of size is not simplified by the existence of adults and young of the same species in the same environ-

ments at the same time. In the desert-dwelling whip-tailed lizard (*Cnemidophorus tigris*) we found that juveniles of the species, weighing two or three grams, keep their bodies at mean temperatures identical with those of adults weighing up to 16 grams. However, we found a difference between adults and juveniles when we recorded the daily variation of their temperatures. The smaller lizards restrict their temperature fluctuations to a narrow zone of five or six degrees, while the activity zones in adults range over 10 or 11 degrees, from 99 to 110 degrees (37.2 to 43.3 degrees C.). The juveniles may be more responsive to heat and so may adjust their exposure more sensitively, or their body temperature may adjust more quickly by virtue of their smaller bulk.

Other things being equal, the temperature of a smaller lizard should rise or fall faster because it has more surface in proportion to its mass. In the first rough experiment we performed to test the validity of this generalization from the physics of inanimate objects, however, we discovered how important "other things" can be if they are not equal. Our subjects were adult speci-

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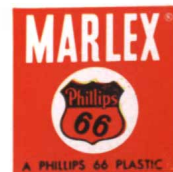
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a report by LINDSAY

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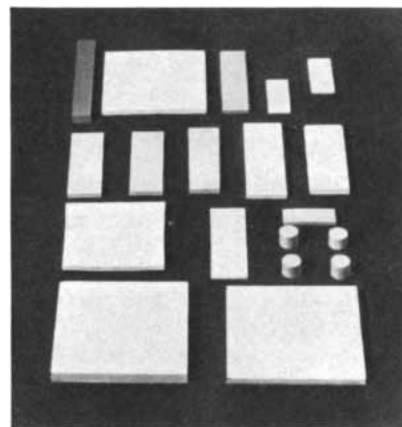
Rare earth garnets for electronic equipment are structurally somewhat similar to the garnet variety grossularite (formula $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$). The most interesting ones are the rare earth-iron garnets such as $\text{Y}_3\text{Fe}_2(\text{FeO}_4)_3$. This mouthful of formula has been abbreviated by researchers to "YIG" for obvious reasons. Other names stem from other rare-earth symbols. These garnets, particularly those of yttrium, gadolinium, erbium, and some others have interesting ferrimagnetic properties, making them useful as ferrite materials in electronic equipment.

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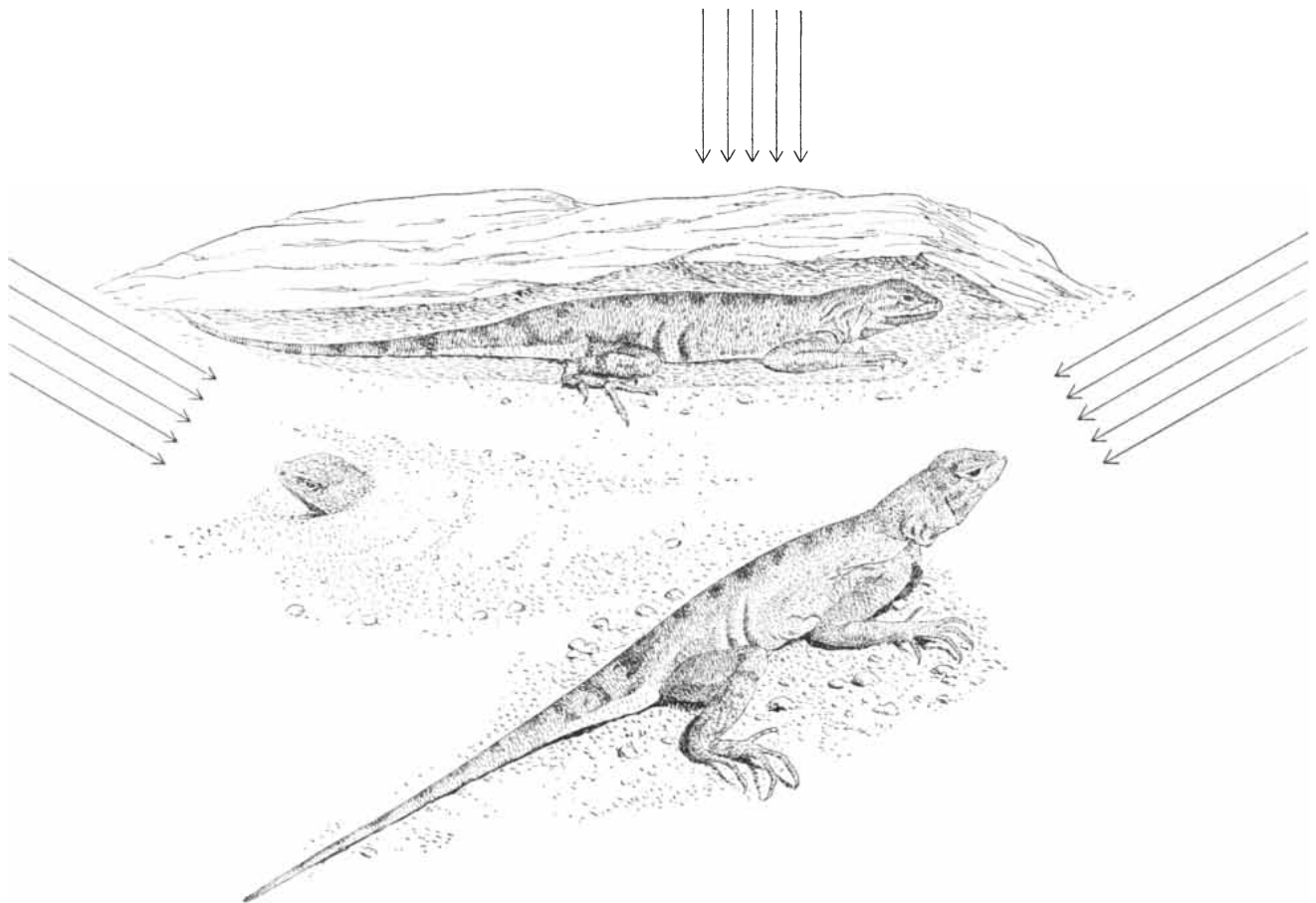
mens of two species of spiny lizard. The larger of the two was a green spiny lizard (*Sceloporus formosus*), a species restricted to open areas in moist forests of broad-leaved trees at elevations above 5,000 feet in central Honduras; its green skin is marked with black pigment sparsely distributed in a reticulated pattern of lines and smaller blotches. The other was a much smaller, slate-colored spiny lizard (*Sceloporus variabilis*) that lives at elevations up to 3,000 feet in the arid valleys below the cloud forests on the mountain summits. In their very different environments the two species keep nearly the same average body temperature.

Though our two specimens had roughly the same bodily proportions, the greenish one, weighing 27.8 grams, had four times the bulk of the other, which weighed only 6.9 grams. The temperature of both lizards was 77 degrees (25 degrees C.) when they were placed in full sunlight with the air temperature at about 90 degrees. Temperatures were recorded at intervals of three minutes. During the first nine minutes the body temperature of the larger lizard lagged

less than a degree behind that of the smaller lizard. But after 12 minutes the temperature of the larger lizard rose slightly above that of the smaller. At the conclusion of the experiment, after 18 minutes, the temperature of the larger lizard was 109 degrees (43 degrees C.), and that of the smaller was 108.7 degrees (42.6 degrees C.). If the two lizards had absorbed heat at rates predicated solely on their weight, the heavier should have required approximately 10 more minutes to reach the temperature attained by the smaller animal in 18 minutes. Though inexact, the results of our simple experiment suggest that the cloud-forest lizard is better equipped, figuratively, "to make hay while the sun shines." Because the pigments in its skin absorb heat so rapidly, it can attain its threshold temperature quickly enough and often enough during the year to permit it to forage and fuel itself.

We suspected that the outcome of this experiment may have been influenced by changes in the pigmentation of one or the other reptile in the course of the experiment. To find out how im-

portant such changes are in regulating the absorption of heat we performed an experiment with individuals of different weights but belonging to the same species. This time we used regal horned lizards (*Phrynosoma solare*) weighing respectively 12.4, 29.4 and 85.5 grams. The experiment was conducted in August on a clear day, with no wind, in the foothills of the Chiricahua Mountains in Arizona. The body temperature of each lizard was 80 degrees (27 degrees C.) at the start of the experiment; within 15 minutes their temperatures simultaneously reached 109 degrees (43 degrees C.), with the curves on the recording instrument indicating that they had risen at a virtually identical rate. About halfway through the experiment the temperature of the smallest lizard ran a degree ahead of the others, but shifted back to the curves being plotted for the other two, as though some mechanism were regulating the rate of heat absorption. This proved to be the case. Although the three lizards were not conspicuously different in color at the beginning of the experiment, we could discern distinct differences at



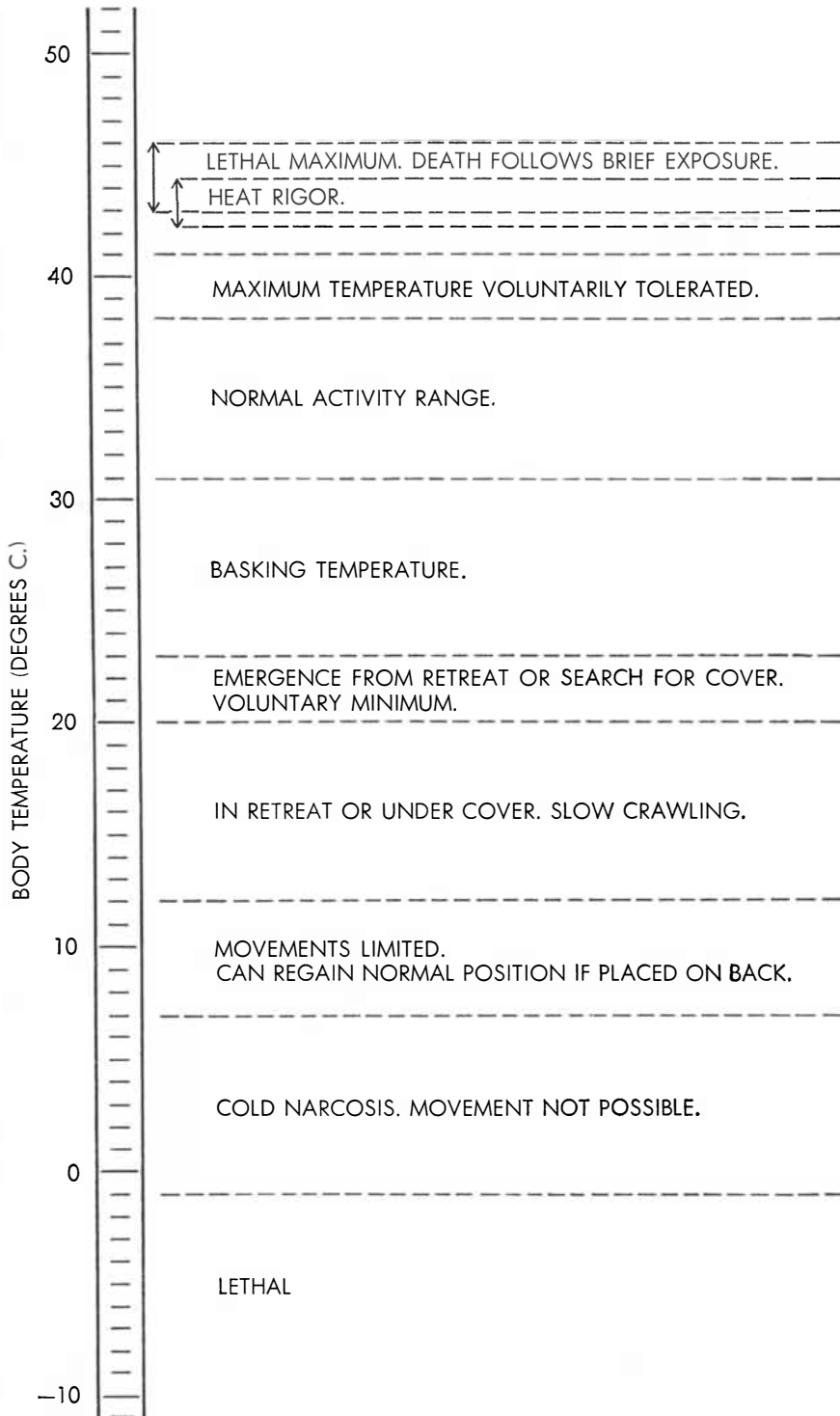
EARLESS LIZARD of the Southwest regulates its temperature within narrow limits by means of its behavior. The morning sun (arrows at left) warms the blood in the animal's head while the

rest of it remains hidden in the sand until it is warm enough to be active. At noon (top) the lizard seeks shelter from the hot sun, but later it emerges and lies parallel to the sun's rays (bottom).

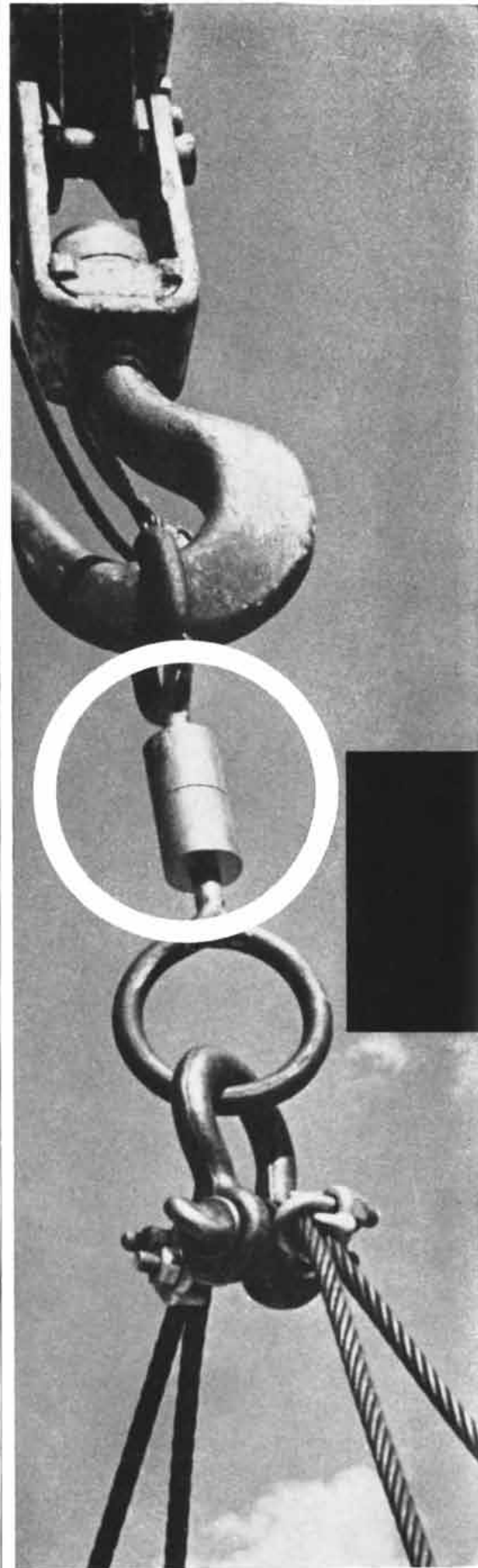
the conclusion. The largest lizard was the darkest of the three, and the smallest lizard the palest.

While their broadly flattened bodies are adapted for the rapid absorption of heat, it is apparent that horned lizards are equally well equipped by pigmentation to regulate the rate at which they

absorb heat. The black-pigmented cells, or melanophores, of their skin expand laterally when the animal is cold, thus darkening the body and increasing the rate at which it absorbs radiant energy. When the body is warm, the same cells contract, thereby exposing light pigments in adjacent cells that reflect infra-



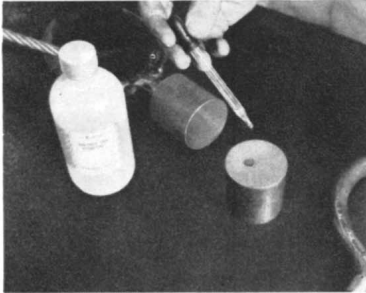
SIGNIFICANCE OF BODY TEMPERATURE to the behavior of reptiles is indicated by this chart giving the approximate temperatures for various activities of spiny lizards. The effects of exposure to heat levels near the extremes depend on duration. Even temperatures near the upper limit for the lizards' normal activity become lethal if exposure is prolonged.



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red radiation. To match such efficiency we would need a mechanism that automatically exchanged our dark winter clothing for white linens with the advent of hot weather.

There appears to be an upper limit of bulk beyond which behavioral and physiological adaptations can no longer secure adequate regulation of a reptile's internal body heat. At the Archbold Biological Station in Florida, E. H. Colbert, R. B. Cowles and I conducted a suggestive experiment with a five-foot, 30-pound alligator as the subject. We found that it took the summer sun 7.5 minutes to increase the animal's temperature by two degrees. To see what this signifies for large reptiles, let us consider the plight of a 10-ton dinosaur under the same circumstances. This creature would have to bask in a blazing sun for more than an hour to elevate its body temperature to the same extent. Suppose our hypothetical dinosaur were active in daytime, and subject to cooling at night, as it would be in any desert region today. If its temperature dropped even four or five degrees below its threshold for activity, the dinosaur would have to bask for a large part of the following day in order to regain the threshold temperature of activity. The odds favor the deduction that dinosaurs, at least the larger ones, lived under fairly constant environmental temperatures. This is an important piece of evidence favoring the conclusion that the earth's climate was once quite uniformly tropical, for the distribution of fossils shows that the large dinosaurs roamed the earth far beyond the borders of the modern tropics.

All the truly large reptiles still abroad in the world today—pythons in Asia as long as 33 feet, anacondas in South America as long as 28 feet, monitor lizards in Indonesia as long as 10 feet, crocodilians in the Americas as long as 23 feet and tortoises in the Galápagos Islands weighing more than 500 pounds—are residents of the tropics. The only exception is the enormous leatherback turtle *Dermochelys*, which is known to reach and possibly to exceed 1,500 pounds and is perhaps the largest living reptile. But this creature is protected by the constant warmth of its oceanic environment. The occasional specimen that turns up on the coast of Nova Scotia is probably carried there by the Gulf Stream.

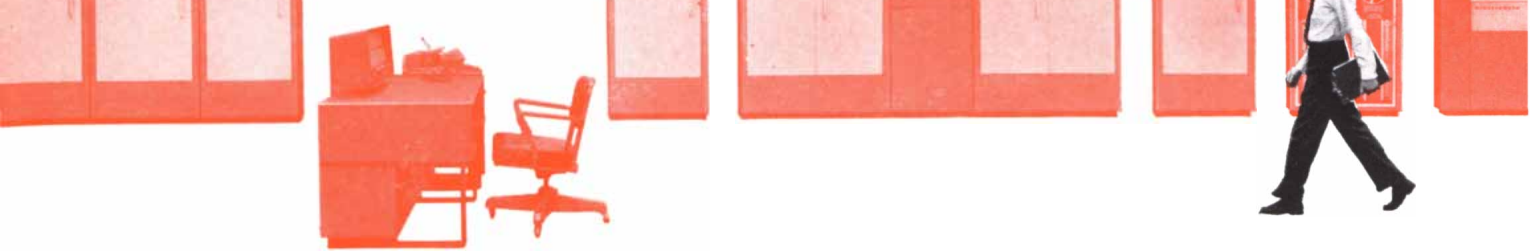
In general the tropics afford stable temperatures that fluctuate in the narrow and comfortable range from 68 to 86 degrees year in and year out. The

hottest places on earth are found not in the tropics but in the desert regions of the zones so inappropriately called "temperate." In winter these same deserts may be bitterly cold, and the daily fluctuation in temperature throughout the year far exceeds any encountered in the tropics. The night temperature of a tropical forest may drop only a few degrees below that of the day. Thus none of the large reptiles is ever exposed to either the freezing or the high temperatures encountered by reptiles in the middle-latitude deserts.

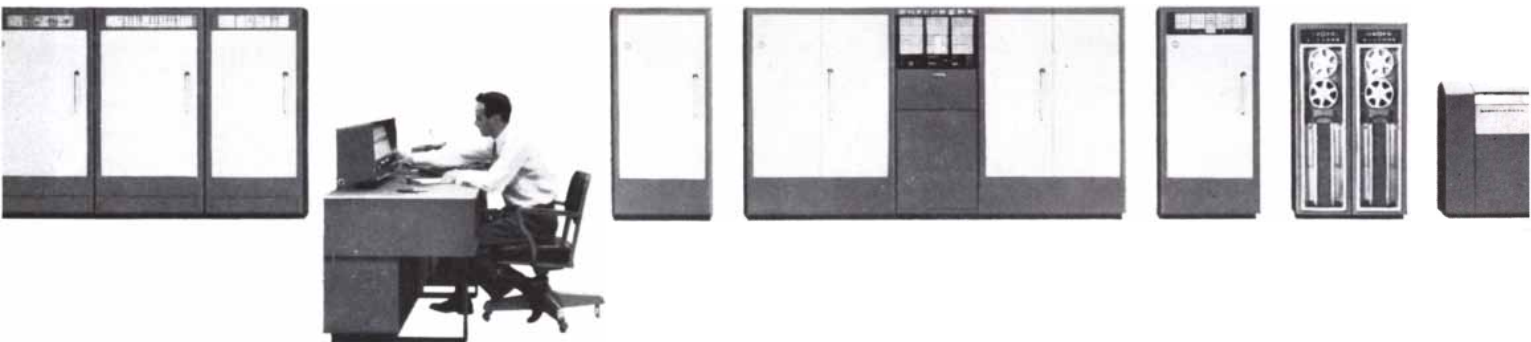
The green iguana (*Iguana iguana*), the largest lizard found on the American continent, illustrates the dependence of large reptiles on the constancy of the tropical temperature-environment. This animal, widely distributed in the lowlands of Latin America, reaches a length of at least 5.5 feet and a weight of 13 pounds. In a population we studied on the west coast of Mexico we found that the body temperature of the green iguana fluctuates much more than smaller lizards living in the same area or in the deserts 700 miles to the north. Green iguanas spend virtually all of their time high up in the crowns of large trees, feeding on leaves, buds or fruits during the day, and sleeping at night with only branches or foliage to conceal them from predators and to protect them from heat loss. They evidently do some basking; we found that the temperatures of nearly 50 iguanas were 10 to 15 degrees above the level of the air. But it is doubtful that there has ever been sufficient stress from heat fluctuations in the environment of the green iguana to induce adaptive changes in its behavior.

We had an opportunity to test this supposition by exposing several green iguanas to summer conditions in the desert. Instead of fleeing from the heat of direct sunlight, as any reptile native to the desert would have done, they literally sat in the sun until they died. The increase in their body temperatures was slowed a little by respiratory cooling when their breathing turned to panting, but this merely prolonged their discomfort before breathing stopped. Green iguanas are equally unprepared for exposure to low temperatures. One specimen at the San Diego Zoo had to be moved indoors overnight because it showed no disposition to seek shelter of its own accord. However, one evening preceding a cold snap the creature chanced to be overlooked. Next morning it was found in a state of cold narcosis, suspended by a single claw accidentally hooked to a twig.

Considering that all reptiles would be



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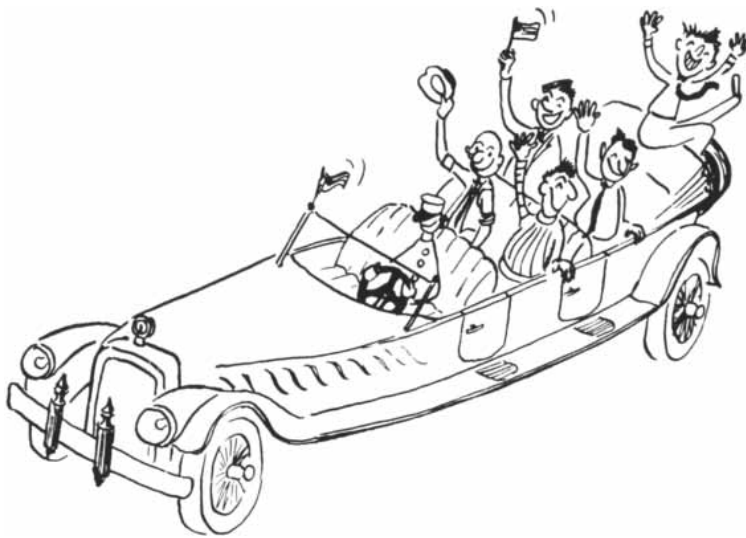


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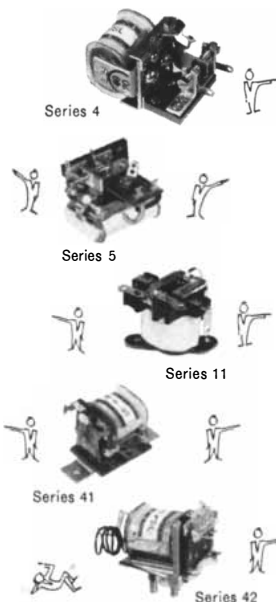
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just about equally vulnerable to cold and heat were it not for their behavioral adaptations, it is remarkable that so many lizard species are established in the temperate zone. It should be noted that snakes and turtles also have adapted themselves by much the same means to survive in rigorous climates. Snakes in particular have gotten around the surface-to-mass limitation by the lengthening of their bodies, which exposes more surface per unit of mass to absorb solar energy. In Canada snakes outnumber lizards and turtles combined, and in Europe one viper (*Vipera berus*) has penetrated to regions within the Arctic Circle. However, one European lizard (*Lacerta vivipara*) ranges even farther to the north, farther from the Equator than any other living reptile.

In common with the majority of reptiles near the northern limit of their distribution, both the snake and the lizard give birth to living young. Some snakes and lizards transfer nutrients and oxygen from maternal blood to the developing embryo by means of mammal-like placental structures. Most of these live-bearing reptiles, however, incubate the eggs within the body of the female, where behavioral regulation of temperatures keeps the eggs at heat levels within the optimum zone for development. Such modification of the reproductive pattern, peculiar to lizards and snakes, gives them a leeway in dispersal not open to turtles and crocodilians. Snakes and lizards are accordingly the most widely distributed reptiles, with lizards having a slight edge in number of species. Of the two groups it is the lizard that best exemplifies the complexity of adaptations involving the coordination of structure, physiology and behavior in response to the interplay of selective forces in the environment.

Perhaps the most amazing behavioral adaptation is that of the earless lizard, which is almost never found abroad with its body temperature below 96 degrees. We exposed its secret only by observing what it did in a laboratory cage provided with sources of radiant heat. From its overnight retreat, submerged in the sand, the earless lizard first thrusts its inconspicuous head above the surface; there it waits until the blood coursing through a large sinus in its head has absorbed enough heat from the sunlight to raise the temperature of its entire body. When its temperature is well above the threshold for efficient activity, this wary reptile emerges from the sand, preheated and ready to take off at top speed.



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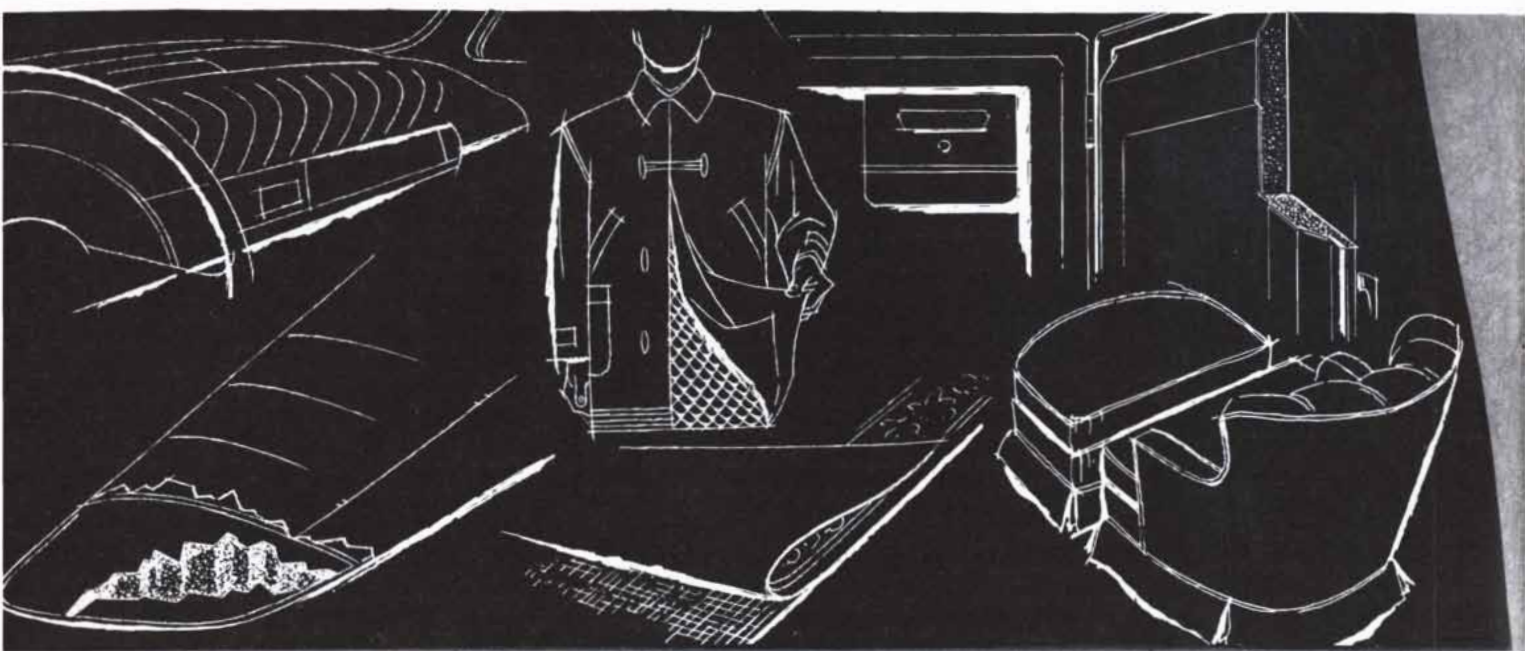
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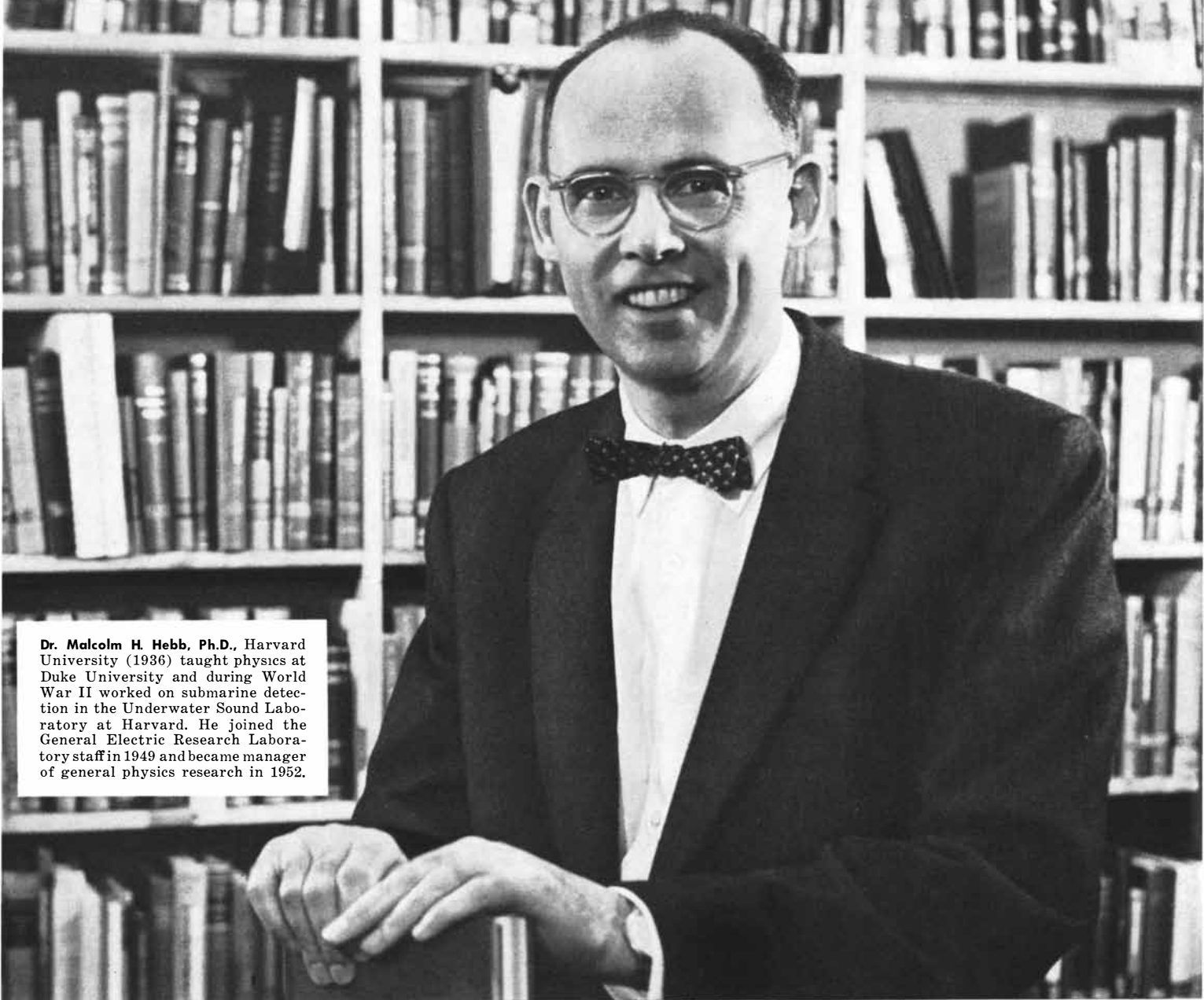
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Dr. Malcolm H. Hebb, Ph.D., Harvard University (1936) taught physics at Duke University and during World War II worked on submarine detection in the Underwater Sound Laboratory at Harvard. He joined the General Electric Research Laboratory staff in 1949 and became manager of general physics research in 1952.

Freedom of inquiry

General Electric's Dr. Malcolm H. Hebb discusses programed and unprogramed research

Scientists in the *General Physics Research Department* at the General Electric Research Laboratory are engaged in fundamental studies of semiconduction phenomena, the generation of light, the behavior of arcs, and a variety of other fields. Making certain that these men and women have the tools, the incentives, and the freedom to seek out new knowledge is the particular concern of the department's manager, Dr. Malcolm H. Hebb.

Recently Dr. Hebb said: "Freedom of inquiry is the very essence of research. Conceivably, there are two idealized approaches to industrial research. On the one hand, the work may be carried out on a strictly *programmatic* basis, in which all of the effort is aimed directly at fulfilling immediate needs. In this ap-

proach, the horizons of tomorrow are limited by the viewpoint of today. At the opposite extreme is completely *unprogramed* research carried out in the hope that the results may somehow prove useful.

"The practical course lies somewhere between these two extremes. Actually, emphasis may shift from time to time, either from necessity or to take advantage of special opportunity. In a research program aimed at opening up virgin territory, to deny freedom of inquiry is to slam the door on discovery."

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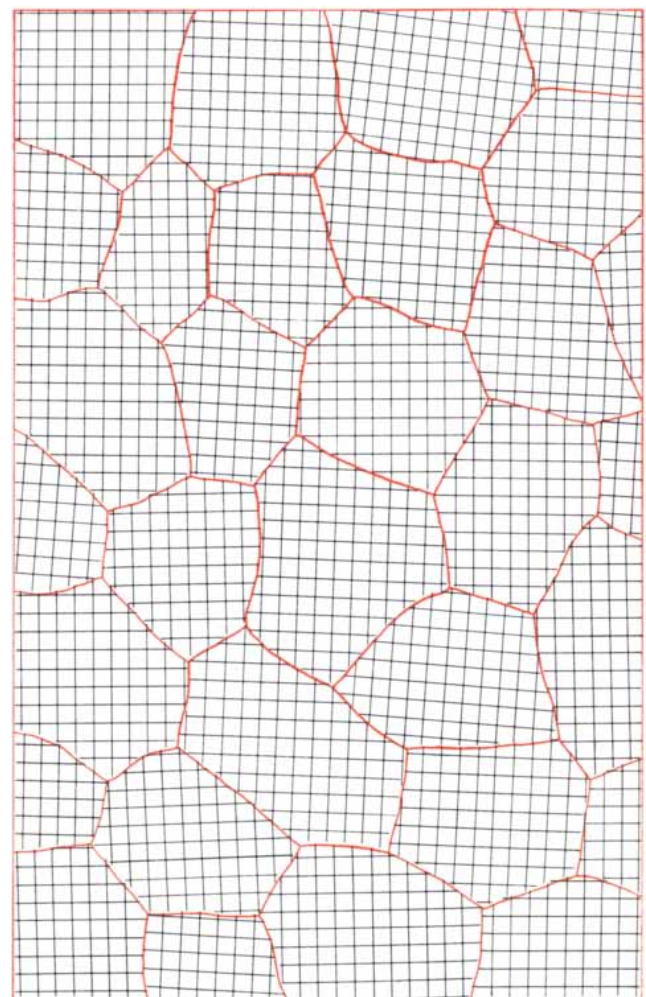
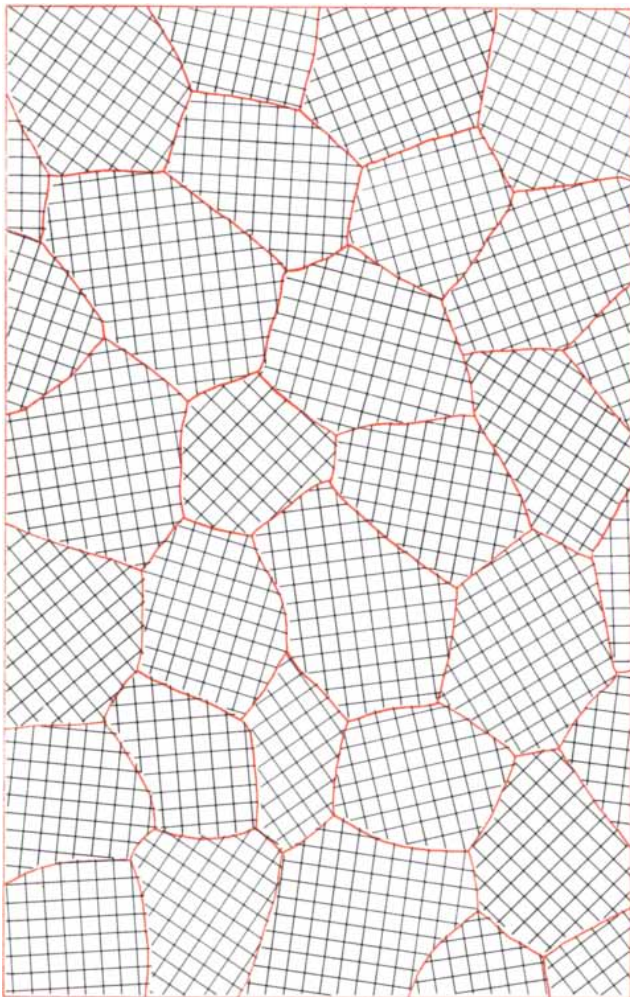
Crystals have different properties in different directions. Alignment of the crystal grains within a piece of metal can significantly alter its mechanical and magnetic behavior

by B. D. Cullity

A man scaled down to the size of an atom would find a trip through a crystal a tedious expedition. Hopping from atom to atom in any one direction, he would find that every jump was as long as the last one, and that the arrangement of atoms to his left and

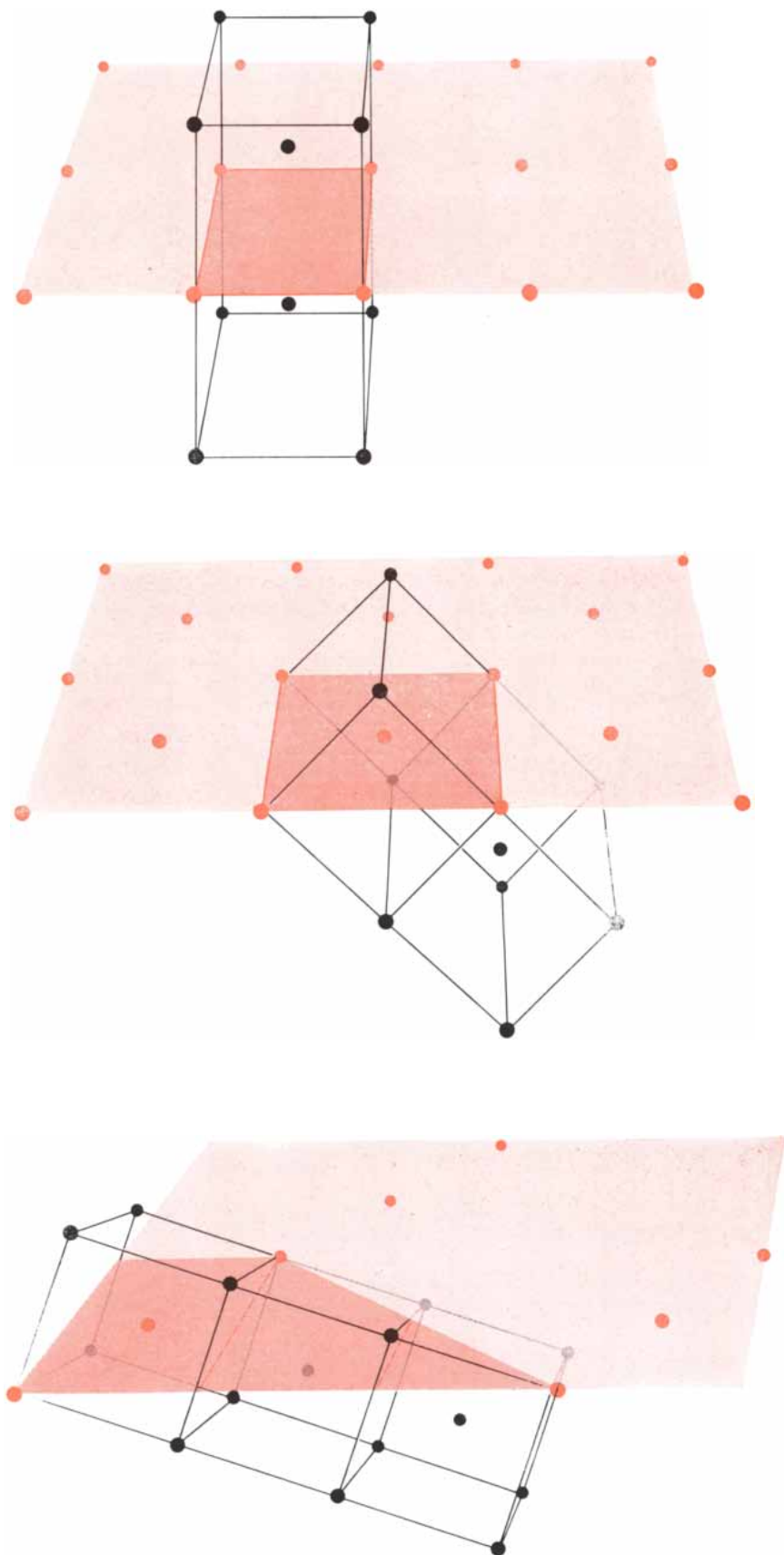
right, and above and below him, remained the same. By changing his direction he could vary the experience momentarily. He would find a different distance between atoms and a different set of surroundings, but then the new pattern would repeat itself until he

changed direction again. An imperfection here and there in the crystal might offer some variety. But he would experience purer monotony only in a non-crystalline, amorphous solid like glass. Here he could not tell from his surroundings which way he was going; the hap-



CRYSTALLINE GRAINS within a metal, shown here schematically, have regular lattices (*black grids*) but irregular boundaries. If the grains are randomly oriented (*left*) the metal will have the

same properties in every direction. With “preferred orientation” (*right*) the metal’s properties will vary from one direction to another. The variations are often troublesome but sometimes useful.



ARRANGEMENT OF ATOMS in a crystal varies with the direction from which it is viewed and thus accounts for directional differences in the crystal's properties. Shown here are cells of the iron-crystal lattice: cubical structures with an atom centered in each cube. Different arrays of atoms (colored dots) are produced by a plane passing through a face of the cube (top), through an edge and a face diagonal (center) and through a body diagonal (bottom).

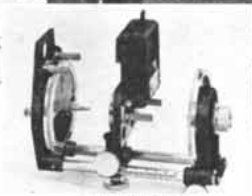
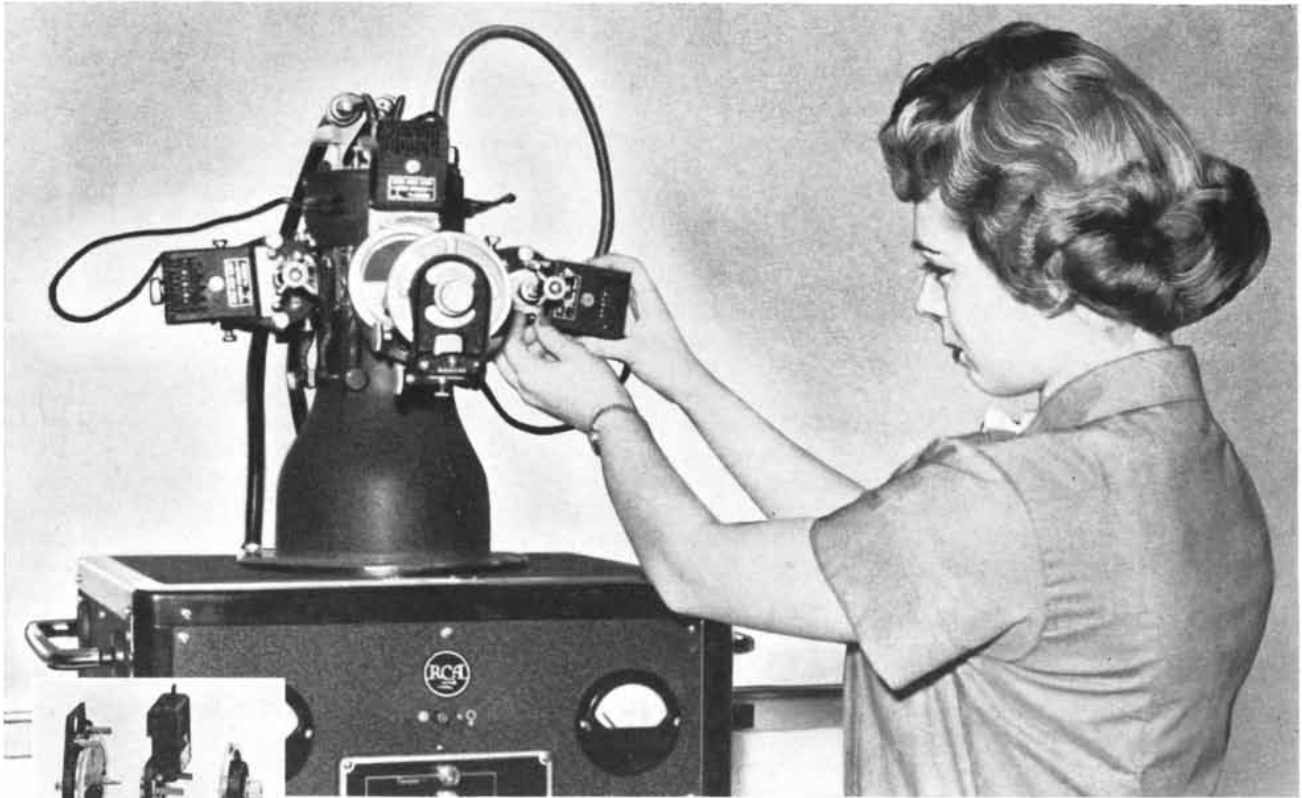
hazard arrangement of atoms would make one direction look more or less like another.

If we can overlook the bleakness of this report from our imaginary explorer, we can find in it some valuable insights into crystal structure. Just because its structure is so regular, a crystal must look different on the atomic scale when it is viewed from different directions. Even for a full-scale man who must look at crystals from the outside, the distance between the corners of a cube appears longer across the diagonal of a face than along an edge, and the distance appears even greater on the diagonal through the center of the cube. Cubes and other regular shapes occur in crystal structures because each structure is built up from a characteristic unit cell bounded at its corners by atoms of the substance; the unit cell repeats a vast number of times until it forms an aggregate of visible dimensions.

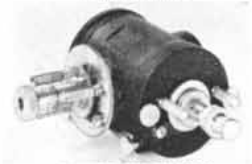
Crystal structure assumes its true significance when we find that a crystal also has different properties in different directions. This fact can be demonstrated by growing relatively large single crystals in the laboratory. From such single crystals we learn, among other things, that a crystal of copper is much stronger when pulled in one direction than in another, that an iron crystal is easier to magnetize in one direction than in another, that a zinc crystal conducts heat much faster in one direction than in any other, and so on.

These properties of crystals do not always show up in pieces of metal or other solids large enough for some practical use. Most solids are polycrystalline; they are made up of a mass of microscopic single crystals, called grains, stuck together at their boundaries. With each grain oriented more or less at random with respect to its neighbors, the variation in properties with crystal direction averages out. Accordingly the material as a whole exhibits the same properties in all directions.

It is possible, however, to give all the grains nearly the same orientation. The directionality of the properties in each little crystal is then magnified to the scale of the aggregate structure of the material. Such "preferred orientation" or "texture" is widespread in nature and in technology. It occurs in metals, rocks, natural fibers and in partly crystalline organic plastics [see "The Mechanical Properties of Polymers," by Arthur V. Tobolsky; SCIENTIFIC AMERICAN, September, 1957]. More is known about it in metals than in any other



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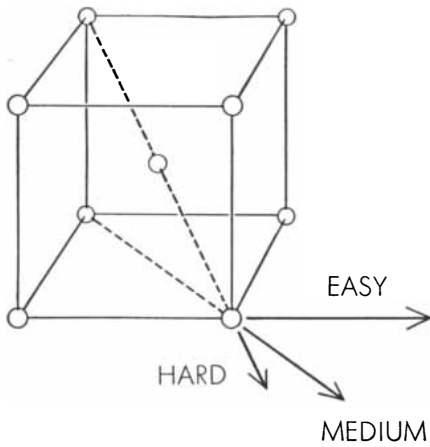
Contract services on RCA X-Ray diffraction equipment and electron microscopes are available through eleven regional offices of the RCA Service Company.

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IRON CRYSTAL can be magnetized most easily along the edge of one of its cubical unit cells. Magnetization along a face diagonal or a body diagonal is more difficult.

group of materials. But we do not know enough about the condition either to produce it at will or to eliminate it entirely in every metal and alloy. As a result, much attention is devoted to holding preferred orientation to a minimum. This is accomplished by empirically prescribed cycles of rolling and heat-treating which are designed to achieve ran-

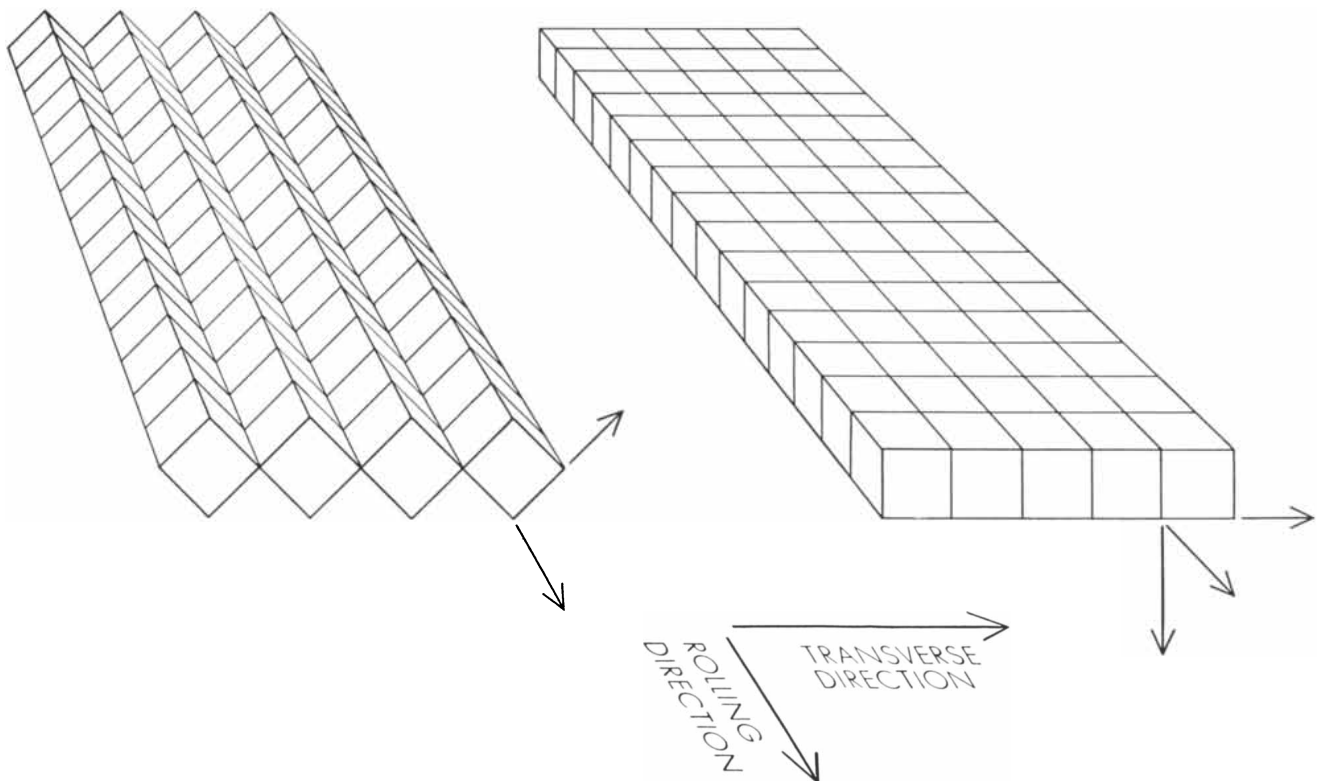
dom orientation of properties in the finished piece of metal. On the other hand, metallurgists have been learning in certain instances how to reproduce the oriented properties of the crystal in the aggregate. In a few materials crystal orientation is already as critical a factor as chemical composition. The day of tailor-made textures is probably not far distant.

Preferred orientation may or may not be a desirable property, depending upon the use of the material or on the kind of treatment it must undergo in manufacture. Consider the making of a cartridge case or, to take a less warlike example, a lipstick case. Both are long cylinders closed at one end. They are made by taking a thick disk of metal, clamping it around the edge and pushing its center into a cylindrical die. During this operation the metal is drastically stretched. If its grains are preferentially oriented, the metal will not flow evenly in all radial directions, and cracks and a scalloped edge at the open end of the cylinder will result. On the other hand, in forming an automobile fender from sheet steel a certain amount of the right kind of preferred orientation is desirable. Here the flow of metal is decidedly unsymmetrical, and it is advantageous to

have a starting material with different properties in different directions.

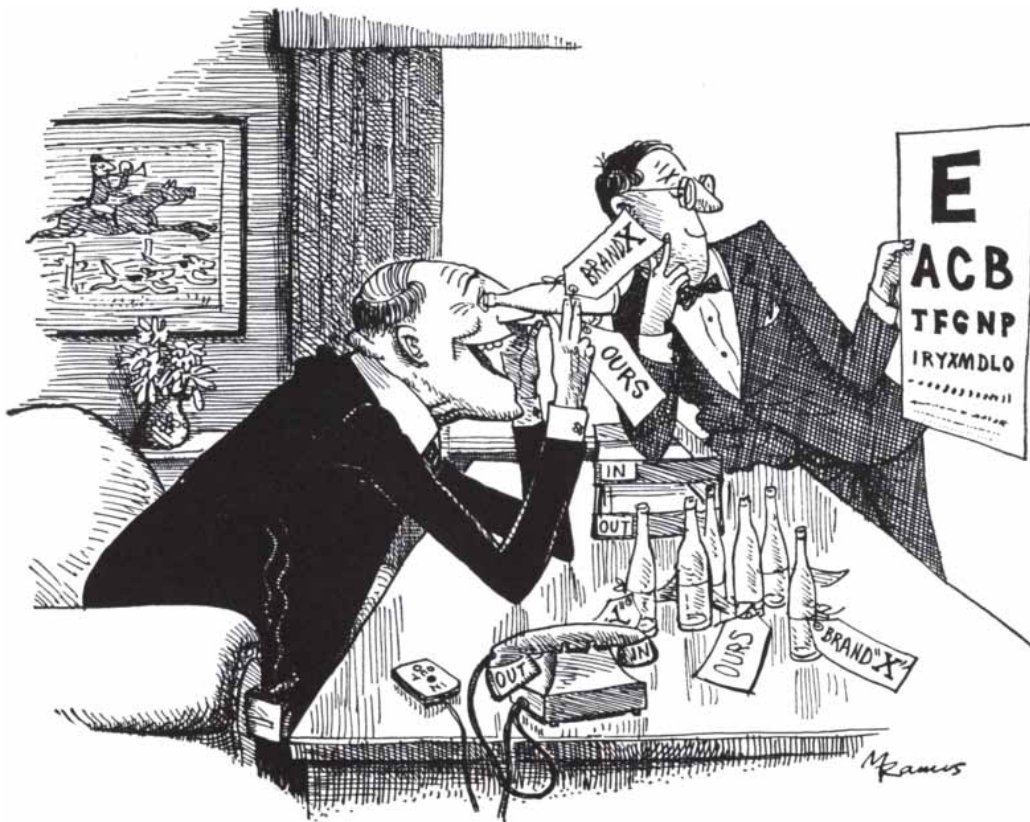
The possibilities of this approach to the control of the internal structure of metals have been most successfully exploited in the design of magnetic alloys. About 25 years ago the metallurgist N. P. Goss set out to improve the properties of the silicon steel that makes up the "iron" core of transformers, electric motors and electric generators. This material is an alloy of iron and a few per cent of silicon. Its function is to act as a conductor of magnetic flux, much as a copper wire acts as a conductor of electricity. In the core of a transformer operating on 60-cycle alternating current the flux must reverse its direction 60 times a second. Efficiency requires that a minimum amount of energy be used to fill the core with flux and produce each reversal; in the language of magnetism the permeability of the material should be high and the hysteresis loss low. Goss found a way to produce steel sheet with these magnetic properties.

His process is complicated, involving a sequence of rolling the sheet at room temperature, heating to cause recrystallization, cold-rolling again to final size and reheating. The resulting sheet has its best properties in the direction in



GRAIN ORIENTATION in sheet steel affects its magnetic properties; cubes symbolize the unit cells within each grain. Rolling and annealing produce "singly oriented" sheet (*left*) which can be

easily magnetized only in the rolling direction. More complex processing yields "doubly oriented" sheet (*right*) which can be easily magnetized in both the rolling and transverse directions.



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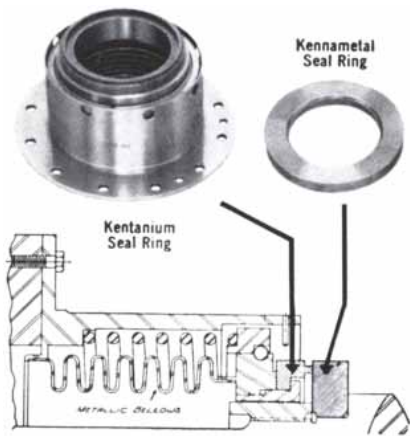


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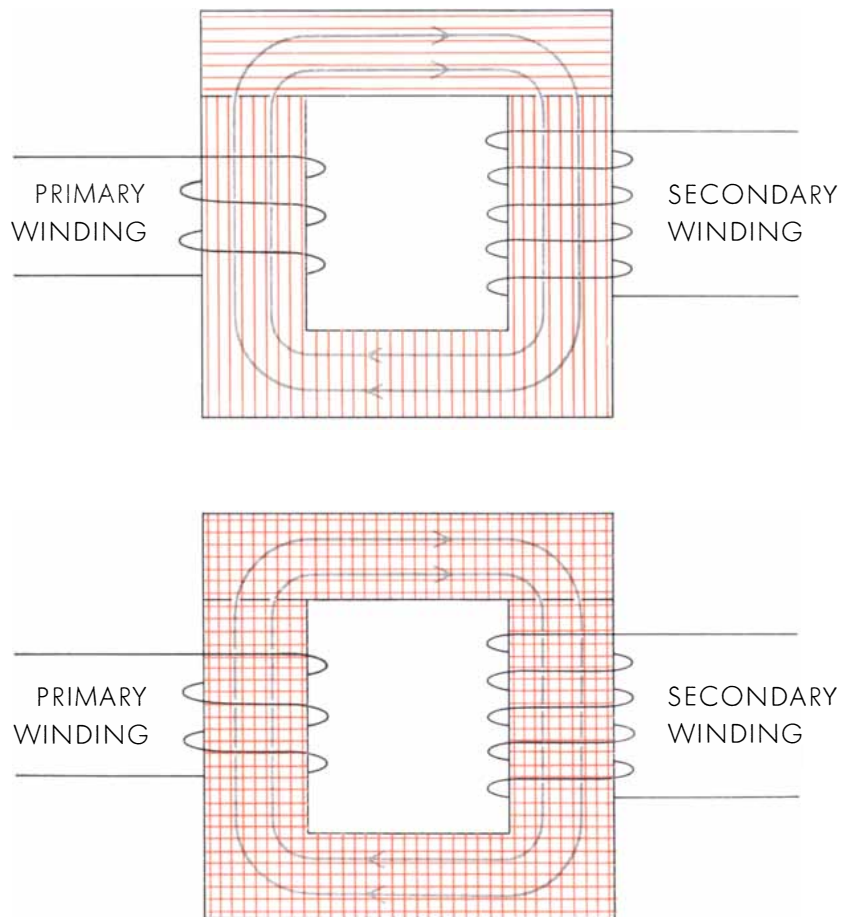


which it is rolled. In the construction of the transformer core this direction is arranged parallel, as far as possible, to the direction of magnetic flux.

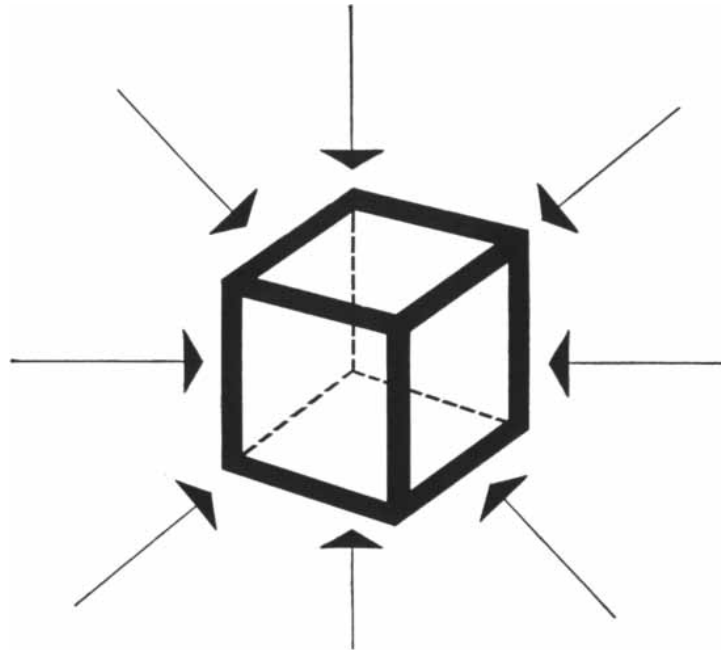
Goss apparently did not understand why his product was as good as it was, but later research provided the reason. To understand this we must picture the unit cell of the iron crystal. It is a cube with an atom at each corner and one in the center. (This unit cell, incidentally, served as the motif of the Brussels World's Fair, in the form of a model several stories high.) Measurements on iron crystals showed that magnetization is easiest in a direction parallel to an edge of the unit cube, harder along a face diagonal and still harder along a diagonal through the body of the cube [see illustration at upper left on page 128]. Analysis of the texture of the Goss sheet by means of X-ray diffraction disclosed that the crystal grains were highly oriented with a single cube-edge direction parallel to the rolling direction [see illustration at lower left on page 128]. This explained the mystery of why the rolling

direction had exhibited superior magnetic properties. The Goss "singly oriented" sheet is used today in large tonnage to reduce the size and operating cost of electrical equipment.

How does the processing of the sheet produce preferred orientation? We can distinguish two operations: cold-rolling and annealing. When a metal is deformed by squeezing it through a pair of rolls in a mill, the grains slip internally, somewhat as the cards in a deck slip with respect to one another when the deck is pushed over. The grains also rotate. The details of this rotation are not known, but it must be quite intricate, inasmuch as each grain must rotate so as to conform to the rotation of its neighbors and still adhere to them at its boundaries. The end result, when the rolling is intensive enough, is that nearly all grains rotate into a preferred orientation. When the metal is then annealed, it recrystallizes, and entirely new crystal grains grow in the cold-worked matrix. These new grains also have a preferred



EFFICIENCY OF A TRANSFORMER depends partly on the grain orientation of its sheet steel core. A singly oriented core (top) permits the magnetic flux (gray lines) to follow the easy magnetization directions (colored lines) in all but the bottom portion of the core. In a doubly oriented core (bottom) the flux follows the easy directions throughout the core.



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Tinned sheet steel, available up to 22 gage, has the strength of steel, and good formability in addition. The coating also serves as an excellent paint base and doesn't require a primer coat. For these reasons it is widely used in the automotive industry for air cleaners, oil filters, covers, vents and hot-air ducts.

Modern pewter is nontarnishing and nontoxic, contains no lead, and does not darken or lose its surface finish. It contains 93% tin, 6% antimony, and 1% copper. Surface finish ranges from a bright, high polish to a subdued satin texture. It can be cleaned with soap and water. Frequent polishing is not necessary.

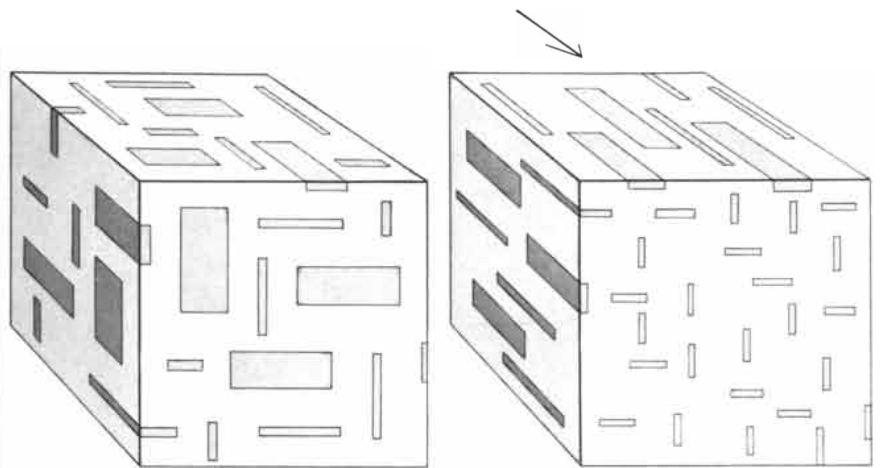
De-icing problem? Perhaps this is the answer. Years ago a transparent electroconductive coating, containing tin, was developed for aircraft. The thin tin-oxide film is applied to glass. A low current passing through the coating generates sufficient heat to de-ice the glass, now standard equipment on most commercial and military planes.

Phosphor bronze, a tin-copper alloy containing up to 10% tin is used in over 30 different aircraft applications. Typical uses are for bushings, bearings, springs, valves, contacts, thermostats and switches.



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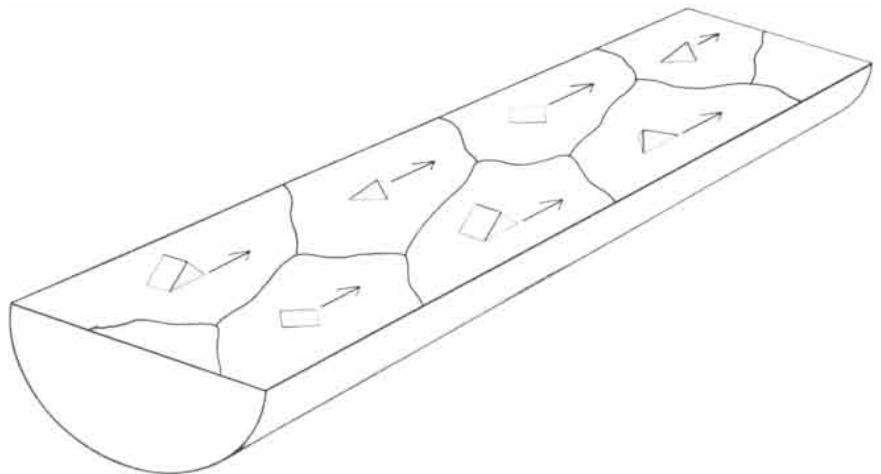
ALNICO CRYSTAL owes its magnetic strength to a magnetic material which precipitates in long thin plates (*shaded*) as the crystal cools. Ordinary cooling (*left*) produces plates parallel to all of the crystal faces. In a crystal cooled in a magnetic field (*right*) the plates grow only in the direction of the field (*arrow*), more than doubling the magnetic strength.

orientation, usually different from the preceding one.

Actually the process of achieving a desired texture in a particular piece of metal is a good deal more complicated. Though theory is advanced, practice does not achieve results at will. For example, the understanding of texture quickly suggested a way to improve on Goss's singly oriented sheet. Metallurgists saw that the texture might be changed so that the face of the unit cell of each crystal grain would be made parallel to the sheet surface. This would bring two directions of easy magnetization, rather than one, into the plane of the sheet [see illustration at lower right on page 128]. In some metals this doubly oriented "cube texture" is easy to produce. But many man-years of research had to be devoted to achieving it in silicon steel. Details of the method, developed independently in 1957 in three dif-

ferent laboratories, have not yet been disclosed. Quite likely it requires an involved sequence of rolling and heating operations.

In the design of materials for permanent magnets the theory and practice of texture control have recently achieved equally impressive results along quite different lines. The properties required of a permanent magnet are just the opposite of those of transformer steel. In a transformer we want a material in which it is easy to reverse the direction of magnetization. But this reversal must be made as difficult as possible in a magnet; otherwise the magnetism of the material will not be permanent and might be reversed or even eliminated by any stray magnetic field it encountered. What is more, the principle of preferred orientation applies here in the large as well as in the microscopic realm of crystal structure. The shape of the magnet itself has



"**FIBER TEXTURE**" of iron wire is due to the preferred orientation of its grains. Unit cells of each grain are parallel (*arrows*) along a face diagonal, but occupy various positions around the axis of this diagonal. Organic fibers have a similarly oriented structure.



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The tuning operation is a series of intricate tests that determine a car's "shake" characteristics—where and how much the metal bends and twists. To produce beaming and torsional moments, a mechanical oscillator is attached to the frame and vibrates the car in a frequency range of 7½ to 15 cycles per second. To measure the displacement of the metal, a velocity pick-up is attached

directly to the area under study. As the metal vibrates, a signal is produced by the pick-up and is fed to a vibration meter where it is integrated. The resulting signal is then transmitted to an X-Y plotter that instantly converts it into a continuous magnitude-vs.-frequency trace.

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Activated charcoal (or carbon), a hard, granular, black material, acts as a molecular sponge, purifies air, gases, liquids—recovers solvents—removes odors and impurities—does hundreds of jobs. Write for Bulletin E-188. Barnebey-Cheney, Columbus 19, Ohio.

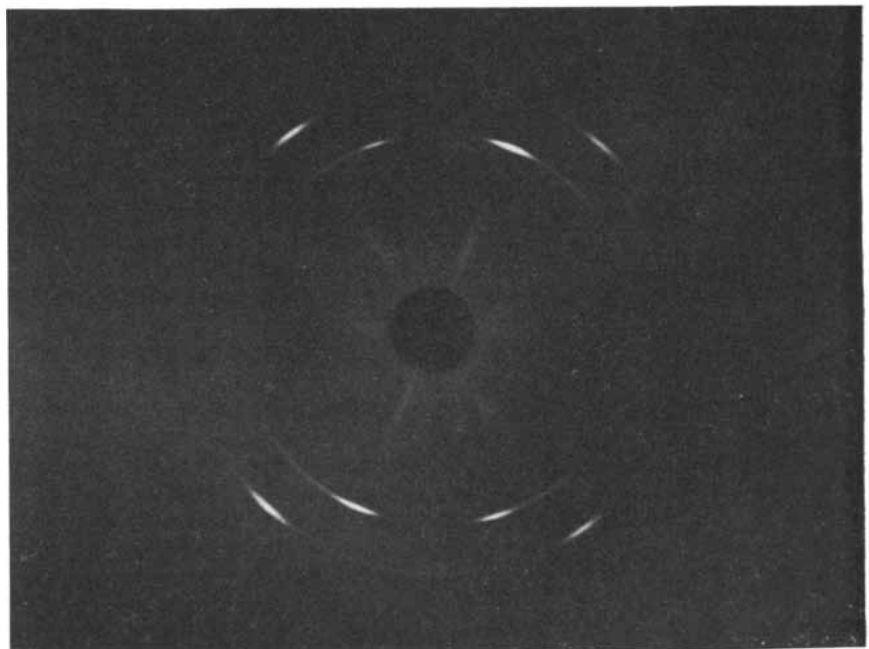
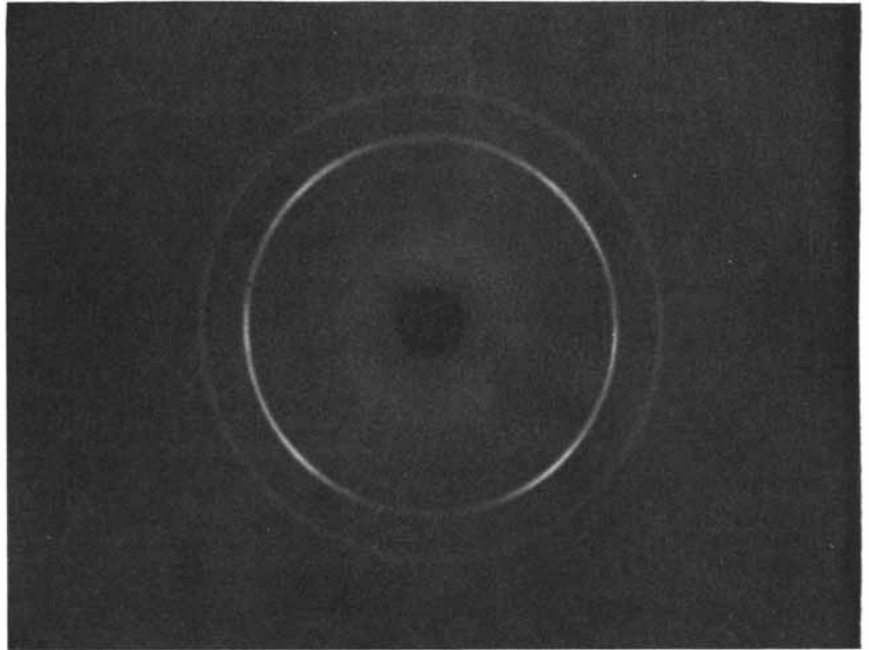
Barnebey Cheney

an important effect: It is much harder to reverse the magnetization of a long needle or plate than that of a sphere or cube. Thus a good alloy for permanent magnets ought to contain a lot of little magnetic needles or plates, and these ought to be lined up parallel to the direction in which we want to magnetize the material.

In the famous alnico magnets we have just such a material. Alnico (named for its constituent aluminum, nickel and

cobalt) was developed, however, by men who used trial-and-error methods to push the art of making good magnets ahead of the theory of their behavior. Its superior properties derive in part from a special processing step: The alloy is heated to a high temperature, withdrawn from the furnace and then subjected to a strong magnetic field while it cools. The treatment more than doubles its magnetic strength.

Only recently, some 15 years after the invention of the alnico magnet, have



X-RAY DIFFRACTION PHOTOGRAPHS show grain orientation in aluminum. Uniform diffraction rings (*top*) produced when a beam of X-rays is passed through heat-treated aluminum indicate that orientation of its grains is almost random. Nonuniform rings (*bottom*) produced by cold-worked aluminum wire show that the grains in it are strongly aligned.

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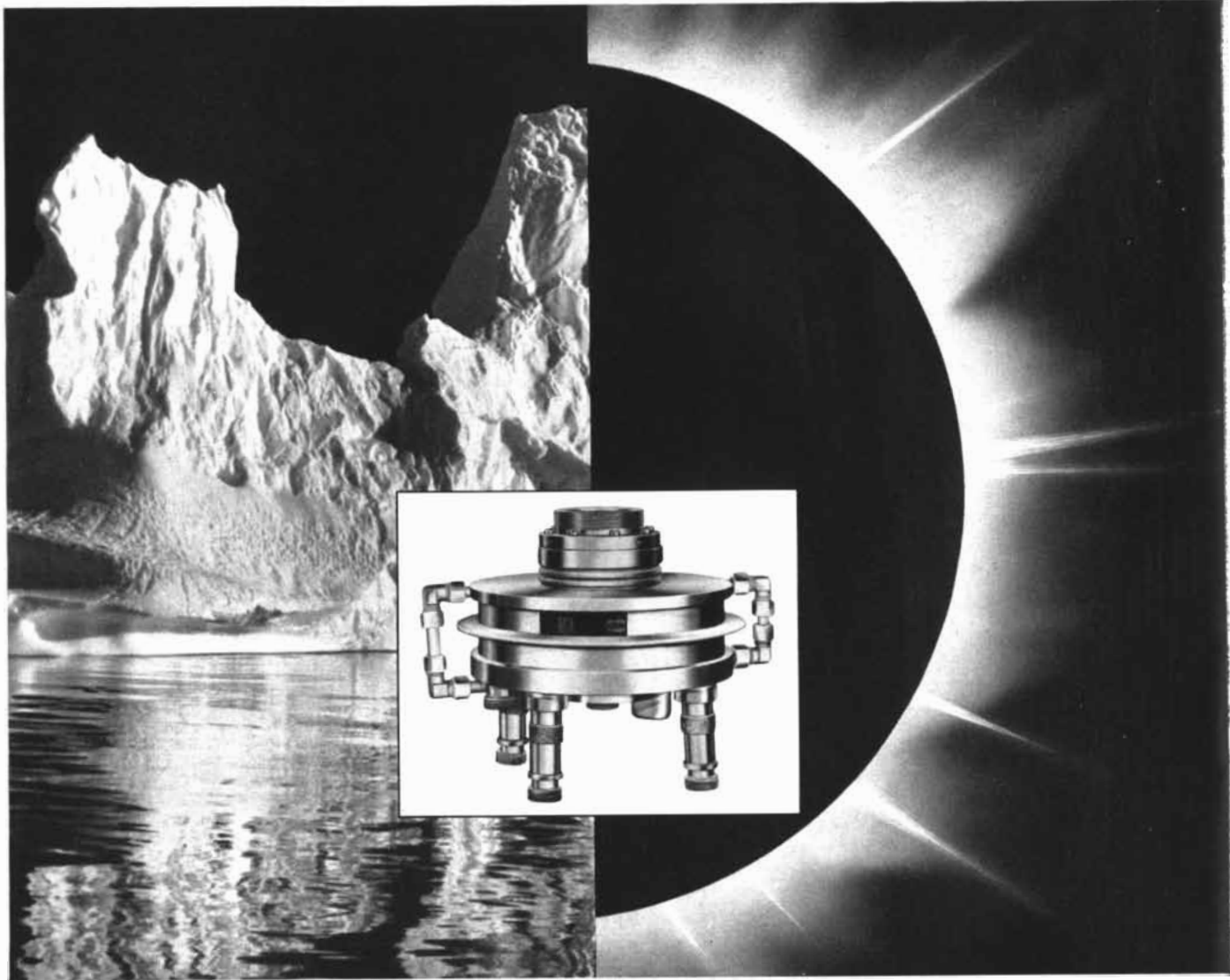
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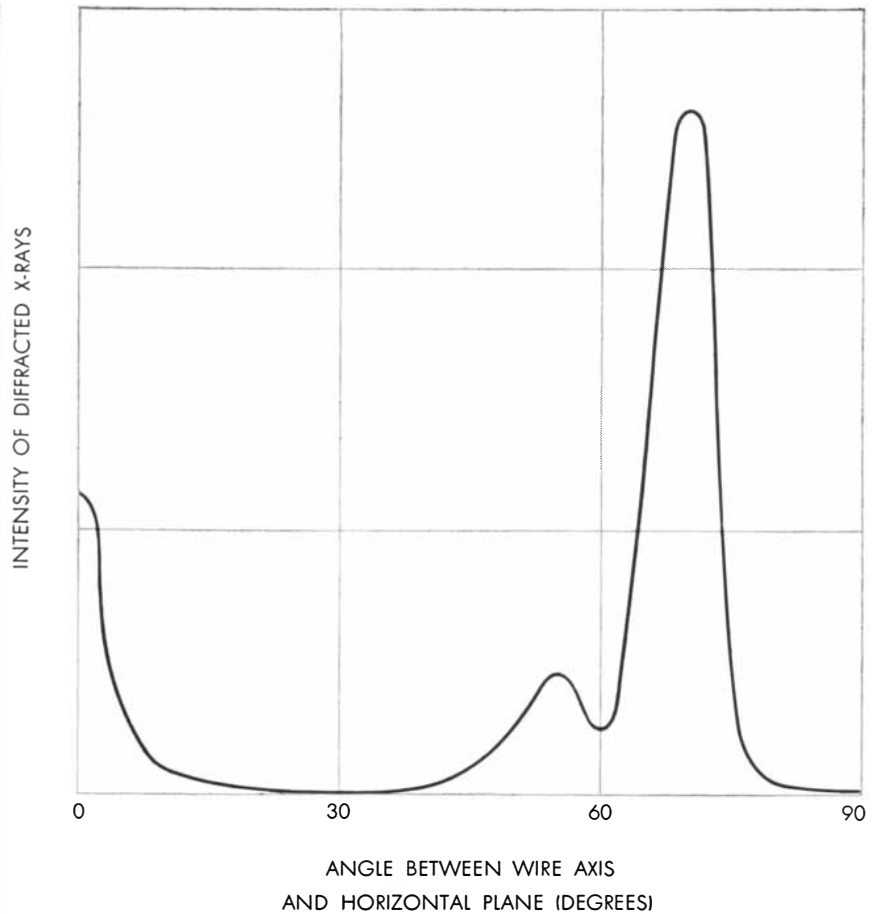
ROTARY SWITCH SIZE REDUCED! Plastic rotors, made by Oak Manufacturing Company of KEL-F® halofluorocarbon, made possible the development of a smaller rotary switch only 1 3/8" in diameter. The zero moisture absorption, high dielectric strength, low co-efficient of friction of the KEL-F rotor aided in miniaturization. KEL-F is chemically inert, resists thermal shock, has high impact strength.

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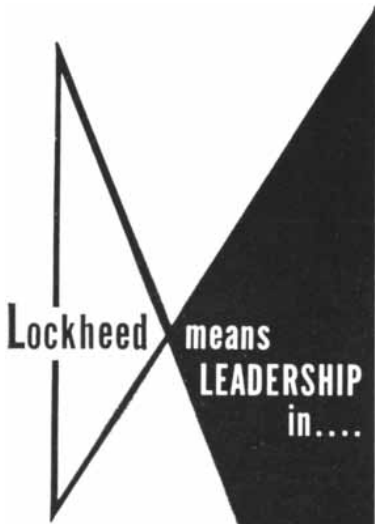


DIFFRACTION INTENSITY at different angles reveals the type of orientation in an aluminum wire. Peaks in the curve at 0 and 70 degrees show that the unit cells in most of the grains have their body diagonals parallel to the axis of the wire. The smaller peak at 55 degrees indicates that unit cells in some of the grains have their edges parallel to the axis.

the physics and metallurgy underlying the behavior of the alloy been worked out in any detail. A combination of X-ray diffraction, electron diffraction and electron microscopy has shown that its properties, whether it is cooled in a magnetic field or not, are due to the precipitation of a magnetic phase of the alloy in the form of long, thin plates inside the crystals. These plates of precipitate lie on planes parallel to the faces of the unit cube of the crystals. If the precipitation takes place during normal cooling, the plates have three different orientations in a single crystal because they can form parallel to any of the three nonparallel faces of the unit cube. The magnetic properties are then very good. They can be made even better by applying a magnetic field during precipitation. The plates then grow only in the direction of the field, because magnetic cooling produces a preferred orientation of the precipitate within each crystal [see illustration at top of page 132].

The final touch was added to this picture of imposed directionality when a way was found to line up the crystals themselves, as well as the precipitate plates inside each crystal. Alnico is so brittle that rolling to produce a preferred grain-orientation is impossible. But a special way of solidifying the molten alloy will produce the same effect: Long, parallel grains freeze in such a way that a cube-edge direction in one grain is parallel to a similar direction in all the others. Then magnetic cooling preferentially orients the precipitate in the same direction.

Modern theory, working from experience with alnico magnets, has guided the development of an even more promising material. It is composed of extremely fine, elongated particles, made by a special electrolytic process, of iron or an iron-cobalt alloy. The particles are mixed with an organic or metallic binder, and the shape effect is exploited by orienting them parallel to one another in a mag-



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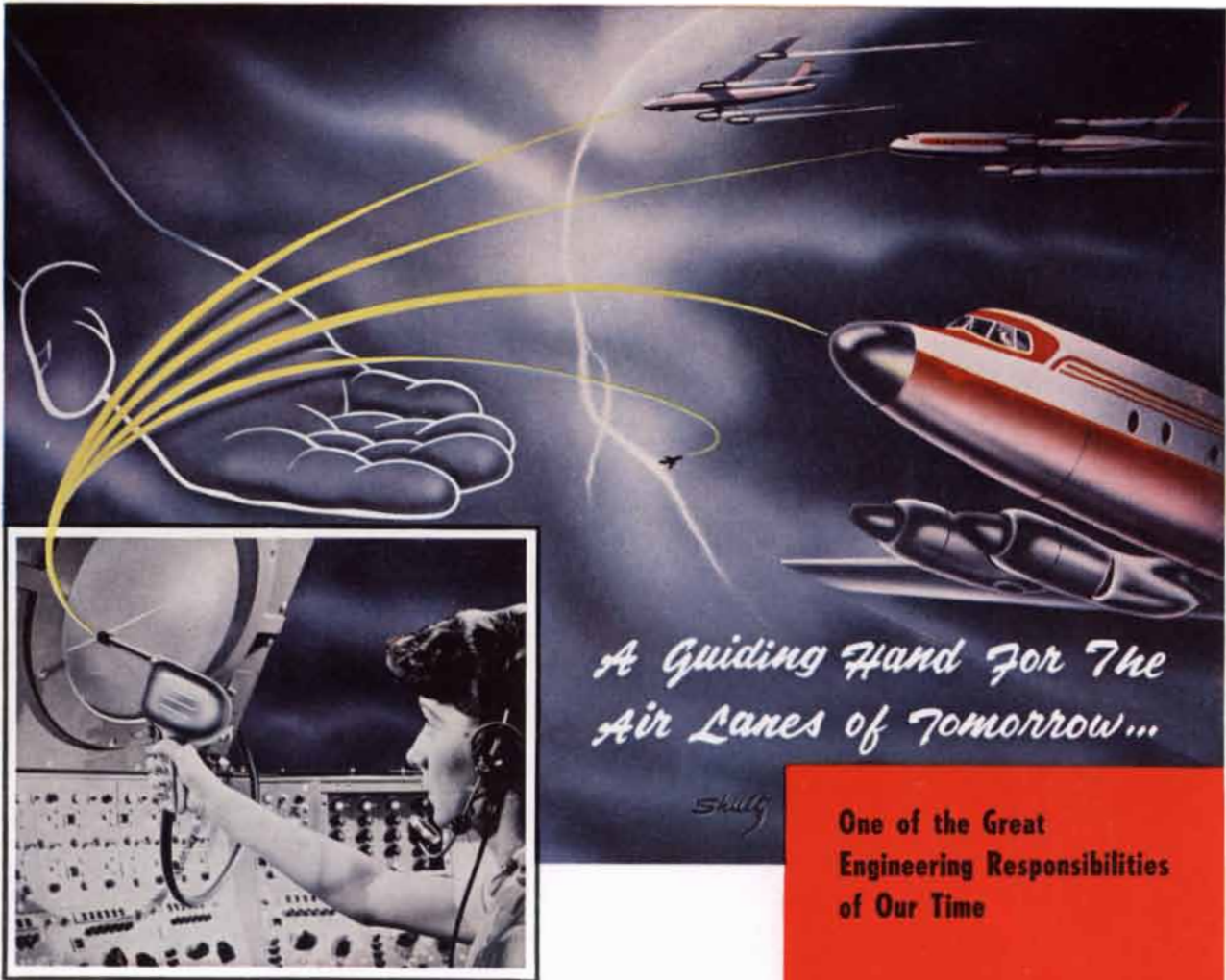
**LOCKHEED AIRCRAFT CORP.
GEORGIA DIVISION
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netic field. These fine-particle magnets promise to surpass alnico V in usefulness. Their magnetic strength is just about as high but, unlike alnico, they can be machined and their properties can be varied to fit specific applications.

“Polaroid” sunglasses afford an instructive example of preferred orientation that accomplishes an entirely different kind of objective. Much of the light reflected from such horizontal surfaces as lakes and highways is horizontally polarized; that is, the light waves vibrate mainly in a horizontal plane instead of in all planes parallel to their direction of travel. On the other hand, various crystals have the property of preferentially absorbing light that vibrates at right angles to a particular crystal direction: their axis of polarization. By tilting the axis of polarization at right angles to horizontally polarized light, the horizontal components that cause “glare” may be filtered out. But single crystals are out of the question for sunglasses. Edwin H. Land of the Polaroid Corporation solved this problem by taking a mass of tiny crystals, arranging them with their polarization axes parallel and enclosing them in a sheet of clear, transparent plastic. More recently the long, tangled molecules of the plastic sheet itself have been forced into parallel alignment; the sheet is then treated to give it polarizing properties.

Metal wire and rod and organic fibers of both natural and synthetic materials exhibit a distinctive kind of preferred orientation. The crystal grains are parallel only with respect to a single crystal direction. Thus in cold-worked iron wire the grains are oriented with the face diagonal of each unit cube parallel to the wire axis. The grains, however, may have any rotational position about this axis, somewhat like beads on a string. This “fiber” texture is set up by the mechanical stresses in the drawing or rolling of the material.

Fiber texture provided a major metallurgical headache in one form of fuel element for nuclear reactors. These are cylinders of natural uranium, cut from rolled rod. The rolling operation, however, caused the grains to take up a fiber texture. In fact, it produced a double fiber texture: two sets of grains each with its own preferred crystal direction parallel to the rod axis. This double texture, coupled with some of the peculiarities of uranium itself, had some startling consequences. When the rod was repeatedly heated and cooled, each thermal cycle caused a small increase in length. After several thousand cycles the



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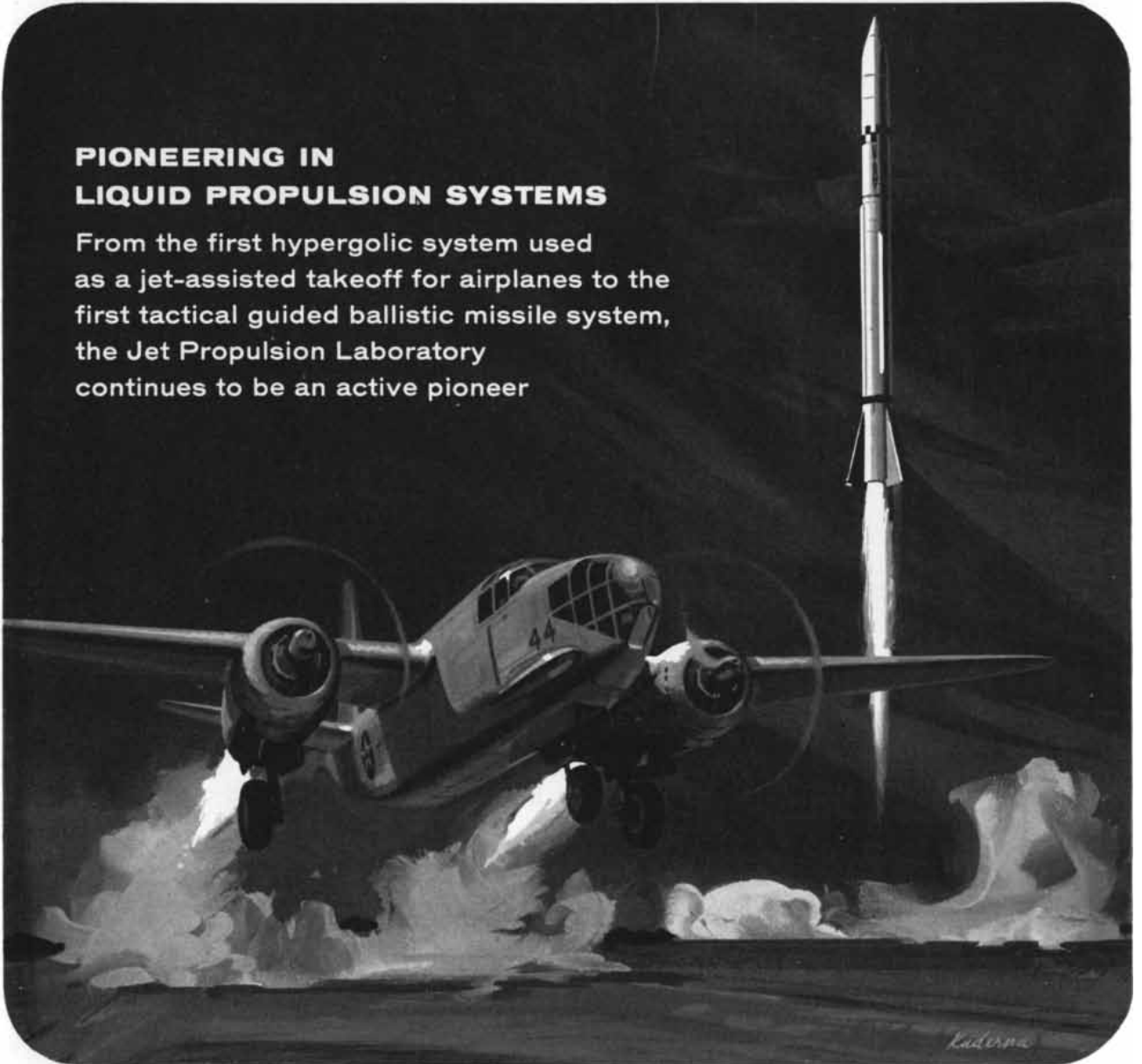
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From the first hypergolic system used as a jet-assisted takeoff for airplanes to the first tactical guided ballistic missile system, the Jet Propulsion Laboratory continues to be an active pioneer



Months before Pearl Harbor, JPL had tested America's first liquid rocket engines using spontaneously igniting propellants. By April 1942, a simple nitric acid-aniline propulsion system was designed into and successfully tested in an A-20-A Bomber for a jet-assisted takeoff. For high-altitude atmosphere research purposes, JPL then used the hypergolic liquid rocket system in the WAC CORPORAL. Placed as a second stage on a V-2 rocket, this became the

BUMPER WAC rocket that established a World's altitude record of 242 miles in February 1949.

At the request of U.S. Army Ordnance, the Jet Propulsion Laboratory now began to develop a long-range guided ballistic missile system, incorporating the proven, smooth-burning light-weight acid-aniline system. These achievements sparked the development of a whole series of rocket vehicles. In 1954, the Army accepted the JPL developed COR-

PORAL, which became America's first tactical guided ballistic missile system; its accuracy exceeded design requirements.

Under the direction of the National Aeronautics and Space Administration, the experienced Jet Propulsion Laboratory research and development team is now working on storable, high-performance hypergolic liquid propulsion systems with which space vehicles may soon orbit the moon and planets.



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rod grew to many times its original length. A special heat-treatment has since eliminated the troublesome texture, but the growth phenomenon itself has continued to arouse considerable scientific interest.

The most plausible explanation of the growth mechanism lies in the crystal structure of uranium. All three edges of the unit cell are of different length; when a uranium crystal is heated, it expands in two of these directions and actually contracts in the third. In the reactor fuel-element rod the crystal direction that contracts on heating is oriented parallel to the rod axis in one texture component (A), while a high-expansion direction is oriented parallel to the axis in the other component (B). During the heating cycle, grains of component B tend to expand lengthwise more than the A grains, and when the temperature becomes high enough, they permanently elongate by slipping with respect to the A grains at the grain boundaries. During cooling this kind of slip cannot take place, and another process takes over. Tensile stress develops in the B grains, because they want to contract more than the A grains and yet are prevented from doing so by the rigidity of the A grains and the stiffness of the grain-boundary material at lower temperatures. This stress causes slip inside the B grains and further elongation of the rod. Thus growth continues during every cycle, by slip at the boundaries during heating and slip inside the grains during cooling. The whole mechanism has been aptly called "thermal ratcheting." The A grains are the "jack" and the B grains are the "ratchet," but a ratchet that is stretched rather than lifted.

Not all fiber textures lead to such dramatic, and undesirable, behavior. Actually there is no good reason why particular fiber textures cannot be obtained that will give wire and rod better strength and elasticity than they now have. The impressive advances in magnetic alloys by the control of texture set a standard for those of us who are working toward this objective. In our laboratories at the University of Notre Dame we are investigating the control of fiber texture and the relation between texture and mechanical properties, with the aim of selectively altering the properties of wire and of devices made from wire. More important, we hope to achieve better basic understanding of how texture develops in a material, because such knowledge will eventually make it possible to control and adapt textures to each application.

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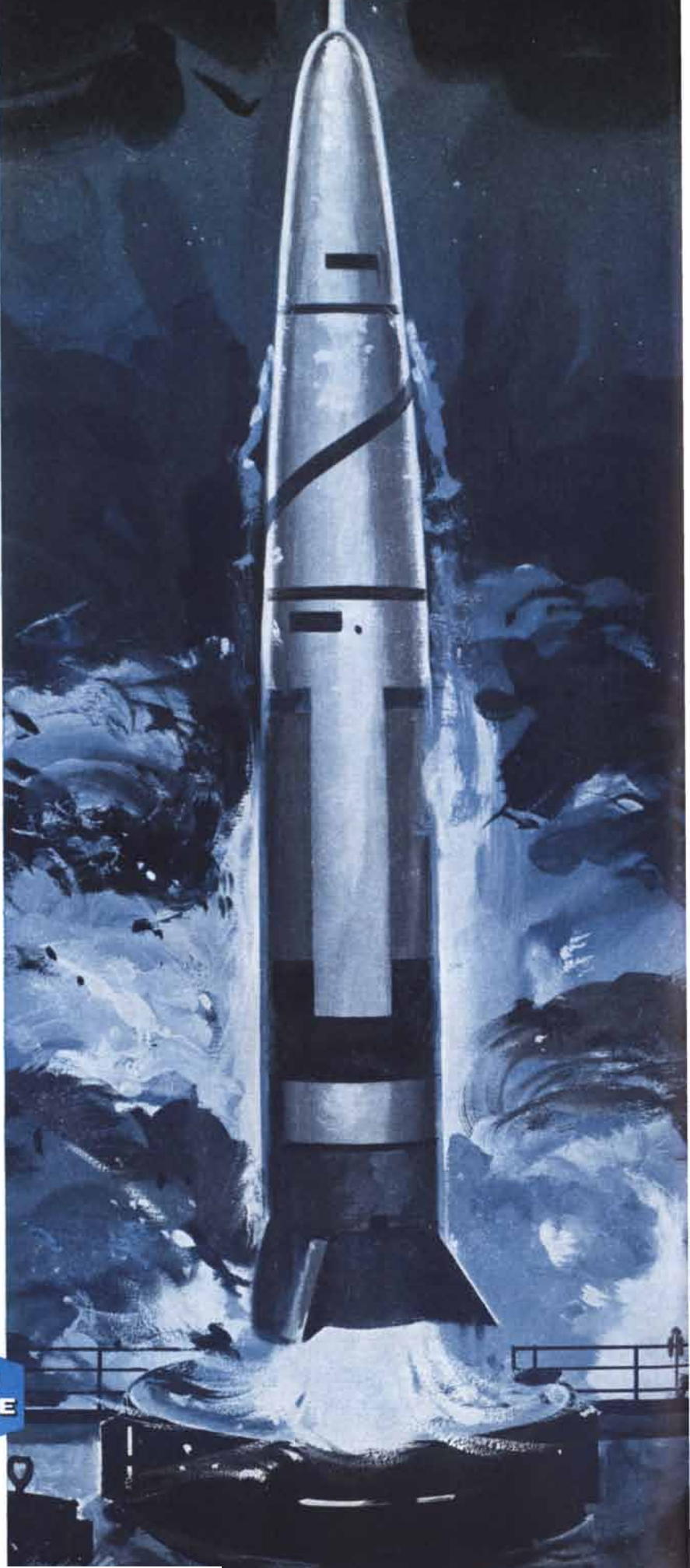
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The Sex Gas of Hydra

Usually this small animal reproduces by budding, but it can also develop male and female organs for sexual reproduction. What factors determine which method of reproduction it uses?

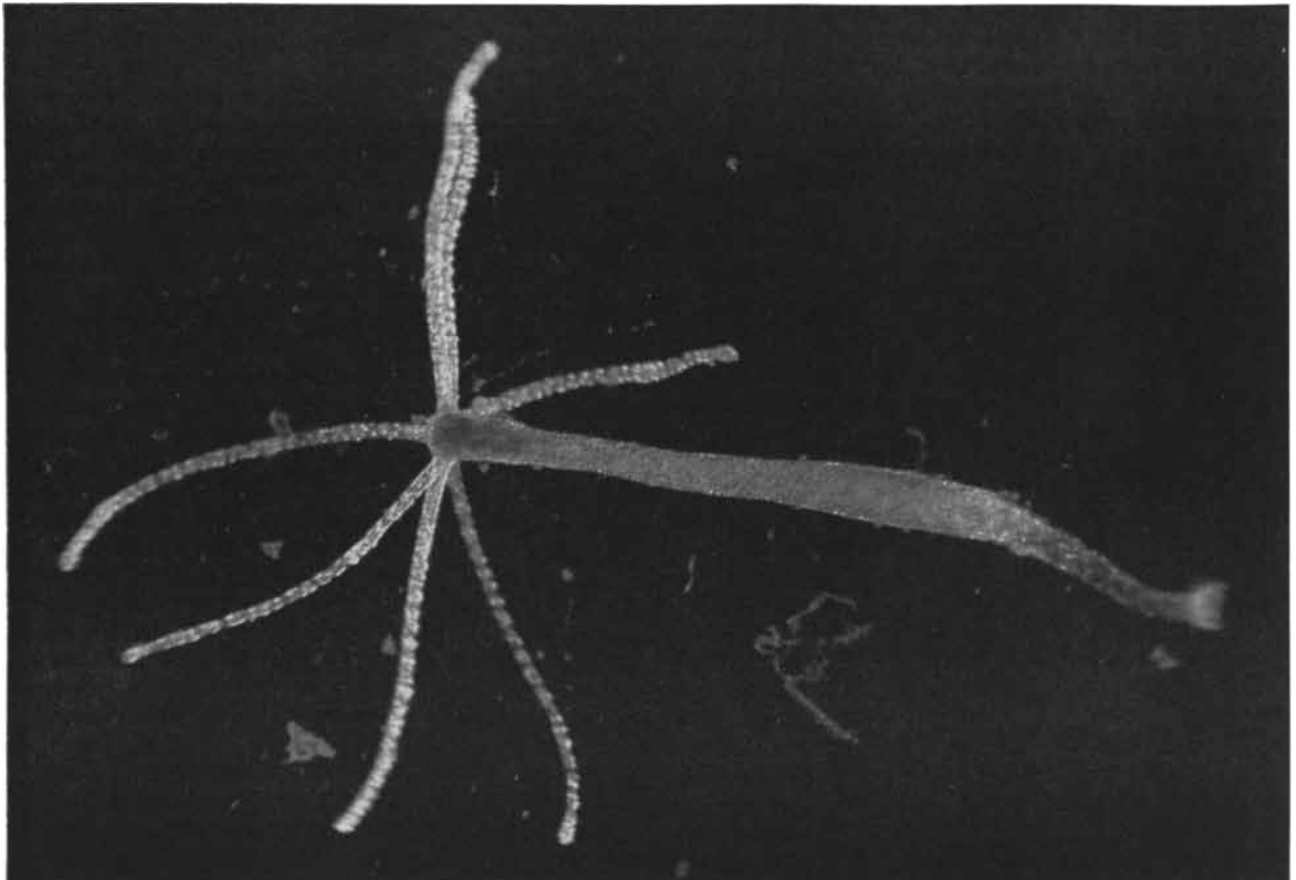
by W. F. Loomis

How does a single egg cell differentiate into muscle cells, nerve cells, blood cells, gland cells—to the whole society of cells that makes up an organism? To use a homely analogy, what makes a nursery full of babies grow up into such different types as doctors, soldiers, lawyers, policemen and so on? The process of differentiation assumes still further fascination when we consider how well it is regu-

lated. It is one of the most highly repeatable phenomena known to science. Witness the amazing similarity between the individual members of a swarm of gnats, a school of fish or a murmuration of sparrows, between the horseshoe crab and its ancestors of millions of years ago. Errors do occur, as in malformed monsters and other aberrations of growth, but they are the exception rather than the rule. Societies also have been known to give rise

to too many soldiers and policemen.

The self-regulating power of differentiation seems almost magical. It will resist even deliberate attempts to derange it. If an egg is split at the two-cell stage, each half reorganizes to produce a complete animal, the result being identical twins. On the other hand, two separate two-cell embryos pressed firmly together will fuse to form a single embryo. Clearly forces that are a function of the whole



HYDRA is a tiny water animal commonly found in ponds. With the tentacles surrounding its mouth it catches water fleas or other

animals for food. This specimen, enlarged about eight diameters, is an asexual form of *Hydra littoralis*, the type used by the author.

organism are at work in the growth of the embryo. Each part contributes its share and responds in turn to some overall field of force. What is the physical or chemical nature of these forces?

About five years ago, with questions like this in mind, I began to study the reproductive habits of the hydra. I

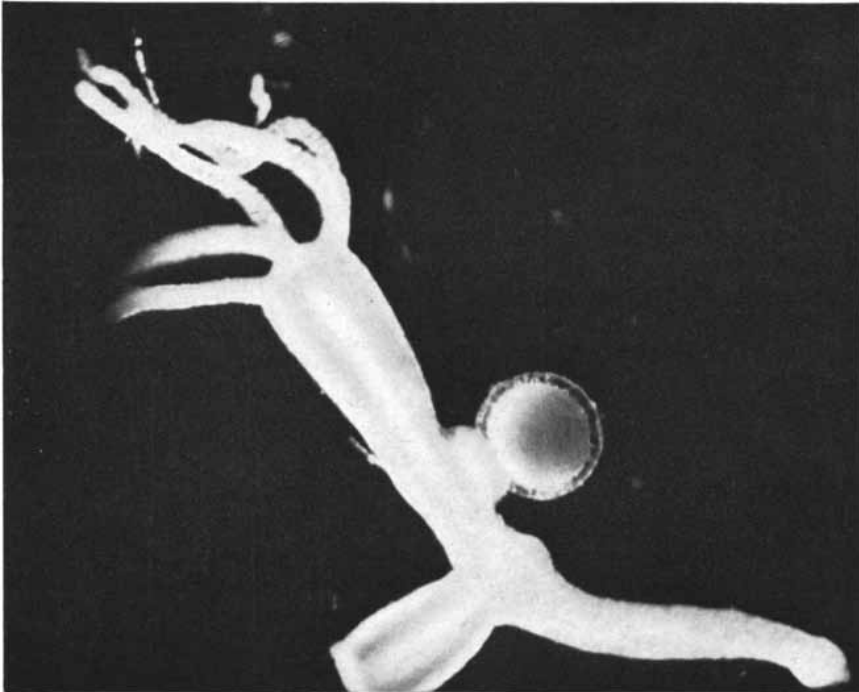
thought that this relatively simple animal might present the questions in miniature, so to speak. A hydra is a little animal smaller than a mosquito. Found in almost every pond in the world, it consists of a short tube ending in a tuft of tentacles [see "The Indestructible Hydra," by N. J. Berrill; *SCIENTIFIC*

AMERICAN, December, 1957]. The whole organism has only 100,000 cells, whereas a man has about 10 trillion. The hydra cells, moreover, are of only seven different types. So the problem of differentiation is reduced in hydra to seven specific questions: How do each of these seven types of cell arise from a single fertilized egg?

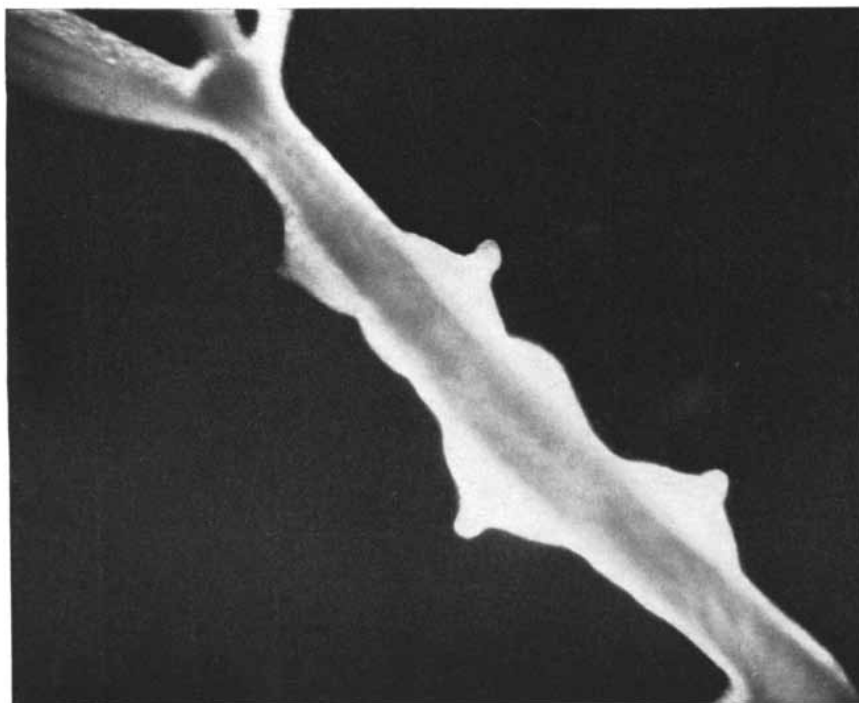
In addressing myself to the hydra, I sought to limit my inquiry to one particular cell: the reproductive or sex cell. Sexual maturation is not a fixed part of every hydra's life cycle, as it is in higher animals. In the warm months the hydra flourishes by asexual reproduction; a bud appears on the wall of the tube, grows into a side tube, puts out tentacles, pinches off and begins life on its own. By this route, male as well as female hydras directly enjoy the pleasures of parenthood. At times, however, their reproduction proceeds sexually. The tissues of adult hydras differentiate to form organs that reveal some to be male and some female. Upon fertilization, eggs are formed that can survive severe winter weather in which adult hydra die. The sexual offspring, being the product of two parents and hence somewhat different from either, also possess the advantage of increased diversity that enables the species to adapt to change in the environment.

For my purposes it was of particular interest to know that, in the opinion of earlier investigators, the appearance of sexual forms in a population of hydra depends upon the condition of the water. To modify and control the water around the hydra seemed a simpler matter than manipulating the internal processes of the animal itself. My aim was to make hydra grow sexual organs on command. If this could be done, then might not something be learned about the forces that control cellular differentiation?

At the outset I had to cope with more immediate problems. No one had ever worked out a way to grow hydra under controlled conditions. Since collected hydra cost 10 cents each, they had to be made to release their vast reproductive powers in the laboratory. The hydra's principal food is the live water flea, *Daphnia*, which the hydra traps and kills with the stinging cells of its tentacles, swallows by the peristaltic action of the muscle cells of its tube and digests in the juices secreted by the digestive cells within. But there was no reliable method for raising *Daphnia* in the laboratory either. Fortunately hydra will also eat living brine shrimp.



FEMALE HYDRA has an already fertilized egg (round structure on the right side of the animal) still attached to the site where it was formed. On the left side of the animal a bud is forming asexually. Hydra can reproduce both sexually and asexually at the same time.



MALE HYDRA has rows of testes containing sperm which burst out through the nipple-like protrusions when they are mature. Testis on lower right side of animal is about to burst.

MEN



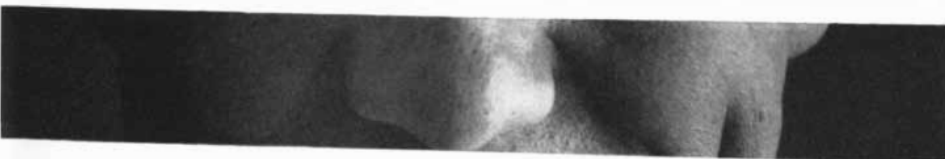
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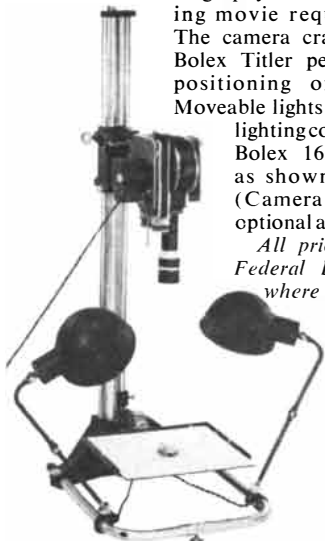
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Dried brine-shrimp eggs, available at tropical fish stores, hatch after a couple of days in salt water, and provide a dependable source of food. Hydra fed on newly hatched brine shrimp multiply at a prodigious rate, doubling their number nearly once a day.

Water was another problem that had to be solved. My first hydra were all raised in pond water, carried to the laboratory by the bucketful. They died when placed in distilled water or in tap water. For a while I was happy to find I could grow the creatures in distilled water if I added some calcium salt. But the difficulty of preparing many gallons of distilled water every day still limited the production of hydra. Why would they not thrive in tap water which originally came from a pond? Evidently the water became contaminated in the course of bringing it into the laboratory. Was the poison chlorine? Fluorine? The answer turned out to be copper from the pipes through which the water was conducted in the laboratory. A simple chemical treatment rendered the copper harmless and made tap water safe for growing hydra.

Now I could obtain thousands and thousands of hydra by growing them on brine shrimp in tap water. The abundance of the creatures made it possible to study the effects upon their life processes of acidity, temperature, osmotic pressure, rate of feeding and a half-dozen other variables. With the knowledge thus gained I felt ready at last to tackle the problem of making hydra differentiate sexually.

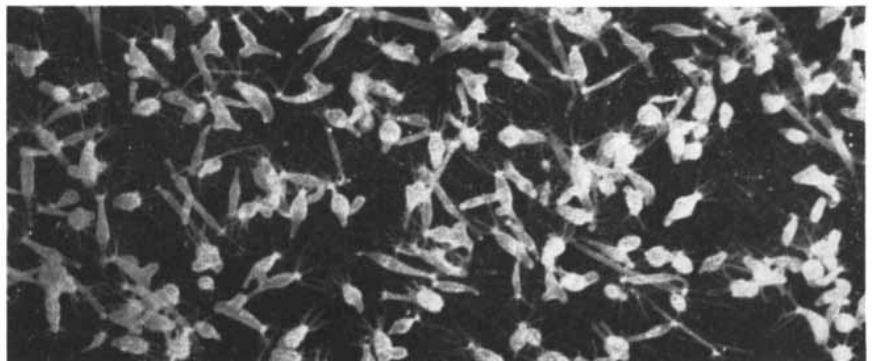
Since sexually mature hydra are often found in nature as winter approaches, investigators had tried to induce the production of sexual forms by placing hydra in refrigerators. The refrigerated animals sometimes developed sexually, but not always. Other investigators tried to correlate rate of feeding with sexual development; one man even

believed that low rates of feeding turned hydra into males, while higher rates of feeding made them into females. It is known today, however, that males and females are quite distinct in most species of hydra, all the buds of a male becoming males, and all the buds of a female becoming females.

Since neither chilling nor changing the feeding rate seemed to be reliable methods for inducing sexuality, I looked for another foothold from which to attack the problem. I remembered that I had once discovered sexual hydra in July in a stagnant aquarium tank. At that time I had been excited to see any sexual forms at all and had been disappointed when they reverted to the asexual state several days after I had turned on the bubbler of the aquarium. I now attempted to duplicate this lucky accident and found that stagnation repeatedly produced sexual development while aeration prevented it. Since the sexual hydra had originally appeared in hot weather, it was clear that stagnation within the icebox had more to do with the induction of sexuality than lowered temperature did. Moreover, in a certain goldfish bowl in the laboratory hydra turned sexual so regularly that the bowl became known as the "sex bowl." This bowl had only a small surface for its large volume, so here was another example of how reduced aeration could induce sex in hydra.

Controlled experiment now showed that identical cultures of hydra could be made sexual or asexual depending upon how often the water was changed or how much it was aerated. I concluded that aeration must prevent sexual development by introducing oxygen into the otherwise stagnant water, while the lowered concentration of oxygen in stagnant water induced sex.

The testing of this hypothesis required a sensitive technique for measuring the



WEEK-OLD HYDRA CULTURE has become relatively crowded, and many individuals in it have formed sexual organs. All these hydra came from one male, so only males are present.



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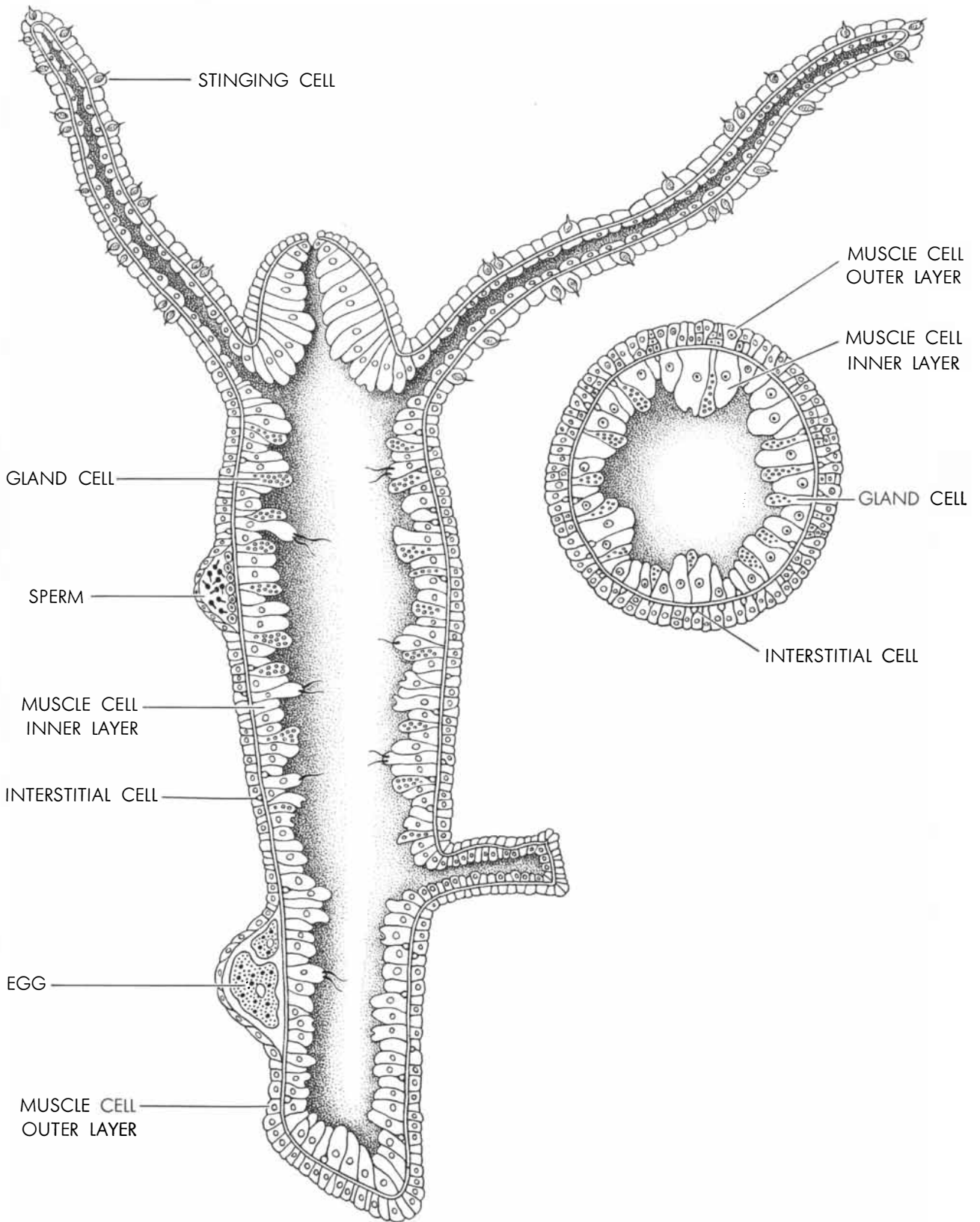
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DIAGRAMS OF A HYDRA cut lengthwise and crosswise show its tubelike structure. The stinging cells aid in capturing food; the gland cells, in digestion; the interstitial cells, in regeneration. The muscle fibers, too small to be drawn, extend along the length of

the animal in the outer layer and circle the animal in the inner layer. The layers are separated by jellylike material. The sperm and eggs for sexual reproduction are not produced by the same individual of this species, but are so drawn for the sake of simplicity.

oxygen dissolved in the small quantities of water that held our cultures. Since there was no such technique available, I had to develop one. As soon as it was perfected, it showed that water in which sexual forms appeared always had a lower oxygen content than water in which no sexual forms developed.

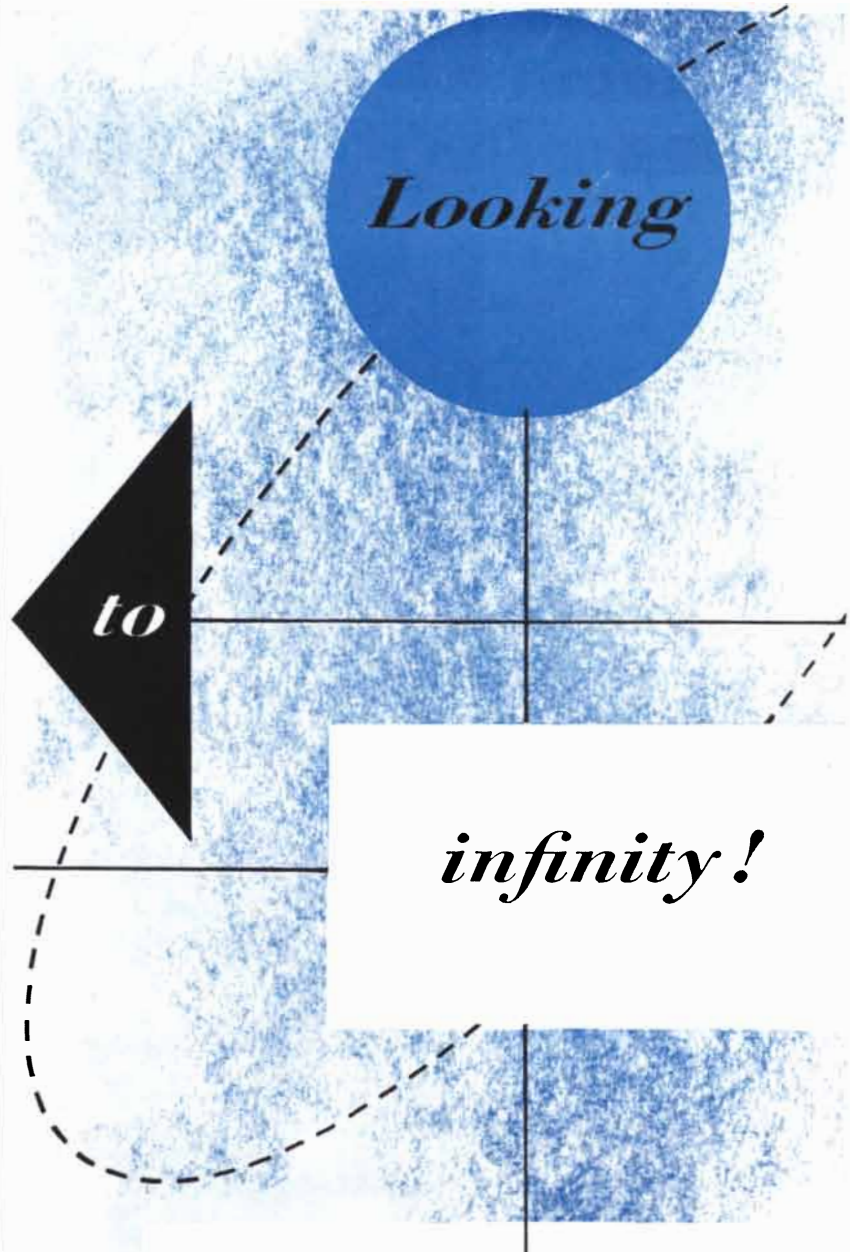
The next step was to induce sexual differentiation artificially by reducing the oxygen content of the water. The first experiments were promising. But as my control over oxygen concentration improved, the results became worse and worse, producing sexuality without apparent relationship to this supposedly critical factor. Eventually I was forced to conclude that, while lowered oxygen pressure usually accompanied sexual differentiation, it did not actually cause the transformation.

What did induce the sexual change? Certainly it was something gaseous, for aeration of the cultures continued to keep them asexual while stagnation regularly made them sexual. At about this time my father, Alfred Lee Loomis, suggested that if lowered oxygen was not the cause, perhaps increased carbon dioxide was.

In accord with this notion, I at once tried out all the standard methods for increasing the concentration of carbon dioxide in the water. But no amount of bicarbonate added to water and no manipulation of the acidity of the solutions would induce sex in aerated cultures. What other gas could accumulate in the stagnant cultures? Ethylene, the gas given off by ripening fruits? Ammonia? Sensitive tests for these and other gases were uniformly negative.

Research often resembles the parlor game of 20 questions. Perhaps my question was too specific. I had been asking: "Are you Napoleon Bonaparte?" Perhaps I should have been asking the more general question: "Are you alive or dead?" In accord with this reflection I stopped trying to guess the nature of the gas and turned to characterizing it chemically.

First I had to prove that stagnant or "sexy" water really did contain a "sex gas." Knowing that aeration removed the gas from the water, I shook samples of "sexy water" with air in a closed syringe and then shook the "sexy air" in the syringe with clean samples of water to see if enough of the gas would enter into solution to make the hydra sexual. Daily for three weeks I passed the gas from "sexy water" to the air and back again into clean water and



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then cultured a batch of hydra in it. By the end of this time it was clear that there really was a sex gas, for all the hydra so treated had become sexual while untreated hydra had not.

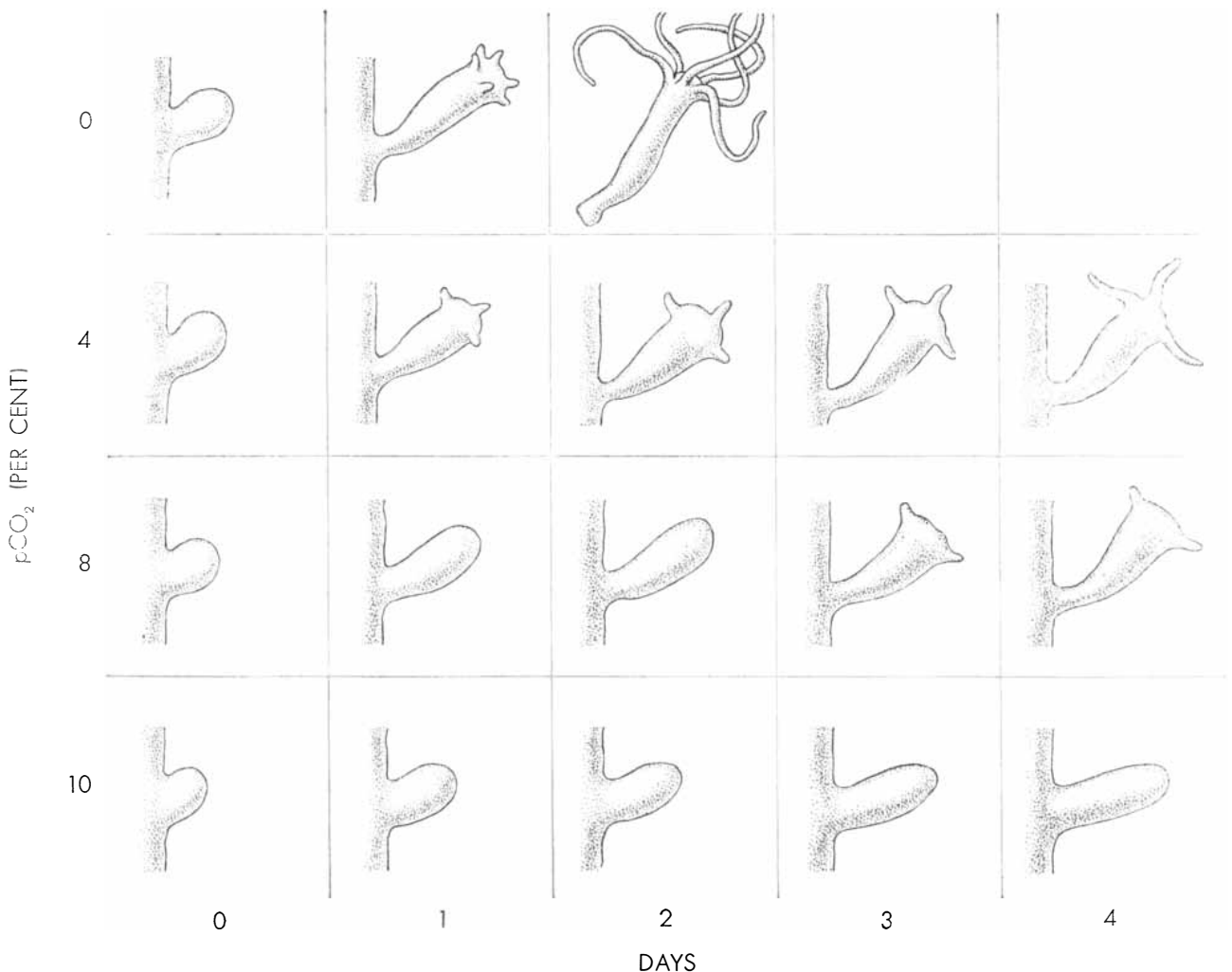
Next I analyzed samples of the sex gas by various sensitive techniques. Unfortunately the tests yielded a complete blank. No gases, other than those found in normal air, were detectable. The analyses did show, however, that sexy air contained increased amounts of carbon dioxide. What could this mean?

At this point I became indebted to Robert K. Crane, of Washington University in St. Louis, for the suggestion that "pCO₂" might be the inducing stimulus. "What is pCO₂ and how does it differ from CO₂?" I asked him. He replied that pCO₂ refers only to the pressure of free carbon dioxide gas dissolved in the water and does not include any other forms of dissolved carbon dioxide such as bicarbonate.

It was easy to test this hypothesis. I simply grew hydra in water that had been shaken with carbon dioxide gas. Within a week testes and ovaries began to form on the treated hydra. Unfortunately sexuality also appeared in untreated hydra in the control vessels. Did the control solution, by any chance, also have a high pCO₂? I shook the water for the controls with a large amount of pure oxygen to wash out any carbon dioxide that it might contain; I then split the water thus treated and shook some of it with a mixture of oxygen and carbon dioxide. The end of the long trail appeared at last. In water treated with oxygen plus carbon dioxide quadruplicate cultures of 10 hydra each turned sexual after growing for nine days. In water treated with pure oxygen the animals remained completely asexual. This and subsequent experiments convinced me that pCO₂—the pressure of dissolved carbon dioxide gas—was the volatile

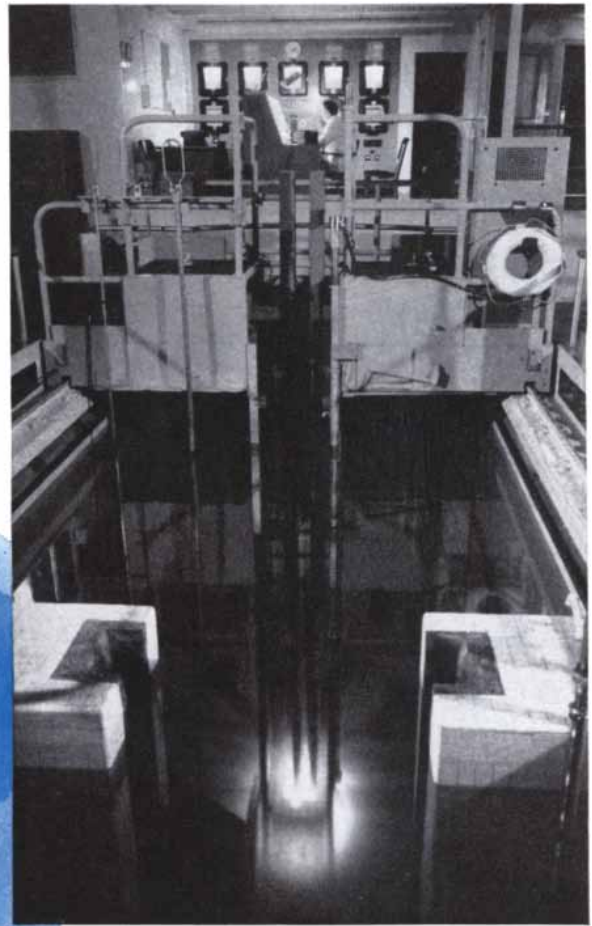
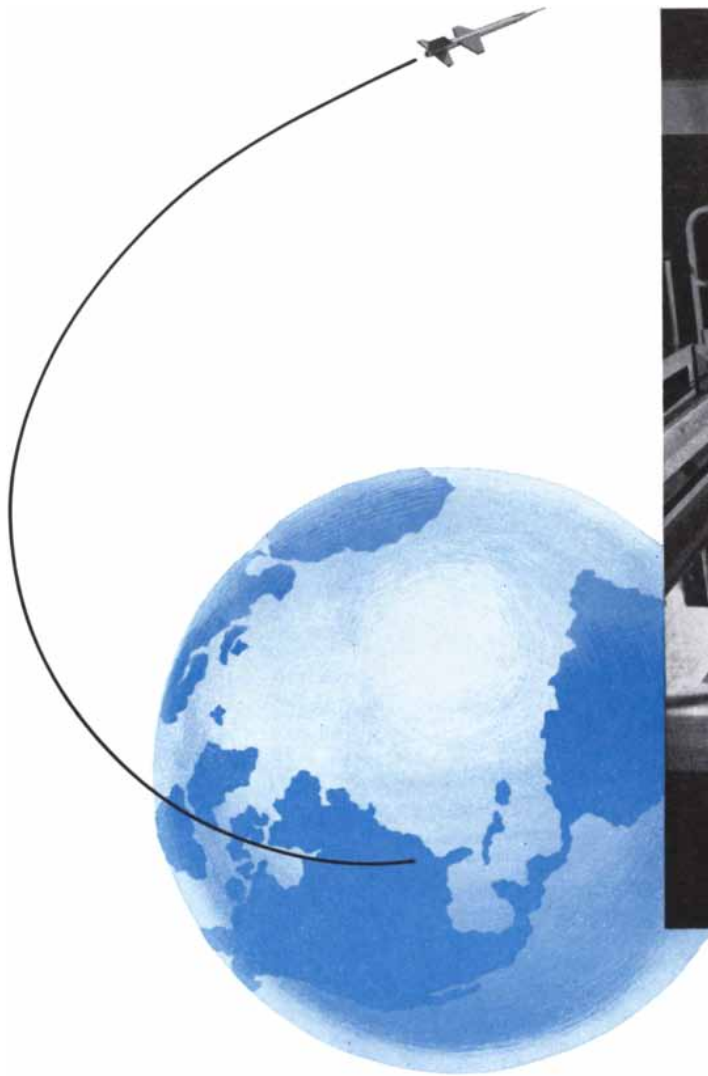
variable that controls sexual differentiation in hydra.

Very little was known about pCO₂, and, as with dissolved oxygen, there was no standard technique for analyzing it in small quantities of water. The next step was to devise such a method. One way that suggested itself was to shake the water in a syringe containing carbon-dioxide-free air. The carbon dioxide gas that thereupon appeared in the air could then be measured. With some refinement, this method proved accurate and reliable. My measurements revealed that water in gaseous equilibrium with normal air has a carbon dioxide pressure of .03 per cent of one atmosphere, identical with that of the air, and shows this pressure regardless of its acidity or bicarbonate content. In the solutions that turned hydra sexual, carbon dioxide pressure proved to be as high as 1.2 per cent of an atmosphere. It was apparent that such pressures could develop only



NEWLY FORMED HYDRA BUDS (left-hand column) were exposed to water containing different amounts of dissolved carbon dioxide gas. With no rise in pCO₂ (first row) the bud grew into a

normal hydra with six tentacles in two days. At pCO₂ of 4 per cent of an atmosphere (second row) the bud grew slowly and produced only three tentacles. Higher levels inhibited buds even more.



Ford Nuclear Reactor at the University of Michigan

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The Bendix Systems Division, using the Ford Nuclear Reactor at the nearby University of Michigan, is developing radiation-resistant Mission and Traffic Control equipment. This work is being conducted by Bendix as a contractor to the Air Force. The objective is an M&TC subsystem providing extreme reliability under severe environmental conditions and over long operating periods.

Hypersonic aircraft and re-entry vehicles require that communications overcome the attenuation of surrounding ionized air. Bendix is carrying out

propagation investigations and experimenting with designing special digital and voice communication systems. This work is under way at the Systems Division, Radio Division, and Pacific Division of the Bendix Aviation Corporation.

Positive communications also require resistance to jamming. Advanced research at the Bendix Systems Division has evolved techniques that combine jamming resistance and security of transmission.

Advanced communications know-how is being applied to additional programs for which the Systems Division has system management and engineering responsibility—such as the Navy EAGLE System and the Air Force AN/AMQ-15 Weather Reconnaissance System—and is applicable to many others.

Bendix Systems Division
ANN ARBOR, MICHIGAN





Internally-cooled blades and vanes for gas-turbine engines

THE NEED—Present uncooled gas turbines have bumped against the top thermal limits of the metals currently used for turbine components. Only by finding ways to increase the turbine inlet temperatures without affecting temperatures of such parts as turbine blades and vanes can gas-turbine engines of greater thrust and efficiency be made.

THE OBJECTIVE—An investigation was made in the TAPCO Group of Thompson Ramo Wooldridge Inc., to develop a way to produce internally-cooled blades and vanes. By cooling these parts, turbine inlet temperatures can be increased as much as 200°F over present limiting temperatures. This increase should permit much higher thrusts to be developed.

Cooling of turbine components can be achieved either by air or water. Air-cooling seems to be more convenient to apply. For this reason, TAPCO investigations have been directed to the production of blades and vanes with internal air passages.

THE METHODS—Fabrication methods reviewed includes powder metallurgy, casting, rolling, forging, and extrusion. TAPCO established projects on rolling, forging, and extrusion methods.

THE RESULTS—Practical methods have been developed at the TAPCO Group for drilling holes economically in such alloys as Udimet 500, Waspalloy and other blade materials.

Extrusion of pierced preforms has been accomplished by the TAPCO Group.

TAPCO engineers and metallurgists have developed practical methods of rolling pierced preforms to produce blades of accurate finished size and contour while maintaining the integrity of internal air passages during forming operations.

Both tapered and straight air passages have been achieved by methods and equipment suitable for mass production of air-cooled blades.

Limitations on the commercially feasible rolling of air-cooled blades and vanes have been established after considerable research on several rolling methods.

TO SUM UP—The TAPCO Group of Thompson Ramo Wooldridge Inc. is able to produce air-cooled blades and vanes from materials currently available to meet the requirements of gas-turbine manufacturers for higher turbine inlet temperatures. When may a TAPCO engineer call to give you complete information and design data?



TAPCO GROUP
Thompson Ramo Wooldridge Inc.

Dept. SA-4259 Cleveland 17, Ohio

in water that was not in equilibrium with the air.

Stagnant water containing hydra could meet this specification, for the constant respiration of the animals generates a steady supply of carbon dioxide gas. The gas, it is true, continually escapes into the air from the surface of the water, but if the surface is small in relation to the volume, or if there are enough animals in the culture, carbon dioxide is produced faster than it is lost. As a result the $p\text{CO}_2$ level can rise as high as 20 to 40 times normal. It thus became clear that stagnation reproduces sexuality by permitting high $p\text{CO}_2$ levels to build up, and aeration prevents it by blowing off the accumulated carbon dioxide gas.

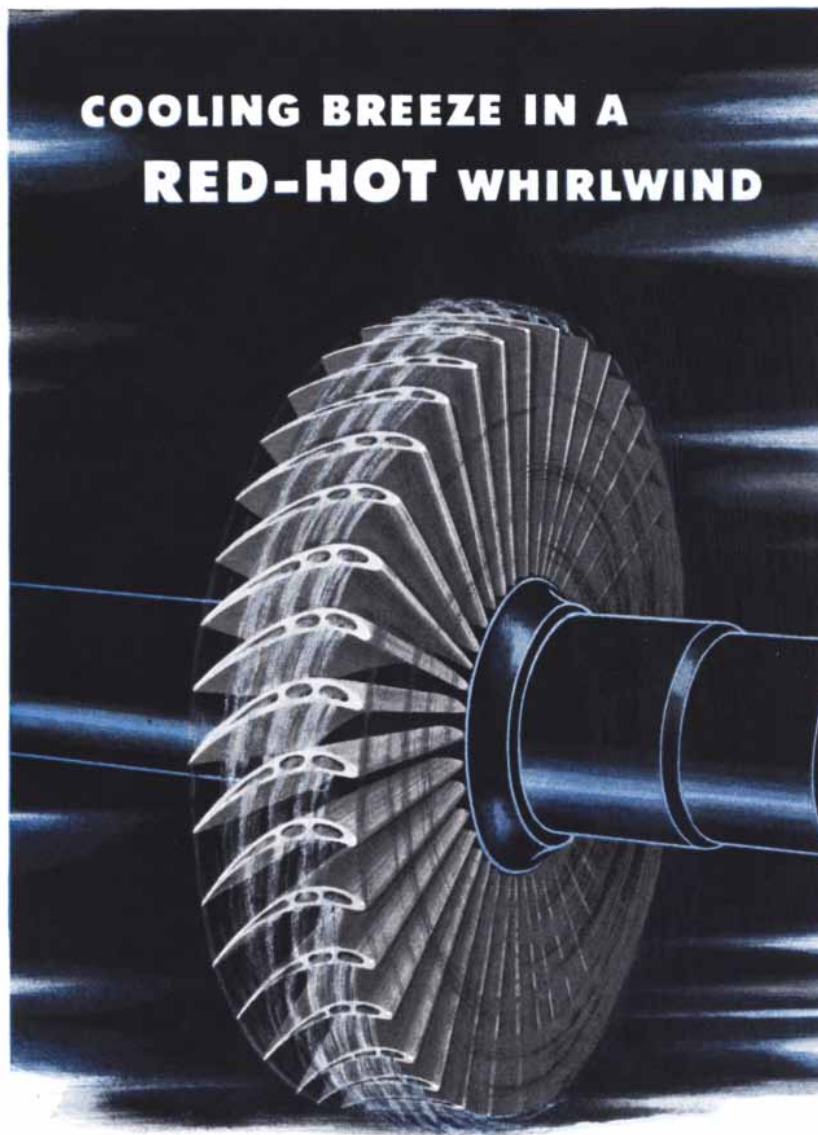
At one time I had been controlling 13 different variables such as temperature, crowding, stagnation and rate of feeding, in the attempt to control sexual differentiation. Now I could see that these variables had significance solely as they affected the single variable $p\text{CO}_2$. The high $p\text{CO}_2$ level generated by the crowding of hydra in a stagnant pond explains why sex is not a part of the life cycle of an isolated hydra but does appear when a hydra multiplies into a swarm. We have thus come upon a chemical factor that controls cellular differentiation in the individual and is itself regulated by the growth of the whole colony!

The next question was whether $p\text{CO}_2$ could control the differentiation of hydra cells other than the sex cells. While sexual differentiation depends on external $p\text{CO}_2$, it seemed possible that internal $p\text{CO}_2$, set up within the organism by the respiration of its cells, might also affect cell development. Carbon dioxide occurs as a free gas in tissue cells, for it is even more soluble in fat than in water and passes through fatty cell walls faster than any other substance, including water. We may visualize a group of CO_2 -producing cells as generating a gradient field of carbon dioxide pressure, higher at the middle of the cell cluster and weaker toward the periphery. The field will adjust to changes in mass; for instance, if some of the tissue is cut away, the gradient field automatically shifts its center of concentration to the middle of the remaining group of cells. This picture of the $p\text{CO}_2$ field suggests an explanation of the fact that a hydra's tentacles always grow from the tip of the hydra's tubelike stalk. Being free on one side, terminal cells are subject to a lower $p\text{CO}_2$ than cells elsewhere in the tube, which are surrounded

on all sides by other carbon-dioxide-producing cells.

The hypothesis that lower carbon dioxide pressure permitted the terminal stalk cells to differentiate into tentacles suggested a simple experiment. It occurred to me that raising the $p\text{CO}_2$ of the surrounding water ought to keep the terminal cells from differentiating into tentacles. Using hydra just beginning to sprout buds, I raised the $p\text{CO}_2$ of the water higher and higher and found that the eventual number of tentacles was reduced from the normal six down through five, four, three and finally to none at all when the $p\text{CO}_2$ was raised to 10 per cent of an atmosphere. We may then speculate that the tentacles normally grow at six equally spaced intervals because each sets up around itself a field of $p\text{CO}_2$ inhibition. The $p\text{CO}_2$ applied artificially from the outside increases the width of these fields so that fewer and fewer tentacles appear. This gives some idea of how steep the $p\text{CO}_2$ gradient might be within a tissue. If my interpretation is sound, then the normal stalk cells sandwiched in between their neighbors must be exposed to a $p\text{CO}_2$ of about 10 per cent of an atmosphere to prevent them from forming tentacles.

Could $p\text{CO}_2$ gradient be a general mechanism for controlling growth and differentiation? Carbon dioxide is produced in the respiration of all living cells. In fields as far apart as ecology, embryology and tissue culture, we know of carbon dioxide effects that would now appear to be the result of $p\text{CO}_2$. More than 20 years ago A. M. Banta at the Carnegie Institution of Washington laboratory in Cold Spring Harbor, N. Y., found that some gas generated in a crowded culture of *Daphnia* causes these creatures to differentiate sexually, and that apparently the same gas given off by other creatures in a crowded natural population in pond water induces sexual differentiation in individual *Daphnia*. The crowding of frogs' eggs has long been known to alter their rate of development. In 1923 G. H. A. Clowes at the Marine Biological Laboratory in Woods Hole, Mass., showed that cell division in marine eggs slowed up when carbon dioxide gas accumulated, and returned to normal when the level of the gas was decreased. For years workers in tissue culture have adjusted the acidity of their fluids by introducing carbon dioxide gas into the culture medium, but they could not explain why they had to use this particular method in preference to simpler ways of controlling acidity. Time and again the trail has led



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Precisely-located, precisely-sized radial holes through the blades carry blasts of cooling air from root to tip. This allows turbine inlet temperatures to be increased as much as 200°F safely, efficiently.

To know more about TAPCO capabilities to make air-cooled blades and vanes, as well as systems and components of any space-age vehicle, write to the address below.



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Write C. F. Johnson, Manager of Education

THE BRISTOL COMPANY
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to carbon dioxide. But no one apparently had thought until now that it might be pCO_2 that matters, rather than the total amount of dissolved carbon dioxide. It was like finding that many fruits cure scurvy but never discovering that the active principle is vitamin C.

Could pCO_2 possibly be the long-sought inhibitor of cell growth in the adult body? Under normal conditions some inhibitor must prevent the body cells from growing even though they are capable of multiplying rapidly in a healing wound or in a tissue culture. Recalling that pCO_2 at 5 to 10 per cent of an atmosphere progressively inhibits the budding of tentacles in the hydra, it may be significant that the body carefully regulates the pCO_2 of the arterial blood to exactly 5.3 per cent of an atmosphere. Since all normal adult cells generate carbon dioxide, it may be that their growth is inhibited by this product of their own respiration. Embryonic cells, on the other hand, produce energy not only by respiration, but also by the fermentation of glucose to lactic acid, a process that does not produce carbon dioxide; they are able to grow continuously so long as they obtain energy by both fermentation and respiration. Upon maturation they lose their fermentative capacity and simultaneously become nongrowing adult cells.

More than 30 years ago the noted German biochemist Otto Warburg showed that cancer cells resemble embryonic cells in deriving large amounts of energy from the fermentation of glucose into lactic acid. Is this fermentative ability the means by which cancer cells pierce the inhibitory barrier of pCO_2 ? Although the chances of a mutation that increases fermentative ability are small, such a mutant tissue cell would be able to resist the inhibition of pCO_2 and hence would be able to grow wildly in cancerous fashion. Just as streptomycin-resistant bacteria arise in cultures inhibited by streptomycin, would not the primeval forces of nature urge tissue cells to mutate in various ways in a continuing effort to escape the continuing inhibition of pCO_2 ?

The French biochemist Pierre Emile Duclaux once wrote that the proper test of a theory was its ability to stimulate further experimentation. The pCO_2 theory suggests endless experiments, and by this test the decision to use hydra for the study of differentiation was a fortunate one. The tiny hydra has led to the discovery of a chemical gradient—a field of force—that apparently affects both the rate of cell division and the process of cellular differentiation.



Some News of Moment to Engineers

and Scientists who have participated in Operations Research & Systems Analysis—from Computer Department of General Electric

IN WASHINGTON, D. C. NEXT WEEK—

and in ensuing weeks, a group of men—whom the engineering world is beginning to call “scientific generalists”—will sit around a table with representatives of the Air Force, defining the problems and formulating the conceptual bases of an unprecedented DATA PROCESSING SYSTEM. This system will handle *evaluation and distribution of continuing variables on a scale never before attempted* and transcend present potentials in Man-Machine Relationships.

These men are drawn from many disciplines—mathematics, psychology, computer and systems engineering, philosophy, communications. In common, they have these attributes: unusual abilities to listen, synthesize, communicate, collaborate, and take a broad, all-encompassing view of multiphase problems.

The program, initiated early in 1958, is being conducted for the Air Force by General Electric's Computer Dept., from its Washington, D. C. offices and headquarters in Phoenix, Arizona.

CONCURRENTLY, SUPPORTING TEAMS OF SPECIALISTS ARE ENGAGING IN INTENSIVE RESEARCH.

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Write, in confidence, to: Mr. J. E. Torrey, Div. 59-MD
COMPUTER DEPARTMENT



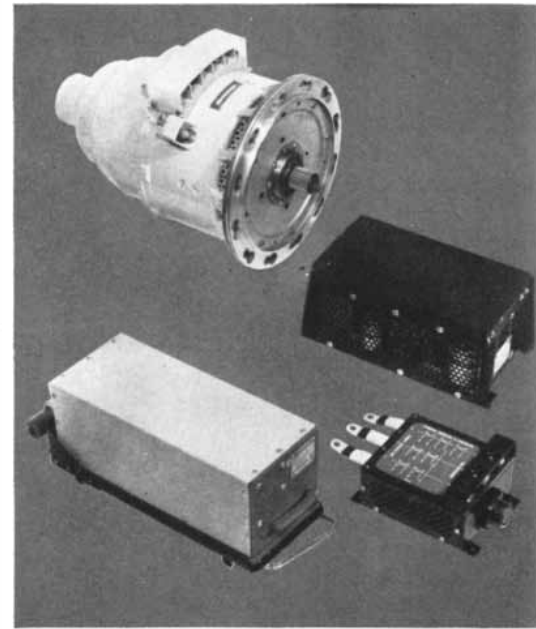
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CAPABILITIES FOR DEFENSE

Westinghouse electrical systems, using first brushless generator, proved in thousands of flight hours



NOW IN FULL-SCALE PRODUCTION. The world's first aircraft brushless generators have a key role in advanced electrical systems provided by Westinghouse for today's military and commercial aircraft. The 40 kva units above are standard in Boeing 707 jetliners. First introduced in 1954 by Westinghouse Aircraft Equipment Dept., Lima, Ohio, these dependable generators have performed thousands of flight hours on the Boeing 707 and the Air Force B-58.



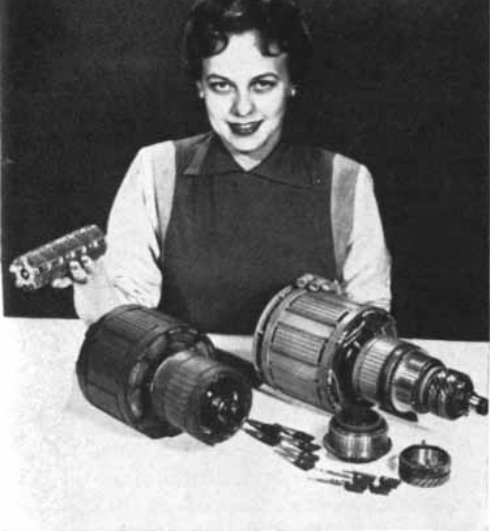
LEADER IN AIRCRAFT ELECTRICAL SYSTEMS. Westinghouse has been producing aircraft electrical systems since World War I—has built more a-c electrical systems for aircraft since World War II than any other company. Shown is the brushless air-cooled generator with control apparatus.



NAVY—The North American A3-J, completing flight tests preparatory to joining the fleet, uses the Westinghouse electrical system, including oil-cooled brushless generators.



AIR FORCE—The Convair B-58 Hustler employs the Westinghouse electric power system, including oil-cooled 40 kva brushless generators.



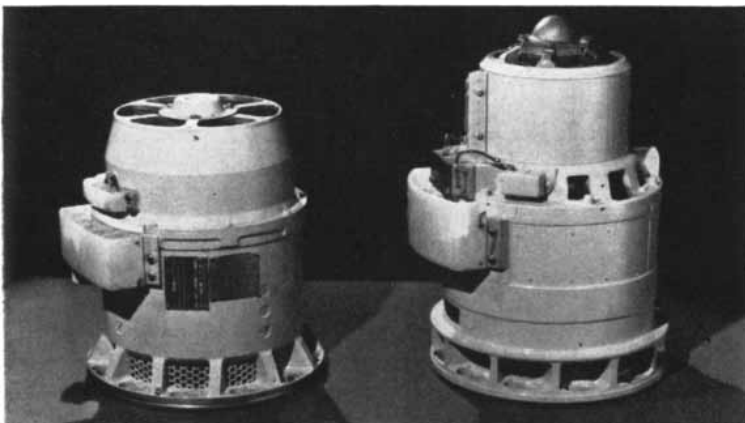
LONGER SERVICE LIFE and greater reliability result from the elimination of commutators, carbon brushes and collector rings, shown at right. A single internal rectifier bundle, held by girl, replaces them. High-temperature silicon diodes, produced by Westinghouse research in semi-conductors, make this possible.



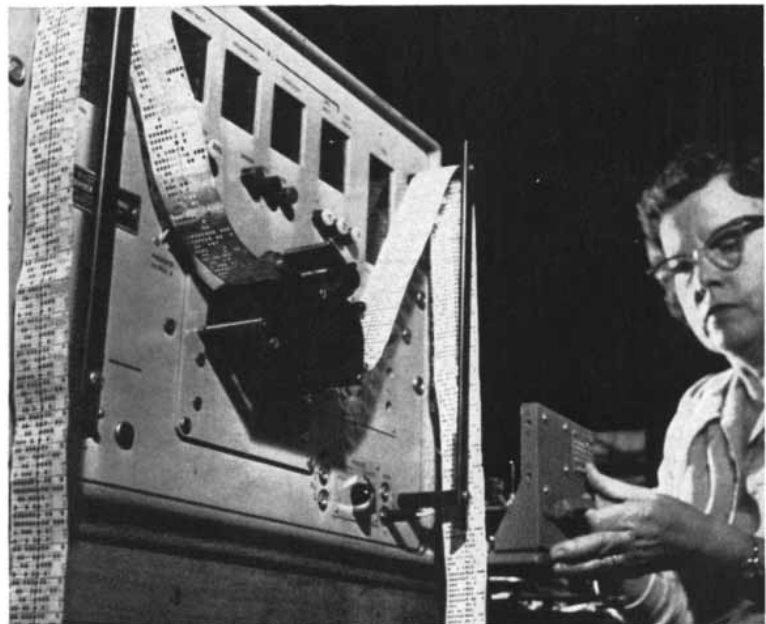
OIL-COOLED GENERATOR for Convair B-58 Hustler achieves major breakthrough of temperature barrier in electrical generator design—is cooled by MIL-L-7808 oil, having inlet temperature of 300° F. Usual generator troubles are eliminated—no brushes, commutating or slip-ring parts to wear. Results: greater economy, less frequent overhaul.



AUTOMATIC FUNCTION SIMULATOR, one of the newer testing techniques used by Westinghouse, assures more reliable protective devices for electrical systems. This machine subjects protective control panel to as many situations as it will encounter in flight operations.



BRUSHLESS VERSUS BRUSH-TYPE GENERATOR. Both generators are 40 kva. The brushless generator on the left above uses less space and weighs less. Longer life is assured—air-cooled brushless generators are guaranteed for 3,000 flight hours, bearings up to 1,500 hours. Brushless generators with even greater life are under test at Westinghouse.



ROBOT CIRCUIT TESTER uses punched tape to check circuitry of control equipment with 100% accuracy, 60 times faster than previous techniques. Westinghouse automatic circuit-testing facilities speed production, eliminate chance of human error, improve product reliability.



COMMERCIAL—The Boeing 707 uses Westinghouse electrical system, including air-cooled brushless generators—proved in thousands of flight hours.

Westinghouse

DEFENSE PRODUCTS

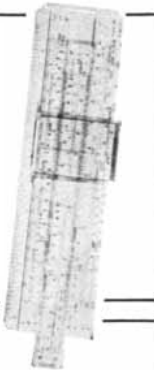
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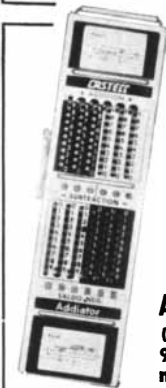
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MATHEMATICAL GAMES

*The mathematical diversions
 of a fictitious carnival man*

by Martin Gardner

The James Hugh Riley Shows, Inc., is one of the country's largest non-existent carnivals. When I heard it had opened at the edge of town, I drove out to the lot to see my old friend Jim Riley; we had been classmates some 20 years ago at the University of Chicago. Riley was then taking graduate courses in mathematics, but one summer he joined a carnival as a "talker" for the girlie show, and during most of the subsequent years he had been, as the carnies say, "with it." To everyone on the lot he was known simply as The Professor. Somehow he had managed to keep alive his passion for mathematics, and whenever we got together I could always count on picking up some unusual items for this department.

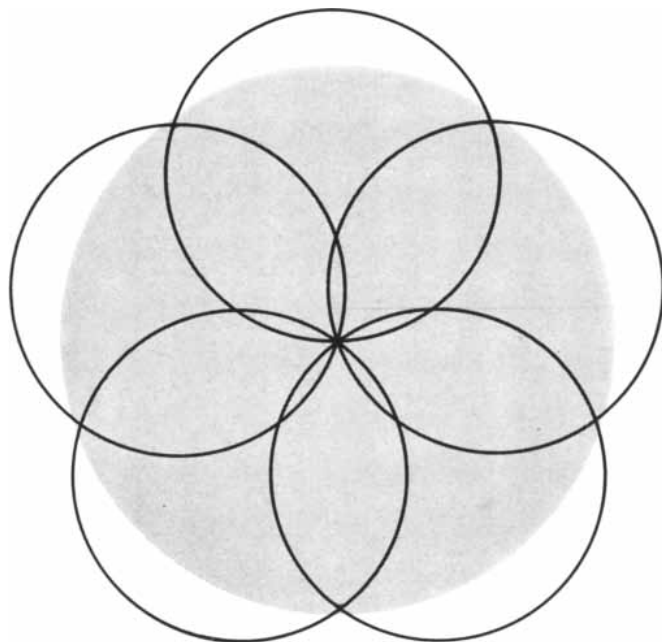
I found The Professor chatting with the ticket collector in front of the freak show. He was wearing a white Stetson

hat and seemed older and heavier than when I had last seen him. "Read your column every month," he said as we pumped hands. "Ever thought about writing up Spot-the-spot?"

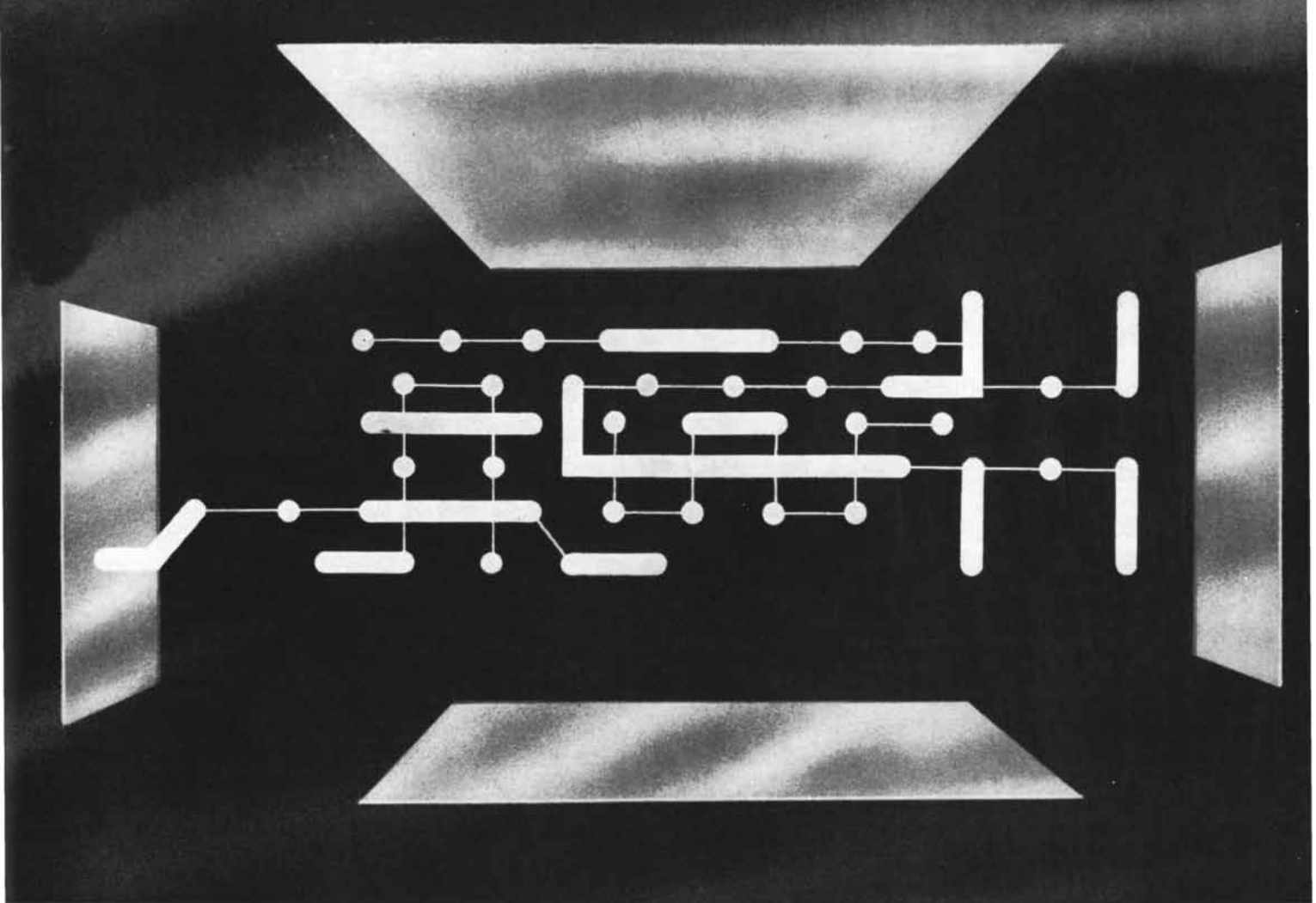
"Come again?," I said.

"It's one of the oldest games on the lot." He grabbed my arm and pushed me down the midway until we came to a concession where a red circular spot a yard in diameter was painted on the counter. The object of the game was to place five metal disks one at a time on this spot in such a way that they completely covered the spot. Each disk was about 22 inches across. Once a disk had been placed the player was not permitted to move it, and the game was lost if even the tiniest bit of red remained visible after the fifth disk was down.

"Of course," said The Professor, "we use the largest possible spot that can still be covered by the disks. Most people think the disks should go like so." He arranged them symmetrically on the spot as shown in the illustration below. The circumference of each disk touched



An inferior method of placing the disks in "Spot-the-spot"



Report from IBM  Yorktown Research Center, New York

LOW TEMPERATURES FOR HIGH-SPEED CIRCUITRY

Certain metals and alloys lose their resistance to electricity at temperatures close to absolute zero. They become "super-conductors." Investigations by Dr. D. R. Young and others at the IBM Yorktown Research Center are directed toward the utilization of this unique property in the development of small-size, high-speed switches with increased logical capacities.

Interestingly, when a "super-conductor" is exposed to certain magnetic fields, it reverts instantly to an ordinary conductor. One experimental switching device that takes advantage of this property has been constructed at IBM. In essence, it is a "sandwich" of glass, tin, silicon monoxide and lead. The device is immersed in liquid helium to bring it close to absolute zero. The tin strip becomes a "super-conductor," so current flows readily through it. When a current is applied to

the lead strip it creates a magnetic field. As a result, the tin strip is no longer a "super-conductor" and now has electrical resistance . . . it is "off." Remove the magnetic field and it is "on" again. This then is an "on-off" device, or switch, that is expected to work at speeds much greater than present switch capacities. There are no moving parts to wear out and 1,000 such devices can be mounted on a bit of glass only a few inches square.

In addition to these experiments, the study of matter at very low temperatures is being applied to other areas at IBM. The immediate objective is to apply the results to the development of device formulations which will greatly accelerate arithmetic speed and increase the logical capacity in electronic computers of greatly reduced size.

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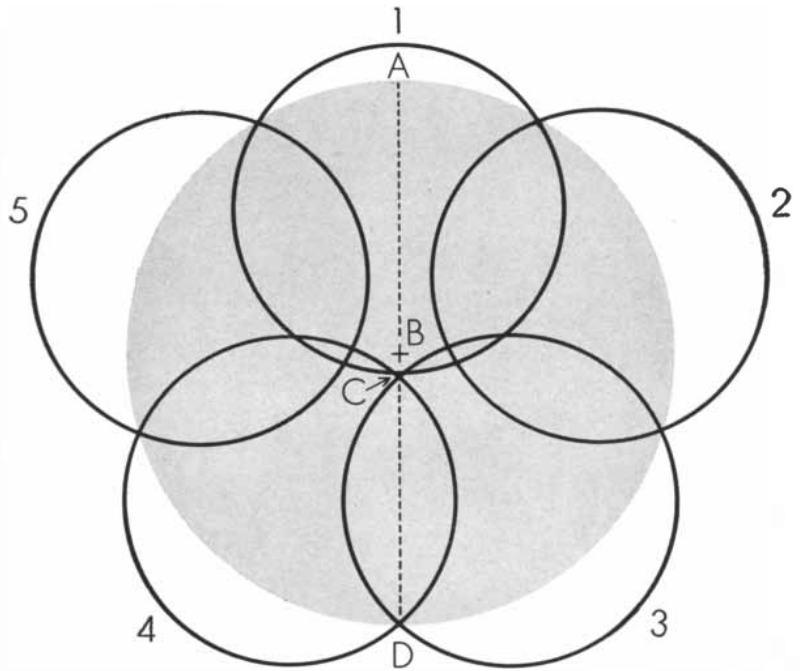
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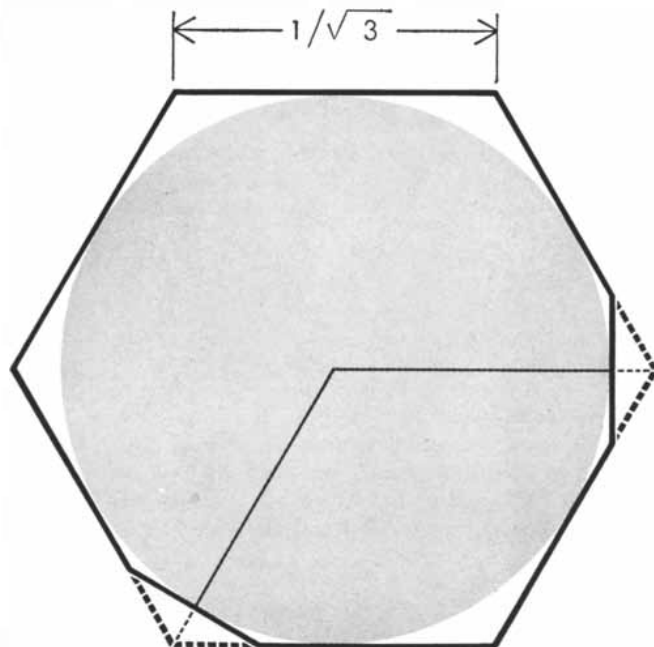
The correct method of placing the disks in "Spot-the-spot"

the spot's center, and the centers of the disks formed the corners of a regular pentagon. Five minute areas of red were visible around the spot's rim.

"Unfortunately," Riley continued, "that doesn't quite do it. To cover the maximum circular area, you have to arrange them this way." He pushed the disks with his finger until they assumed the formation shown in the illustration above. Disk No. 1, he explained, has its center on diameter AD and its circum-

ference on point C, which is slightly below the spot's center (B). Disks No. 3 and No. 4 are then placed so their edges pass through C and D. Disks No. 2 and No. 5 cover the rest of the spot as shown.

Naturally I wanted to know the distance of BC. Riley couldn't remember exactly, but he later sent me the reference to an article in which this difficult problem is worked out in detail: "On the Solution of Numerical Functional Equations, Illustrated by an Account of a



A truncated hexagon that will cover any area with a "diameter" of 1



NEW VOUGHT CRUSADER FOR FLEET NEXT YEAR!

Navy orders fourth version of flexible, economical fighter

For the fourth time in three years, a new *Crusader* type is extending the power of the Fleet. Chance Vought's F8U-2N has been ordered by the Navy for delivery next year. It will deploy alongside the Navy's swiftest photoplanes and two first line day fighters — all *Crusaders*.

The F8U-2N is another step in *Crusader* growth. Speed of this newest version has been advanced to near Mach 2. It will carry the deadliest air-to-air missiles. It is instrumented and radar-equipped for supersonic

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Popular Puzzle and Its Solution," by Eric H. Neville (*Proceedings of the London Mathematical Society*, Second Series, Vol. 14, pages 308-326; 1915). If the radius of the spot is unity, the distance BC is a trifle more than .0285 and the smallest radius possible for the disks is .609418. If the disks are placed as shown in the illustration on page 160, they must have a radius of .6180340 in order to cover the spot completely. The curious feature of the problem is the smallness of difference between the areas covered by the two methods of arranging the disks. Unless the spot is about a yard in diameter, the difference is scarcely detectable.

"This reminds me," said I, "of a fascinating minimal-area problem still unsolved. You define the diameter of an area as the longest straight line that will join two points on it. The question is: What are the shape and area of the smallest plane figure that will cover any area of unit diameter?"

The Professor nodded. "The smallest regular polygon that does it is a hexagon with a side of $1/\sqrt{3}$, but about 30 years ago someone improved this by chopping off two corners." He took a pencil and pad of paper from his jacket and sketched the pattern reproduced in the illustration at the bottom of page 162. The corners are sliced off along lines tangent to the inscribed circle (which has a unit diameter) and perpendicular to lines from the circle's center to the corners.

"Is that the best solution so far?" I asked.

Riley shook his head. "I've heard that a few years ago someone at the University of Illinois sliced off another small piece, but I don't know the details."

We sauntered down the midway and stopped in front of a concession where three enormous dice were tum-

bling down a corrugated incline to a flat surface below. Large white digits from 1 to 6 were painted on the counter. A player could put as much money as he wished on any digit. The dice were rolled. If his number appeared once on the dice, he received back his bet plus the same amount of money. If the number appeared twice, he got back his bet plus twice the amount. If the number showed on all three dice, he got back his bet plus three times the amount. Of course if the number did not show at all, he lost his bet.

"How can this game show a profit?" I asked. "The probability of a certain number showing on one die is $1/6$, so with three dice the probability is $3/6$ or $1/2$ that the number will show at least once. If the number shows more than once, the player can win even more than he bets, so it looks to me like the game favors the player."

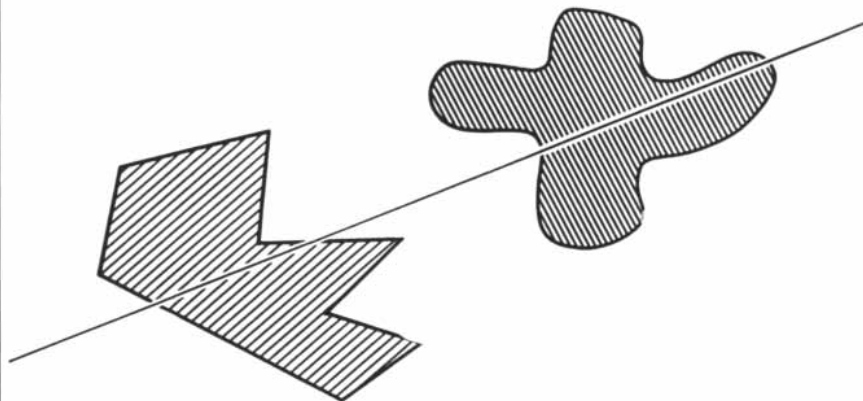
The Professor chuckled. "That's just how we want the marks [carny slang for suckers] to figure it. Think about it again." When I did think about it later, I was astonished. Perhaps some readers will enjoy calculating just how much, in the long run, a player can expect to receive back for every \$10 that he puts out.

Before I left the lot, Riley took me into one of his "cook houses" (as he called them) for a bite to eat. Our coffee was served at once, but I decided not to touch it until our sandwiches came.

"If you want to keep your coffee hot," The Professor said, "better pour your cream now instead of later. The hotter the coffee is the faster its rate of heat loss."

I dutifully poured my cream.

When The Professor's ham sandwich arrived, sliced neatly through the middle, he gazed at it for a moment and



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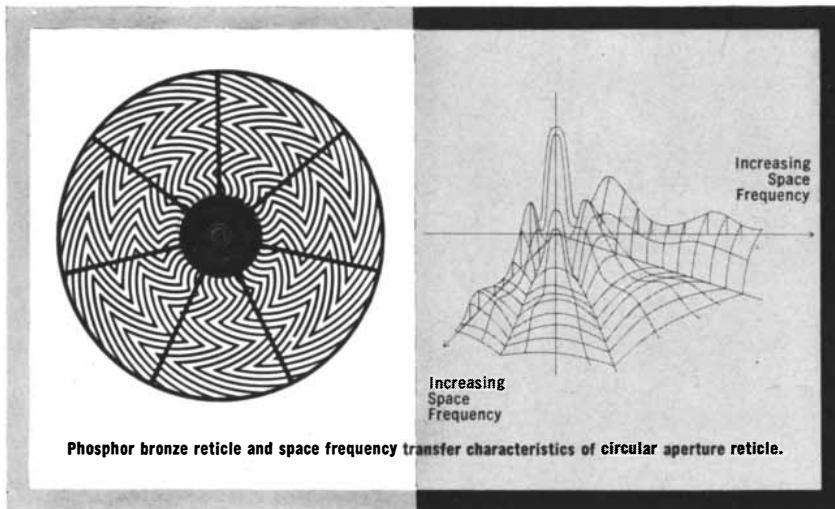
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said, "Have you ever come across a paper by Tukey and Stone on the generalized ham-sandwich theorem?"

"You mean John Tukey and Arthur Stone? Two of the co-discoverers of flexagons?"

"The same."

I shook my head. "I don't even know about the ungeneralized ham-sandwich theorem."

Riley took out his pad again and drew a line segment on it. "Any one-dimensional figure can always be bisected by one cut. Right?" I nodded while he drew two irregular closed curves, then a straight line that sliced both of them [see illustration on page 164]. "Any pair of areas on a plane can be exactly bisected by one straight line. Correct?"

"I'll take your word for it."

"It's not hard to prove. There's an elementary proof in *What Is Mathematics?*, by Richard Courant and Herbert Robbins. It makes use of Bolzano's theorem."

"Ah, yes," I said. "If a continuous function of x has positive and negative values, it has to have at least one zero value."

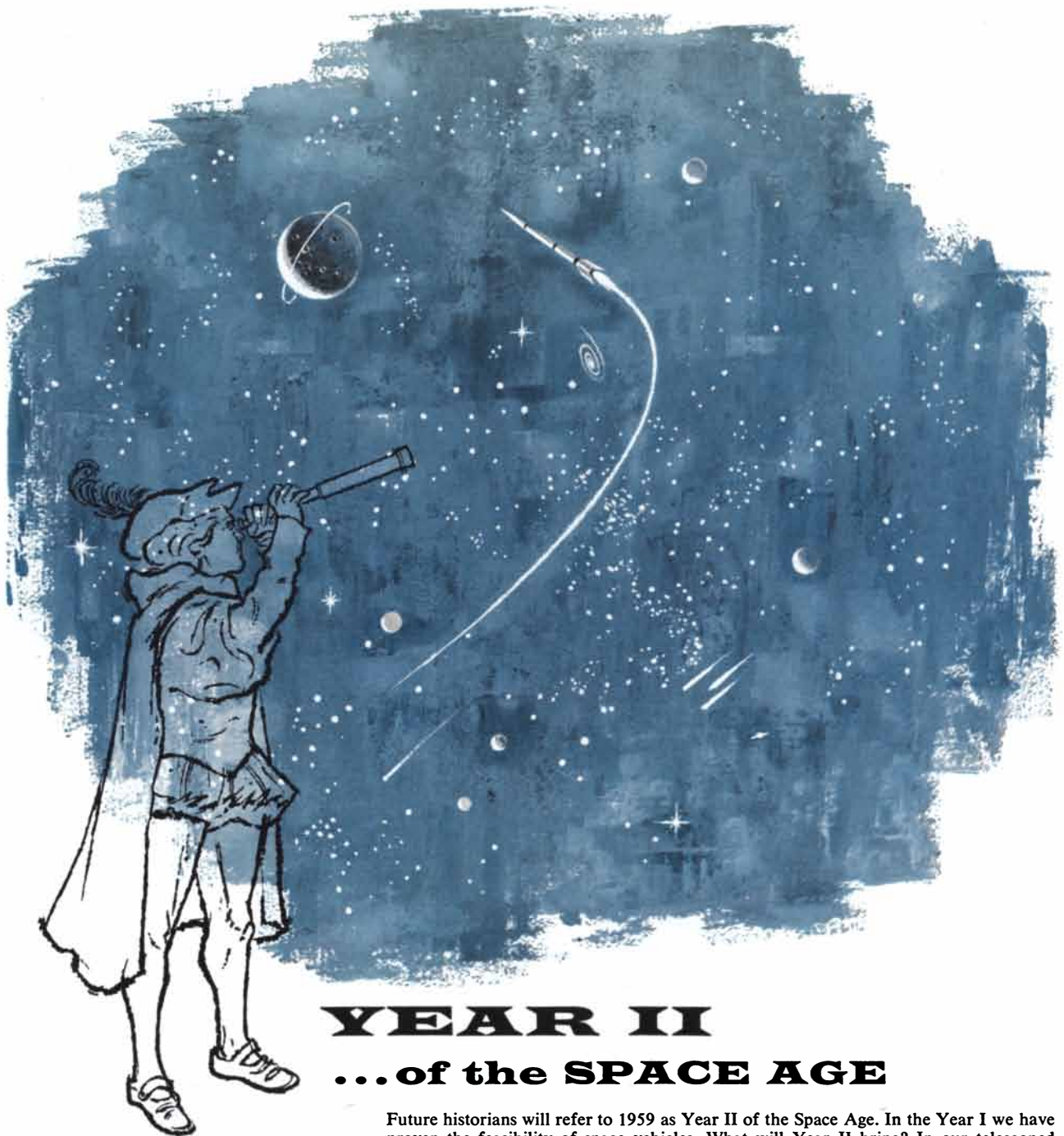
"Right. It seems trivial, but it's a powerful tool in all sorts of existence proofs. Of course in this case the proof doesn't tell you how to construct the line. It only proves that the line exists."

"Where do ham sandwiches come in?"

"When we move on to three dimensions. The volumes of any three solids, of any size or shape, placed anywhere in space, can always be exactly and simultaneously bisected by a plane—like bisecting two pieces of bread and a slice of ham in between. Stone and Tukey generalized this for all dimensions. They proved that there is always a plane that bisects four four-dimensional solids placed anywhere in four-dimensional space, or five five-dimensional solids, and so on."

The Professor drained his cup, then pointed across the counter to a pile of doughnuts. "Speaking of slicing solids, here's a question you might ask your readers sometime. What's the maximum number of pieces you can get with three plane cuts through one doughnut? It's a problem I thought of myself."

I closed my eyes and tried to visualize it while the merry-go-round calliope wheezed off key, but the problem made my head throb and I finally gave up. Next month's department will include the answer to the dice problem, and two months from now we will discuss the best solutions received on the doughnut question.



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THE AMATEUR SCIENTIST

How amateurs can build a simple magnetic-resonance spectrometer

Conducted by C. L. Stong

Shortly after World War II a group of physicists wrapped a coil of wire around a glass tube in which water had been sealed, put the assembly between the poles of a magnet and sent a high-frequency current through the coil. When the frequency was raised or lowered through a critical range, the current flowing in the coil varied sharply. This occurred precisely at the point where the frequency of the oscillating magnetic field set up by the coil resonated with the magnetized nuclei of hydrogen atoms in the water. Further experiment showed that other atoms as well as molecules of many kinds react in the same way. Of more interest, however, was the observation that the current varies uniquely for each kind of substance sensitive to the test. In the dozen years since these relatively simple experiments were made the technique has given rise to an instrument called the magnetic-resonance spectrometer which rivals the power of the optical spectroscope for investigating the structure of matter [see "Magnetic Resonance," by George E. Pake; *SCIENTIFIC AMERICAN*, August, 1958].

In the course of applying the new technique to the analysis of biological substances, a group working under Miles A. McLennan in the Bioelectronics Section of the Aero Medical Laboratory at the Wright Air Development Center has designed a simple version of the magnetic-resonance spectrometer that amateurs can make at home. It should serve not only as an introduction to an interesting new field of experimental physics but should also make an attractive classroom demonstration or science-fair project.

According to the "classical" theory of physics, all elementary particles of matter spin on their axes like tops, and those

that have an electric charge (*e.g.*, electrons and protons) generate magnetic fields. (The classical picture has now been superseded by the quantum-mechanical view, but it will suffice for the purposes of this discussion.) Particles bound in atoms and in molecules not only spin but also move on orbits. This motion adds to the field generated by the spin. The fields of neighboring particles merge; depending on the structure of the atoms or molecules and on the direction in which the magnetic forces point, the fields tend to cancel in some cases and to reinforce in others. In consequence all atoms and molecules are characterized by unique patterns of interacting magnetic forces.

What will happen to these tiny magnets if they are subjected to the influence of an external magnetic field? It was this question that led to the development of the new technique. In the case of the single-proton nuclei of the hydrogen atoms of water, the magnetic axes normally point in random directions. It might therefore be supposed that an external field would cause the proton axes to line up in the direction of the field. This, however, does not happen. Instead the field causes the protons to precess, or wobble like a spinning top that has been tipped from the vertical. We might say that each particle now has two axes, one about which it spins and the other about which it precesses. The axes on which the particles precess line up with the external field, but attempts to align the axes on which they spin get nowhere. Increasing the strength of the external field merely causes the particles to precess faster. In fact, the rate of precession varies in proportion to the field strength and is equal to the intensity of the field (expressed in gauss) multiplied by 4,228.5. Thus when a sample of water is placed between the poles of a typical magnetron magnet with a field strength of 1,450 gauss, the hydrogen nuclei precess at the rate of 6,131,325 revolutions per second.

It is possible to disturb the particles, however. They can even be flipped over so their "north" and "south" poles are

reversed. This is accomplished by setting up a second external field at right angles to the first and causing it to oscillate or reverse direction precisely in step with the rate at which the particles are precessing. In the case of water in a biasing field of 1,450 gauss the critical frequency is 6.1 megacycles. Energy is absorbed by the particles from the oscillating field during each alternation, just as a tuning fork is set into vibration by the sound waves to which it is resonant. Resonance between the particles and the oscillating field can be established by adjusting either the frequency of the current through the coil or the strength of the biasing field (which determines the rate at which the particles precess). As the oscillating-field frequency approaches resonance the particles absorb energy. As they recede from resonance the borrowed energy is emitted, part being returned to the coil and the remainder being shared with neighboring particles.

In most substances the exchange of energy between the particles and the coil is surprisingly sluggish with respect to the speed of most atomic processes. Some particles respond immediately at resonance, but others require intervals ranging from a few seconds to several minutes. This complicates the design of magnetic-resonance spectrometers because their electrical circuits must be made extremely stable and their output must be observed with the aid of pen recorders.

It turns out, however, that the addition of ferric nitrate to water increases the susceptibility of the particles to the outside field and radically decreases the time required for energy exchange without affecting the rate at which the particles precess. According to the Aero Medical Laboratory group, no completely satisfactory explanation for the action of ferric nitrate has been advanced. It may be that ferric ions in solution decrease the magnetic interaction of the particles and thus render them more susceptible to the influence of external fields. Whatever the explanation, ferric nitrate dissolved in water makes it possible to demonstrate the phenomenon of

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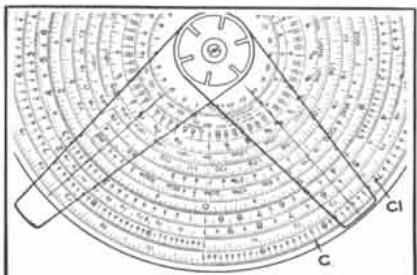
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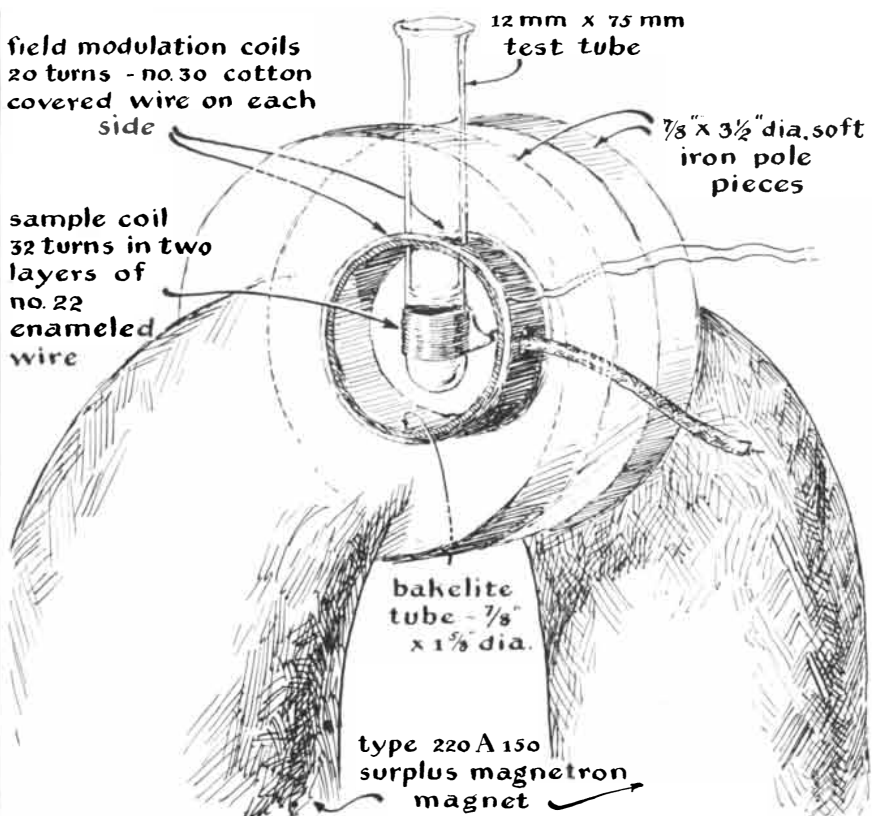
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Magnet assembly of the magnetic-resonance spectrometer

magnetic resonance with relatively simple apparatus.

The experiment consists of placing a test tube containing the solution of ferric nitrate in the pulsating field of a magnetron magnet and, by means of an oscilloscope, observing the exchange of energy at resonance between the sample and a coil around the test tube which is energized by a vacuum-tube oscillator. The energy absorbed during a single flip of the particles is too small for detection by conventional electronic devices. Hence in this experiment the frequencies are brought in and out of resonance 60 times per second. The frequency of the vacuum-tube oscillator is held constant while the rate of precession is varied by modulating the biasing field of the magnetron magnet. This is accomplished by placing a second coil energized by 60-cycle alternating current between the poles of the magnetron magnet; the flux of this modulating coil alternately reinforces and opposes that of the magnet. The rate of precession varies in proportion. The vacuum-tube oscillator is equipped with two controls, one for adjusting the frequency to the average rate at which the proton axes precess and the other for adjusting the amount of energy fed back from the plate circuit of the vacuum tube to the grid circuit. The latter control regulates

the intensity at which the tube oscillates. With this control the oscillator can be put into or out of operation or, when desired, set at the marginal oscillating condition. The modulating coil is wound with a space in the center to admit the test tube, and placed so that its axis is concentric with the biasing field [see illustration above].

With the sample in position the oscillator is turned on and adjusted as closely as possible to 6.1 megacycles, the average frequency at which the protons precess. The feedback control is adjusted for the marginal condition at which oscillations are barely sustained. At this critical point current flowing in the plate circuit of the oscillator tube is highly responsive to changes of energy in the coil around the test tube. The intensity of the plate current is observed by connecting the plate circuit to the vertical terminals of the oscilloscope as shown in the illustration on page 174. A spot of light will appear on the screen, indicating that a fixed value of plate current is flowing. The modulating coil of the biasing magnet is now energized. If the frequency of the oscillator has been adjusted to the average rate of precession, the spot of light will expand into a vertical line, indicating that the plate circuit is responding to energy exchanged between the coil and the parti-

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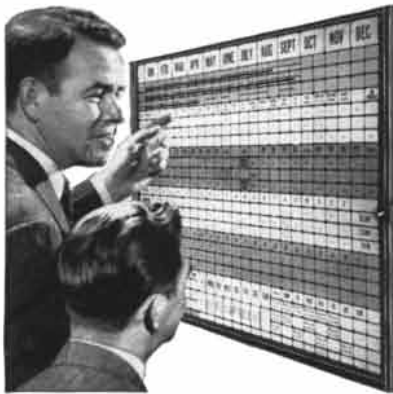
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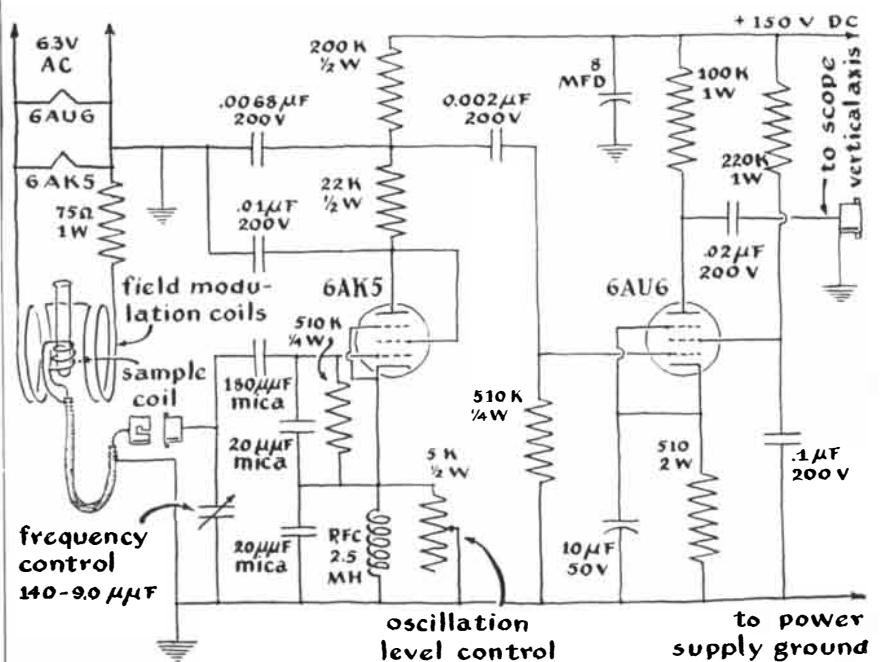
cles. The display can be made more interesting by connecting the horizontal plates of the oscilloscope to the 60-cycle power supply which energizes the modulating coil. Typical patterns are shown on page 176.

In the apparatus designed at the Aero Medical Laboratory the magnetic biasing field is supplied by a Type 220A 150 surplus magnetron magnet. The pole faces of the magnet were replaced by soft iron disks 3 1/2 inches in diameter and 7/8 inch thick to provide a field over a large area. For maximum response all protons must precess at the same rate, which means that all must be acted upon uniformly by the modulated biasing field. The intensity of the field will vary with the distance between the pole faces. Hence these must be made parallel and free from surface irregularities. Surplus magnets from magnetrons of the radial-cathode type usually bear a small white dot on the base which gives an approximate figure in gauss for the field strength that may be expected in the air gap. The magnet used in the instrument constructed at the Aero Medical Laboratory is rated at 1,450 gauss. It was modulated by a coil consisting of 20 turns of No. 30 cotton-covered magnet wire wound on a Bakelite tube 1 5/8 inches in outside diameter and 7/8 inch long. Ten turns of the coil are wound at one end of the tube and 10 turns are wound in the same direction at the other end. A hole 5/8 inch in diameter is cut in the center of the coil form to admit the test tube. A second hole 3/8 inch in

diameter is made at right angles to the first to admit a length of coaxial cable for linking the oscillator coil to the source of high-frequency current. The modulating coil is energized by the transformer which supplies the tube heaters, and it sweeps the strength of the biasing field 50 gauss above and below its mean value.

The test tube is 12 millimeters in diameter and 75 millimeters long. A two-layer coil of No. 22 enameled magnet wire, consisting of 16 turns per layer, is wound on the straight portion of the tube as close as possible to the closed end. The tube and coil are mounted vertically in the Bakelite form on which the modulating coil is wound.

The circuit construction is conventional. The oscillator is designed around a 6AK5 pentode tube. When used with an oscilloscope of high sensitivity, output from the oscillator may be taken at the junction between the 22,000-ohm resistor and the 200,000-ohm resistor in the plate circuit. With scopes of lower sensitivity, such as the Heathkit Model O-10, a single-stage amplifier using a 6AU6 pentode is added as shown in the circuit diagram. A variable capacitor, such as the Hammarlund Type MC-140-M, is used for adjusting the frequency of the oscillator. These components are assembled on an aluminum chassis three inches high, five inches wide and six inches long. Input and output connections are made through RG 58/U coaxial cable equipped with UG 290/U and UG 88/U terminals. Power



Circuit diagram for the magnetic-resonance spectrometer

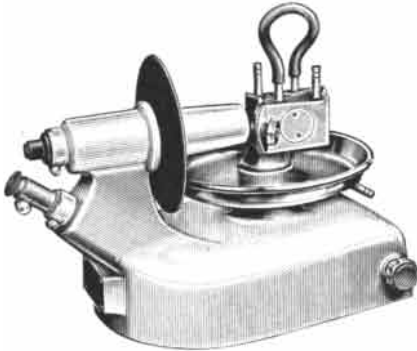
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may be taken from any supply capable of delivering 100 milliamperes of direct current at 150 volts to the tube heaters and 60-cycle alternating current at 6.3 volts to the modulating coil.

The test solution is prepared by dissolving 4 gram of ferric nitrate in 100 cubic centimeters of distilled water. Two cubic centimeters of this solution are added to the test tube and placed in the biasing field. Power is applied. After the horizontal-sweep circuit of the oscilloscope has been made synchronous with the 60-cycle modulating voltage, a pattern should appear on the screen. The pattern may resemble a horizontal figure eight, as shown at left in the illustration below. This indicates that the frequency of the oscillator coil lies outside the limits within which the particles are precessing and that resonance is not established. To search for resonance, set the oscillator capacitor for minimum frequency (the plates of the capacitor meshed fully) and adjust the intensity (feedback) control to the point where the oscillator is on the verge of going out of operation. Then increase the frequency slowly while observing the 'scope. It may be necessary to trim the feedback control occasionally to maintain the marginal oscillating condition. The procedure can be simplified with the aid of a short-wave radio receiver. If the receiver is equipped for continuous-wave reception, the oscillator signal will be heard as a shrill whistle. If not, it will make a rushing sound, perhaps accompanied by a 60-cycle hum. The receiver is particularly useful in checking the point at which the oscillator goes out of operation when adjusting the feedback control. If the receiver is calibrated, it may be used to calibrate the oscillator. If not, the receiver can be calibrated easily by tuning in on the time signal of Station WWV.

When resonance is established, the display will resemble the center figure below. Usually two peaks appear which are joined at the bottom by loops. This indicates a displacement (phase differ-

ence) in the time at which signals arrive at the vertical and horizontal plates of the 'scope. The Heathkit Model O-10 'scope is equipped with a line-sweep switch and a phase control for manipulating the display. When these are properly adjusted, the peaks coincide as shown in the figure at right below.

What does the display mean? The height of the figure is proportional to the number of protons resonating with the oscillator; the width of the figure, to the range through which the particles precess. Accordingly if all of the particles were precessing at precisely the same rate and all flipped over precisely at resonance with the oscillator, the pattern would resemble an inverted "T." The spectrometer could then be said to have perfect resolution. Evidently in this instrument all the particles do not precess at the same frequency. Part of the explanation lies in the interaction of magnetic forces within the test sample. The fields of neighboring protons merge in such a way that some particles are partially shielded from the influence of the outside field. But in this instrument the breadth of the peaks is largely explained by cross-sectional variations in the strength of the biasing field. Particles in regions of high-field intensity precess at higher rates than those in regions where the field is relatively weak. These differences are preserved when the field is modulated. Some particles are swept into resonance with the oscillator earlier or later than others, and the displayed peak is broadened accordingly. The width of the peak illustrated is about 20 gauss, which means a difference of some 85,000 revolutions per second in the rate of precession of the slowest and fastest particles.

With an instrument of high resolution many substances show fine multiple peaks. This is due to the complex magnetic interaction between systems of particles and the consequent shielding of the biasing field. Many substances are not sensitive to an external magnetic field because the magnetism of their



Nuclear magnetic-resonance patterns on an oscilloscope

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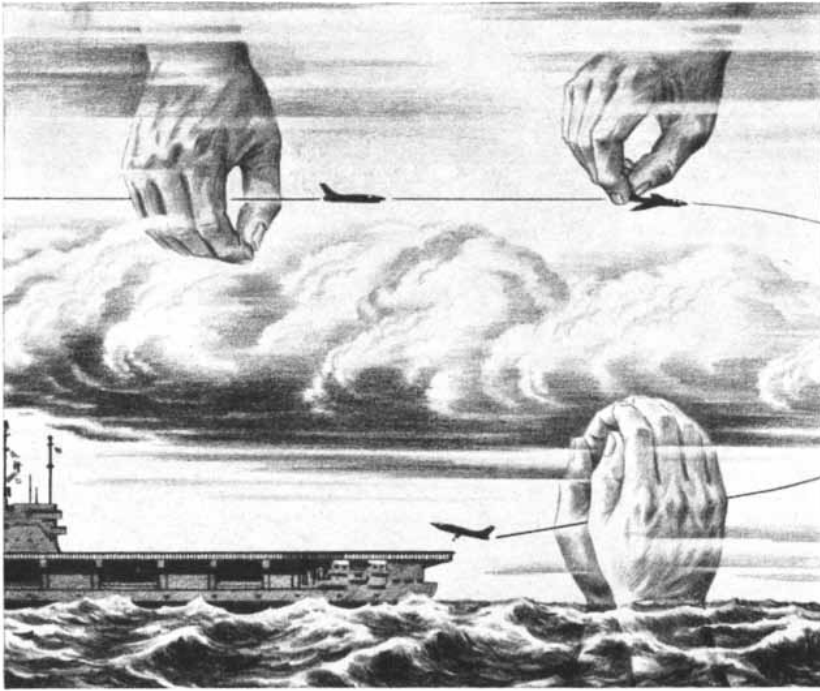
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Langley; Ames; Lewis

Please address your inquiry concerning any of the programs listed here to the Personnel Director of the appropriate NASA research center:

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spinning particles cancels out. But those substances that do respond can be identified by the characteristic pattern which shows up on the 'scope. The resolution of the apparatus described here is not high enough for fine spectroscopic work. As indicated earlier, it is intended to serve as a simple demonstration of the magnetic-resonance effect.

Modifications to adapt the apparatus for limited applications would include the provision of larger pole faces on the magnetron magnet to provide a more uniform biasing field. In contrast with the 20-gauss peak-width displayed by the apparatus, the best instruments made today resolve to a few ten thousandths of a gauss; this means that irregularities in the biasing field must be kept below this figure. High resolution also requires precise and calibrated control of the intensity, frequency and amplitude of the biasing field. In this demonstration the high sweep-rate of 60 cycles per second is made possible by limiting the experiment to a test solution of ferric nitrate. Few substances are so responsive.

Incidentally, the magnetic-resonance spectrometer can also be used for measuring the strength of magnets. The magnet to be tested supplies the biasing field. It is modulated as described above, and the oscillator is adjusted to resonance. The strength of the unknown field in gauss is equal to the frequency of the oscillator when it is at resonance divided by 4,228.5.

James H. Bly of the High Voltage Engineering Corporation in Burlington, Mass., recommends a change in the design of the particle accelerator described in this department last January. "In general, I think it is fair to say that we like the design approach to this machine very much," Bly writes. "However, we are somewhat concerned over those portions of the article that are concerned with the hazards involved. We agree wholeheartedly with what was said concerning the hazards of glass breakage and the use of mercury. We feel strongly, however, that there is inadequate discussion of the potential hazards due to X-rays and electrons. Even though the experimenter restricts himself to targets of low atomic number, there will inevitably be some generation of high-energy X-rays when using electrons of 200 to 300 kilovolt energy. If currents as high as 20 microamperes are achieved, we are sure that the resultant hazard is far from negligible. In addition, there will be substantial quantities of scattered electrons, some of which will inevitably pass through the observation peephole. Al-

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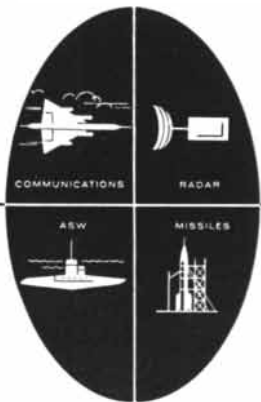
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though it is conceivable that it would be safe to look through this peephole from a distance of two feet, we are very doubtful that this is in fact the case. We believe the article would have been improved considerably if these hazards had been more thoroughly explored."

The apparatus described has been in operation for a year and has been tested exhaustively for radiation hazard. The article might well have pointed out, however, that one invites trouble by remaining near particle accelerators when they are in operation, or even by staying in the same room with them during prolonged periods of operation. F. B. Lee, who designed the apparatus, does not share Bly's concern about the hazard of scattered electrons from the peephole. As a precaution, however, the peephole may be covered on the inside by a small piece of window glass which will plug the hole completely for electrons. As an alternative the neon tube can be cemented in the peephole and connected with its circuit through a pair of contacts (an arrangement that would permit the high-voltage terminal to be removed when desired). The lamp could then be observed at a distance with the machine in operation.

George Gaylord Simpson, curator of fossil mammals and birds at the American Museum of Natural History, calls our attention to a hazard of a different sort. He writes: "In your February issue 'The Amateur Scientist' urges more amateurs to collect fossils and assures them that 'on public lands U. S. citizens can gather as many as they want.' That statement has two grossly incorrect implications.

"First, the applicable laws and regulations make no distinctions in favor of U. S. citizens. Some other countries do discriminate against collection of fossils by noncitizens. To scientists it is a matter for pride that our country does not do so, and the fact should be known.

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BOOKS

Charles Sanders Peirce, a prodigious but little-known American philosopher

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COLLECTED PAPERS OF CHARLES SANDERS PEIRCE: VOL. VII, SCIENCE AND PHILOSOPHY; VOL. VIII, REVIEWS, CORRESPONDENCE AND BIBLIOGRAPHY. Edited by Arthur W. Burks. Harvard University Press (each volume \$8).

Although American contributions to philosophy during the past 50 years are by no means negligible, there is a fair consensus among historians of ideas that Charles Sanders Peirce remains the most original, versatile and comprehensive philosophic mind this country has yet produced. Nevertheless, except to members of the profession, his name and achievements are relatively unknown, despite the fact that men with world-wide reputations, such as William James and John Dewey, have repeatedly acknowledged their profound indebtedness to him.

Peirce was born in 1839 and died in 1914. His father was a distinguished professor of mathematics at Harvard, and stimulated his son's interest early in life in science and philosophy. For a time Peirce was associated in various capacities with the U. S. Coast and Geodetic Survey; during this period he made internationally recognized contributions to astronomy, geodesy and photometry. But his chief claims to be remembered rest on other grounds. He was a pioneer in mathematical logic and in the logical analysis of the foundations of mathematics. He created a substantial portion of the calculus of relations, a branch of study initiated by Augustus De Morgan; he showed how this calculus can be fused with the logical algebra developed by George Boole (thereby constructing a unified theory of logic that in its essentials is adequate for analyzing the content and structure of all mathematical reasoning); and in unpublished papers he anticipated by many years some of the relatively recent work on decision procedures in formal logic. Moreover,

he was a profound student of the logic of scientific inquiry and of the conditions for the significant use of language. He formulated what subsequently came to be called the pragmatic theory of meaning, and is thus a spiritual ancestor not only of various forms of pragmatism, but also of logical empiricism and operationalism. In a series of brilliant essays he laid the foundations for a frequency interpretation of probable inference, and outlined a statistically grounded rationale for inductive reasoning.

But Peirce was also a philosophic system-builder in the grand manner. He proposed, and developed with great ingenuity, a set of fundamental categories under which everything actual and possible is to be subsumed; and he gave intriguing sketches of a comprehensive evolutionary cosmology, according to which the uniformities found in the world are the products of a habit-forming tendency for spontaneous variations to acquire patterns of regularity. At a time when belief in strict determinism was scientific orthodoxy, he advanced cogent arguments based on scientific data for the reality of a "chance" element in the universe, and for a statistical interpretation of the laws of nature. In addition, Peirce lectured and wrote extensively on the history of science, on psychology and telepathy, on philology and literary criticism, on ethics and theology, and on much else.

It is safe to say that no thinker since Leibniz in the 17th century has exhibited Peirce's mastery over so many diverse disciplines, or possessed his wealth of seminal ideas for cultivating them. Nevertheless, except for five years as an instructor at Johns Hopkins during its early days, Peirce held no academic post. He was a creative thinker of high order. But he was also somewhat erratic by temperament, unconventional in his private life, and decidedly undiplomatic in his manner toward men in positions of authority. Peirce's personal traits undoubtedly explain President Charles W. Eliot's refusal not only to appoint him to the Harvard faculty, despite strong urging by William James, but also to

sanction any lectures by him on university property.

However this may be, Peirce's repeated failure to secure a teaching position at an institution of higher learning was a misfortune, for himself as well as for the subsequent history of philosophy. From 1891 until his death he lived the life of a recluse in Milford, Pa., subsisting on a small inheritance, the scanty sums he earned by free-lance writing and the precarious bounty of friends. When not driven to undertake writing jobs for the sake of money, he devoted most of his waking hours to putting down on paper his teeming ideas. He planned a series of books, all of them ambitious and at least one of them in 12 volumes; but he managed to complete only one of them, and he found a publisher for none. His manuscripts amply testify to the zealous care with which he sought to give his ideas literary form. He made repeated drafts of articles and chapters, abandoned what seem like excellent beginnings only to start fresh fragments, and inserted innumerable annotations into his published papers. But although some of the products of his labors appeared in various periodicals, and although he gave occasional public lectures, his isolation left a mark upon him. He lacked the opportunity that a post at an outstanding university would have given him to participate in critical discussions of his ideas. There was no steady external pressure upon him to communicate his thoughts to those not already familiar with them; in consequence, he frequently tended to manifest his undoubted literary gifts in a private jargon. Moreover, since his solitary reflections were not forced to conform to any time limits, his writing became prolix and often exhibited no obvious lines of relevant development. In a moment of extreme self-depreciation, he characterized himself as "a mere table of contents, so abstract, a very snarl of twine." Late in life he remarked that his publications in logic were "simply outcroppings here and there of a rich vein which remains unpublished. Most of it I suppose has been written

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down; but no human being could ever put together the fragments. I could not do so myself." It is difficult to deny at least the partial justice of these self-assessments. It is equally difficult to dismiss as unfounded the conviction that had Peirce lived in a community of his peers, he would not have had the occasion to pass such judgments on his own work. Nor is the conjecture unwarranted that had Peirce's personal fortunes been different, the state of logical and philosophical studies would today be much further advanced.

Most of Peirce's voluminous literary estate eventually became the property of Harvard University. The manuscript material was in great disorder; even after funds for publishing a complete edition of his writings were obtained, the preparation of the material for the printer was a taxing and expensive undertaking. Ten volumes of *Collected Papers* were originally planned, six of which appeared between 1931 and 1935. The two new volumes recently published do not include everything else he wrote. But for various reasons, among others the fact that some of the material is now badly out of date, these latest volumes are also the final ones, at least for the present. They are valuable additions to the available Peirce *corpus*. They contain his more important reviews of philosophical books, as well as revealing selections from his philosophical correspondence. They also include philosophically significant portions of his strictly experimental contributions to physical and psychological science, and so provide material for appreciating how Peirce's experience as a laboratory scientist supplied the stimulus for his theory of meaning and his espousal of indeterminism. Above all these final volumes contain invaluable discussions of the logic of science, in which Peirce amplifies, clarifies and illustrates important doctrines in his theory of knowledge.

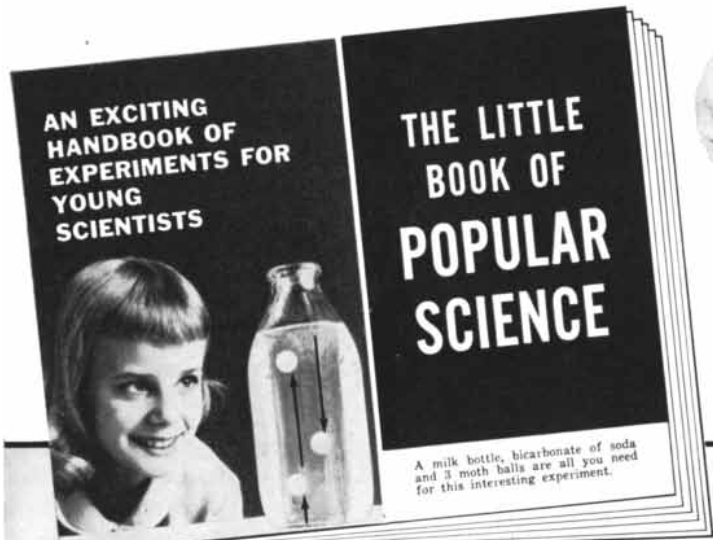
If Peirce's technical contributions to mathematical logic are left out of account, it is his analyses of scientific method that assure him a place in the history of thought and make him a figure of contemporary relevance. Peirce viewed science as an enterprise carried on by a theoretically endless community of investigators, employing a distinctive logic of inquiry. It is an enterprise seeking to remove doubt by establishing stable beliefs, because it is directed toward finding a definite answer to any question or doubt that may be raised, where the resolution of the question will not depend on the idiosyncrasies of any investigator. However, unlike other in-

stitutions that also aim at achieving firm beliefs free from doubt, science is the only one that recognizes that any given belief may be erroneous, and that therefore builds into its method of answering questions ways of progressively correcting deviations from the truth. Peirce was impressed by the fact that few of the propositions proclaimed throughout the history of mankind as indubitable have survived the continuing inquiry that makes up the history of science. He therefore rejected the conception, enshrined in an influential tradition that still retains its hold on many minds, that true beliefs can be established by appeals to self-evidence, whether in logic, mathematics, physics, ethics or everyday affairs. Such appeals seemed to him to set arbitrary barriers to the exercise of critical thought, and to violate the fundamental canon of reason never to block the way of inquiry.

But even though all claims to knowledge are fallible, and are in principle always subject to emendation, some claims are better than others. In particular, the claims of science are stronger than are beliefs otherwise supported, because the former are the products of a general *policy* of assessing conclusions in the light of the available evidence—a policy that in the long run yields a larger fraction of beliefs requiring little or no subsequent revision. Accordingly Peirce's doctrine of fallibilism does not imply a wholesale and stultifying skepticism. On the contrary, those who suppose we can doubt everything overlook the crucial fact that genuine doubt is possible only if some things are not doubted. In consequence those whose quest for certainty takes the form of a search for an indubitable Archimedean point upon which knowledge is to rest, render a serious disservice to the cause of critical intelligence. For although they claim to put all doubtful beliefs into question, they are dogmatically if unwittingly assuming many highly questionable things that it has never occurred to them to regard as anything but indubitable. In any event Peirce worked out in considerable detail a thoroughgoing experimental and fallibilistic theory of knowledge, whose scope includes not only the positive sciences but also logic, mathematics, ethics and everyday affairs.

As Peirce saw it, a supreme task of logic is to classify, examine and evaluate the types of argument by which men seek to find settled answers to their questions. According to him logic is the science that teaches whether efforts to produce a settlement of opinion—a settle-

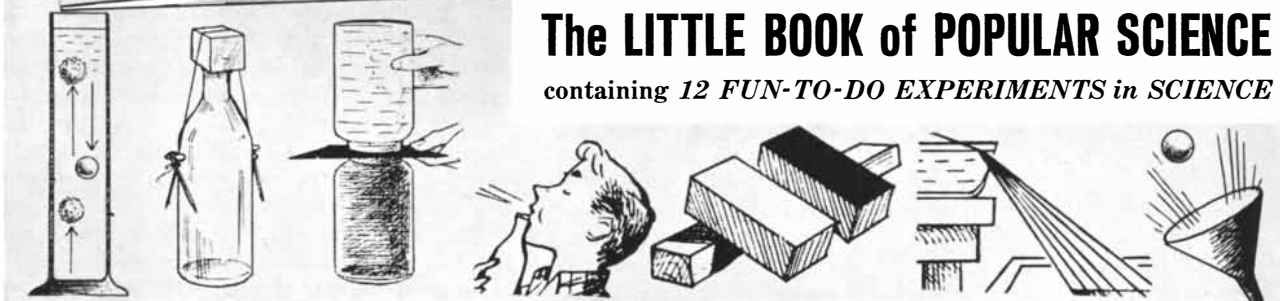
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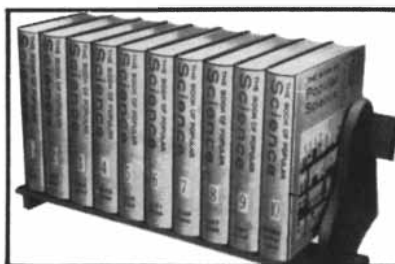
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ment that "shall be independent of all individual limitations, independent of caprice, of tyranny, of accidents of situation"—are rightly directed. He regarded logic so construed as having not only utmost practical value, but also as essential for a high civilization. "The theory of any act in no wise aids the doing of it," he declared, "so long as what is to be done is of a narrow description, so that it can be governed by the unconscious part of our organism. For such purposes, rules of thumb or no rules at all are the best. . . . But when new paths have to be struck out, a spinal cord is not enough; a brain is needed, and that brain an organ of mind, and that mind perfected by a liberal education. And a liberal education—so far as its relation to the understanding goes—means *logic*. That is indispensable to it, and no other one thing is." And he added that because so many scientific men have never stopped to reflect on the rationale of their habitual procedures of investigation, they do not in his opinion stand much higher intellectually than "an apprentice in a machine shop."

One of the overt signs of logical immaturity is the perennial occurrence of interminable and irresolvable controversies concerning certain sets of issues—controversies that in Peirce's judgment are generated because of the obscurity of our ideas. He maintained that most of traditional metaphysics is "moonshine" for just this reason; and he partly explained the successes of modern science in terms of the intellectual habits competent scientists exhibit when they construe the meanings of scientific concepts. With these habits in mind, it seemed to him nonsense to say, for example, that though we may understand precisely what are the effects of a force, what force itself is we do not understand. He therefore proposed that to make an idea clear we should consider what effects an object supposedly has that might have practical bearings, since our conception of those effects is the whole of our idea of that object. This is the famous "pragmatic maxim" which James exploited for his own ends, and interpreted in a fashion that Peirce found objectionable. Peirce stated his rule in a much clearer way when he said that "the intellectual significance of beliefs lies wholly in the conclusions which may be drawn from them, and ultimately in their effects upon our conduct. For there does not seem to be any important distinction between two propositions which never can yield different practical results." The substance of Peirce's logical pragmatism was thus the recommendation that gen-

eral ideas are to be understood by exploring their consequences, and ultimately in terms of their concrete applications. This recommendation, if accepted, certainly condemns much philosophical discussion (including some of Peirce's metaphysical speculations) as idle play with empty words. It is a salutary rule, for it is an effective help in preventing the identification of profound if difficult discourse with obscure and hollow rhetoric.

Peirce's views on probable inference, though he left them in unfinished state, are especially noteworthy. He recognized that at least two frequently confounded senses of the word "probable" must be clearly distinguished: the sense relevant in applications of the mathematical calculus of probability; and the sense required in so-called inductive inference, when some proposition (*e.g.*, that Caesar crossed the Rubicon) is said to be probable on the available evidence—that is, when the weight of the evidence for a given hypothesis is estimated. Peirce was a vigorous critic of the classical Laplacian notion, according to which the application of the probability calculus rests ultimately on the use of the Principle of Indifference (also known as the principle of the equal distribution of our ignorance). He argued that the probability calculus requires for its premises assumptions about the relative frequency of events in given classes of occurrences. He was therefore a proponent of a conception of probability that in one form or another is central to current statistical theory.

On the other hand, Peirce did not think that a similarly simple frequency interpretation is tenable for inductive probability. Unlike other students of inductive inference, however, Peirce believed that induction is neither a rationally unjustifiable act of animal faith, nor that induction can be justified only by appealing to some grand cosmic principle such as the doctrine of the uniformity of nature. He pointed out that every inductive inference is an instance of some policy for accepting hypotheses on the basis of certain types of evidence. Moreover, since there are alternative policies for doing this, it is in principle possible to compare policies in terms of the success-ratios with which the policies yield conclusions that stand up when subjected to further experimental probing. In the end, therefore, Peirce advanced a frequency interpretation, though of a subtle and complicated kind, even for inductive probability. His approach to an old and vexing problem of logic has not been fully articulated and exploited,



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even by those who have adopted Peirce's views on this matter. It is nevertheless an approach that holds great promise as a viable alternative to the fatally inadequate answers others have proposed for the problem.

Peirce's rejection of a metaphysical determinism was inspired, at least in part, by the development of statistical theories in physics as well as by his own experiences as a laboratory scientist. He called attention to the fact that no law in natural science is in precise agreement with the observed course of events. "Try to verify any law of nature," he declared, "and you will find that the more precise your observations, the more certain they will be to show irregular departures from the law." He therefore argued that it is just *a priori* dogmatism to maintain that all events take place in accordance with absolutely constant relations of dependence; and he pointed to the occurrence of random fluctuations as evidence for the reality of chance and for the growth of novelty in the world. Moreover, he challenged the assumption that the regularities admittedly present in the universe must be regarded as ultimate. This assumption blocks the way of inquiry, since it dismisses without warrant the possibility of explaining regularity in terms of a statistical analysis of random variations. Had Peirce lived to see the advent of modern quantum theory, he could have easily convinced himself that though his prophecies about the structure of fundamental physical theory were not immediately realized, he had nevertheless prophesied truly.

However, Peirce based his radical indeterminism only partly on ostensibly sound scientific evidence, for this doctrine was an essential ingredient in the speculative metaphysics he constructed and for which he claimed other support as well. He maintained that spontaneity or chance, regularity or law, and generality or a tendency for things to take on more or less fixed habits, are the three primal elements in the universe, allegedly present in some form in everything that is real. He therefore devised a system of categories, based on these primal factors and arranged in series of cognate triads, into which everything actual can supposedly be fitted. Peirce's almost compulsive penchant for triadic schematization is not the only respect in which his metaphysics resembles that of Hegel. For Peirce also claimed that every sound philosophy must provide an evolutionary account of the world, and he had the courage to propose a grandiose evolutionary cosmology. The net outcome is a highly original version of objective ideal-

ism. According to Peirce, mind is the ultimate "stuff" of the universe, and is manifested in purest form in spontaneous or chance variation. However, because of the assumed universal tendency toward repetition or habit formation, mind eventually acquires more or less regular patterns of manifestation, and so comes to exhibit the "effete" or inert properties of matter. The tendency toward the formation of habits is also construed by Peirce as a tendency of ideas to become inclusive and general. He therefore finds the growth of civilization through the spread of ideas among men a capital illustration of his ground plan of the cosmos.

Although Peirce gave ample hints of his speculative metaphysics in numerous articles printed during his lifetime, most of its details have become available only with the publication of the *Collected Papers*. To some admirers of Peirce it is this side of the man that is most deserving of close study; and the renaissance of interest in Peirce that has taken place in this country during the past quarter-century has been largely centered in Peirce the metaphysician. It is difficult to assent to these assessments of what is important in Peirce. It is certainly impossible to acquit him of the charge that he forgot his invaluable pragmatic maxim when he turned his attention to metaphysical construction; that he converted distinctions into causally efficacious agents; that he was indulging in poetic fantasy when he construed all regularities to be akin to thought, or when he saw an analogy between the regularities of inanimate nature and the habits that living organisms can acquire or drop; that he was dogmatizing without warrant when he claimed that regularities always require explanation but what is fortuitous does not; that he was badly mistaken in supposing that regularities can be explained without assuming other regularities in the explanatory premises. Indeed, on this last point he eventually admitted his error, for he declared that "uniformity or necessary law can only spring from another law; while fortuitous distribution can only spring from another fortuitous distribution." In any event Peirce the metaphysician of objective idealism has exercised only negligible influence, and it is unlikely that this influence will ever be considerable. It is Peirce the logician and the analyst of science who has made intellectual history, and who has rendered heroic service in the cause of intellectual sanity. It is the writings of this Peirce that can still be read with profit and a sense of great illumination. It is the thought of



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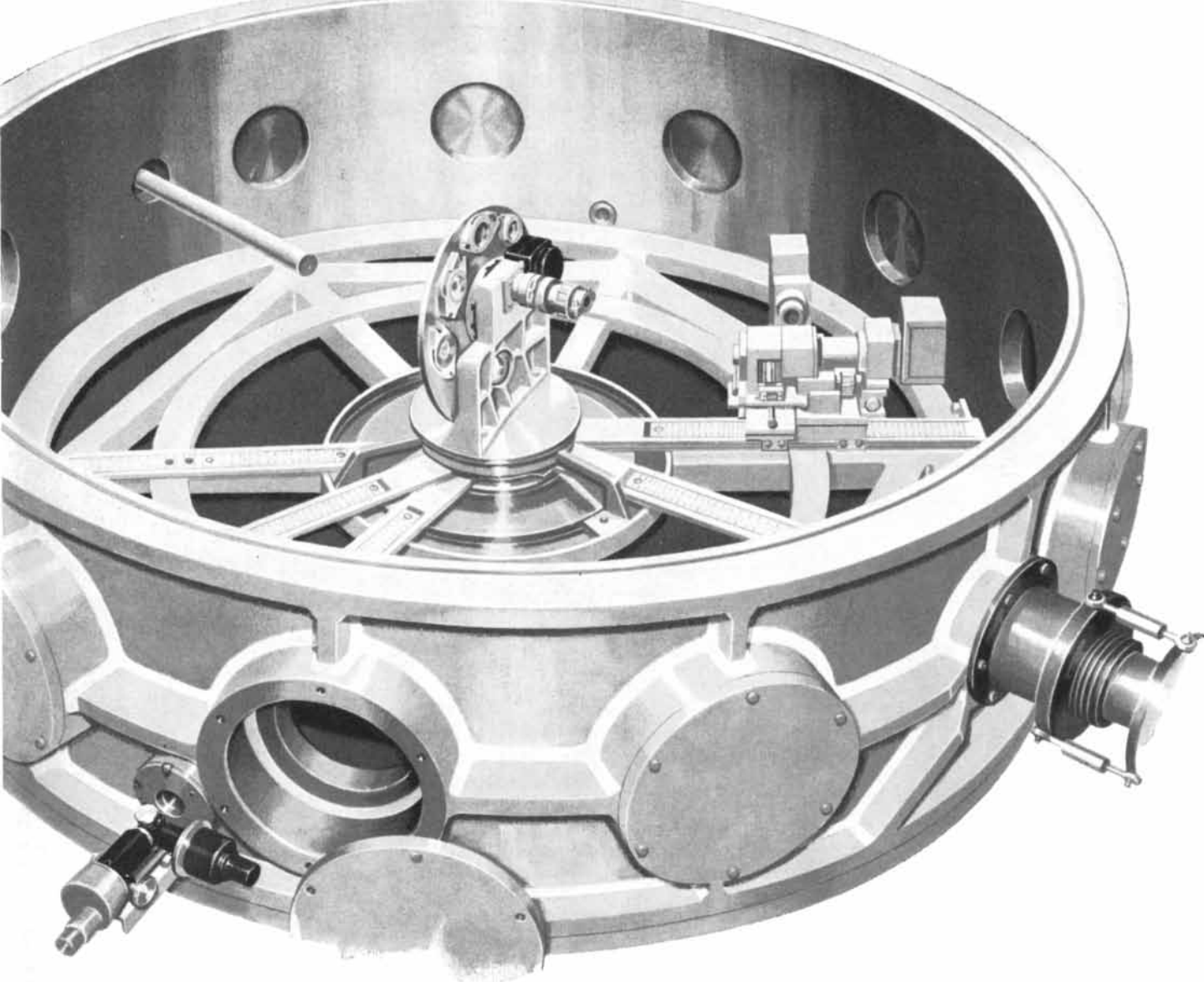
this Peirce that deserves to be mined for the wealth of insight it can yield concerning the requirements that must be satisfied by successful quests for reliable knowledge.

Short Reviews

ENERGY FOR MAN, by Hans Thirring. Indiana University Press (\$6.95). A distinguished Austrian physicist, known for his scientific and technical researches, his popular writings on relativity and the hydrogen bomb and his membership in the Austrian atomic energy commission, presents what is unquestionably the best survey yet made of the world's energy resources, from windmills to nuclear power. The world, says Thirring, is faced with three great tasks that are interconnected: increasing food production to keep pace with the steady rise in population (he envisages an ultimate stabilization of population at a ceiling of between six and 10 billion); conserving, increasing and developing power resources; educating and re-educating the great body of mankind so that it can make better use of what its planet has to offer and learn to live and let live. It is with the second task that this book is concerned, but throughout Thirring's study we are made aware of the broad social outlook and deep feeling for human welfare which determine his approach to the technology of power. The book deals with every aspect of a complex and extensive subject. It explains the concepts of power, energy and heat, including the laws of thermodynamics; the different types of engines used in power production: steam, internal combustion, gas turbines, electric motors; the several sources of energy, such as coal, petroleum and natural gas, vegetation fuels (wood, farm waste, alcohol, Chlorella), water power, solar energy, tidal power, wind power, ocean and earth heat, atomic energy; the life expectancy of fossil-fuel reserves; nuclear reactors and thermonuclear reactions. He makes strikingly clear how inefficient we are in the use of our dwindling energy reserves. For example, less than 5 per cent of the potential energy in crude petroleum consumed as gasoline in the average car is used to move the car; the other 95 per cent is spent "to extract and refine the crude oil, to carry the petrol to the filling station, to heat the water in the radiator and the gas in the exhaust, to operate motor-car auxiliaries, to overcome friction in gears and tires." Other glaring instances of waste occur in large power-stations whose enormous quantities of reject heat, representing 80

per cent of the energy of the fuel consumed, serve no better purpose than to warm the outer surroundings. ("The reject heat of a moderately large power-station of 100,000 KW installed capacity suffices to heat a district of about 10,000 houses.") He discusses several gigantic projects for hydroelectric plants in the U.S.S.R. and Tibet. One involves creating an inland sea in Siberia; another, the greatest of all, requires harnessing the enormous concentration of water power at the bend of the Tsangpo River in eastern Tibet, which would yield one and a half times the total hydroelectric production of the U. S. All such projects, however, as well as other ingenious developments (e.g., solar energy) are of relatively minor importance compared with nuclear energy, which, says Thirring, "will free us from the fear that our energy reserves will run out within quite a short period of history." But he warns of the accompanying danger of fission products, and of the ever-present menace of a nuclear war, unless men can learn to control themselves as well as they can control the atom. He is not overly impressed with the advances made thus far in taming thermonuclear energy, but he does not regard it as too optimistic to expect that this trick can be learned before the global thorium and uranium reserves are exhausted. This is not always an easy book, but it is a masterly job, recommended without reserve to any thoughtful reader.

MASTERS OF PHOTOGRAPHY, edited by Beaumont and Nancy Newhall. George Braziller, Inc. (\$12.50). **THE PICTURE HISTORY OF PHOTOGRAPHY**, by Peter Pollack. Harry N. Abrams, Inc. (\$17.50). These volumes are pure delight, refreshing excursions which the eye and mind can take again and again. The Newhalls have prepared an album of some 150 choice examples of the photographs of David Octavius Hill and Robert Adamson, Eugène Atget, Ansel Adams, Alfred Stieglitz, Edward Steichen, Edward Weston, Erich Salomon, Paul Strand, Henri Cartier-Bresson, Dorothea Lange and others. Each selection is prefaced by a brief biographical sketch, and the publisher has made an elegant home for these treasures. Pollack's history is a much more ambitious venture, presenting over 600 admirable reproductions of photographs, from Nicéphore Niepce's epochal view from his window, caught on a pewter plate, to today's stunning technical and artistic achievements in black and white and in color. The accompanying text is short but to the point, describing the



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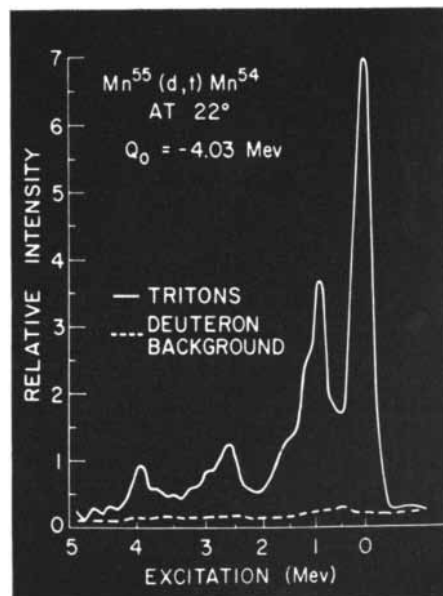
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A BIBLIOGRAPHY OF INTERNAL MEDICINE: COMMUNICABLE DISEASES, by Arthur L. Bloomfield. University of Chicago Press (\$10). During his long teaching career as professor of medicine at Stanford University the author of this book became convinced that the periodical and other literature of medicine has become so unwieldy that students and practitioners are in real danger of being completely cut off from "our medical past and relapsing into a sort of modern Dark Age." A historical approach, an understanding of the development of ideas, is essential, he says, for critical comprehension of a medical subject or of a disease, yet neither is within easy reach of the hard-pressed student who has all he can do to complete the donkey work of his training, cram the facts he needs to pass his general examinations and keep up with "the new, the curious and the esoteric" which Specialty Board examiners are apt to spring on him. This selected bibliography, listing the important contributions of modern medicine (19th and 20th centuries) with critical comments, is a very effective tool to remedy the neglect of medical history. Bloomfield has read through a huge mass of English, German, French and Italian writings on communicable diseases and has prepared excellent summaries, which include substantial excerpts, of every reference of fundamental importance. Among the diseases he covers in all their aspects are typhoid and typhus, cholera, dysentery, plague, Brucella infection, scarlet fever, erysipelas, gonorrhoea and syphilis, tuberculosis, leprosy, diphtheria, tetanus, malaria, influenza, the common cold, measles, smallpox, rabies, yellow fever, mumps, whooping cough.

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Bloomfield writes clearly and interestingly, with a nice feeling for the sidelights that enliven a historical account. His book is much more than an annotated bibliography; as an account of the evolution of ideas it is a notable contribution to medical history and an invaluable supplement to medical education. One looks forward to his extension of this fine work to other branches of internal medicine.

THE PAPERS OF THOMAS JEFFERSON, VOL. XIV, edited by Julian P. Boyd. Princeton University Press (\$10). This volume in the magnificent Princeton edition of Jefferson's papers covers the period October, 1788, to March, 1789, when he was still busy as our Minister to France but was coming to the end of his stay. Among the major political documents are the complex negotiations for a Consular Convention, analyses of the crisis in whale fishery brought on by British dumping, exchanges on the foreign debt of the U. S., Madison's denigrative appraisal of the Bill of Rights, letters on the first elections of the Federal Government. But apart from the writings on such weighty subjects, there is the usual delightfully varied assortment of material about Jefferson's personal life: his letters to and from friends, his financial transactions, his concern over the education of his daughters, his book purchases and his scientific and mechanical interests. The latter include botanical and agricultural questions, bridge design (exchanges with his friend Tom Paine), paleontology (*e.g.*, a fossilized skeleton of a glyptodon found in Buenos Aires), the construction of a cabriolet and a phaeton, architecture, thermometry, a press for making "the best macaroni." Jefferson knew how to make the most out of life, and these superbly edited volumes permit us to share this gift.

NIELS HENRIK ABEL: MATHEMATICIAN EXTRAORDINARY, by Oystein Ore. University of Minnesota Press (\$5.75). Though he died at the age of 27, Abel was one of the great mathematicians of the 19th century. He made brilliant contributions to analysis and the theory of elliptic functions, he proved the impossibility of solving the general equation of the fifth degree (or higher), he wrote on transcendental functions, and his name has been given to equations, functions and integrals developed in his researches. The importance of his work was recognized in France and Germany, but he was unable to gain a permanent academic post in his native Norway. He



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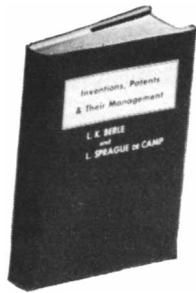
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was lonely, wretched, poverty-ridden, burdened by familial cares and illness. His neglect and suffering are a tragic monument of bureaucratic and academic stupidity. Ore's biography covers a great deal of the primary material in detail. It is an honest, scholarly and sympathetic portrait, but not lively, nor very clear for the nonspecialist in its descriptions of Abel's mathematical achievements.

WILD PARADISE, by Guy Mountfort. Houghton Mifflin Company (\$7).

On the southwest coast of Spain is a 67,000-acre tract called the Coto Doñana, a wild and almost inaccessible region of marshes and deserts. Long a hunting preserve of grandees (three of whom still own it), it is the last great wildlife sanctuary of Europe. Large flocks of migratory birds, representing half the species of Europe, sweep over the Coto skies; the land is inhabited by red and fallow deer, wild boar, lynxes, ocellated lizards, mongooses, polecats, snakes, wildcats and genets. Mountfort organized three scientific expeditions (in 1952, 1956 and 1957) to explore this wild paradise. Roger Tory Peterson, James Fisher, Sir Julian Huxley and the noted bird photographer Eric Hosking were among those in the several parties. Their experiences and adventures, together with scientific descriptions of the ornithological and other species occurring in the Coto, and stories of the local people, are presented in this uncommonly attractive book, which is written with infectious enthusiasm and is handsomely illustrated.

MEDIEVAL ENGLAND, edited by Austin Lane Poole. Oxford University Press (\$17.50). This splendid survey is an almost completely rewritten successor to H. W. C. Davies' 1924 volume of the same name, which itself was a revised edition of F. P. Barnard's *Companion to English History*. Nineteen specialists have contributed up-to-date historical articles on various aspects of the medieval English scene: the landscape; domestic, ecclesiastical and military architecture; the art of war; shipping and communication; towns and trade; coinage; civil costume; arms and armor; heraldry; religious life and organization; art, learning and education; handwriting; books; science; recreations. The articles teem with details that bring the period to life and make its ways seem less fabled and more real. One does not need to be an expert to appreciate the different accounts; to give a single exam-

ple, the essay on heraldry tells a delightful and fully comprehensible story of the rise of a fascinating art and conceit of manners. The book is finely illustrated with plates, cuts and maps, and there are helpful lists of reference works after each chapter.

LATE BABYLONIAN ASTRONOMICAL AND RELATED TEXTS, copied by T. G. Pinches and J. N. Strassmaier; prepared for publication by A. J. Sachs. Brown University Press (\$5). In the Babylonian archives of the British Museum is a large number of tablets, excavated in the late 19th century, which are the principal sources for the study of late Babylonian astronomy. Most of the tablets were copied between 1895 and 1900 by the assyriologist T. G. Pinches, and a few by J. N. Strassmaier. About 1,350 copies, representing "a substantial fraction" of the scientific portion of the archives, appear in this volume. They embody fragments of astronomical diaries, normal-star almanacs, goal-year texts, planetary and lunar observations, horoscopes and other astrological topics, and mathematical tables.

DICTIONARY OF PHYSICS, compiled and edited by H. J. Gray. Longmans, Green and Co. (\$16.50). This desk volume, with contributions from a number of leading scientists, gives information on physics and its applications and includes a certain amount of material in closely related subjects such as astronomy, mathematics and electronics. Most of the articles are short but provide satisfactory quick-reference data; there is also a number of longer key articles (*e.g.*, on nuclear reactors, force, astronomy, atom, distortion), entries for the isotopes of each element, bibliographical data and many biographical sketches (the last a useful feature not found in most technical dictionaries). Despite curious omissions—for example, no entries occur for parity, nuclear fusion, magnetohydrodynamics—this is a sound, attractive compendium that will give good service to scientists, engineers, teachers and students in many fields.

STATISTICS OF EXTREMES, by E. J. Gumbel. Columbia University Press (\$15). A study of the statistical theory of extreme values by the foremost investigator of the subject. The theory deals with two types of question: Does an individual observation in a sample taken from a distribution fall outside what may reasonably be expected? Does a series of extreme values exhibit a regular behavior? ("Reasonable" and "regular" must

of course be defined by an operational procedure.) The oldest problems connected with extreme values arise from floods. Until recently these were treated by purely empirical methods; now, however, the statistical nature of these phenomena is recognized and new methods of analysis derived from the theory of extreme values are coming into use. Among other phenomena to which the theory can be usefully applied are annual droughts, largest precipitation, snowfalls, maxima and minima of atmospheric pressure and temperature, metal fatigue.

THE WORKS OF GEORGE BERKELEY, BISHOP OF CLOYNE: VOL. VIII, edited by A. A. Luce; VOL. IX, edited by A. A. Luce and T. E. Jessop. Thomas Nelson and Sons Ltd. (30 shillings each). These two volumes, the first containing Berkeley's letters; the second, notes and a general index to the work as a whole, mark the completion of a definitive nine-volume edition of the famous Irish philosopher's writings. Reviews of the earlier volumes, and of Luce's life of Berkeley published separately as a companion, have appeared in these columns as the set progressed; now with its completion Luce and Jessop are to be congratulated on the fruit of their labors, an exemplary scholarly achievement for which students of Berkeleyian philosophy will be most grateful.

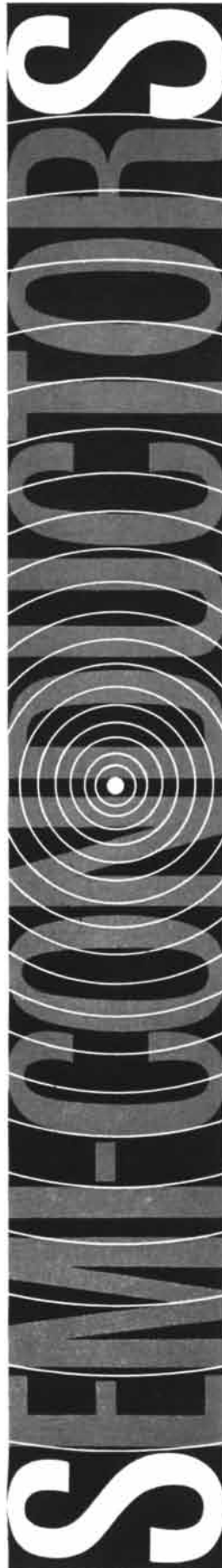
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THE PHYSIOLOGY OF FOREST TREES, edited by Kenneth V. Thimann, William B. Critchfield and Martin H. Zimmermann. The Ronald Press Company (\$12). A collection of papers delivered at a symposium held at the Harvard Forest in 1957.

CALCULUS OF FINITE DIFFERENCES, by George Boole. Chelsea Publishing Company (\$4.95). A reprint of the fourth edition of a treatise on the calculus of finite differences by the famous 19th-century English logician.

FUNCTIONS OF REAL VARIABLES; FUNCTIONS OF A COMPLEX VARIABLE, by William Fogg Osgood. Chelsea Publishing Company (\$4.95). Two standard monographs based on the author's lectures on function theory given at Harvard University and at the University of Peking in the 1930s are here bound together in one volume.

SOUND PULSES, by F. G. Friedlander. Cambridge University Press (\$7.50). A



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technical monograph describing the theory of sound pulses—aperiodic disturbances with clearly defined fronts—and its recent developments.

PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY, by Julius S. Bendat. John Wiley & Sons, Inc. (\$11). This book considers the problems of evaluating properties of random noise as it may affect our understanding of physical phenomena and the performance of electronic control-systems.

INTRODUCTION TO THE DESIGN OF SERVO-MECHANISMS, by John L. Bower and Peter M. Schultheiss. John Wiley & Sons, Inc. (\$13). Discussed here are the principal approaches to the design of feedback control-systems.

BEHAVIORISM, by John B. Watson. University of Chicago Press (\$1.50). A paper-back reissue of a classic of American psychology.

THE GENETICAL THEORY OF NATURAL SELECTION, by Ronald A. Fisher. Dover Publications, Inc. (\$1.85). This paper-back is the second revised edition of a well-known exposition, first published in 1929, of the theory of natural selection.

CHAMBERS'S TECHNICAL DICTIONARY, edited by C. F. Tweney and L. E. C. Hughes. The Macmillan Company (\$7.50). The revised edition of this compact, dependable and inexpensive reference book includes an enlarged supplement containing new terms in science and technology.

ADVANCES IN CANCER RESEARCH; VOL. V, edited by Jesse P. Greenstein and Alexander Haddow. Academic Press, Inc. (\$10.80). Articles on tumor-host relationships, carcinoma of the liver, protein synthesis with reference to normal and abnormal growth processes, new concepts of cancer toxins, chemically induced tumors, anemia in cancer, tumor antigens, carcinogenesis and metabolism of fluorenamine and related compounds.

PRINCIPLES OF GENETICS, by Edmund W. Sinnott, L. C. Dunn and Theodosius Dobzhansky. McGraw-Hill Book Company, Inc. (\$6.75). The fifth edition of this noted text in genetics has been completely revised. Much new material has been added, including a new chapter on varieties of sexual reproduction and an appendix chapter on statistical inference in genetics. The book has been entirely reillustrated.

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BIBLIOGRAPHY

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

THE MOHOLE

DRILLING ON ENIWETOK ATOLL, MARSHALL ISLANDS. H. S. Ladd, Earl Ingerson, R. C. Townsend, Martin Russell and H. Kirk Stephenson in *Bulletin of the American Association of Petroleum Geologists*, Vol. 37, No. 10, pages 2,257-2,280; October, 1953.

THE EARTH. Harold Jeffreys. Cambridge University Press, 1952.

THE NATURE OF THE MOHOROVICIC DISCONTINUITY. J. F. Lovering in *Transactions American Geophysical Union*, Vol. 39, No. 5, pages 947-955; October, 1958.

THE OCEANIC CRUST. H. H. Hess in *Journal of Marine Research*, Vol. 14, No. 4, pages 423-439; December 31, 1955.

ON THE ISOSTATIC STRUCTURE OF THE EARTH'S CRUST. W. Heiskanen in *Publications of the Isostatic Institute of the International Association of Geodesy*, No. 24; 1950.

FAMILY PLANNING IN THE U. S.

CONTROLLED FERTILITY. Regine K. Stix and Frank W. Notestein. The Williams & Wilkins Company, 1940.

CURRENT RESEARCH IN HUMAN FERTILITY. Milbank Memorial Fund, 1955.

FERTILITY CONTROL IN THE LIGHT OF SOME RECENT CATHOLIC STATEMENTS. William J. Gibbons in *Eugenics Quarterly*, Vol. 3, No. 1, pages 9-15; March, 1956. Vol. 3, No. 2, pages 82-87; June, 1956.

MEDICAL HISTORY OF CONTRACEPTION. Norman E. Himes. The Williams & Wilkins Company, 1936.

SOCIAL AND PSYCHOLOGICAL FACTORS AFFECTING FERTILITY. P. K. Whelpton and Clyde V. Kiser, editors. Milbank Memorial Fund, 1948-1956.

THE USE OF VARIOUS METHODS OF CONTRACEPTION. John Winchell Riley and Matilda White in *American Sociological Review*, Vol. 5, No. 6, pages 890-903; December, 1940.

VISUAL PERCEPTION AND PERSONALITY

THE HONI PHENOMENON: A CASE OF SELECTIVE PERCEPTUAL DISTORTION.

Warren J. Wittreich in *The Journal of Abnormal and Social Psychology*, Vol. 47, No. 3, pages 705-712; July, 1952.

THE INFLUENCE OF SIMULATED MUTILATION UPON THE PERCEPTION OF THE HUMAN FIGURE. Warren J. Wittreich and Keith B. Radcliffe, Jr. in *The Journal of Abnormal and Social Psychology*, Vol. 51, No. 3, pages 493-495; November, 1955.

A PRELIMINARY INVESTIGATION OF CERTAIN ASPECTS OF PERCEPTION, INCLUDING THE HONI PHENOMENON. Warren J. Wittreich in *Human Behavior from the Transactional Point of View*, pages 239-254. Institute for Associated Research, 1953.

GERMINATION

GERMINATION INHIBITORS. Michael Evenari in *The Botanical Review*, Vol. 15, No. 3, pages 153-194; March, 1949.

PHYSIOLOGY OF SEEDS. William Crocker and Lela V. Barton. *Chronica Botanica* Company, 1953.

RECENT DEVELOPMENTS IN SEED TECHNOLOGY. R. H. Porter in *The Botanical Review*, Vol. 15, No. 4, pages 221-282; April, 1949. Vol. 15, No. 5, pages 283-324; May, 1949.

SEED GERMINATION. Michael Evenari in *Radiation Biology*, Vol. 3, pages 518-550; 1956.

THE SOLAR SYSTEM BEYOND NEPTUNE

THE GEORGE DARWIN LECTURE: THE MOTIONS OF THE OUTER PLANETS. Dirk Brouwer in *Monthly Notices of the Royal Astronomical Society*, Vol. 115, No. 3, pages 221-235; April 6, 1955.

THE ORIGIN OF THE SATELLITES AND THE TROJANS. Gerard P. Kuiper in *Vistas in Astronomy*, Vol. 2, pages 1,631-1,666; 1956.

HOW REPTILES REGULATE THEIR BODY TEMPERATURE

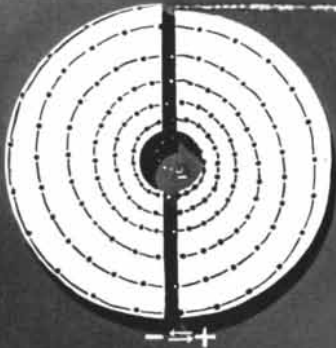
A PRELIMINARY STUDY OF THE THERMAL REQUIREMENTS OF DESERT REPTILES. Raymond Bridgman Cowles and Charles Mitchill Bogert in *Bulletin of the American Museum of Natural History*, Vol. 83, Article 5, pages 265-296; 1944.

RATTLESNAKES: THEIR HABITS, LIFE HISTORIES, AND INFLUENCE ON MANKIND. Laurence M. Klauber. University of California Press, 1956.

THERMOREGULATION IN REPTILES—A FACTOR IN EVOLUTION. Charles M.

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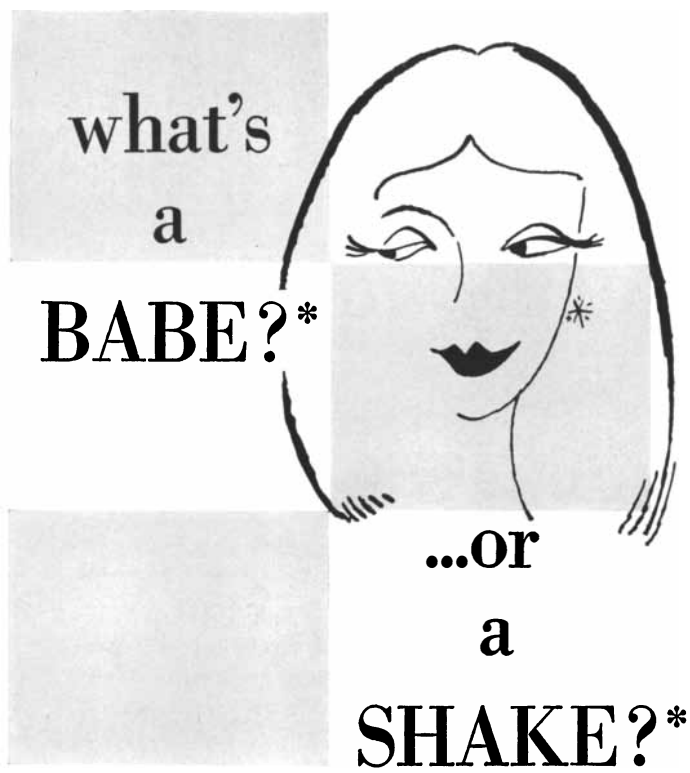
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Bogert in *Evolution*, Vol. 3, No. 3, pages 195-211; September, 1949.

TEMPERATURE TOLERANCES IN THE AMERICAN ALLIGATOR AND THEIR BEARING ON THE HABITS, EVOLUTION AND EXTINCTION OF THE DINOSAURS. Edwin H. Colbert, Raymond B. Cowles and Charles M. Bogert in *Bulletin of the American Museum of Natural History*, Vol. 86, Article 7, pages 331-373; 1946.

ALIGNED CRYSTALS IN METALS

FACTORS AFFECTING DIRECTIONAL PROPERTIES IN ALUMINUM WROUGHT PRODUCTS. Kent R. Van Horn in *Transactions of American Society for Metals*, Vol. 47, pages 38-76; 1955.

MAGNETIC PROPERTIES OF CUBE TEXTURED SILICON-IRON MAGNETIC SHEET. J. L. Walker, W. R. Hibbard, H. C. Fiedler, H. E. Grenoble, R. H. Pry and P. G. Frischmann in *Journal of Applied Physics*, Vol. 29, No. 3, pages 363-365; March, 1958.

PHYSICAL STRUCTURE AND MAGNETIC ANISOTROPY OF ALNICO 5. PART I AND II. R. D. Heidenreich and E. A. Nesbitt in *Journal of Applied Physics*. Vol. 23, No. 3, pages 252-271; March, 1952.

QUANTITATIVE METHOD FOR THE DETERMINATION OF FIBER TEXTURE. B. D. Cullity and August Freda in *Journal of Applied Physics*, Vol. 29, No. 1, pages 25-30; January, 1958.

STRUCTURE OF METALS. Charles S. Barrett. McGraw-Hill Book Company, Inc., 1952.

THE STRUCTURE OF POLYCRYSTALLINE AGGREGATES. B. D. Cullity in *Elements of X-Ray Diffraction*, pages 259-296. Addison-Wesley Publishing Company, Inc., 1956.

THE SEX GAS OF HYDRA

SEXUAL DIFFERENTIATION IN HYDRA: CONTROL BY CARBON DIOXIDE TENSION. W. F. Loomis in *Science*, Vol. 126, No. 3,277, pages 735-739; October 18, 1957.

MATHEMATICAL GAMES

GENERALIZED "SANDWICH" THEOREMS. A. H. Stone and J. W. Tukey in *Duke Mathematical Journal*, Vol. 9, No. 2, pages 356-359; June, 1942.

THE AMATEUR SCIENTIST

NUCLEAR MAGNETIC RESONANCE. Edward Raymond Andrew. Cambridge University Press, 1955.

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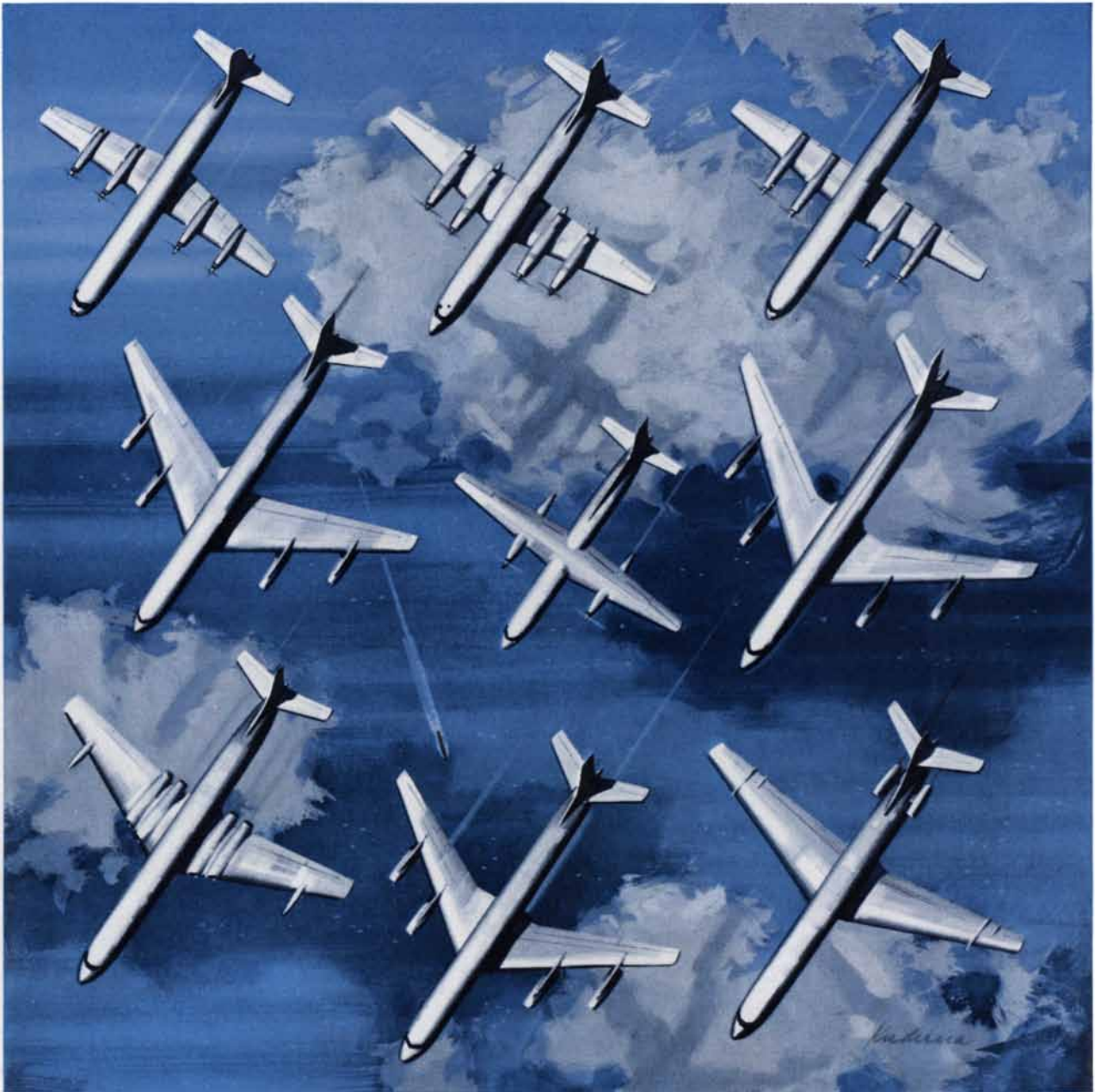
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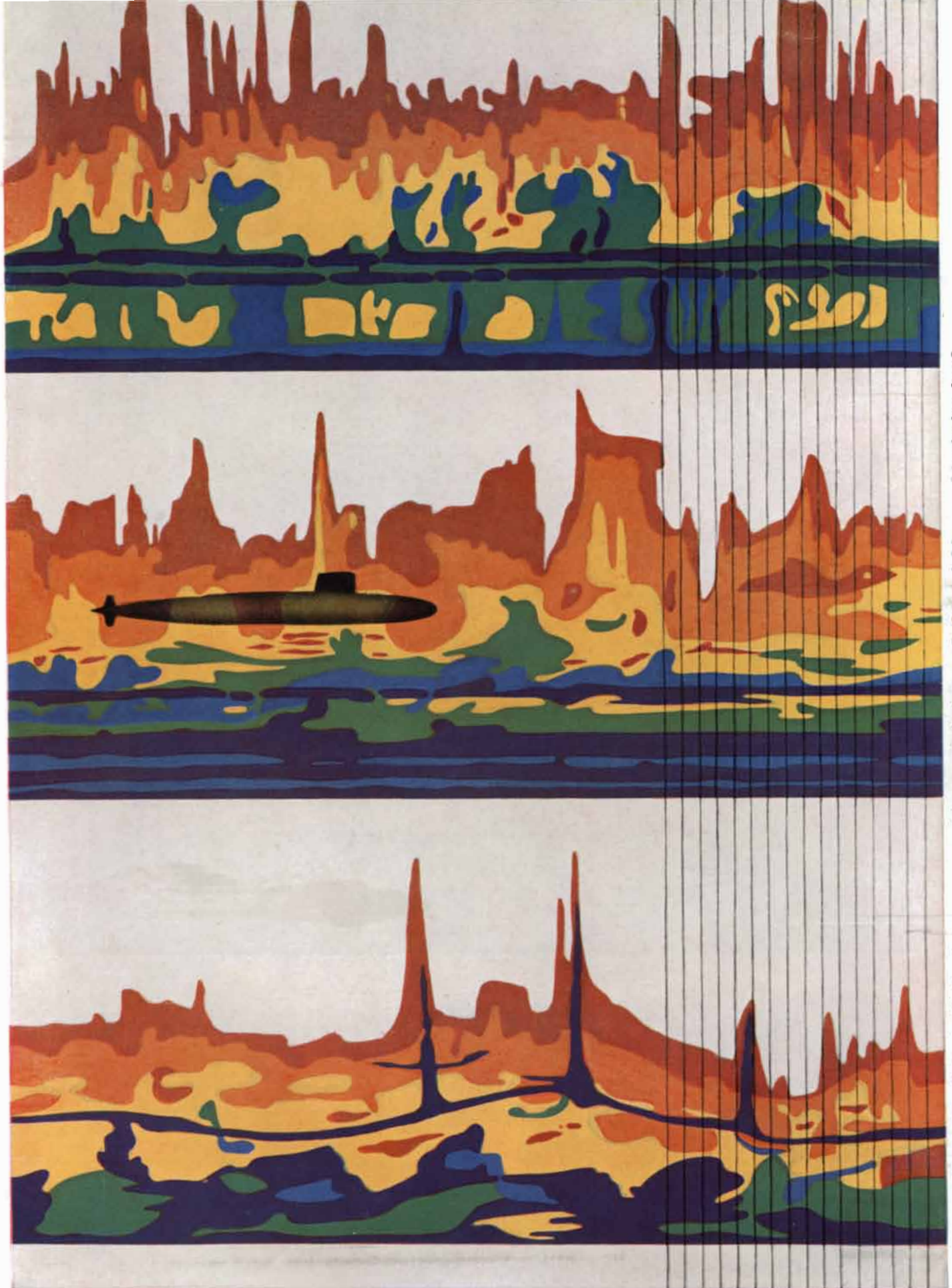


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