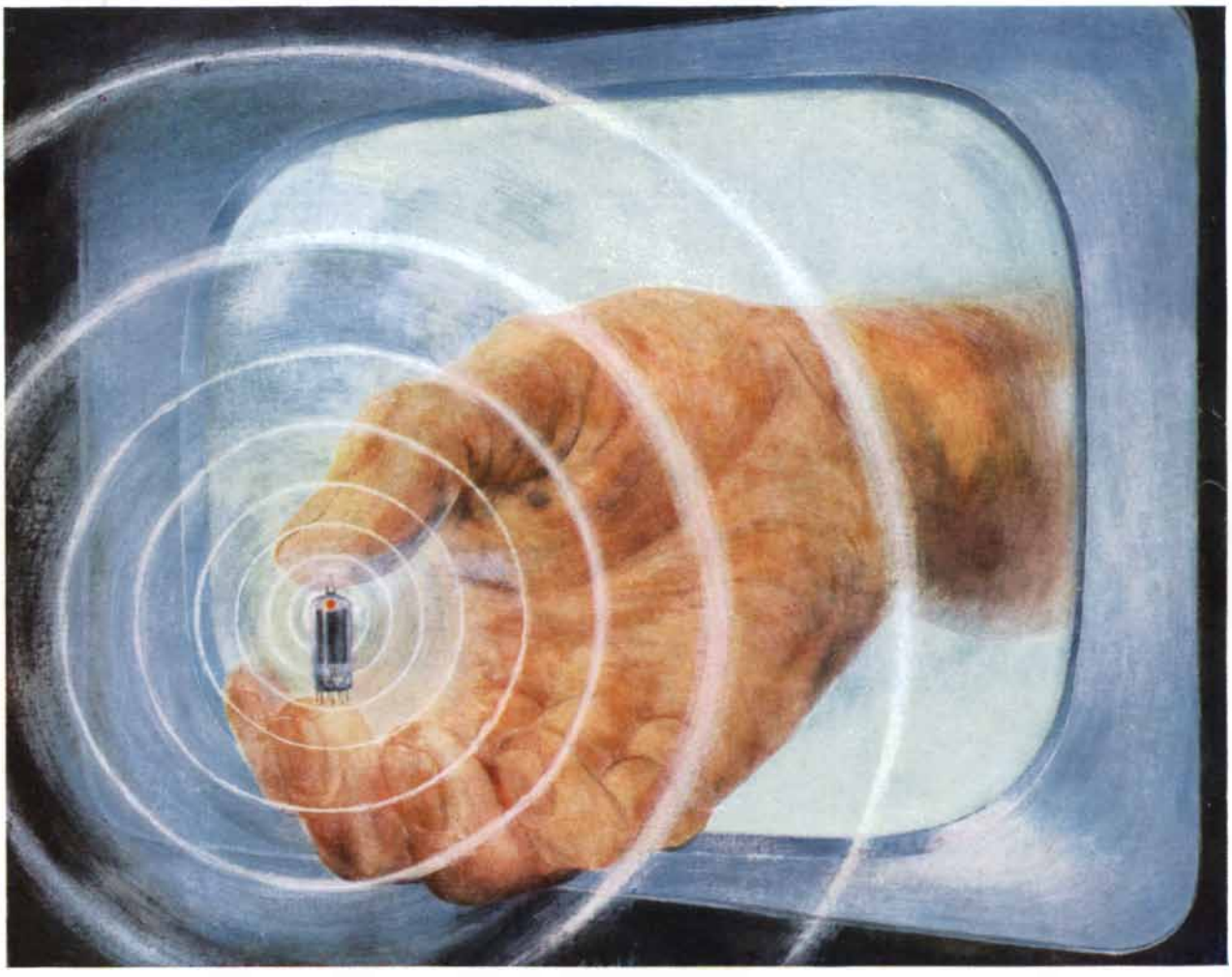
SCIENTIFIC AMERICAN

FLOWERING EXPERIMENT

FIFTY CENTS

May 1952



Miracle in the Home

The vacuum tube is working magic in our homes — to bring us the miracle of television

When the pianist strikes high "C" that string starts vibrating at more than 1,000 times per second—sending its musical tone across the room and perhaps across the nation.

But little tubes in your television set have electrical currents vibrating within them at more than 200 million times each second! That's almost beyond imagination.

FROM WAVES TO PICTURES—It's these tubes that make it possible for your set to receive the invisible television waves and convert them into the sound you hear and the picture you see.

One of the secrets of the tubes that perform such miracles is that they must operate under a high vacuum — as nearly nothing as possible.

HOW TO PRODUCE "NOTHING"—When the tube is being made, all possible air is pumped out and the tube is sealed. Then a tiny "getter"—built into the tube—is set off by electricity. There is a flash . . . and any remaining oxygen is burned up—leaving nothing.

UCC AND TELEVISION—Producing efficient getters for vacuum tubes is only one way in which the people of Union Carbide serve the electronics industry. They make ingredients for stainless steel that goes into picture tubes, chemicals for synthetic crystals, and plastics for insulation and for the cabinets themselves.

FREE: *Learn more about the interesting things you use every day. Write for the 1952 edition of the booklet "Products and Processes" which tells how science and industry use the* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS *made by Union Carbide. Ask for booklet D.*

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NEW THERMAL NEUTRON DETECTOR

G-E Universal Scintillation Counters detect thermal neutrons and alpha, beta, gamma radiation with high efficiency, by means of easily interchanged phosphors. Large sample chamber with adjustable platform permits accurate measurement of disintegration rate. See bulletin GEA-5735*, "G-E Radiation Instruments."

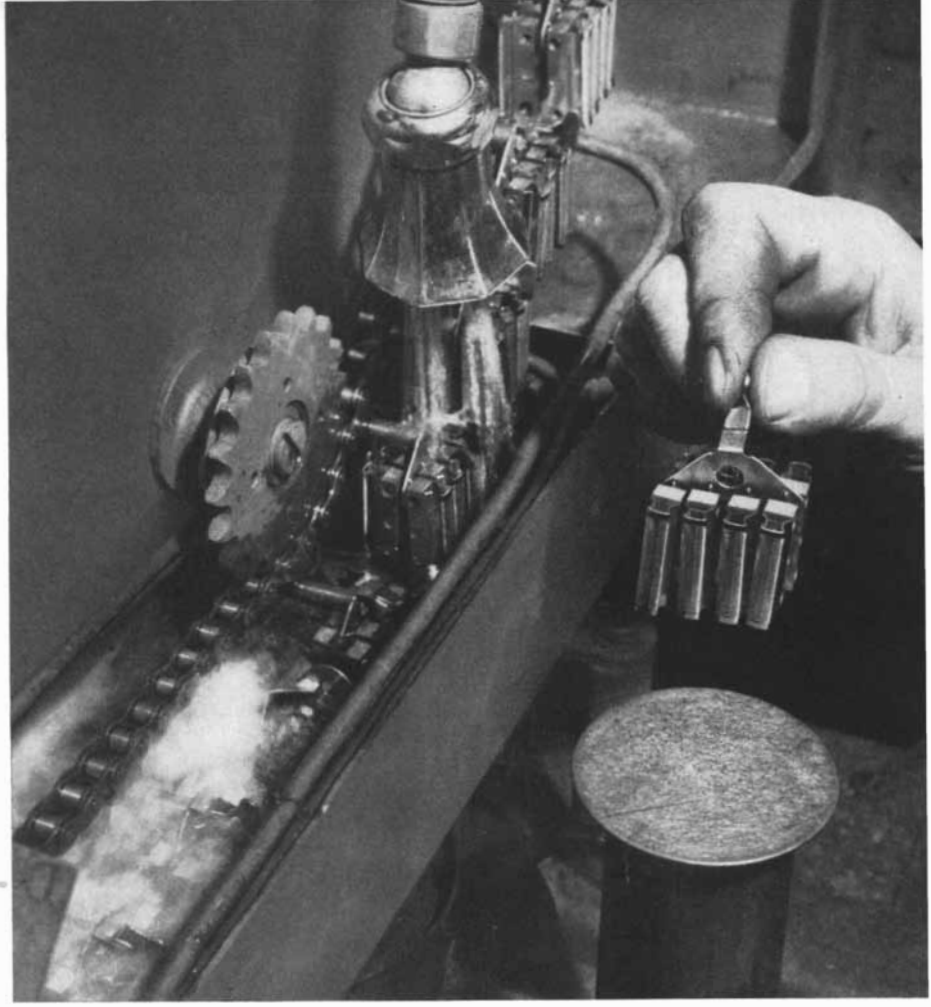
IMPROVED MASS SPECTROMETER

Faster and more accurate gas analysis by mass separation is now possible with new improved G-E Mass Spectrometers. The sample introduction system has been relocated. Ion source temperature is controlled to within a fraction of a degree. Range is increased to mass 500. See bulletin GEC-587*.

MEASURES SPECTRAL ENERGY

New G-E Recording Spectroradiometer provides increased sensitivity for automatic measurement and recording of spectral energy in ultraviolet, and visible spectrum. Measures dyes, inks, paints, textiles, plastics, TV tubes, etc. See bulletin GEC-604A*.

*** Let General Electric help you with your special process and instrumentation problems. Write, stating details, on your business letterhead to General Electric Co., Sect. 687-98, Schenectady 5, N. Y.**



Shaver heads are cleaned (left) then rinsed at Schick, Inc., Stamford, Conn. The result . . .

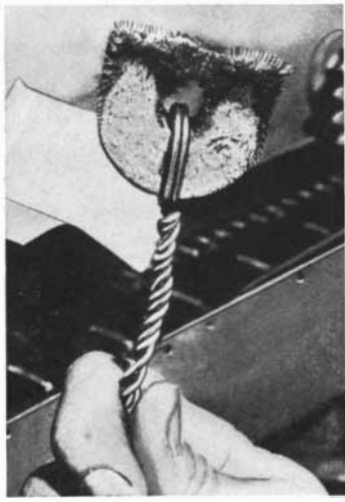
CLEANING COSTS CUT 58% WITH ULTRASONIC VIBRATIONS

G.E. Develops New Technique For Cleaning Small Metal Parts

Research men at General Electric showed that high-frequency sound (300–1000 kc) increased the action of many standard cleaning solvents 10 to 100 times. Inaudible sound waves set up in the liquid accelerated the removal of oil, grease, tars, resins, metal chips, and machining and buffing compounds.

The ultrasonic cleaning unit developed by G.E. enabled Schick, Inc. to cut over-all cleaning costs 58%. This new technique has also been applied to ball bearings, watch gears, and precision instrument parts.

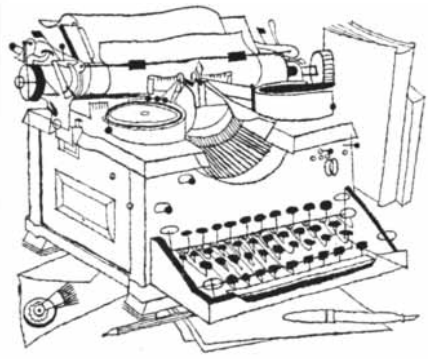
Here is an example of research put to work . . . a specialty at General Electric, where research and development are linked to provide more and better instruments and processes for modern industry.



Magnet shows metal chips removed from shaver heads by ultrasonics.

GENERAL ELECTRIC

687-98



Sirs:

When I came to the end of the article in your March issue entitled "The Quantum Theory," I was surprised to discover that someone had scrawled at the bottom of the page (and in my handwriting, at that!) the following quatrain:

Dear reader, you're a hopeless dope;
The quantum's quite beyond your scope.
I'll give you just the easy bit—
You wouldn't *get* the rest of it!

This conceivably puts the case a little too strongly. All the same, I hope that in his future articles Dr. Darrow will see fit to come to grips a little less diffidently with the problem of communicating the ineffable mysteries of physics to the nonphysicist. I for one would be willing to follow him, even if he marked the road "Travel at your own risk."

WILLIAM HOSKINS

Jacksonville, Fla.

Sirs:

I enjoyed Dr. A. J. Haagen-Smit's informative article on smell and taste (*Scientific American,* March, 1952). I would, however, like to add a point of information.

One need not substitute one element for another to get a change from a sweet to a bitter taste; one need only change the configuration of the substance and a difference in taste results. As an example of this, the amino acid phenylalanine. The D (+) form is sweet while the L (—) form is not sweet.

DONALD M. KIRSCHENBAUM

Brooklyn, N. Y.

Sirs:

In his interesting article "Smell and Taste" Professor A. J. Haagen-Smit, speaking of a theory which "plausibly explains our sense of smell and the wide range of compounds that possess odors," states: "The consulting chemist Jerome Alexander and George B. Kistiakowsky of Harvard University have suggested that the odoriferous substances act by interfering with enzyme-catalyzed reactions in the odor receptors."

This statement gives two entirely erroneous impressions: (1) that I had collaborated with Professor Kistiakowsky, or had at least published my views about the same time as he published his views; (2) that our views are alike. As a matter of fact, my theory was first published in 1937 in the fourth edition of my book *Colloid Chemistry* and was later referred to in *Chemical and Engineering News.* Professor Kistiakowsky's views were printed in *Science* in 1950.

In *Chemical and Engineering News* I wrote: "Briefly, the theory is this: The odor-producing substances affect the catalyst balance of the olfactory cells by any or all of the following mechanisms: (1) by modifying existing catalysts, an effect analogous to that of promoters in commercial catalysts; (2) by forming new catalysts (neocatalysts); (3) by inhibiting all or part of the activity of normal cellular catalysts. H. S. Taylor showed that catalysts may have several different specific catalyst areas, which can be selectively inhibited. If the effects are desirable, industrialists call this beneficial poisoning. If the odor material serves as a prosthetic group for a specific carrier, or *vice versa,* and the genetic make-up of the individual fails to supply the missing part, that person may be unaffected by the odor material." This broad view is consonant with wide application of catalysis in biological happenings.

On the other hand, Professor Kistiakowsky hamstrings my theory by *limit-*

LETTERS

Scientific American, May, 1952, Vol. 186, No. 5. Published monthly by Scientific American, Inc., 2 West 45th Street, New York 36, N. Y.; Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer. Entered at the New York, N. Y., Post Office as second-class matter June 28, 1879, under act of March 3, 1879. Additional entry at Greenwich, Conn.

Editorial correspondence should be addressed to The Editors, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

Advertising correspondence should be addressed to Charles E. Kane, Advertising Manager, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y.

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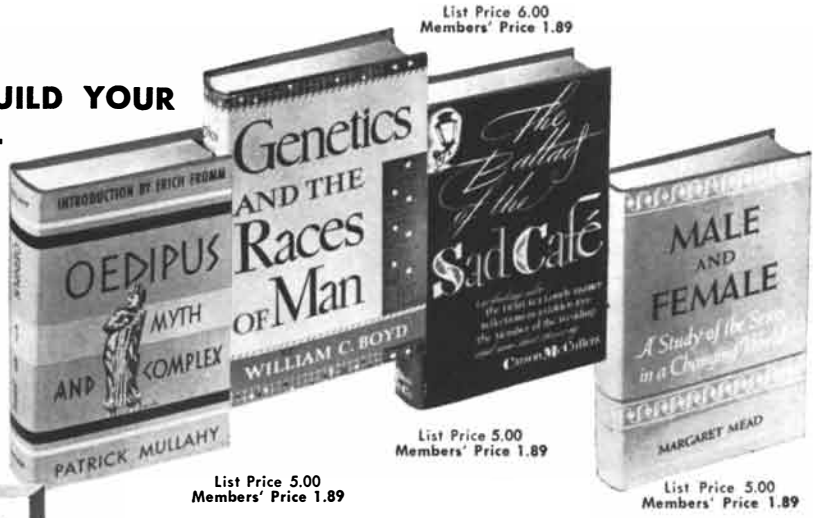

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ing it to inhibitions. He wrote in *Science:* "The effect of a compound possessing the property of odor is the inhibition of one or more of these enzymes, causing a shift in relative concentrations of A′, B′, C′, etc., and thus producing signals in the nerves that respond to these compounds."

JEROME ALEXANDER

New York, N. Y.

Sirs:

There has been so much misunderstanding in the press of the position of the Christian Science church on medical teaching in the New York schools that I am asking for space for a word about the brief item in your February issue entitled "The Right to be Ignorant."

Any move to bar teaching of the germ theory of disease from the New York State school curriculum or the examination questions because of our religious convictions is deplored by the Christian Science church. We don't want our views imposed on others. All we ask is the right to live them ourselves and to do this in a neighborly way, without injury to others. In a letter to the State Board of Regents last April the Christian Science Committee on Publication for New York specifically asked that changes not be made in the examination questions because of certain legal exemptions available to Christian Scientists.

The State action you report as ordering exemption of Christian Science children from instruction in public health and sanitation—including control of communicable disease, importance of pure food and water, what bacteria are, first aid, and other such items you list—was not requested, and is not supported by the Christian Science church.

All we would ask is exemption for our children from purely medical indoctrination through teaching of symptomology and the depiction of the terrifying processes of certain diseases in movies, slides, or other instruction. Such teaching tends to undermine the religious teaching given Christian Science children in the home. In so doing it invalidates a right of individual conscience priceless to all free men.

Regarding the title of your article "The Right to be Ignorant," we don't ask such a right. We ask the right to practice that intelligence which flows from a correct understanding of God and sincere love of Him. Christian Scientists don't ask the right to be sick; they ask the right to use the spiritual resources they are profoundly convinced by their experience bring true healing.

GEORGE CHANNING

The First Church of Christ, Scientist
Boston, Mass.

There's been a cold war on in Minnesota lately

. . . And our metallurgists have won it.

Up in the iron ore range, where 40 below zero can be expected frequently, shovel operators usually plan their operations to remove a year's supply of ore during warm weather months when the ore is workable. But recently, with steel requirements ever increasing, shovel operators began working around-the-calendar.

And they ran into trouble.

During one cold spell when the temperature dropped to 40° below throughout the iron ore range, the ore froze solid. The extreme cold caused steel in the equipment to lose some of its toughness, and power shovel booms and dipper sticks broke all over the range as the huge steel dippers were rammed into the frozen ore with tremendous force.

But there was one significant exception. Operators using shovels with booms and dipper sticks made of one particular steel went right on gouging up frozen ore without any equipment trouble.

Those shovels stood up because the heavily stressed parts were made from U·S·S Tri-Ten—a remarkably strong steel that has a high degree of toughness, even at low temperatures.

Moreover, the users were able to cut the weight of their Tri-Ten parts by 25%, even though some working stresses were increased *50%*. "And," says one shovel manufacturer, "Tri-Ten has enabled our customers to operate this equipment successfully at temperatures as low as —45°F."

U·S·S TRI-TEN is only one of hundreds of steel compositions (carbon, high-strength low-alloy, alloy and stainless) made by United States Steel to meet all service conditions. Our metallurgists are at your service to help you solve any problem involving the more efficient use of steel. Just call our nearest district office or write to United States Steel Company, Room 2802-J, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS

2-619

UNITED STATES STEEL

SCIENTIFIC AMERICAN

SCIENTIFIC AMERICAN

50 AND 100 YEARS AGO

MAY, 1902. "C. Nordmann regards the sun as the source of all kinds of electromagnetic waves, although many of these are absorbed by the atmosphere of the earth. The photosphere is probably the source of electromagnetic waves of great length as well as of light waves. Hertzian waves should be chiefly produced in the zone of sunspots and faculae, and at the maximum of solar activity. Since the filaments of the corona are probably due to the pressure of light, the filaments should be shorter during a sunspot period than at other times, and this is corroborated by observation. The incandescence of the upper portions of the sun's atmosphere cannot be due to heat alone, as it is particularly intense during a maximum of sunspots, when the surface radiation of the sun is reduced. It is, therefore, extremely probable that it is due to Hertzian waves, which are then at their maximum."

"Lord Kelvin and Lady Kelvin, who had arrived in New York on April 19, were tendered a reception at Columbia University on the evening of April 21. Dr. Francis B. Crocker presided and introduced Nicholas Murray Butler, the new president of Columbia University, who extended to Lord Kelvin an entertaining address of welcome."

"M. Curie has been making a series of experiments upon the action of radium rays and also of the X-rays upon various dielectrics. It has been already found that these rays increase the electrical conductivity of air and gases, and M. Curie now finds that they act in the same way upon liquid dielectrics."

"Count von Zeppelin, who has the distinction of having built the largest of all airships, has been financially ruined by his aeronautical experiments. Unable to obtain means for carrying out his new projects, he is now breaking up the old framework of his airships in order to sell the aluminium of which they are composed."

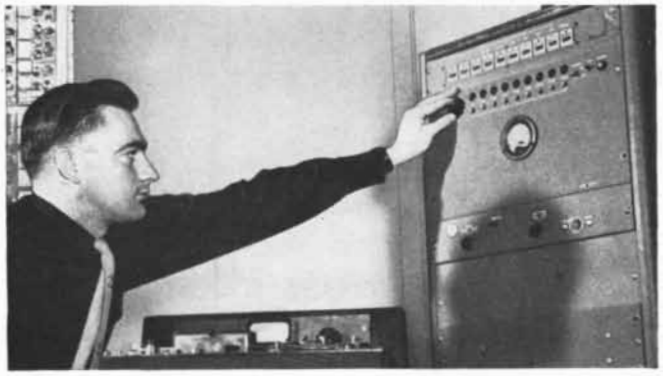
"In a very complete article recently published in the *Philadelphia Medical Review*, Dr. E. A. Codman discusses the burns caused by exposure to Roentgen rays. Nearly 200 cases are cited, and this large number should silence any doubts as to the reality of the danger. The cause of the Roentgen-ray burns is not known. A very curious feature of these burns is the fact that while in some instances the injury appeared immediately, in most cases a period of 10 days elapsed before the burn was noticed. Another curious phenomenon in connection with these rays is the fact that a repetition of the exposure on the same surface results in a cumulative injury. A number of safe exposures oft repeated are seemingly as dangerous as a single long exposure."

"Terrible news comes from Martinique. The town of St. Pierre has been completely destroyed by fire, with a loss of life that is appalling. The cause of the disaster was the eruption of the volcano Mont Pelée. On the morning of May 9, the crater began to belch forth molten rocks and ashes. Within a radius of four miles, in which district the town of St. Pierre is included, terrible destruction was wrought. The entire population of about 25,000 persons is thought to have perished."

"To the list of enthusiastic aeronauts who have sacrificed their lives in the interests of aerial navigation, the name of Augusto Severo must now be added. At about 5 o'clock on the morning of May 12, a crowd of spectators was gathered in the airship grounds in the Rue Quintinie to witness the ascent of Severo in his airship *Pax*. The airship sailed off steadily enough in the direction of Issy, where the experiments were to be made. As the ship hovered over the Avenue Demaine, she was caught by a puff of wind and blown about in such a fashion that to the onlookers it became immediately apparent that Severo had lost all control. A bright flash of light suddenly enveloped the balloon. A loud report instantly followed. From a height of 1,500 feet the machine fell toward the earth, crashing through branches of trees, finally landing in the Avenue Demaine. Severo was hurled from the balloon as it fell, and struck the ground near the Montparnasse Station. He was picked up a mangled corpse."

MAY, 1852. "The Boston *Journal* describes, as one of the curiosities of the age, an electric clock recently completed by Mr. N. Farmer on an entirely new principle, and pronounced by scientific men to be the most perfect and simple of any. All wheelwork in the time-keeping part is dispensed with, therefore all friction is

Thunder Hunters



Thunder hunting equipment on location near Madison, Florida. Loop antenna on truck picks up static. The engineer in top picture is watching the indication of a circuit which registers how often the static exceeds a given level.

Many new telephone circuits have two jobs to do—carrying your voice and transmitting signals to operate dial exchanges in distant towns. And an old-fashioned thunderstorm can interfere with both!

"Rolling static" comes from many storms over a wide area and can interfere with clear telephone talk. A nearby lightning flash makes "crack static" which, unchecked, plays hob with dial system signals.

So Bell Laboratories scientists go "Thunder Hunting" in the storm centers of the United States — "capturing" storms by tape recorders. Back in the Laboratories, they recreate the storms, pitting them against their new circuits. This method is more efficient and economical than completing a system and taking it to a storm country for a tryout. It demonstrates again how Bell Telephone Laboratories help keep costs down, while they make your telephone system better each year.

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Improving telephone service for America provides careers for creative men in scientific and technical fields.

overcome. The time-keeping part of the clock is simply a pendulum, an electro-magnet, and two armatures. The vibrations of the pendulum break and close the circuit of electricity, while the combined action of the electro-magnet and armatures keep it in motion."

"The Paris correspondent of the Boston *Atlas* states that the Academy of Sciences, of France, at their last session, unanimously voted to give the Cuvier prize to Prof. Agassiz for his *Recherches sur les Poissons Fossiles*. This is the first time the prize has been given."

"Geologists are now, from recent discoveries and observation, in a tolerably safe position to prove not only the vegetable origin of coal, but of the comparative geological period at which the several deposits were formed. The theory of the vegetable origin of coal is founded on the regular mineralogical gradation traceable from bog, wood or peat through lignite and common bituminous coal to anthracite. In peat there is the organic structure as perfect as in living wood; in lignite the woody fiber is still marked, but less obvious, while bituminous coal obeys the law of true rock or mineral cleavage, in which no vestige of vegetation is visible to the naked eye; but let a thin slice be placed under the microscope, and the most beautiful vegetable structure is apparent."

"The London *Lancet* says there are two modes of administering chloroform: one consists in using a small quantity of it, to be inhaled in a very short time, with hardly any admixture of atmospheric air. Patients are in this manner quickly rendered insensible. The method is dangerous; and though but comparatively few accidents have occurred, the latter have struck such terror into the practitioners and members of the community that this mode should never be followed. Chloroform should first be inhaled with a large quantity of atmospheric air; respiration should be allowed to go on regularly and normally; the chloroform is then gradually inhaled in a more concentrated form, and left off as soon as any unpleasant symptoms occur."

"Among the interesting facts developed by the recent census are some in relation to the laws that govern life and death. Ten thousand two hundred and sixty-eight infants are born on the same day and enter upon life simultaneously. Of these, 1,243 never reach the anniversary of their birth. At the end of the third year only 8,183, or about four-fifths of the original number, survive. At 21, the commencement of maturity and the period of highest health, 7,134 enter upon the activities and responsibilities of life—more than two-thirds of the original number."

AN IMPORTANT MESSAGE ABOUT NUCLEAR ENERGY

***from* PRATT & WHITNEY AIRCRAFT**

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This program offers you not only a chance to get into the field of nuclear energy . . . it also provides an opportunity to work under conditions that are ideal for creative talent . . . and build a sound career in private industry.

We need today Physicists, Mathematicians, Chemists, Metallurgists, Designers, and Engineers who will serve as members of a team. They must be more than theorists. They must combine a sound knowledge of their field and imagination with the ability to apply their talents to realistic and practical work.

You will enjoy working and living with us Your work will be important to the community as well as the nation. And we have the resources and research equipment to stimulate and further the most advanced scientific thinking.

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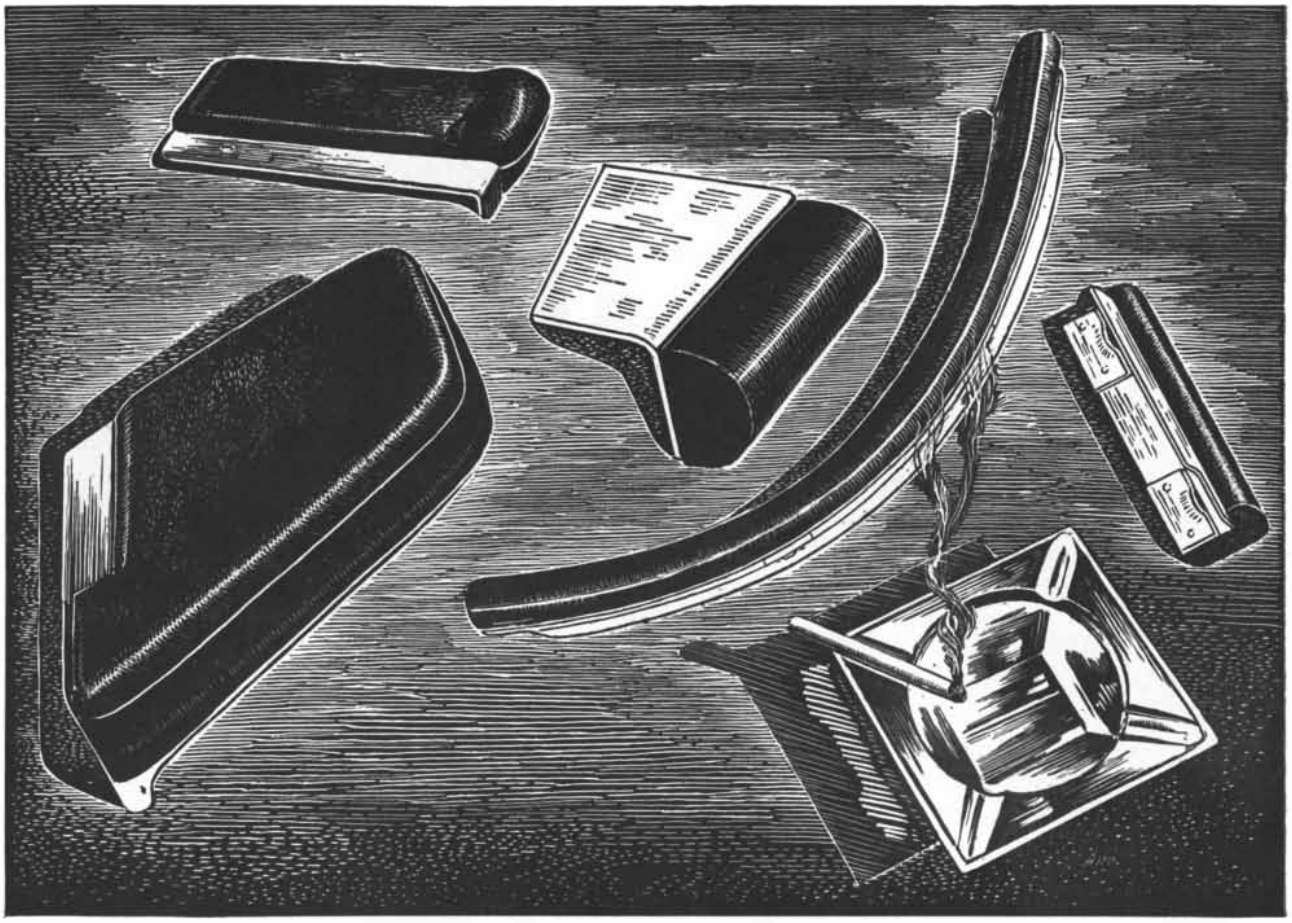
THE COVER

The painting on the cover shows a scene symbolic of research in the control of flowering (*see page 49*). Growing from the flowerpot at lower left is a "baby's breath" plant with two branches. One branch is allowed to grow in the open; the other is enclosed in a small house. By turning a light in the house on and off at various intervals, the investigator can determine such things as the length of day which causes the plant to flower, and whether the appropriate cycle of light causes one branch to manufacture a chemical which makes the other branch flower. The plant was supplied by A. E. Hitchcock of the Boyce Thompson Institute for Plant Research.

THE ILLUSTRATIONS

Cover painting by Stanley Meltzoff

Page	Source
15	Fairchild Aerial Surveys, Inc.
16-19	Stanford Research Institute
20-25	Courtesy Grahame Clark
26-27	James Egleson
28	Mount Wilson and Palomar Observatories (*top*); courtesy R. S. Richardson, Mount Wilson and Palomar Observatories (*bottom*)
29	High Altitude Observatory, Harvard University and University of Colorado
31	Allan Chappelow
32-34	Dwinell Grant
49	Courtesy C. B. Lyon, Hawaiian Pineapple Co.
50-52	Eric Mose
53	Courtesy Aubrey W. Naylor (*top*); courtesy M. W. Parker, Dept. of Plant Industry, U. S. Dept. of Agriculture (*bottom*)
54	Courtesy Aubrey W. Naylor
58	Courtesy Erwin W. Müller
59	Courtesy Erwin W. Müller (*photographs*), Irving Geis (*drawings*)
60	Courtesy Erwin W. Müller
62	Irving Geis
65	C. N. Jones, Jr.
66-68	Sara Love
73-75	Irving Geis
86-90	Roger Hayward



CELLULAR RUBBER BONDED TO METAL

one more example of the versatility of SPONGEX

Each of these parts was made by bonding Spongex cellular rubber to metal. Yet in each, Spongex had to meet different specifications. In one, Spongex must remain flexible even at −65° F. In another, it must be heat resistant and fire retardant. A third must have low water absorption. *All* possess one important quality . . . the superior bonding characteristics of Spongex for unexcelled adhesion of rubber to metal.

Bonding of Spongex to metal might not be your need. But if your need is cellular rubber, we've got it . . . in strips, rolls, cording, tubing and die-cut shapes. Learn more about how Spongex can help you . . . write for "Properties of, and Test Data on, Cellular Rubber."

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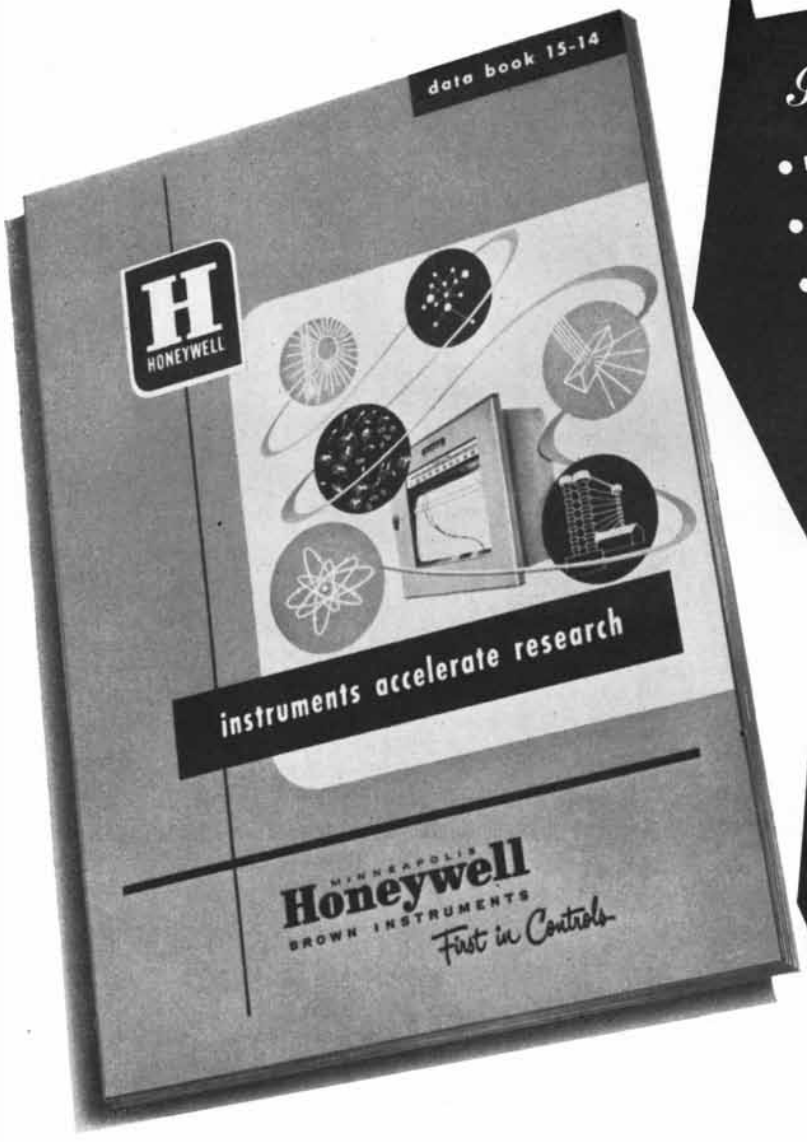

Instruments

- BROWN ELECTROMETER Pages 64-66
- FUNCTION PLOTTER Pages 54-56
- EXTENDED RANGE PRECISION INDICATOR . . . Page 56
- DUPLEX TWO PEN RECORDER Pages 60-61
- NARROW SPAN RECORDERS Pages 57-59
- ElectroniK HIGH SPEED RECORDER . . Pages 62-63

Components

- BROWN CONVERTERS Pages 86-87
- BROWN SERVO AMPLIFIERS Pages 90-95
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CONTENTS FOR MAY, 1952 VOL. 186, NO. 5

ARTICLES

SMOG by A. M. Zarem and W. E. Rand

An enormous quantity and great variety of materials pollute the air in a modern industrial city. Many investigators are now attempting to identify the contaminants and determine their effects on community health. **15**

A STONE AGE HUNTERS' CAMP by Grahame Clark

The excavation of a lakeside settlement in Yorkshire uncovers waterlogged implements of bone and wood, preserved for some 10,000 years, which tell much about the life of the ancient people who made them. **20**

ELECTRICITY IN SPACE by Hannes Alfvén

Sunspots, cosmic rays and radio waves from stars are electromagnetic phenomena which have puzzled astronomers. The behavior of mercury in a magnetic field suggests a new theory of the origin of these effects. **26**

SHERRINGTON ON THE EYE

Sir Charles Sherrington, the great English physiologist who died last March, was a talented writer. Reprinted here is his poetic description of the embryological development and the structure of the human eye. **30**

THE CONTROL OF FLOWERING by Aubrey W. Naylor

What makes a plant suddenly stop growing stems and leaves and begin to flower is unknown, but the search for the mechanism which sets off the change has already yielded much interesting and useful information. **49**

A NEW MICROSCOPE by Erwin W. Müller

Electrons or protons streaming from a fine needle-point to a fluorescent screen make possible the direct examination of crystal structure in atomic detail, and even give us a blurred picture of molecules and atoms. **58**

INHERITED SENSE DEFECTS by H. Kalmus

Not everyone sees all colors, hears all tones, tastes all flavors. A discussion of these and several other sense differences from the standpoint of their genetic study and of their relationship to other bodily functions. **64**

THE CORIOLIS EFFECT by James E. McDonald

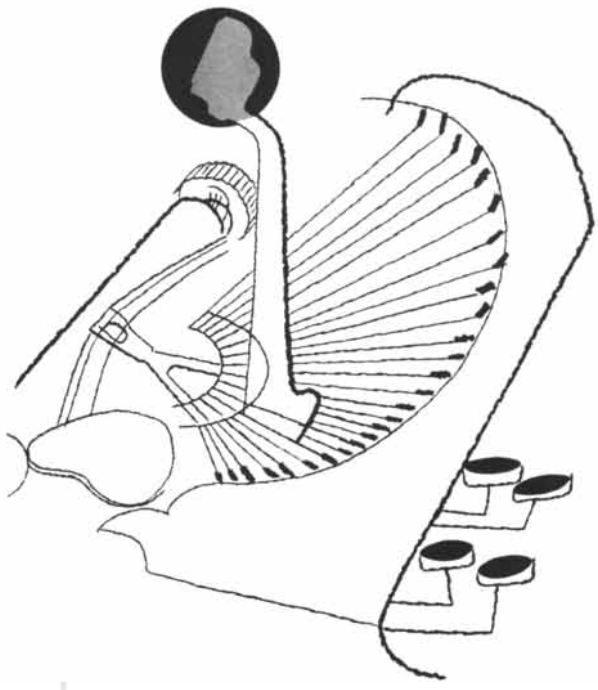
A game of catch on a merry-go-round illustrates a curious effect which causes moving bodies on the earth to slip sidewise, producing such results as deflection of long-range missiles and changes in our weather. **72**

DEPARTMENTS

LETTERS **2**
50 AND 100 YEARS AGO **6**
SCIENCE AND THE CITIZEN **36**
BOOKS **80**
THE AMATEUR SCIENTIST **86**
BIBLIOGRAPHY **92**

What's Happening at CRUCIBLE

about special shape type steel



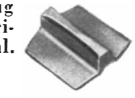
Crucible special purpose steel for type character application

The development of cold rolled special shape type steel is one of Crucible's important contributions to the business machine industry. A major part of the type characters used for the manufacture of typewriters are made from this special shape.

Here's the step-by-step process:

1. Cold rolled special shape produced by Crucible.

2. The type slug cut from the special shape material.



3. The wings of the type slug are bent down and taper formed toward the edges.

4. The type characters are cold swadged on the solid edge of the bent type slug.

5. The flash trimmed off after the swadging operation.

6. The finished type ready for hardening, plating and soldering to the type bar.

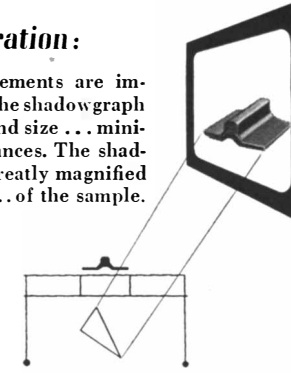
The production of Crucible steel for this job is the result of engineering and practical know-how combined with a special method of manufacture to assure a homogeneous microstructure for maximum forming properties, excellent surface characteristics for good die life, and close accuracy control for all dimensions of the shape.

The production of type steel requires the use of small precision rolling mills equipped with shaped rolls and operated by skilled workmen. During preliminary and final inspection, shadowgraph equipment is constantly used to check for size accuracy.

As a result of its outstanding quality, Crucible's special shape type steel is constantly in demand and used by leading typewriter manufacturers.

Shadowgraph Operation:

Since micrometer measurements are impractical due to the shape, the shadowgraph is used to measure shape and size . . . minimum and maximum tolerances. The shadowgraph is a projection, greatly magnified . . . on a calibrated screen . . . of the sample.



Schematic of shadowgraph

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SCIENTIFIC AMERICAN

MAY, 1952 VOL. 186, NO. 5

SMOG

As the metabolism of our cities quickens, their inhabitants breathe increasingly polluted air. The study of the problem is unusually difficult, but good beginnings have been made

by A. M. Zarem and W. E. Rand

EACH DAY the average human adult eats two and three-quarters pounds of food, drinks four and a half pounds of water and breathes about 30 pounds of air. We are rather careful about what we eat and drink, but we give very little thought to what we take into our lungs. The smog disaster in Donora, Pa., in 1948 reminded us acutely that air pollution has become something to think about. We are beginning to realize that the murky air of our cities is not merely a nuisance but can be a serious threat to our health, and the smoke pouring from factory stacks, once a proud symbol of prosperity and industrial might, is no longer a pleasant sight.

What can be done? Merely to find out what contaminants are in the air and how they affect our health is a gigantic job. As the industrial and chemical revolution has advanced, the pollution of our atmosphere has grown steadily worse. As early as 600 years ago the air in English towns had become so noxious that the burning of certain fuels was outlawed. Technicians have recently coined the word "smog" to describe the urban combination of smoke and fog. Today we have a vastly more complex mixture to worry about—not only smoke particles but an almost infinite variety of chemical compounds in solid, liquid and gaseous form.

The sources of air pollution are many. Let us consider first the combustion of fuel. The burning of coal discharges into the air soot and fly ash, water vapor, carbon dioxide, carbon monoxide, sulfur dioxide, oxides of nitrogen, hydrocarbons, oxygenated hydrocarbons and organic acids. In the Detroit-Windsor area, for example, it is estimated that the combustion of solid fuels alone annually releases into the air about 430,000 tons of sulfur dioxide. Liquid and gaseous fuels, though cleaner-burning than coal as far as soot is concerned, discharge all sorts of organic gases and vapors: methane, acetylene, aldehydes, phenols, ketones, ammonia and alcohols. As an indication of the size of this problem, we can cite some rough estimates of the burning of liquid and gas fuels in

LOS ANGELES, as shown in this aerial photograph, is frequently covered with a layer of smog. Because there are mountains on three sides of the city, there is seldom a wind strong enough to dissipate the polluted layer.

DEVELOPMENT OF SMOG is shown by these photographs made from a site in Los Angeles. In the first photograph, made at 9:15 a.m., the smog is clearly visible; observers could also detect its odor. In the second, made at 10, the haze is thicker; observers reported a stronger odor. In the third, made at 10:45, visibility is

the Los Angeles area. There each day some two million automobiles, buses and trucks burn a total of four million gallons of gasoline and oil, releasing nearly four billion cubic feet of exhaust! This means that more than 125,000 tons of contaminated air goes into the atmosphere every day from this one source. In addition, Los Angeles, including its industries, daily burns 21,000 tons of fuel gas, 7,300 tons of fuel oil, 260 tons of Diesel oil and 170 tons of coke.

Then we have the vast outpourings from industrial processing plants: chemical, metallurgical, petroleum refining, and so on. Large amounts of chemical vapors are also released into the air constantly by the evaporation of solvents, paints, varnishes, gasoline and other materials. And all these multitudes of substances may react with one another in the air, perhaps forming completely new compounds of unknown composition.

Finally, we must take account of the natural dusts, pollen, crystals, aggregates and miscellaneous particles in a wide assortment of sizes that are always in the atmosphere.

THE pollution problem has three phases. We need to find out (1) what substances are in the atmosphere, (2) in what quantities, and (3) in what concentrations or forms they may be harmful to man and his food or other products. On all these matters our information is woefully sketchy. We have to collect, isolate and analyze relatively minute quantities of materials in huge volumes of air—air that is not static but is constantly altered by changing weather and ventilation conditions.

That the questions are very complicated is illustrated by the problem of solid particles in the atmosphere. We know that the amounts are large. One measure of the quantity of dirt in the air is the amount that falls out of it. Sample measurements of the dust and soot fall have been made in several cities at various times during the past 20 years or so. In Grafton, W. Va., the annual rain of dirt was found to amount to 1,876 tons per square mile! In Baltimore it was 1,800 tons; in Pittsburgh, 1,031 tons; in Chicago, 782 tons; in Cleveland, 780 tons; in Detroit, 678 tons; in Los Angeles, 332 tons. But the dust problem does not involve merely the particles that are large enough to settle to the ground. Much of the material in the air consists of particles so small that they remain permanently suspended as aerosols. The human respiratory system filters out nearly 90 per cent of the larger particles (over one five-thousandth of an inch in

EFFECTS OF TURBULENCE on smog is depicted by the two photographs on this and the opposite page. The view is south across Hollywood; the day was classified as moderately smoggy. The photograph at the left was

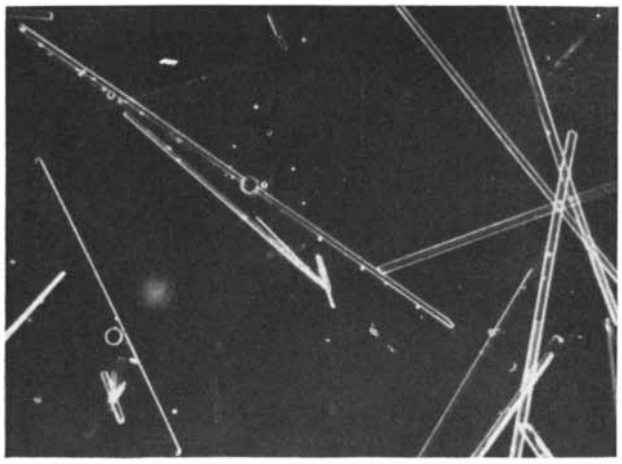
at its minimum for the day; the odor was at its strongest. In the fourth, made at 11:30, the haze begins to clear; observers reported a slight eye irritation. In the fifth, made at 1:30 p.m., the haze clears further; some eye irritation was still noticeable. In the last, made at 3:45, the smog is almost entirely gone.

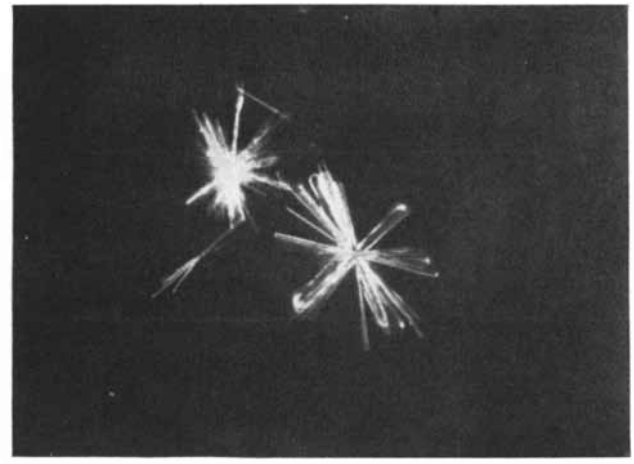
diameter). The smaller ones, however, particularly those less than 20 millionths of an inch in diameter, penetrate into our respiratory system; hence our "census" of the atmosphere must include measurement of the sizes of the various particles.

Our knowledge of human tolerances to the substances in the air is equally meager. We know that some of them can affect us in extremely small amounts. Formaldehyde is irritating to the eyes in a concentration of one part per million. Our threshold for odor perception goes even lower: we can detect some chemicals in concentrations of one part per billion. For certain chemicals and dusts industrial hygienists have determined the maximum safe concentrations: carbon monoxide, for example, is said to be unsafe if it exceeds 100 parts per million parts of air; chlorine, 1 part per million; fluorine, 3 parts per million; nitrogen oxides, 25 parts per million; sulfur dioxide, 10 parts per million; cadmium dust, .1 milligram per cubic meter; lead, .15 milligram; manganese, 60 milligrams; zinc, 15 milligrams. Fortunately, it appears that no city atmosphere, not even Donora's, has yet reached these levels of contamination. But as to the effects of the total content of the air, we are very much in the dark. We do know that some of the materials have caused damage to crops and livestock; hydrogen fluoride in a concentration of only one part per 200 million, for example, damages some plants after only a few hours of exposure.

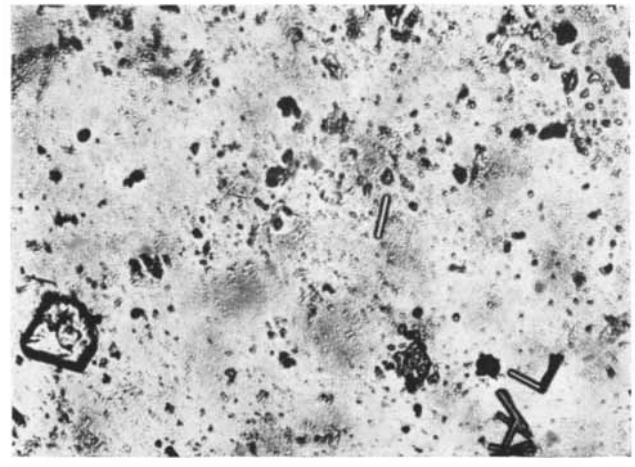
WE SHALL report here on some of the work done in Los Angeles, where one of the most extensive air-pollution studies yet attempted has been going on. Los Angeles is an air-conditioned paradise compared with some other big U. S. cities, but it has a very real smog problem at times (about 30 days of the year). This is due chiefly to its unusual topography and weather. Los Angeles is closed in on three sides by a ring of mountains and is open only on the ocean side. Rarely does a strong wind sweep over the city. Instead, a gentle motion of air, seldom exceeding 10 miles per hour, washes to and fro over the basin. Moreover, the city is generally blanketed by a canopy of hot, dry air created by the Pacific High. On days when the canopy is lower than the surrounding mountains, it seals the Los Angeles area and prevents vertical mixing of its air. On such days the activities of the area's millions of people overtax the natural ventilation. Visibility is noticeably decreased, and people complain

made at 6:30 a.m.; the smog hugs the ground in long streaks. The photograph at the right was made at 8:20; increased turbulence has mixed the smog more or less evenly through a much thicker layer of the atmosphere.

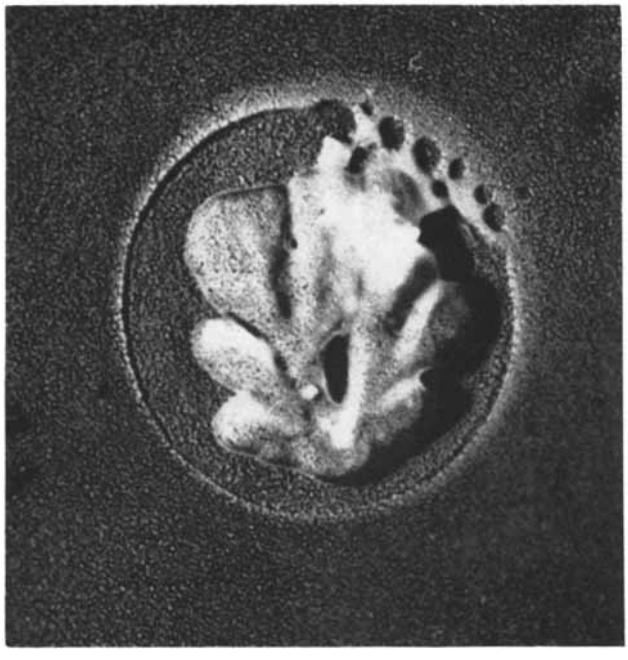


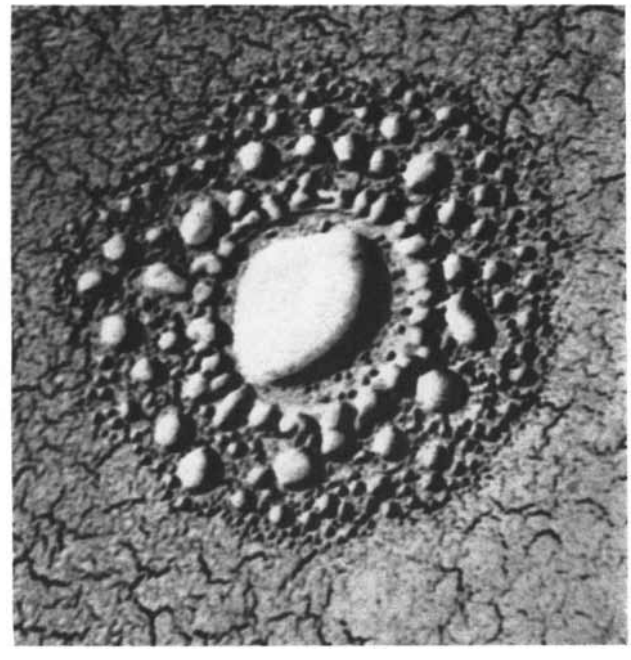


AUTOMOBILE-EXHAUST condensates contained the crystals shown in these two photomicrographs. The crystals are probably ammonium or calcium sulfate. In Los Angeles some 10,500 tons of gasoline are burned daily.



POWER PLANT burning oil produced the crystals in these two photomicrographs. Los Angeles burns about 7,300 tons of fuel oil, 650 million cubic feet of fuel gas, 9,165 tons of refuse and 260 tons of Diesel oil a day.





SMOG yielded the particles in these electron micrographs. The micrograph at left shows the solids that remained after the droplet containing them had evaporated. The droplet at right is from an artificial smog.

of eye irritation. In the Los Angeles atmosphere rubber deteriorates rapidly and sensitive crops often suffer.

Four years ago the Committee on Smoke and Fumes of the Western Oil and Gas Association commissioned the Stanford Research Institute to investigate Los Angeles' smog. We have undertaken to make a complete analysis of the Los Angeles atmosphere by almost every known method of analytical chemistry, including infrared and ultraviolet spectroscopy, X-ray diffraction, mass spectrometry, chromatography and microscopic techniques. We have even analyzed dust particles by applying reagents to individual specks with a hypodermic needle under a microscope! The study has given special attention to two types of pollutants: organic compounds, particularly hydrocarbons, and aerosols. Hydrocarbons, heretofore largely overlooked, are difficult to detect in small concentrations, and we have had to develop new techniques for doing so. The tiny particles of aerosols concern us both because of their ability to penetrate the defenses of our respiratory systems and because they provide surfaces on which other chemicals in the atmosphere can react.

One specific investigation well illustrates the nature of the study, and the interesting, often surprising, trails it opens up. We set out to try to find out what ingredients of Los Angeles smog are responsible for eye irritation. Sulfur dioxide had long been the chief suspect. Under the action of sunlight it can react with oxygen to form sulfur trioxide, which in turn can combine with water vapor to make a sulfuric acid mist. To test the sulfur dioxide theory we exposed people to this gas in a special "smog chamber" at the Stanford Research Institute. In the concentrations in which it occurs in the Los Angeles atmosphere, sulfur dioxide caused no eye irritation. Nor did any of the other known Los Angeles pollutants when they were tried individually in the chamber. We did, however, produce a synthetic smog, using nine ingredients of the Los Angeles air, that smelled like natural smog and irritated the eyes.

Smog has a striking general property that offered a possible clue: it possesses uncommonly strong oxidizing power. A. J. Haagen-Smit, California Institute of Technology biochemist, has suggested that the oxidizing material in smog may combine with hydrocarbons and other organic compounds in the air to produce irritating and noxious substances. Experiments with plants at Caltech have seemed to bear out this theory. Haagen-Smit found that by exposing plants to certain substances formed by oxidation of hydrocarbons he could produce damage such as Los Angeles smog produces.

What is the oxidizing ingredient in smoggy air? Various possibilities have been suggested, but one stands out. On smoggy days the Los Angeles air has a heavy odor of ozone. Ozone, a strong oxidant, attacks rubber, and the fact that rubber products crack in an extraordinarily short time in Los Angeles gives weight to the idea that ozone is indeed the chief oxidant in smog.

EYE IRRITATION caused by smog is measured at the Stanford Research Institute by conducting artificial smog into a special experimental mask.

THE ANALYSIS of what is in the air is only one part of the research problem. How does the polluted air of our cities actually affect the health of their people? Two years ago the U. S. and Canadian Governments formed an International Joint Commission to make an intensive study of that question in the Detroit-Windsor area. This vast undertaking will seek to compare the health of people who live in clean air with that of those who live in polluted air. The Commission has already selected a number of matched pairs of communities for comparison. It will compare high-income groups, middle-income groups, low-income groups and Negro groups, in each case taking one in a high-pollution area and another in a low-pollution area. The groups are large enough to give statistically significant results. The Commission will analyze the air in these communities, follow the weather conditions and take a continuous record of the people's health. Each family will be interviewed once a month, perhaps for several years. Data will be collected on deaths and illnesses, particularly those calling for the services of allergists and eye, ear, nose and throat specialists. The study will be expensive, but it is the only kind that can come near yielding the desired information.

A large-scale laboratory investigation of the effects of air pollution on experimental animals has also been suggested by many students of the problem. Animal colonies would be raised in several large cities with various conditions of pollution. The experimenters would use identical strains of animals, give them all the same diet and care, make standard measurements of their health and growth and perform a post-mortem examination on each animal at death. Such an experiment, extending over several years and a number of generations, would tell a good deal about the effect of air pollutants on health, nervous habits, the span of life, physiological processes, and so on. The animals exposed to pollution would be compared with control groups grown in filtered air or in suburban areas.

AFTER THE Detroit-Windsor population study and laboratory animal investigations have determined how polluted air affects health, the next step will be to test individual air contaminants on animals to identify the harmful substances and establish permissible levels of pollution. We shall need new measuring techniques and a great deal more technical information to solve the air pollution problem. Its various facets call for cooperative efforts by a large number of specialists: meteorologists, physicists, chemists, physiologists and many others. It is clear that hardly a field of science will not somehow be touched and enriched by the inquiry.

A. M. Zarem is chairman of the National Air Pollution Symposium and director of the Los Angeles Division of the Stanford Research Institute. W. E. Rand is assistant director of the Institute.

A Stone Age Hunters' Camp

Beside an ancient lake bed in Yorkshire archaeologists have unearthed stone and organic relics of the pre-agricultural folk who inhabited the forests of Europe 10,000 years ago

by Grahame Clark

A LITTLE more than half a century ago a party of archaeologists from the National Museum of Denmark began to explore traces of a Middle Stone Age settlement in the Great Bog on the Danish island of Sjaelland. They found some hand-chipped flints, which was not too remarkable. But because they were digging in a site which had been waterlogged for a very long time, they had the great luck to find also some preserved organic material: tools and equipment fashioned from bone, antler and even wood; discarded animal remains, and traces of the vegetation that had grown at the time the site was occupied.

The time was not long after the last Ice Age. The climate was still cold, with rather more marked seasonal differences than obtain today. Sea levels were a good deal lower than now, due to the amount of water still locked up in the Pleistocene ice-sheets. The vegetation was dominated by pine forests. Oak and other warmth-demanding trees were still rare. Elk and wild ox were the chief game animals; there were also some red and roe deer and wild pigs. The people who had camped at the site were hunter-fishers who did not yet know agriculture.

To these people archaeologists gave the name Maglemosian, after *Magle Mose,* Danish for Big Bog, where the first settlement was found. It was a new Middle Stone Age culture previously unknown. During the past 30 years, however, traces of similar settlements have turned up at widely separated

EXCAVATIONS at Star Carr in Yorkshire uncovered the camp. Beyond the excavations is the site of a former lake, on the shore of which the camp was located. At the lower right a group of Cambridge University students work. On a platform between two ladders at the upper left two workers photograph the brush floor of the camp.

points over the whole plain of Northern Europe, from Eastern England and Northern France to as far east as Estonia. Evidently hunting bands of the Maglemosian type had ranged over the whole of these extensive territories during the time when much of the North Sea was still dry land and the Baltic was a landlocked lake. Everywhere the hunters had camped on the shores of lakes, most of which have since been filled up and converted into bogs.

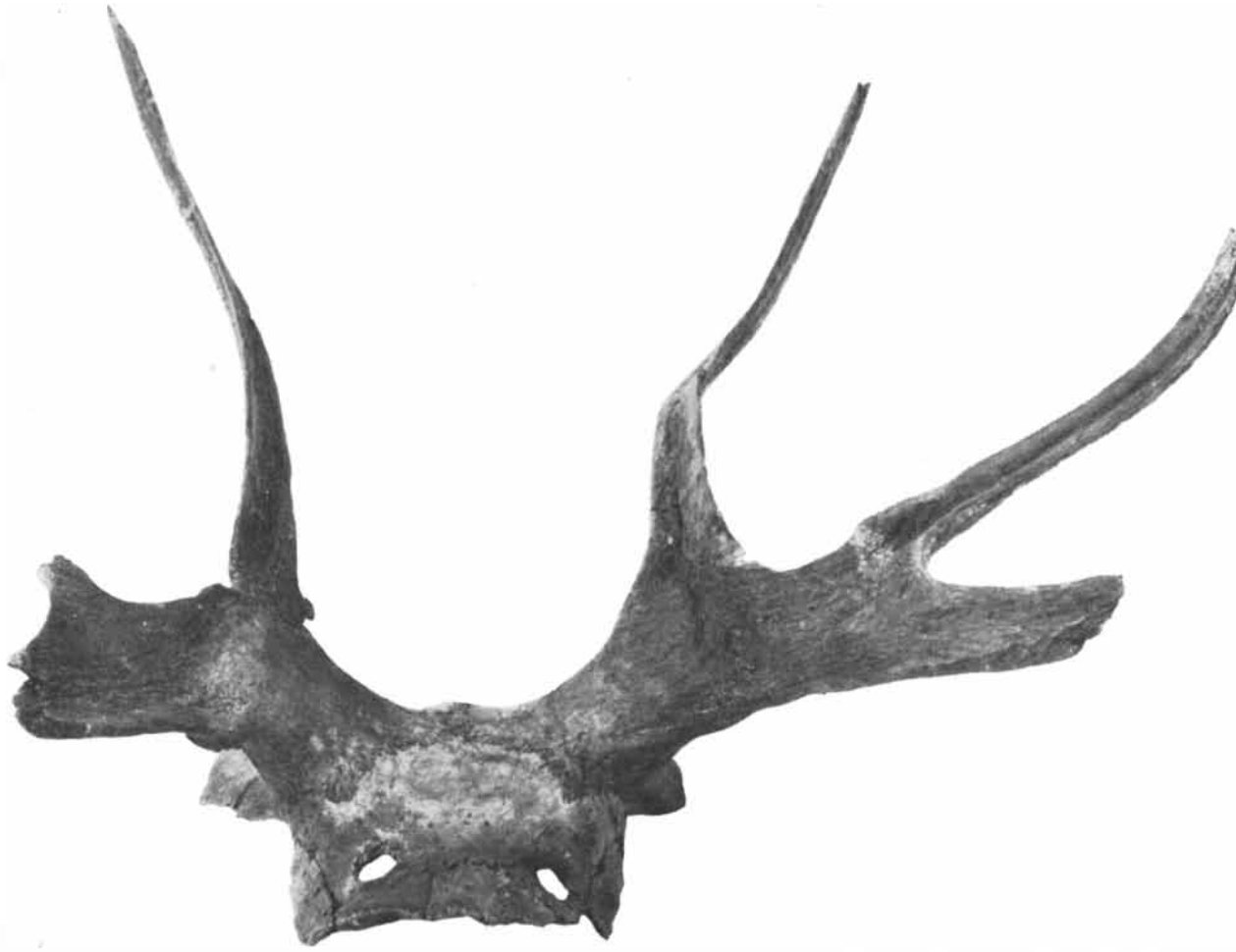
Three years ago a party of young Cambridge University archaeologists started digging in Yorkshire to find out more about these people. Although a fair amount had been learned about their geographical spread in Europe, very little was known about any single group of them outside the West Baltic area, and almost nothing about the British Maglemosians. We located a likely site on the edge of an ancient lake bed at Star Carr, in east Yorkshire, and explored it during the summers of 1949, 1950 and 1951.

AS SO OFTEN happens in archaeology, we did not find precisely what we had expected. It turned out that the settlement we excavated at Star Carr was a good deal older than any previously explored on the Continent at which organic substances had survived. In other words, we had the chance to investigate an earlier phase in the adaptation of the North European hunters to the incoming forest. Our Star Carr people were living at a time when the forests were still composed almost entirely of birch trees with but a small proportion of pine. How long ago was this? According to our best information, including radiocarbon measurements of two samples of birchwood, it was somewhere between 9,000 and 10,000 years ago.

On digging away the overlying peat and mud, we found a small camp site of not more than 300 to 350 square yards; hardly more than three or four families can have occupied it at once. The people evidently wanted to live as near the lake as possible, for they pitched their camp directly on the reeds bordering the open water. They threw down quantities of birch brushwood, interspersed with stones and wads of clay, to help consolidate the yielding surface of the swamp. The inhabitants must have sheltered in skin tents or temporary huts.

Since the Maglemosian economy was to a large extent based on hunting, we were glad to recover quantities of animal remains—antler and bone. On the drier landward side this material was badly decayed, where it had not entirely vanished. But the bone and antler recovered from the lakeward side was quite solid and a beautiful pale chestnut brown. Because it would split and eventually disintegrate if allowed to dry

BIRCH TREES felled by the hunters were preserved by the waterlogged soil. The axe-hewn base of the larger tree (*bottom*) is at the edge of the brush floor of the camp. At the upper right the intake of a pump drains the trench.



SKULL of a red deer had been hollowed out so that only a light shell remained. The skull had also been perforated with two holes and the roots of its antlers scraped. This object may have been worn as a mask.

FLOOR of the camp was composed of brush interspersed with pebbles and lumps of clay. This made a firm platform on the swampy shore of the lake. At the lower right is the stump of a birch tree that had been cut down.

out, every piece had to be impregnated with polyvinyl acetate under vacuum conditions to preserve it.

All the mammals represented were wild, and with few exceptions they were forest forms. The foremost victim of the Star Carr hunters was the red deer. Roe deer, elk, beaver and two races of wild ox were also fairly common. In addition there were a few remains of wild pig, fox, wolf, marten, badger and single bones of a hare and a hedgehog. That the Star Carr people also carried on fowling activities was witnessed by the bones of a number of birds, including the red-throated diver, red-breasted merganser, crane, white stork and grebe—all species at home on inland waters. We found no fish-bones, but it seems altogether likely that these people, living at the edge of a lake, must have fished. We did recover the middle portion of a wooden paddle, apparently the oldest implement of water navigation yet found anywhere in the world. Unfortunately there was no clue to what kind of boats the Star Carr people had. At the edge of the brushwood, where the open water of the ancient lake began, was a group of felled birch trees, which may have been a rough landing-stage.

VACUUM CHAMBER was brought to the Star Carr site by the archaeological party to impregnate fragile animal remains with polyvinyl acetate.

GREAT quantities of worked flint, mostly the debris chipped off in the manufacture of tools, lay about the site. The extreme freshness of the material has made it possible to study the processes of manufacture in unusual detail. One of the most significant tools represented was the axe or adze. There were axe marks on the stumps of the felled birch trees. Apparently this tool was put to considerable use and frequently resharpened, because there were many flakes of the kind that would be struck off in the process of renewing its cutting-edge.

Most of the flint tools and fragments were connected more or less directly with hunting or with working the various materials obtained from wild animals. Among the commonest kinds were tiny pointed flakes, some of which were used to tip arrows and others as barbs set lower down the shaft. These small flints were held in position by resin, perhaps distilled from birch bark as in stone-age Switzerland. The Star Carr people gathered birch bark and, like the modern Lapps, stored it in tightly wound rolls. Other common flint tools at the Star Carr site were various scrapers, indicating that the people used animal skins for clothing and possibly for tents and boats.

Most striking, however, was the large number of flint burins—tools for working bone and antler. Animal antlers and bones played an important part in the economy of these people. We found at Star Carr no fewer than 193 barbed spearheads, almost all made from the antlers of red deer. Narrow splinters were cut out of the antlers with burins, and a row of pointed barbs was then cut along one edge. These spearheads, ranging from about 3 to 14 inches long, undoubtedly were attached to wooden shafts, sometimes in pairs or bunches. One of the points we recovered may have been a harpoon-head: it had two barbs and a hole through one end. It is likely that the inhabitants caught fish with forked spears and other weapons, as did Maglemosians in other parts of Europe.

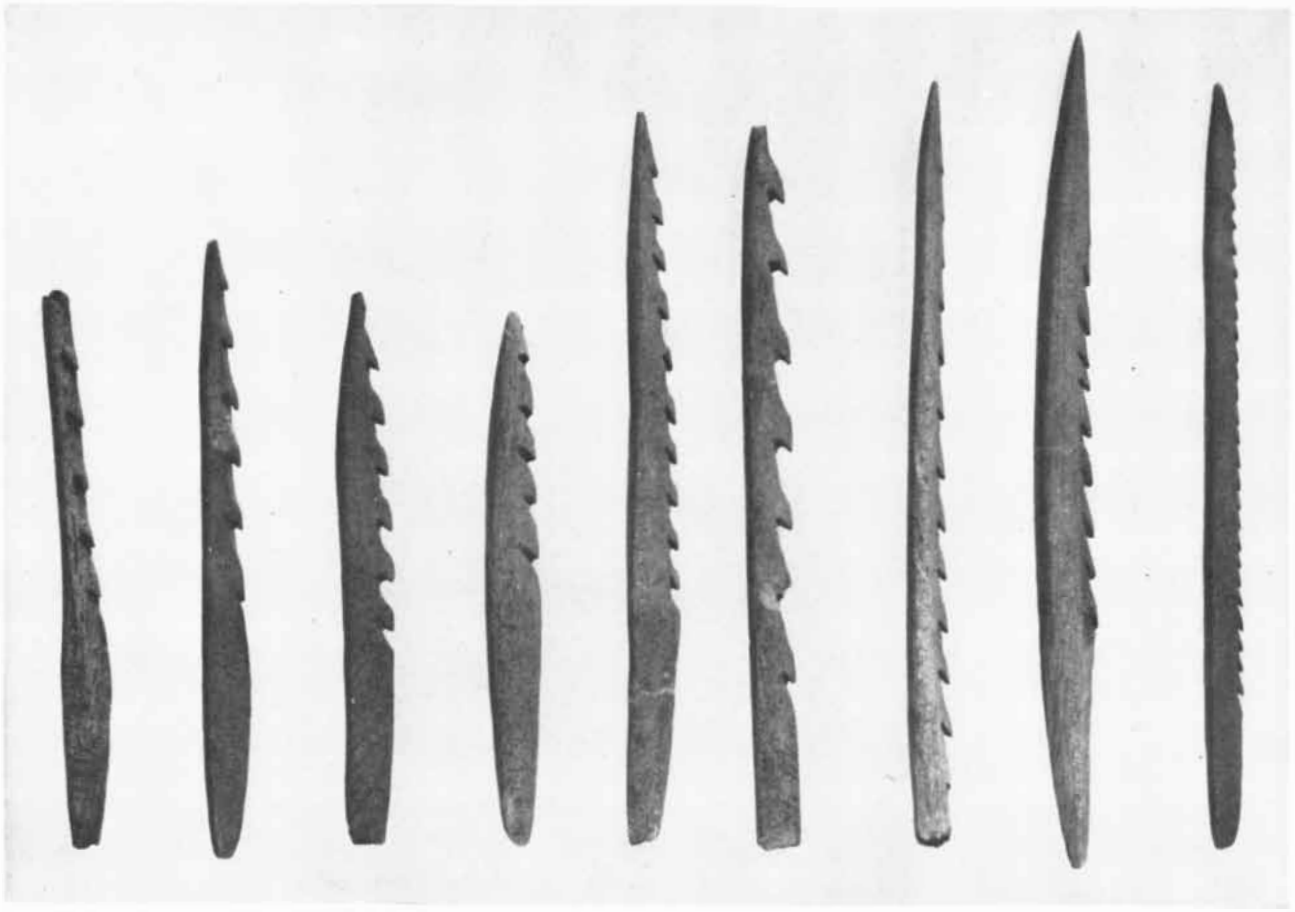
The Star Carr people's preference for antler in making their spearheads is most interesting, because all other groups of Maglemosians whose remains have so far been discovered preferred to make them of bone. In form the spearheads of the Star Carr people are typically Maglemosian, but their use of antlers and their technique of cutting the splinters resemble the practices of earlier deer hunters of the Old Stone Age. This further goes to show that the Star Carr culture represents a transition phase in the early development of the Maglemosians of the Middle Stone Age.

It is instructive to see how selective the Star Carr craftsmen were in the use of their bone and antler materials. For example, although they utilized the red deer's antlers (for spearheads, clubs and spatulate tools), they seem to have made no use whatever of the bones of this animal. On the other hand, in the case of oxen they used only the main leg bones. From them they made hammering tools, what seem to be anvils on which to rest flint while flaking it, and tools with concave, highly polished working ends, very much like the implements used by Eskimos for leather-stretching.

From the antlers of the elk the Star Carr people fashioned two kinds of mattock-heads; these, attached to wooden handles, were probably employed for breaking the soil. The only bones of this animal used for toolmaking were those of the lower legs. We found one large elk bone that was heavily battered, as if flint had been flaked on it, and another from which strips had been cut, perhaps for bone spearheads. There were also some small sharpened elk bones that may have been employed as pins to fasten skin cloaks together. Although there was a good deal of bone and antler of roe deer lying about, we could discover no sign of any tools of this material; apparently this animal was killed only for its meat and skin.

THE PICTURE we have painted so far is that of a small community encamped in a reed swamp close to the margin of a lake and preoccupied almost entirely with preying on other forms of life, on which it depended for its food and much of its material equipment. Yet even at this rather brutish level the Star Carr people conformed to a recognizable cultural pattern.

Their culture, indeed, went a bit beyond stratagems to make a living. Amid



NINE SPEARHEADS are only part of the 193 found at the Star Carr site. Ranging from 3 to 14 inches in length, they had been cut from the antlers of the red deer with flint tools and then notched with barbs.

TWO JAWBONES are among the many animal remains found at the site. At the top is the jawbone of an elk; at the bottom, that of a red deer. The bottoms of both jawbones had been broken off to extract the marrow.

the welter of discarded meat-bones and workshop debris it was pleasant to find a few articles of personal adornment. Here and there were a few beads made of thin, disklike pebbles smaller than a thumbnail, with holes bored through the middle, apparently by a bow-drill. The beads lay in groups, perhaps where they had fallen when necklaces broke. We also found some animal teeth and lumps of amber perforated with holes, indicating that they, too, were used as pendants. But none of the beads or pendants was decorated in any way, nor was there a trace of decorative carving on any bone or antler at the site.

We did, however, find some red-deer antlers that had been treated in a very peculiar manner. These antlers, in every case those of young stags, had been pared down and hollowed out, so they were merely a light shell. The inner side of the roots, where the antlers had been attached to the animal's head, was scraped smooth, but the outer side was left rough. And two or three holes were cut in the bony base of the frontlets.

The holes suggest that the antlers were meant to be mounted in some way. On posts? If so, it is difficult to account for their being reduced in bulk and scraped smooth on one side. It looks very much as if they were meant to be worn on the head as some kind of mask.

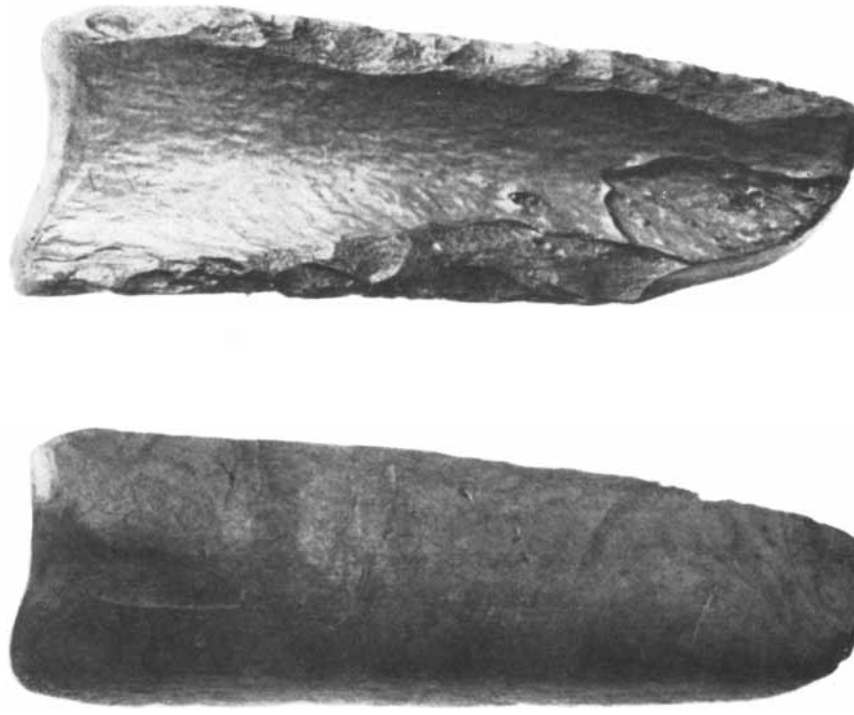
What, it may well be asked, would stone-age savages be doing with deer's-head masks? Two possibilities suggest themselves. It may be that the Star Carr hunters wore them while stalking stags at the mating season, to attract and draw them within range, much as some Caribou Eskimo are known to have done. The other possibility is that the Star Carr people wore them in some kind of ritual dance designed to assist the fertility and increase of the red deer, on which the economy of these people mainly depended. Dancing with animal masks goes back at least as far as the latter part of the Old Stone Age in Europe. One might mention the engravings of dancers with chamois masks found in Paleolithic caves of Southwest France, or the fantastic Sorcerer of Trois Frères crowned with reindeer antlers, or the dances of Tungus shamans wearing frontlets and antlers of reindeer that are illustrated in an early 18th-century work, or even the still-surviving horn dance of Abbots Bromley, England.

Yet when all is said, no certain explanation of the Star Carr frontlets can be offered. As so often happens when we deal with the remote past, scientific procedures enable us to advance knowledge only up to a certain point, beyond which stretches a vast realm of conjecture.

Grahame Clark is lecturer in archaeology at Cambridge University.

WOODEN PADDLE, shown in two views, indicates that the hunters went out on their lake. The paddle is the oldest evidence of human navigation.

MATTOCK HEAD, made from the antler of an elk, was apparently used to break the soil. The hole suggests that the head was attached to a handle.



BONE TOOLS resemble those used by modern Eskimos to stretch leather. These tools were made only from the metacarpal bones of the wild ox.

ELECTRICITY IN SPACE

The motion of a conducting fluid in a magnetic field generates a hitherto unknown kind of wave. This may be a mighty force of nature which causes such phenomena as sunspots and cosmic rays

by Hannes Alfvén

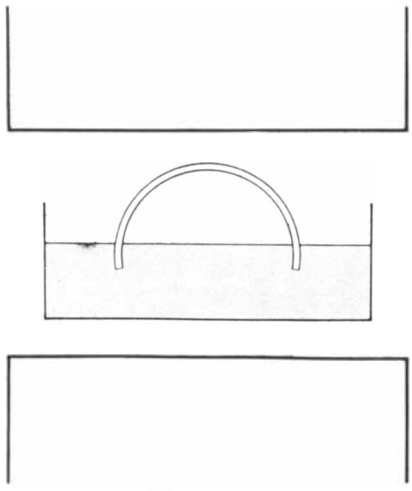
NEARLY everything we know about the celestial universe has come from applying principles we have learned in terrestrial physics. Newton's laws of motion, our studies of the spectrum of light, our explorations of the nucleus of the atom and other major discoveries in our physics laboratories have contributed to our enlightenment about the stars—their motions, their chemical composition, their temperatures and their source of energy.

Yet there is one great branch of physics which up to now has told us little or nothing about astronomy. That branch is electricity. It is rather astonishing that this phenomenon, which has been so exhaustively studied on the Earth, has been of so little help in the celestial sphere. Electricity has illuminated our cities but has shed no light on stellar phenomena; it has linked the Earth with a dense net of communications but has given no information about the universe around us.

Certainly we have seen plenty of evidence of electrical phenomena out in space. Within the last few decades we have discovered several important electrical effects in the heavens: strong stellar magnetic fields such as could only be caused by large electric currents, radio waves emanating from the sun and from many star systems, and the energetic cosmic rays, which are electrically charged particles accelerated to tremendous speeds.

These phenomena, however, are still very mysterious. We have no idea how electric currents may be generated and transmitted in the stars or in space. Although we know a great deal about electricity, almost everything we know is based on its behavior in wires. We generate electricity by moving copper wires in a magnetic field, and we can transport, broadcast and use electrical energy only by means of wires. Any electrical engineer, asked what he could do without using metal wires at all, would certainly say: nothing.

But there are no wires in the stars. They consist entirely of hot gases. While physicists have given much study to the behavior of electric currents in gases, we know of no means by which gases can generate electricity. Hence the electrical phenomena in stars present us with a completely new problem.



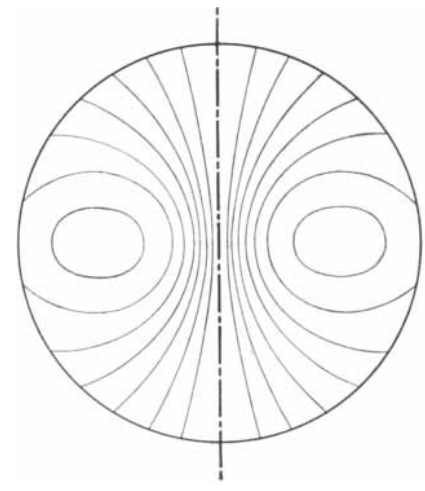
POOL OF MERCURY in a magnetic field is viscous. When a loop is drawn through the mercury, it is like syrup.

WE CANNOT bring the stars into our laboratories. But we can investigate electrical behavior in a medium roughly comparable to the gaseous body of a star and under comparable conditions. We know that there are magnetic fields in stars. We also know that very hot incandescent gases, such as make up a star, are good electrical conductors. In the interior of a star the gases are under such great pressure that they may be much denser than ordinary liquids. Since we cannot work with gases under such pressure in a laboratory, the closest we can come is to use a liquid. Of the common liquids, mercury is the only one which is a good conductor of electricity.

We have recently conducted some simple experiments with mercury in a magnetic field and observed several very curious and striking results.

Everyone is acquainted with the "mercurial" behavior of mercury. If you tap the side of a vessel containing a pool of mercury, the surface quakes and ripples as if it were alive. We found that when we placed such a pool in a strong magnetic field of 10,000 gauss, its behavior instantly changed. It did not respond to jarring of the vessel; its surface stiffened, so to speak. The magnetic field gave a curious kind of viscosity to the mercury. This was illustrated dramatically when we dipped the two ends of a bent metal wire into the liquid and moved them through it. Ordinarily an object dragged through mercury moves as easily as through any liquid. But when the magnetic field was applied, the wire pulled the mercury with it, producing a big surge in the pool. It was like moving a stick through honey or syrup.

This behavior is easily explained. The wire and the surface of the mercury between its ends form an electricity-conducting circuit. When the wire is moved across the magnetic field, it creates an electric current. Since an electric current always produces a magnetic field, the new current creates a second magnetic field. This interacts with the one we

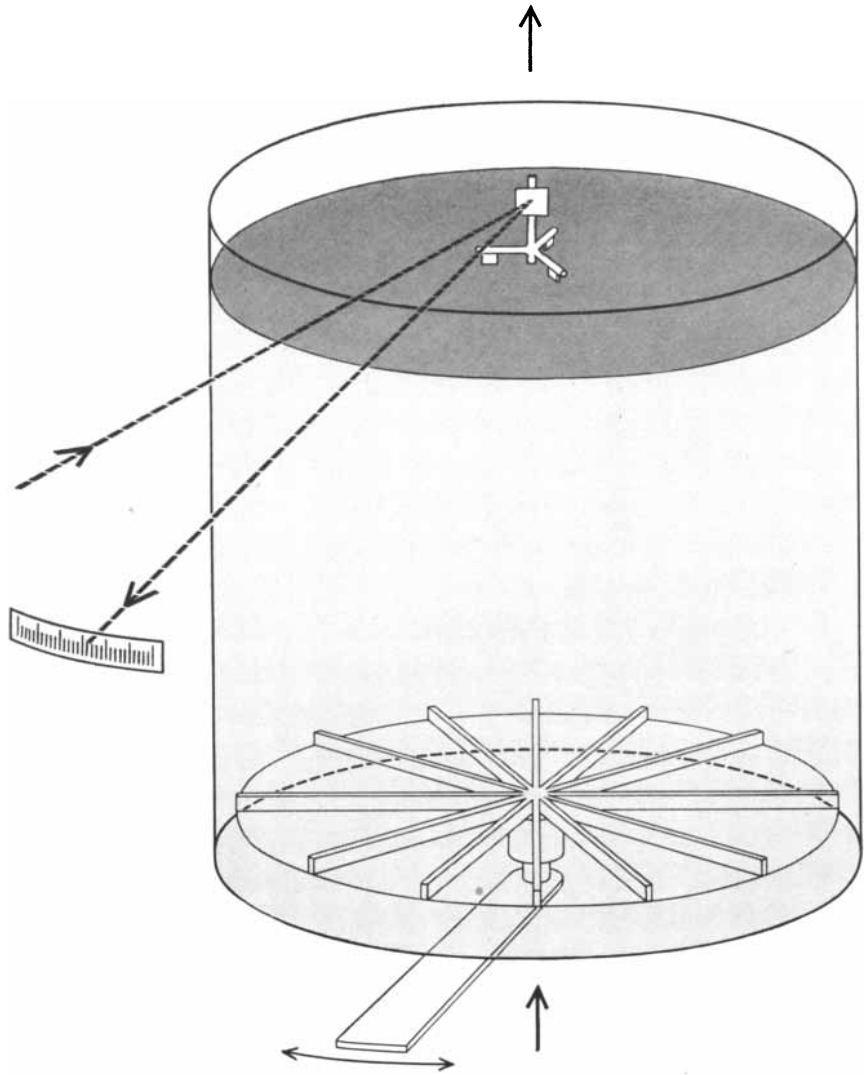


LINES OF FORCE passing through the turbulent interior of the sun may give rise to spots on its surface.

have already applied to the pool of mercury, just as two magnets attract or repel each other. The force between the two magnetic fields opposes the motion which is producing the current. As a result the wire sticks to the mercury as if it were a very viscous liquid.

Let us now consider another experiment that disclosed a more remarkable and illuminating phenomenon. We fill a small tank with mercury. The tank has a movable bottom which can be rotated back and forth like the agitator in a washing machine. In the absence of a magnetic field, the slow oscillation of this agitator, stirring the mercury at the bottom of the tank, will not disturb the surface of the mercury at the top of the tank; the mercury molecules slide past one another so that the motion dies out before it proceeds very far up the tank. A mirror floating on the surface, with a beam of light shined on it to show any slight movement, stays perfectly still. When a strong vertical magnetic field is applied to the tank, however, the motion at the bottom is quickly communicated to the top.

What we have created here is a new kind of wave, which was predicted theoretically about 10 years ago but was actually produced for the first time in this experiment. The wave is the result of a coupling between magnetic and hydrodynamic forces. When the mercury at the bottom moves in the magnetic field, it generates electric currents. These currents, with their attendant magnetic fields, produce mechanical motion in the mercury immediately above, which in turn creates new currents that act on the next layer. Thus the movement is communicated up through the whole body of the liquid. This rising wave of motion is called a magneto-hydrodynamic wave. It has three characteristics: it produces (1) mechanical motion, (2) a magnetic field, and (3) an electric field.



TANK OF MERCURY was placed in a strong magnetic field (*vertical arrows at top and bottom*). When the vanes at the bottom of the mercury were moved back and forth, the mirror on its surface described a similar motion.

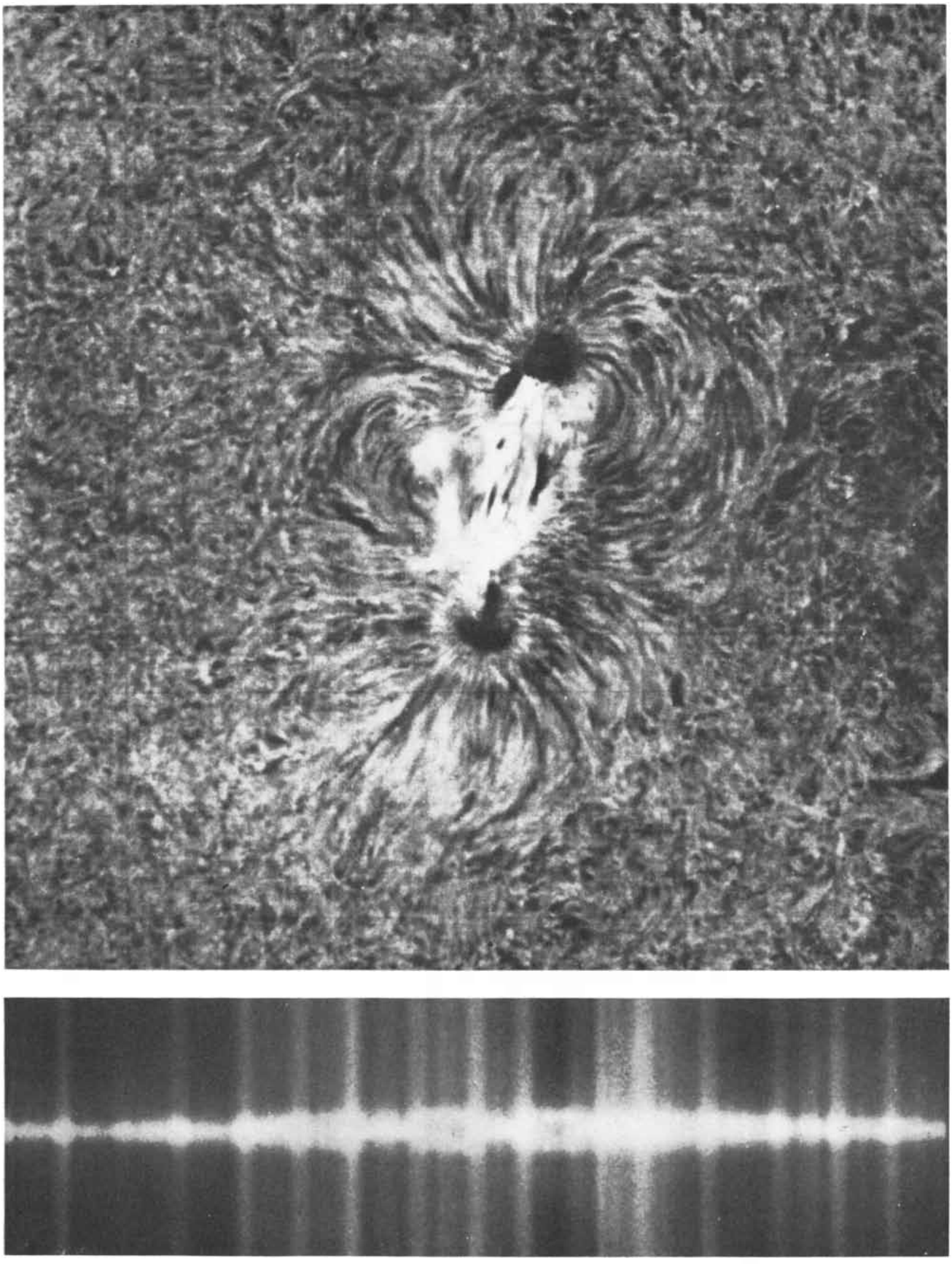
WHAT has all this to do with the stars? It is possible to show that our mercury model reproduces many of the essential properties of stellar matter. To be sure, the magnetic fields in the stars are very much weaker than the 10,000 gauss of our experiment (the sun's general field is estimated at between 1 and 25 gauss). But our theory tells us that if we made the vessel larger, we could produce the magneto-hydrodynamic effects with a smaller magnetic field; the magnetic force required would decline in proportion to the increase in size of the vessel. Hence in a star, which is, say, 10 billion times as large as our experimental vessel, the magnetic field need be only one 10-billionth of the laboratory field. The stars' fields are much stronger than this.

The results of our experiments lead to an entirely new way of looking at the behavior of stellar matter. It has always been assumed that the movement of gases in stars obeys the laws of hydrodynamics, as they apply to ordinary liquids and gases. But if a magnetic field drastically changes the properties of the dense stellar gases, as it does in the mercury model, then they must behave very differently from ordinary fluids. Let us see whether the curious behavior of mercury in a magnetic field can shed any light on some of the great mysteries in astronomy.

Consider sunspots. Few astronomical phenomena have been more thoroughly studied. We have charted their paths across the sun's surface, discovered their cycle of activity and their effects on solar radiation, analyzed their light and learned from the splitting of their spectral lines (the so-called Zeeman effect) that they have strong magnetic fields. But what sunspots are, how they originate, how they can produce magnetic fields—that seems more difficult to explain. It was once thought that sunspots were great eddies in the solar atmosphere, similar to cyclones on the Earth. The motions of gas in sunspots, however, are not at all like those of the air in cyclones.

The pieces of the puzzle begin to fall into place if we think of the mercury model. We can assume that the energetic nuclear reactions in the interior of the sun cause violent motions of the matter there. This would correspond to the stirring of the mercury at the bottom of the vessel. In the sun's general magnetic field, whose lines of force apparently run from the center of the sun out to the surface, these motions would generate magneto-hydrodynamic waves that would travel to the surface. The waves would account for the strong magnetic fields associated with sunspots.

As we have seen, magneto-hydrodynamic waves also generate an electric field. This may well account for some of the other phenomena observed on the



SUNSPOTS have strong magnetic fields which may be due to magneto-hydrodynamic waves. The photograph at the top, made by the light of one spectral line of hydrogen, suggests magnetic lines of force around two sunspots. The photograph at the bottom shows one spectral line of iron from the region of a sunspot. Photographed through a system of polarizing filters, the line is split apart in the middle by the magnetic field of the spot.

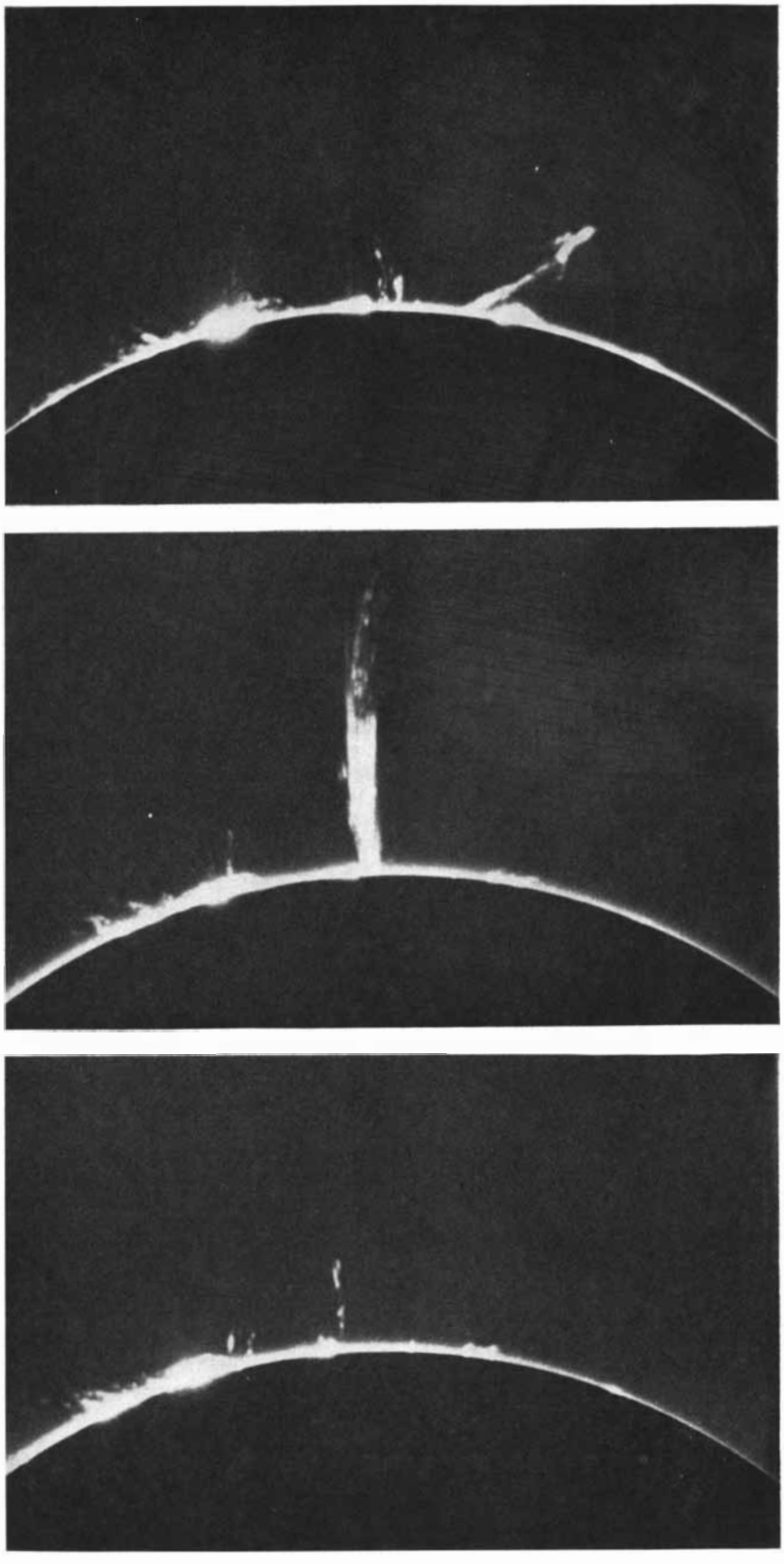
sun's surface. The very high voltages generated by the waves may discharge into the sun's atmosphere, very much as a discharge tube in the laboratory produces corona discharges into the air. Such discharges would explain the solar prominences. The marvelous motion pictures of solar prominences taken at Pic du Midi in the Pyrenees and at the High Altitude Observatory near Climax, Col., give a vivid impression that they are electrical discharges.

The sun's emission of radio noise, another great mystery, would also be accounted for by this method of generating electricity. As radio listeners know too well, all sorts of electric currents—in transmission lines, household appliances and so on—produce radio noise. The large electric currents generated in stars by magneto-hydrodynamic forces would give rise to radio waves and broadcast them into space.

FINALLY, the magneto-hydrodynamic process seems to offer a plausible explanation for the great energy of the cosmic rays. How these particles are driven to their fantastic energies, sometimes as high as a million billion electron volts, is one of the prime puzzles of astronomy. No known (or even unknown) nuclear reaction could account for the firing of particles with such energies; even the complete annihilation of a proton would not yield more than a billion electron volts.

But if we suppose that the cosmic-ray particles are driven by electric and magnetic fields in space, in the same way as we accelerate particles in our big laboratory accelerators, it is easy to see how they could reach very high energies indeed. We know that interstellar space is not absolutely void. Although the matter in it is very thin, certainly not more than an average of one atom per cubic centimeter, in the vastness of the universe it adds up to an enormous amount of material. In at least some regions the interstellar matter is ionized, so that it is a good electrical conductor. Furthermore, there are good arguments for assuming that a weak magnetic field (some millionths of a gauss) pervades all of space. It is likely, therefore, that magneto-hydrodynamic waves roam ceaselessly through space, generating weak but very extensive electric fields, especially near the stars. If so, we can picture charged atomic nuclei being propelled across electrified space, gathering speed as they go and crashing into the Earth's atmosphere with energies far beyond any that could ever be generated within any star or planet.

Hannes Alfvén is professor in the department of electronics at the Royal Institute of Technology in Sweden.



SOLAR PROMINENCE suggests an electrical discharge due to magneto-hydrodynamic waves. In this series of photographs, made by the coronagraph at the High Altitude Observatory, the disk of the sun is artificially blacked out, leaving only the curved luminous line of its edge.

SHERRINGTON ON THE EYE

The great English physiologist, who died in March at 95, was also a remarkable writer. Presenting his poetic account of the eye and how it makes itself

SIR CHARLES SCOTT SHERRINGTON, who died last March 4 at the age of 95, was one of the great creative intellects of our era. To take an apt title from the terminology of chess players, Sherrington was a grand-master of science. He is best known for his work in physiology, particularly on the nervous system; *The Integrative Action of the Nervous System,* published in 1906, stands as a monadnock of scientific thought. But his activities and interests ranged over a much wider field than the study of the brain. During his lifetime he occupied himself with such diverse subjects as the specific gravity of blood, knee jerk, eye movements, muscular function, the effects of alcohol, fatigue, sundry aspects of bacteriology (which he had studied with the great Virchow and Koch in Germany), the "life condition and infectivity of the oyster," the history of science, the nature of sensation, cardiac physics, the teaching of histology, the health of school children, the use of chloroform, cholera epidemics in Spain and Italy, the mechanism of "locked-jaw," the effects of strychnine and other drugs, body metabolism in cancer, color blindness, the lighting of factories. Between the years 1884 and 1951 he produced more than 325 scientific papers on various subjects.

Even this gargantuan record conveys an inadequate picture of his output, not to say his talents. Sherrington was a man of exceptional sensibility: a poet, a philosopher, a literary craftsman extraordinarily gifted in descriptive writing. His books included works on biography, poetry, philosophy and literary criticism as well as on science. *Man on his Nature,* the collection of his Gifford Lectures at Edinburgh in 1937-38, has been described as "one of the landmarks in the history of man's speculation."

A full measure of recognition came to Sherrington during his lifetime. The Nobel prize in medicine (awarded to him jointly with his pupil E. D. Adrian in 1932), the presidency of the Royal Society and of the British Association for the Advancement of Science, the Holt professorship of physiology at the University of Liverpool, the Fullerian professorship at the Royal Institution, the Waynflete professorship at Oxford University, distinguished lectureships on both sides of the Atlantic, honorary degrees almost by the score, knighthood, the coveted Order of Merit—these were some of his many honors. But Sir Charles' own writing remains his richest enduring memorial. A selection from it is reprinted below. This excerpt, a description of the embryological development, the structure and the functions of the human eye, is taken from the chapter called "The Wisdom of the Body" in *Man on his Nature.* It epitomizes the great Englishman's work and his spirit.

THE BODY of a worm and the face of a man alike have to be taken as chemical responses. The alchemists dreamed of old that it might be so. Their dream, however, supposed a magic chemistry. There they were wrong. The chemistry is plain everyday chemistry. But it is complex. Further, the chemical brew, in preparation for it, Time has been stirring unceasingly throughout some millions of years in the service of a final cause. The brew is a selected brew.

Can then physics and chemistry out of themselves explain that a pin's-head ball of cells in the course of so many weeks becomes a child? They more than hint that they can. A highly competent observer, after watching a motion-film . . . of a cell-mass in the process of making bone, writes: "Team-work by the cell-masses. Chalky spicules of bone-in-the-making shot across the screen, as if labourers were raising scaffold-poles. The scene suggested purposive behaviour by individual cells, and still more by colonies of cells arranged as tissues and organs." That impression of concerted endeavour comes, it is no exaggeration to say, with the force of a self-evident truth. The story of the making of the eye carries a like inference.

THE eye's parts are familiar even apart from technical knowledge and have evident fitness for their special uses. The likeness to an optical camera is plain beyond seeking. If a craftsman sought to construct an optical camera, let us say for photography, he would turn for his materials to wood and metal and glass. He would not expect to have to provide the actual motor power adjusting the focal length or the size of the aperture admitting light. He would leave the motor power out. If told to relinquish wood and metal and glass and to use instead some albumen, salt and water, he certainly would not proceed even to begin. Yet this is what that little pin's-head bud of multiplying cells, the starting embryo, proceeds to do. And in a number of weeks it will have all ready. I call it a bud, but it is a system separate from that of its parent, although feeding itself on juices from its mother. And the eye it is going to make will be made out of those juices. Its whole self is, at its setting out, not one ten-thousandth part the size of the eye-ball it sets

about to produce. Indeed it will make two eye-balls built and finished to one standard so that the mind can read their two pictures together as one. The magic in those juices goes by the chemical names, protein, sugar, fat, salts, water. Of them 80 per cent is water. . . .

The eye-ball is a little camera. Its smallness is part of its perfection. A spheroid camera. There are not many anatomical organs where exact shape counts for so much as with the eye. Light which will enter the eye will traverse a lens placed in the right position there. *Will* traverse; all this making of the eye which *will* see in the light is carried out in the dark. It is a preparing in darkness for use in light. The lens required is biconvex, and [is] to be shaped truly enough to focus its pencil of light at the particular distance of the sheet of photo-sensitive cells at the back, the retina. The biconvex lens is made of cells, like those of the skin but modified to be glass-clear. It is delicately slung with accurate centring across the path of the light which *will* in due time some months later enter the eye. In front of it a circular screen controls, like the iris-stop of a camera or microscope, the width of the beam and is adjustable, so that in a poor light more is taken for the image. In microscope, or photographic camera, this adjustment is made by the observer working the instrument. In the eye this adjustment is automatic, worked by the image itself!

The lens and screen cut the chamber of the eye into a front half and a back half, both filled with clear humour, practically water, kept under a certain pressure maintaining the eye-ball's right shape. The front chamber is completed by a layer of skin specialized to be glass-clear, and free from blood-vessels which if present would with their blood throw shadows within the eye. This living glass-clear sheet is covered with a layer of tear-water constantly renewed. This tear-water has the special chemical power of killing germs which might inflame the eye. This glass-clear bit of skin has only one of the fourfold set of the skin-senses; its touch is always "pain," for it should *not* be touched. The skin above and below this window grows into movable flaps, dry outside like ordinary skin, but moist inside so as to wipe the window clean every minute or so from any specks of dust, by painting over it fresh tear-water.

The light-sensitive screen at back is the key-structure. It registers a continually changing picture. It receives, takes and records a moving picture life-long, without change of "plate," through every waking day. It signals its shifting exposures to the brain.

This camera also focuses itself automatically, according to the distance of the picture interesting it. It makes its lens "stronger" or "weaker" as required. This camera also turns itself in the direction of the view required. It is moreover contrived as though with forethought of self-preservation. Should danger threaten, in a moment its skin-shutters close, protecting its transparent window. And the whole structure, with its prescience and all its efficiency, is produced by and out of specks of granular slime arranging themselves as of their own accord in sheets and layers, and acting seemingly on an agreed plan. That done, and their organ complete, they abide by what they have accomplished. They lapse into relative quietude and change no more. It all sounds an unskillful overstated tale which challenges belief. But to faithful observation so it is. There is more yet.

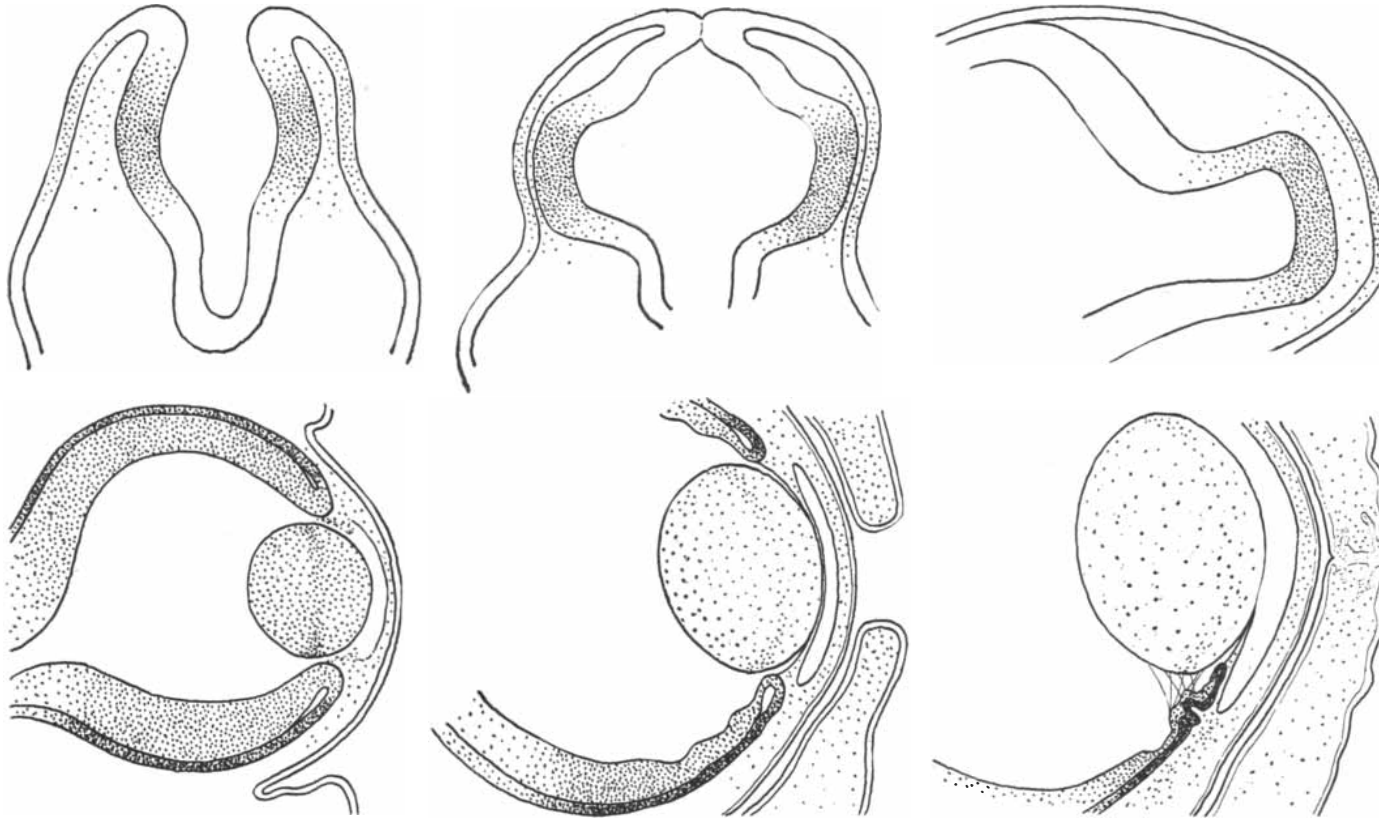
SIR CHARLES SHERRINGTON was born in 1857. This photograph was made by Allan Chappelow in 1951.

THE LITTLE hollow bladder of the embryo-brain, narrowing itself at two points so as to be triple, thrusts from its foremost chamber to either side a hollow bud. This bud pushes toward the overlying skin. That skin, as though it knew and sympathized, then dips down, forming a cuplike hollow to meet the hollow brain-stalk growing outward. They meet. The round end of the hollow brain-bud dimples inward and becomes a cup. Concurrently, the ingrowth from the skin nips itself free from its original skin. It rounds itself into a hollow ball, lying in the mouth of the brain-cup. Of this stalked cup, the optic cup, the stalk becomes in a few weeks a cable of a million nerve-fibres connecting the nerve-cells within the eye-ball itself with the brain. The optic cup, at first just a two-deep layer of somewhat simple-looking cells, multiplies its layers at the bottom of the cup where, when light enters the eye—which will not be for some weeks yet—the photo-image will in due course lie. There the layer becomes a fourfold layer of great complexity. It is, strictly speaking, a piece of the brain lying within the eye-ball. . . .

The deepest cells at the bottom of the cup become a photo-sensitive layer—the sensitive film of the camera. If light is to act on the retina—and it is from the retina that light's visual effect is known to start—it must be absorbed there. In the retina a delicate purplish pigment absorbs incident light and is bleached by it, giving a light-picture. The photo-chemical effect generates nerve-currents running to the brain.

The nerve-lines connecting the photo-sensitive layer with the brain are not simple. They are in series of relays. It is the primitive cells of the optic cup, they and their progeny, which become in a few weeks these relays resembling a little brain, and each and all so shaped and connected as to transmit duly to the right points of the brain itself each light-picture momentarily formed and "taken." On the sense-cell layer the "image" has, picture-like, two dimensions. These space-relations "reappear" in the mind; hence we may think their data in the picture are in some way preserved in the electrical patterning of the resultant disturbance in the brain. But reminding us that the step from electrical disturbance in the brain to the mental experience is the mystery it is, the mind adds the third dimension when interpreting the two-dimensional picture! Also it adds colour; in short it makes a three-dimensional visual scene out of an electrical disturbance. . . .

THE FIRST and greatest problem vision faces is doubtless that attaching to it as part of the matter-mind relation. How is it that the visual picture proceeds—if that is the right word—from an electrical disturbance in the brain? But



EMBRYOLOGY OF THE EYE is shown in two schematic sequences. The six drawings extending across the top of these two pages are cross sections through the heads of embryos between 20 and 35 days old. The first

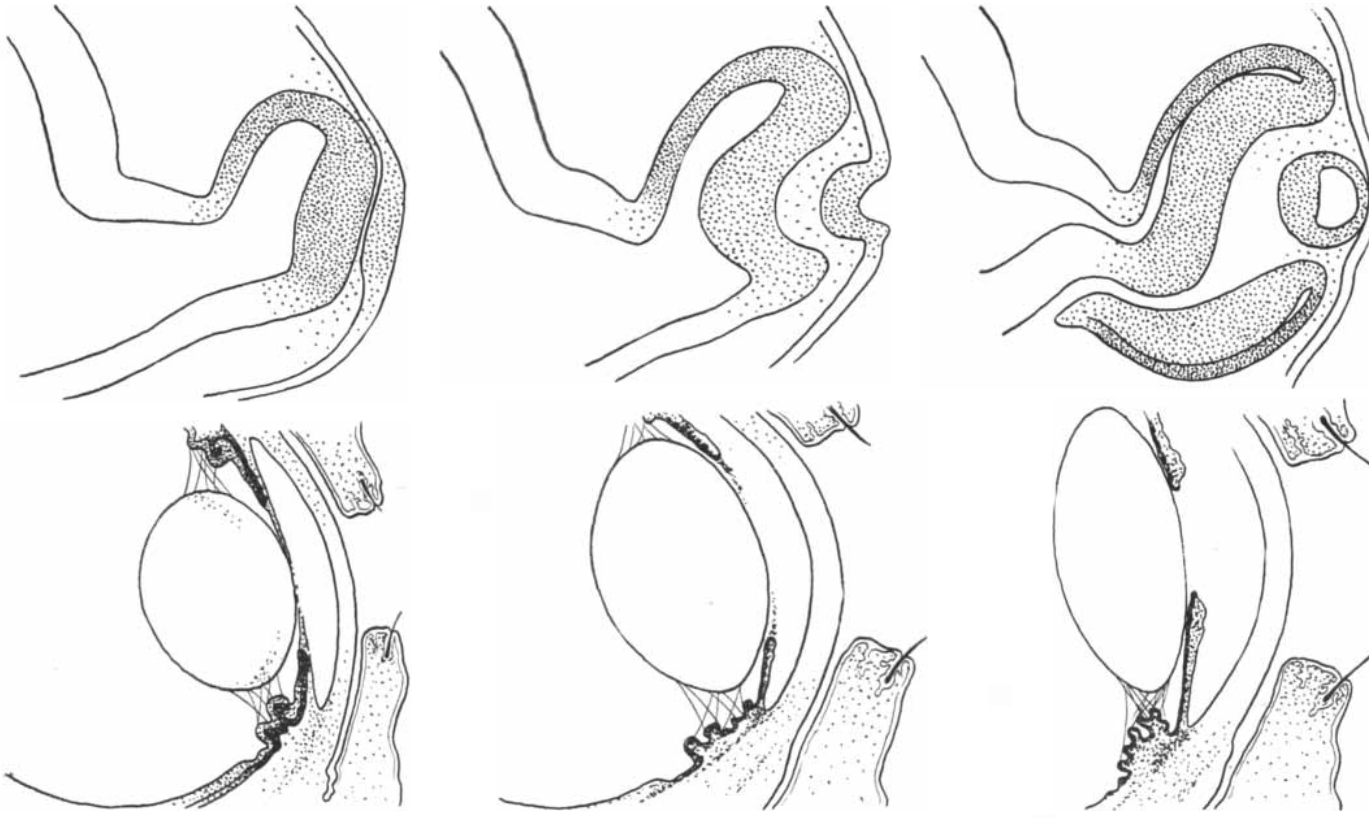
as a sub-problem of high importance concerning vision comes that of pattern-vision. The study of vision, pursued comparatively in different animal forms, indicates that the primitive vision widely prevalent in simpler forms of life attains merely to the distinguishing of "light" from "no light." It usually reaches the refinement of distinguishing grades of intensity of light. This primitive vision, however, does not attain to distinguishing shape or figure. It does not arrive at what is called "pattern-vision." Our own seeing makes so rich a contribution to the shapes of our world that it is a little puzzling for us to think of unpatterned seeing. . . .

Over a great diversity of more highly developed vision, the eye supplies a definite image of what it looks at. There we must suppose "pattern-vision"; without it the optical apparatus would seem wasted. In many cases the eye has means of focusing its image. That gives further development of the well-known relation between nerve and mind, namely that the "*place*" of a stimulated sensual point acts on the mind; whence "sensual space" with "local sign." It holds certainly not least in visual sense. If the sensitive sheet receiving the light-image be arranged as a mosaic of sub-areas corresponding severally with quasi-independent nerve-elements each with its access to "sense," then any light-image affecting two or more such sub-areas simultaneously begins to have "shape," or when affecting them successively begins to "move." The *spatial* pattern of the image thus acts on the mind. Different patterns acting differently enable mental distinction between them. For instance, a moving object tends to "catch" vision.

We know enough of pattern-vision in ourselves to recognize that it is the foundation of a perceptual analysis of our visible world which is of supreme service to us. We know enough of our animal kith and kin to judge that in them it serves not greatly otherwise for them. We must think that in each instance a great nervous rallying-place for confluent nerve-impulses from the quasi-independent elements of the ocular-sheet and for reactions between them must be appended to the eye. And that is what is found. Serving the eye there are condensed masses of nerve-structure which, examined by the microscope, are thickets of seeming entanglement, doubtless replete with meaning could we read their scheme. . . .

THE HUMAN EYE has about 137 million separate "seeing" elements spread out in the sheet of the retina. The number of nerve-lines leading from them to the brain gradually condenses down to little over a million. Each of these has in the brain, we must think, to find its right nerve-exchanges. Those nerve-exchanges lie far apart, and are but stations on the way to further stations. The whole crust of the brain is one thick tangled jungle of exchanges and of branching lines going thither and coming thence. As the eye's cup develops into the nervous retina, all this intricate orientation to locality is provided for by corresponding growth in the brain. To compass what is needed adjacent cells, although sister and sister, have to shape themselves quite differently the one from the other. Most become patterned filaments, set lengthwise in the general direction of the current of travel. But some thrust out arms laterally as if to embrace together whole cables of the conducting system.

Nervous "conduction" is transmission of nervous signals, in this case to the brain. There is also another nervous process, which physiology was slower to discover. Activity at this or that point in the conducting system, where relays are introduced, can be decreased even to suppression. This lessening is called inhibition; it occurs in the retina as elsewhere. All this is arranged for by the developing eye-cup when preparing and carrying out its million-fold connections with the brain for the making of a seeing eye. Obviously there are almost illimitable opportunities for a false step. Such a false step need not count at the time, because all that we have been considering is done months or weeks before the



two drawings show the beginnings of both eyes; the next four, the development of one eye. The six drawings across the bottom of the illustration show the growth of the eye from the second month of life to the time of birth.

eye can be used. Time after time so perfectly is all performed that the infant eye is a good and fitting eye, and the mind soon is instructing itself and gathering knowledge through it. And the child's eye is not only an eye true to the human type, but an eye with personal likeness to its individual parent's. The many cells which made it have executed correctly a multitudinous dance engaging millions of performers in hundreds of sequences of particular different steps, differing for each performer according to his part. To picture the complexity and the precision beggars any imagery I have. But it may help us to think further.

There is, too, that other layer of those embryonic cells at the back of the eye. They act as the dead black lining of the camera; they with their black pigment kill any stray light which would blur the optical image. They can shift their pigment. In full daylight they screen, and at night they unscreen, as wanted, the special seeing elements which serve for seeing in dim light. These are the cells which manufacture the purple pigment, "visual purple," which sensitizes the eye for seeing in low light.

Then there is that little ball of cells which migrated from the skin and thrust itself into the mouth of the eye-stalk from the brain. It makes a lens there; it changes into glass-clear fibres, grouped with geometrical truth, locking together by toothed edges. The pencil of light let through must come to a point at the right distance for the length of the eyeball which is to be. Not only must the lens be glass-clear, but its shape must be optically right, and its substance must have the right optical refractive index. That index is higher than that of anything else which transmits light in the body. Its two curved surfaces back and front must be truly centred on one and the right axis, and each of the subspherical curvatures must be curved to the right degree, so that, the refractive index being right, light is brought to a focus on the retina and gives there a shaped image. The optician obtains glass of the desired refractive index and skillfully grinds its curvatures in accordance with the mathematical formulae required. With the lens of the eye, a batch of granular skin-cells are told off to travel from the skin to which they strictly belong, to settle down in the mouth of the optic cup, to arrange themselves in a compact and suitable ball, to turn into transparent fibres, to assume the right refractive index, and to make themselves into a subsphere with two correct curvatures truly centred on a certain axis. Thus it is they make a lense of the right size, set in the right place, that is, at the right distance behind the transparent window of the eye in front and the sensitive seeing-screen of the retina behind. In short, they behave as if fairly possessed.

I WOULD NOT give a wrong impression. The optical apparatus of the eye is not all turned out with a precision equal to that of a first-rate optical workshop. It has defects which disarm the envy of the optician. It is rather as though the planet, producing all this as it does, worked under limitations. Regarded as a planet which "would," we yet find it no less a planet whose products lie open to criticism. On the other hand, in this very matter of the eye the process of its construction seems to seize opportunities offered by the peculiarity, in some ways adverse, of the material it is condemned to use. It extracts from the untoward situation practical advantages for its instrument which human craftsmanship could never in that way provide. Thus the cells composing the core of this living lens are denser than those at the edge. This corrects a focusing defect inherent in ordinary glass-lenses. Again, the lens of the eye, compassing what no glass-lens can, changes its curvature to focus near objects as well as distant when wanted, for instance, when we read. An elastic capsule is spun over it and is arranged to be eased by a special muscle. Further, the pupil—the camera stop—is self-adjusting. All this without our having even to wish it; without even our knowing anything

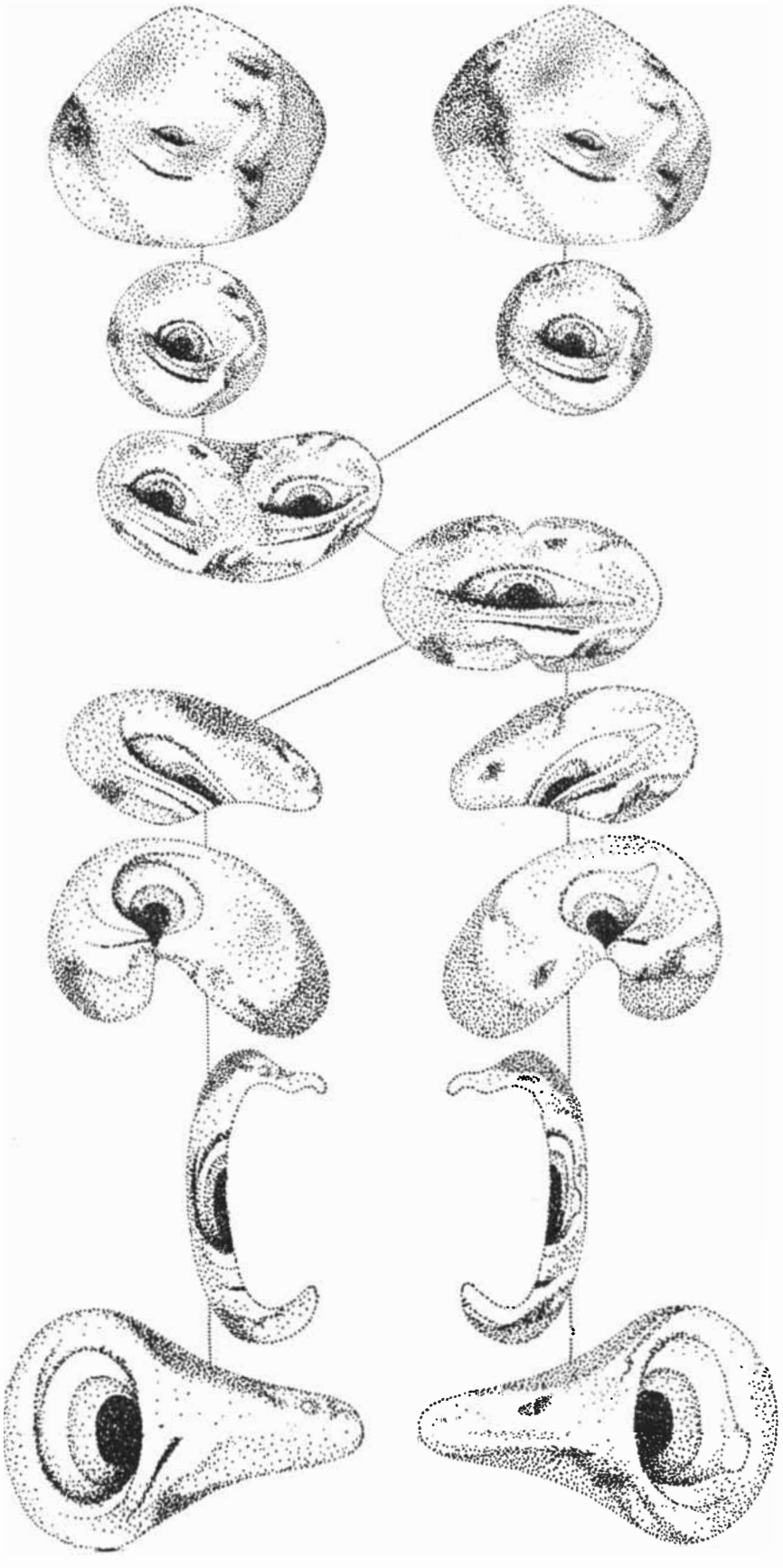


IMAGE recorded by the eye and transmitted to the visual area of the brain cortex goes through a series of distortions. The two drawings at the top show the image as it is projected on the retina. The remaining drawings show the pattern of the electrical impulses between the retina and the cortex.

about it, beyond that we are seeing satisfactorily. . . .

The chief wonder of all we have not touched on yet. Wonder of wonders, though familiar even to boredom. So much with us that we forget it all our time. The eye sends, as we saw, into the cell-and-fibre forest of the brain throughout the waking day continual rhythmic streams of tiny, individually evanescent, electrical potentials. This throbbing, streaming crowd of electrified shifting points in the spongework of the brain bears no obvious semblance in space-pattern [to] the tiny two-dimensional upside-down picture of the outside world which the eye-ball paints on the beginnings of its nerve-fibres to the brain. But that little picture sets up an electrical storm. And that electrical storm so set up is one which affects a whole population of brain-cells. Electrical charges having in themselves not the faintest elements of the visual—having, for instance, nothing of "distance," "right-side-upness," nor "vertical," nor "horizontal," nor "colour," nor "brightness," nor "shadow," nor "roundness," nor "squareness," nor "contour," nor "transparency," nor "opacity," nor "near," nor "far," nor visual anything—yet conjure up all these. A shower of little electrical leaks conjures up for me, when I look, the landscape; the castle on the height, or, when I look at him, my friend's face, and how distant he is from me they tell me. Taking their word for it, I go forward and my other senses confirm that he is there.

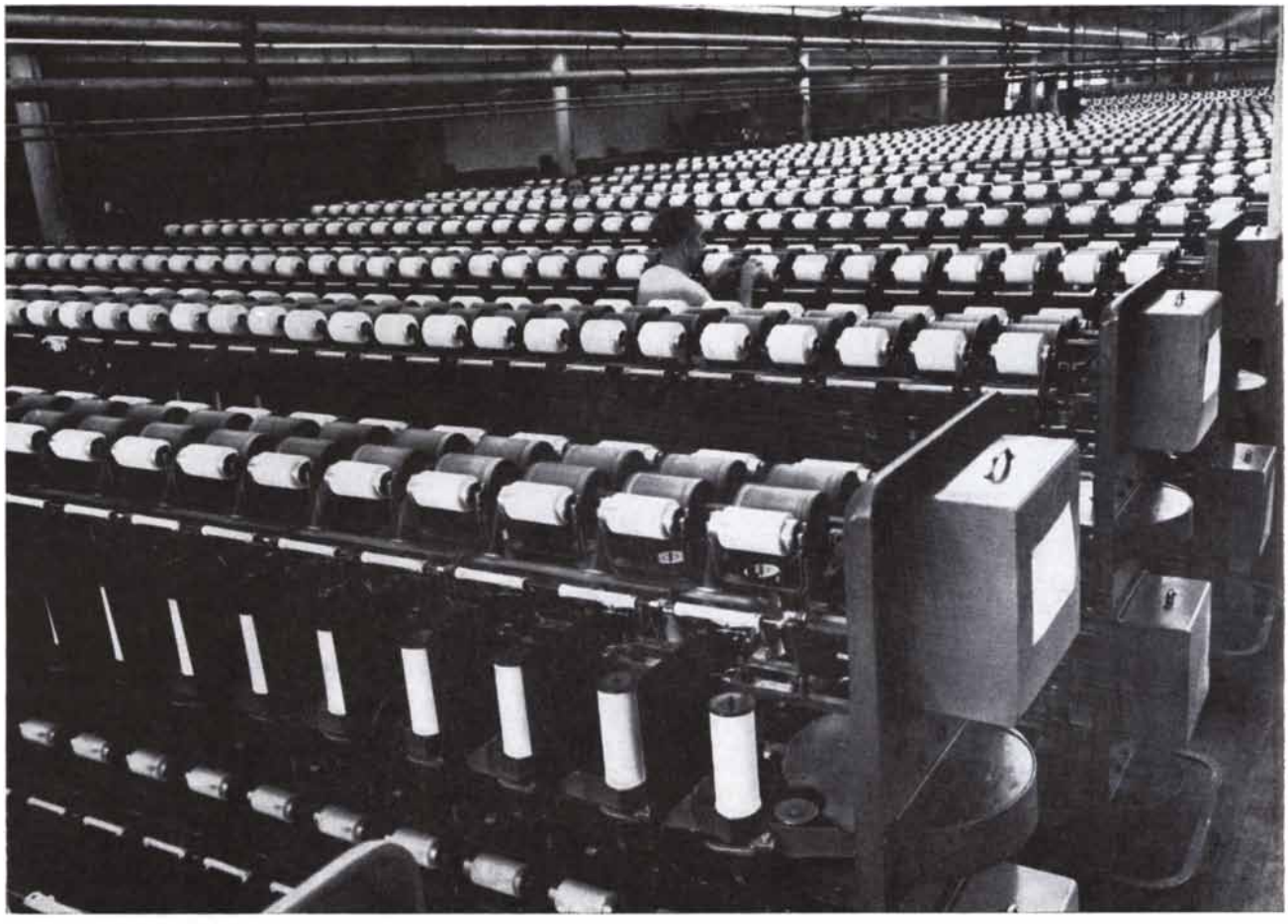
IT IS A CASE of "the world is too much with us"; too banal to wonder at. Those other things we paused over, the building and shaping of the eye-ball, and the establishing of its nerve-connections with the right points of the brain, all those other things and the rest pertaining to them, we called in chemistry and physics and final causes to explain to us. And they did so. . . .

But this last, not the eye, but the "seeing" by the brain behind the eye? Physics and chemistry there are silent to our every question. All they say to us is that the brain is theirs, that without the brain which is theirs the seeing is not. But as to how? They vouchsafe us not a word. . . .

It is less than a generation since Edouard Gley, at the end of an address inaugurating the academic year in Paris, remarked that Aristotle's causes had become largely Physics and Chemistry as a means of explanation in Biology. But, he added, one biological domain there is which it will never take over: the growth of the egg into a child.

This passage from Man on his Nature *is reprinted with the kind permission of the Cambridge University Press.*

TURNING IDEA-PLASTICS INTO DOLLARS



Bearings of Du Pont nylon never need oiling . . . new twist that lowers yarn makers' costs

Sometimes changing a single machine part can result in many cost-cutting advantages. The use of nylon bearings on yarn twisting machines is a good example.

Bearings of Du Pont nylon run without oil . . . show no wear after two years of use. Yarn stays free of spattered oil and metal particles from abraded, worn bearings. The long service life of nylon and the elimination of oiling and shutdown time to clean bearings mean important savings.

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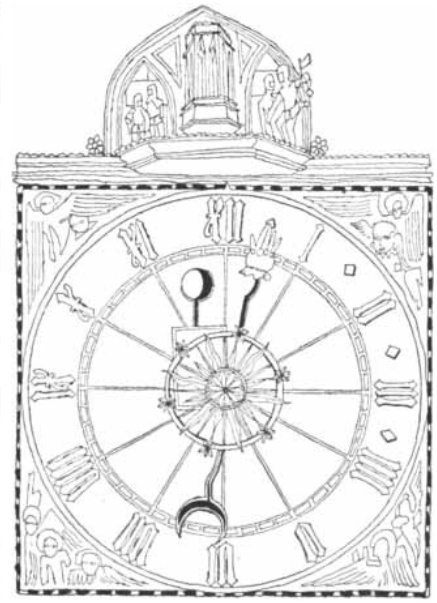


Helpful Poisons

THE HUGE tonnages of insecticides now being sprayed on U. S. fruit trees have made horticulturists increasingly uneasy. The chemicals kill the bugs, but what will they do to the trees and the soil? After intensive tests the U. S. Department of Agriculture has just reported a most surprising discovery: the sprays actually increase the trees' growth.

In the spring of 1948 the West Virginia Agricultural Experiment Station and the Federal Bureau of Entomology and Plant Quarantine undertook to find out whether chemicals commonly sprayed on orchards might poison the soil if they accumulated underneath the trees over a period of years. In each of several hundred test plots the experimenters planted a young peach tree and a young apple. Then they treated the plots with various concentrations of one or another of 10 garden chemicals: lead arsenate, parathion, benzene hexachloride, chlordane, toxaphene, zinc-lime, sulfur, fermate, DDT and 2,4-D. Some plots received the quantity of a chemical that would normally be used in a single season of heavy commercial spraying; some got 10 times that amount and some 30 times.

To the investigators' astonishment, in most of the treated plots the trees grew more vigorously than those in untreated soil. The most effective growth stimulator seemed to be benzene hexachloride; in plots treated with 10 times the normal dosage of this chemical, young peach trees showed more than four times as much growth as unsprayed trees at the end of the first growing season. Peaches also benefited greatly from heavy concentrations of sulfur, and apples from similar doses of chlordane. The only chemical that caused any damage was arsenate of lead; it injured peach trees when applied in above-normal concentrations.

The investigators are still at a loss to account for the chemicals' growth-stimulating effect. They did observe that no weeds grew on plots treated with benzene hexachloride (BHC), and that during a season when aphids made unusually heavy attacks on the roots of apple trees all over the area, not a single aphid appeared in any BHC plot. But whether the control of weeds and aphids was responsible for the increased vigor of the trees is still an open question. One puzzling complication was that after the original apple trees were uprooted for study of the aphid infestation and new stock was planted in their place, all the new trees planted in heavily dosed BHC and sulfur plots died. In the plots treated with the other chemicals, however, the new plantings thrived.

From the Slag Heaps

MANGANESE, an essential component of steel, is a critical metal; most of the U. S. demand must be imported. Yet there is enough manganese in the slag discarded by steel mills to supply the major part of the nation's needs. Metallurgists in the Bureau of Mines now think they have found a way to recover the metal from the slag at reasonable cost.

Manganese goes a strange journey through the blast furnace and the open hearth. The Mesabi iron ore fed into U. S. furnaces contains plenty of manganese. After the ore has been reduced to pig iron in a blast furnace, the manganese is still in the iron, reduced to metallic form. But when pig iron is converted into steel, most of the manganese is oxidized, and the unusable compound is drawn off as a waste product in the slag. While throwing away some 700,000 tons of manganese a year in this way, because the metal is too costly to separate from the slag, U. S. steelmakers have been buying over a million tons of metallic manganese a year from abroad to work into their steel.

Russell C. Buehl and a group of assistants at the Bureau of Mines have developed a two-stage process to recover manganese from slag. In the first stage the slag is put through a blast furnace to remove its silica, lime, magnesia and alumina. The remaining metal, which is about 20 per cent manganese and 70 per cent iron, with small percentages of carbon, phosphorus and silicon, is then heated in a converter with air blowing through it. This process separates the manganese into a new slag that is 60 per

THE CITIZEN

cent manganese. From this slag ferromanganese, the form in which the metal is needed, can readily be produced.

In the pilot-plant phase the recovery cost so far has been much higher than the price of the metal in the world market. But the process yields a by-product that is potentially very valuable: a high-phosphorus iron. It is thought that the phosphorus can be removed by another blowing in the converter, and that the iron may sell for enough to pay most of the cost of the process.

Guayule Rubber

IMPORTANT progress toward production in the U. S. of another critical raw material has also been announced. After several years of work on the guayule shrub, Department of Agriculture researchers have succeeded in obtaining from it natural rubber as high in quality as imported rubber from East Indian trees. At the annual meeting of the National Farm Chemurgic Council in St. Louis they displayed a heavy-duty guayule rubber truck tire that had been run more than 50,000 miles.

In North America the guayule shrub grows wild in North Central Mexico and in the Big Bend country of Texas. Now that high-quality plants have been produced on experimental plots, the way is open for large-scale cultivation.

Better Health

LAST YEAR the U. S. death rate dropped to the lowest in the nation's history. The annual report of the U. S. Public Health Service, covering the year ending July 1, 1951, said that the death rate was 9.6 per thousand, 10 per cent lower than a decade ago.

The report summarized a half-century of progress in the nation's health. Since 1915 the infant death rate has been reduced from 100 per thousand to 29 per thousand, and the mortality of mothers in childbirth from 57 to 7 per thousand. The average life-expectancy of Americans at birth is now 68 years, against only 47 in 1900. "The longer life-line for the average man," said the report, "may be traced in large part to steady reductions in the death rates for the infectious and communicable diseases." Tuberculosis, the most serious remaining germ disease, showed a 50 per cent drop in mortality in the past decade; its death rate is now 22 per thousand cases.

The Public Health Service called attention, however, to some remaining liabilities: cancer and heart disease are increasingly serious problems; the nation

needs 870,000 more hospital beds; 40 million Americans still have no full-time local public health service, and the P.H.S. hospitals for drug addicts at Lexington, Ky., have had record enrollments, with 7,968 patients last year.

Space Flight

TEN MICE have survived a flight 40 miles into space—the highest any living creatures have ever risen safely from the earth. They went up in a 2,000-miles-per-hour Aerobee rocket, and their behavior and physiological reactions during the voyage were recorded by automatic motion-picture cameras and instruments attached to radio equipment. The U. S. Army, which launched the test flight from its proving grounds in New Mexico, last month announced some of the results.

During three minutes of the return trip, as the rocket rushed earthward faster than gravity could pull it, the mice achieved the rare state of weightlessness. The pictures show some of them floating about in the air in their small cabin. But beyond a momentary holding of their breath, they did not lose possession of their faculties. After a parachute opened and checked the fall of the rocket, releasing them from this strange condition, the mice romped and played quite normally as they drifted down to the ground.

A monkey sent to the same height in another rocket also made a safe landing, but it died of heat prostration in its cabin on the desert sands before the experimenters could reach it. The Army actually sent a mouse and several monkeys twice as high as these animals in V-2 rockets, but they were killed when their parachute failed to open. During the flight their behavior was like that of the animals in the 40-mile rockets.

The experiments appear to establish that animals can fly at least 80 miles into space in present ships without suffering any serious physical effects from the acceleration, altitude or temporary weightlessness.

Sofar

A NOVEL method of signaling over extremely long distances at sea has been announced by the U. S. Navy. The system, known as "SOFAR," utilizes a wartime discovery about the travel of sound under water.

Sound is propagated through ocean water at different speeds, depending on the depth. It moves most slowly at a depth of about 4,000 feet, because above this level the higher temperatures and below it the higher pressures make sound travel faster. Since sound waves moving into areas of higher velocity are refracted toward the region where they travel most slowly, a natural sound channel is created at the 4,000-foot level

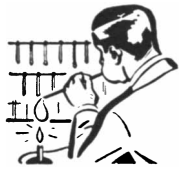
(A Quick Quiz on modern pH advancements)

Do you know these important facts about BECKMAN pH CONTROL?

Do you know...

That Beckman pioneered modern glass electrode pH equipment?

Until Beckman pH instruments were developed, glass electrode pH equipment was a cumbersome, complicated laboratory curiosity. It was Beckman that pioneered today's simple, compact, highly accurate and completely dependable glass electrode pH equipment!



That Beckman pioneered virtually every major development in modern glass electrode pH equipment?

Such far-reaching advancements as glass electrodes that can be used at temperatures as high as 130° C, and show negligible deviation even in high temperature-high pH ranges ... glass electrodes that can be used at temperatures as low as −20° C and will withstand repeated freezing ... glass electrodes so strong they can even be used as stirring rods—so abrasion-resistant they readily withstand long service in abrasive slurries ... these and other vital glass electrode advancements were *all* pioneered by Beckman. *Many of these advancements are still available exclusively in Beckman equipment!*

That Beckman offers the industry's most complete line of glass electrode pH instruments?

Included in the complete Beckman line are instruments specially designed to combine the high precision and wide versatility necessary for advanced research, medical and laboratory applications . . . others that combine maximum simplicity and high accuracy with complete portability for plant and field applications . . . still others that combine maximum simplicity and high accuracy with the plug-in convenience of full AC operation . . . plus *completely automatic* pH equipment for continuous pH indication, recording and control on large-scale processing applications.

That Beckman also provides the industry's most complete line of modern glass electrodes?

Although glass electrode pH instruments are the most efficient pH equipment obtainable, no glass electrode pH instrument is better than the versatility, accuracy and dependability of the electrode assemblies available for use with it.

Beckman provides the industry's most complete line of glass electrodes for use with Beckman pH instruments—a type of electrode assembly to meet every industrial, research, laboratory and field requirement!

That there are so many money-saving applications for Beckman pH control that you may be losing important profits unless you make a complete investigation of your operations?

There is pH wherever there's water, water solutions, moist pastes, sludges, slurries or other moisture-containing substances. And wherever there is pH, chances are the operation can be done better . . . with greater uniformity and less waste at lower overall cost . . . by Beckman-controlling the pH of the various processing operations.

WHETHER *you manufacture food products or treat sewage ... do metal plating or refine crude oil ... make textiles or process ore—in fact, no matter* WHAT *your field of operation ... if you have not yet determined whether Beckman pH Control can be used to advantage in your operations—possibly is already* BEING *used to cut costs by your competitors—let us study your processes and make helpful recommendations. No obligation, of course.* BECKMAN INSTRUMENTS INC., SOUTH PASADENA 68, CALIFORNIA. Factory Service Branches: New York, Chicago, Los Angeles.

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For an informative, non-technical outline of modern pH control — what it is and how it's used — send for this free booklet "What Every Executive Should Know About pH." Ask for Bulletin 1—48!

INSTRUMENTS CONTROL MODERN INDUSTRIES

pH Meters and Electrodes — Spectrophotometers — Radioactivity Meters — Special Instruments

whose effect may be compared with that of a speaking tube.

It occurred to Maurice Ewing, the Columbia University oceanographer, that this natural phenomenon could be useful to man. He and a group of colleagues discovered that the noise from the explosion of a four-pound charge of TNT in this "speaking tube" could be heard and identified by sound receivers at enormous distances, apparently up to 10,000 miles. The signal's arrival time can be read with an accuracy better than a twentieth of a second. If the signal is intercepted by three suitably located stations, the point of origin can be located within one mile.

All this suggested a simple way by which people in trouble on the high seas can signal for help. The Navy is equipping lifeboats and rafts with standardized explosives, and is setting up a system of monitors at various Pacific posts to keep their ears to the "speaking tube."

Geologists and oceanographers have also found underwater sound devices useful for exploring the ocean floor and locating submarine volcanoes ("The Pacific Floor," by Robert S. Dietz; SCIENTIFIC AMERICAN, April).

Cortisone by Brewing

A RADICALLY new process for producing cortisone which may make the drug much less costly was reported by workers of the Upjohn Company last month. It uses fermentation to solve the main problem in synthesizing cortisone: attaching a key oxygen atom to the carbon atom at the number-11 position in the steroid nucleus of the molecule.

Cortisone is now made from cattle-bile acid, because the oxygen atom can be transferred to the necessary position most easily in this compound. But bile acid is scarce, and chemists have been working hard to find a way to synthesize cortisone from more plentiful steroids. The Upjohn process has succeeded in manufacturing the basic cortisone building block from progesterone, a much less expensive raw material than bile acid, and the Upjohn workers believe it can be applied to other steroids as well.

The method was described in the *Journal of the American Chemical Society* by D. H. Petersen and H. C. Murray. The active agent is a bread mold. In 24 to 48 hours the fermentation process activated by this mold converts progesterone into a molecule with oxygen attached to the number-11 position. The Upjohn Company has found the method so promising that it is preparing to build a $3 million production plant at Kalamazoo, Mich.

The Tuberculosis Drugs

THE new drug that has recently shown remarkable effects in the treatment of tuberculosis will soon be in

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quantity production by at least four manufacturers, according to plans announced last month.

The drug is isonicotinic acid hydrazide. Hydrazine, an essential ingredient for its manufacture, is an oxidizing agent which the U. S. Army uses in its newest liquid fuels for propelling rockets, and the Army has heretofore pre-empted most of the supply. But the Defense Department announced that it would permit "substantial quantities" of hydrazine to be diverted for the manufacture of the drug.

Dermatitis from Brass

IS BRASS TOXIC to the skin? Compensation boards and insurance companies have held that there is no medical evidence that it is. But George E. Morris of the Tufts College Medical School now contends that he has obtained such evidence.

In *The New England Journal of Medicine* Morris reports five cases of industrial workers who developed skin disease from handling brass in their work. To find out whether contact with brass was really the cause of their dermatitis, he made patch tests on them. He fixed a small piece of brass against a spot of healthy skin on each patient. After two to four days the skin in contact with the brass became reddened and sore.

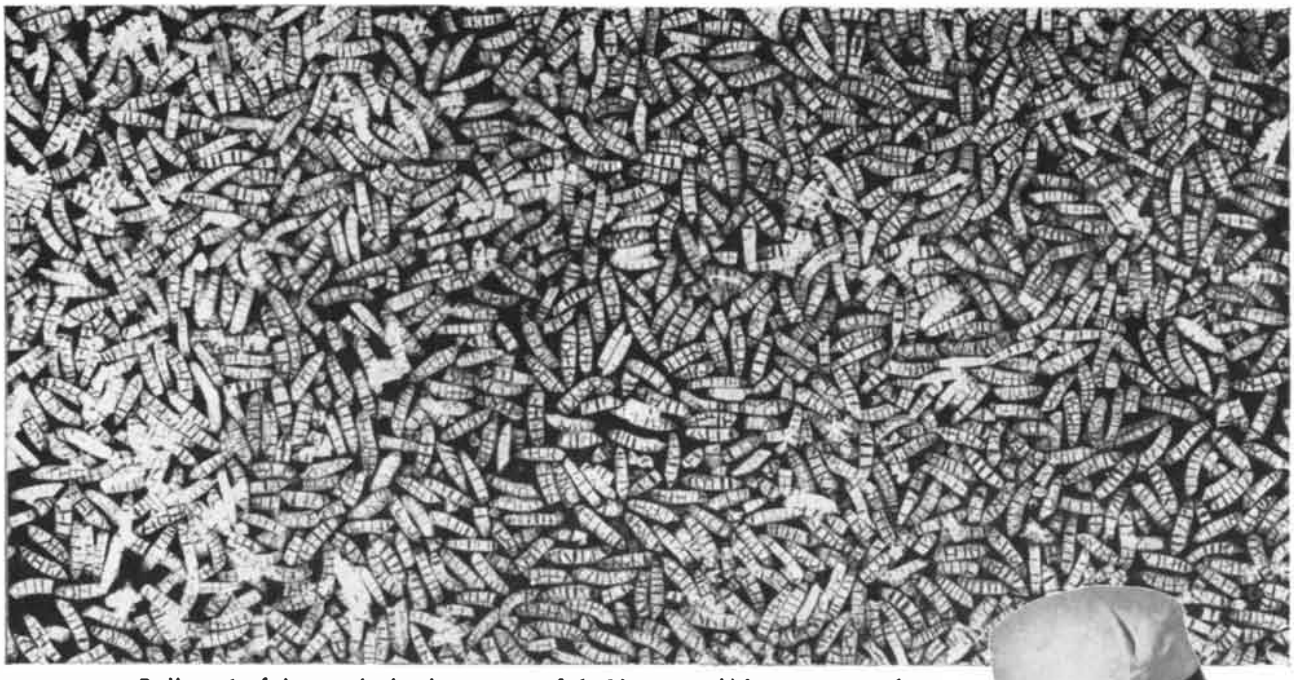
Brass is an alloy of copper and zinc, with trace amounts of arsenic, tin, lead, antimony and nickel. Morris remarks that copper can cause greenish discoloration of the hair and skin and that some zinc salts are irritants, though the element itself does not appear to cause skin disease in zinc foundry workers.

Sickle Cells in India

THE endlessly fascinating study of blood traits, which has lately provided a new means of finding out about the migrations of peoples over the earth in prehistoric times, has just yielded another surprising piece of information. Two British investigators think they have found blood evidence that Africa was peopled in part by migrants from India.

H. Lehmann, a pathologist at St. Bartholomew's Hospital in London, was interested in the fact that natives in East and Central Africa often tell of "tall men, fairer than themselves, bearded and with long hair, who came from afar bringing codes of law, handicrafts and cattle" in the distant past. He also took note of reports that some cattle and poultry in Africa resemble those of India. It occurred to him that the possible connection between Indians and Africans might be investigated by analyzing their blood for sickle cells.

The hereditary sickle-cell trait (sickle-shaped red blood cells) has been supposed to be peculiar to African blood;



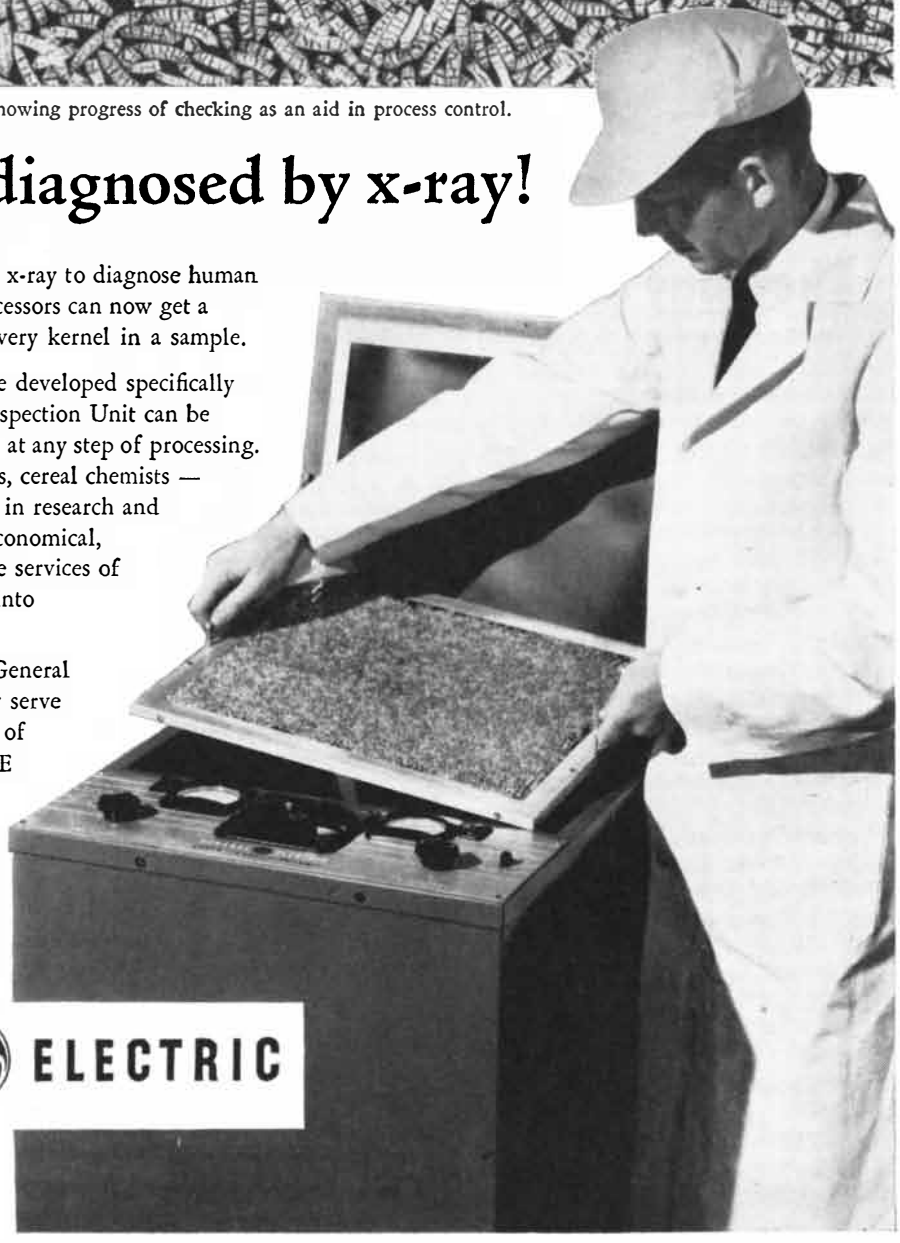
Radiograph of rice sample showing progress of checking as an aid in process control.

Now grain is diagnosed by x-ray!

Just as the medical profession utilizes x-ray to diagnose human ills — so millers and other grain processors can now get a fast, exact picture of the inside of every kernel in a sample.

The first commercial x-ray machine developed specifically for this purpose — the GE Grain Inspection Unit can be used for radiography of any grain . . . at any step of processing. Biologists, agronomists, entomologists, cereal chemists — all will find this new tool invaluable in research and process control. More — this safe, economical, compact machine does not require the services of a trained technician, can be plugged into any 115-volt a-c outlet.

This is another example of how General Electric has made the magic of x-ray serve industry. To get a complete analysis of your inspection problems, call the GE x-ray representative near you, or write X-Ray Department, General Electric Company, Milwaukee 14, Wisconsin, Room TT5.



GENERAL ELECTRIC

it has seldom been found in the blood of any other peoples. Lehmann and an assistant, Marie Cutbush, began a study of the blood of three aboriginal tribes in Southern India—the Badagas, the Todas and the Irulas. They discovered that all three groups had substantial percentages of people with sickle cells in their blood, ranging from 3.3 per cent of the Todas to 30 per cent of the Irulas.

This, they recognized, did not necessarily mean that Indians had migrated to Africa; it might mean that Africans had migrated to India. To check further, they studied other factors in the blood. There are two factors that are considered almost distinguishing marks of African blood—a certain Rh factor known as Ro and one called He. The two investigators found little of the former and none of the latter in the Indian tribes' blood. They conclude, therefore, that the migration was from India to Africa.

Golden Gloves

PROFESSIONAL boxers usually come from the lowest income groups. This circumstance gave S. Kirson Weinberg, a sociologist of Roosevelt College in Chicago, and Henry Arond, a former boxer and fight manager himself, an idea for a sociological study. They reasoned that as one ethnic group replaces another near the bottom of the socio-economic ladder, its young men become dominant in the ring. What trends have occurred during the past few decades, and what makes young men take up boxing?

According to the statistics collected by the two sociologists, early in this century about 40 per cent of all professional boxers in the U. S. were Irish. In the 1920s and 1930s Jews and Italians took the lead. And by 1948 nearly half of all boxers were Negroes, with Italians and Mexicans next.

Boxing, say Weinberg and Arond, attracts adolescents and young men in underprivileged groups for much the same reasons as crime does. Experienced in individual and gang fights, offered little but unskilled and disagreeable work, generally isolated from middle-class culture, slum boys are tempted by dreams of "easy money" and quickly-won esteem, say the sociologists. They argue that whether a poor boy chooses to become a criminal or a boxer depends very largely on what models of success he observes among older men in his community.

The two investigators, presenting their report in *The American Journal of Sociology,* suggest that Negro boys may have begun to turn away from boxing: "The eyes of the boys who once looked upon Joe Louis with pride and envy and wanted to emulate him now are focused on Jackie Robinson and other top-notch ballplayers."

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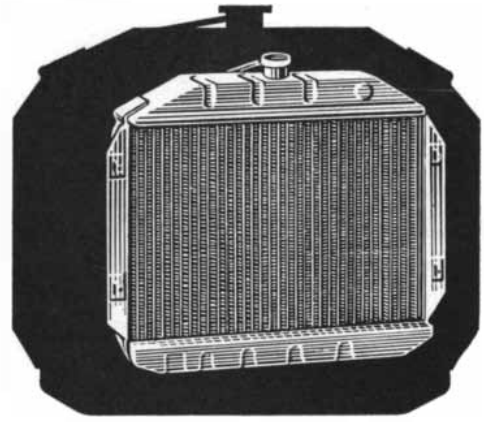

But there are instances, of course, when no practical substitute can be found, when only one material offers just the right combination of good qualities required for a given application. Take the automobile radiator. This has always been made of copper, because copper is the one and thus far only metal that perfectly meets all the requirements of manufacture and service. To make a radiator, very thin copper sheet and strip must be crimped, bent and otherwise formed. Copper's easy workability makes it ideal from the manufacturing standpoint. After assembly, the radiator is cleaned, and made water-tight by dipping in a bath of hot solder. Copper is exceptionally easy to solder. When in service on a car, truck or bus, the radiator must not rust, and must resist corrosion by water and anti-freeze. Copper is notable for its resistance to corrosion in such use. The radiator must also cool the water by radiating its heat into the air stream; copper has the highest heat conductivity of all commercial metals. A copper radiator thus is the most efficient and durable. It should outlast the car unless accidentally damaged, and when the injury is not so great as to make replacement necessary, the nearest shop can make repairs easily.

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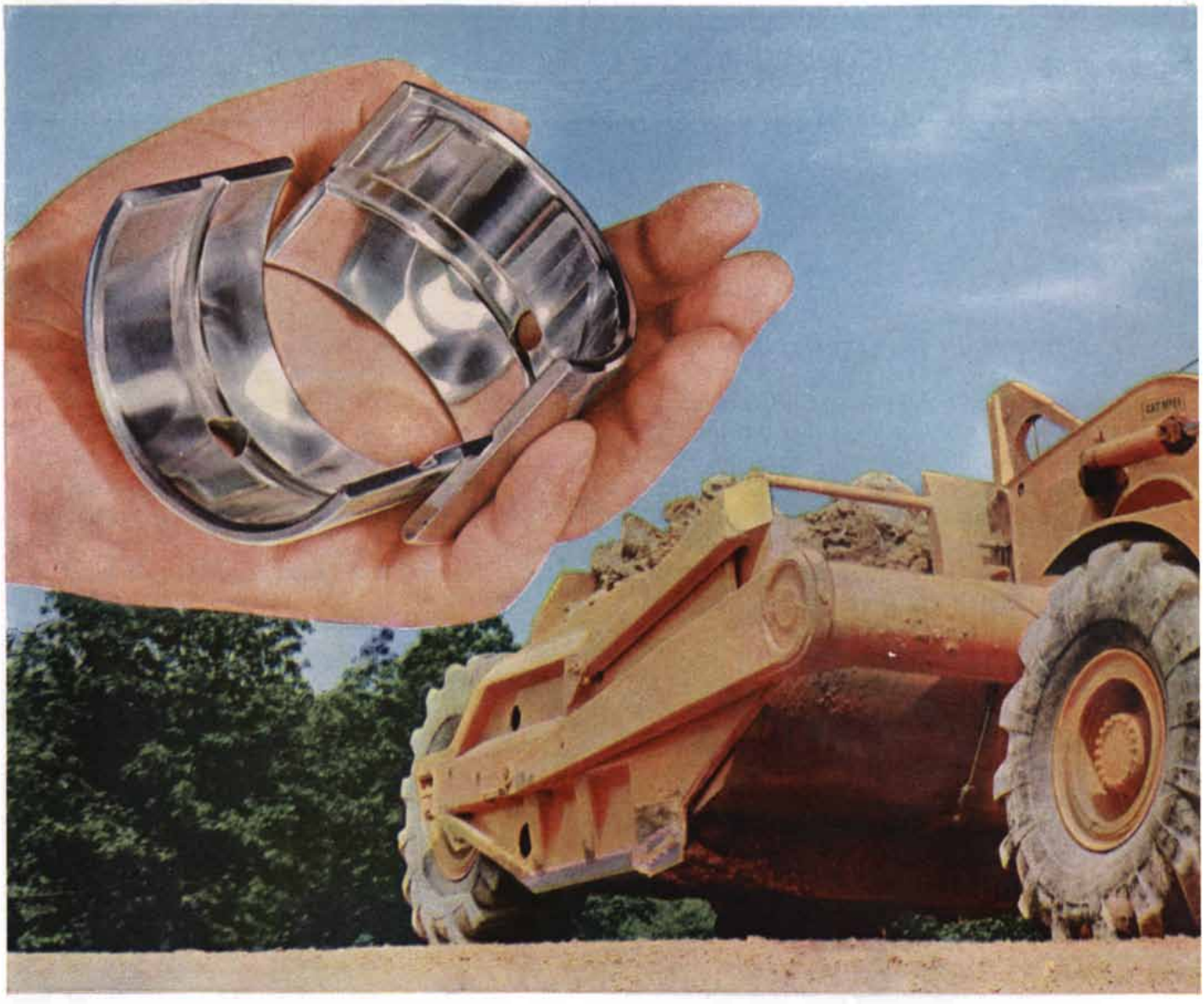

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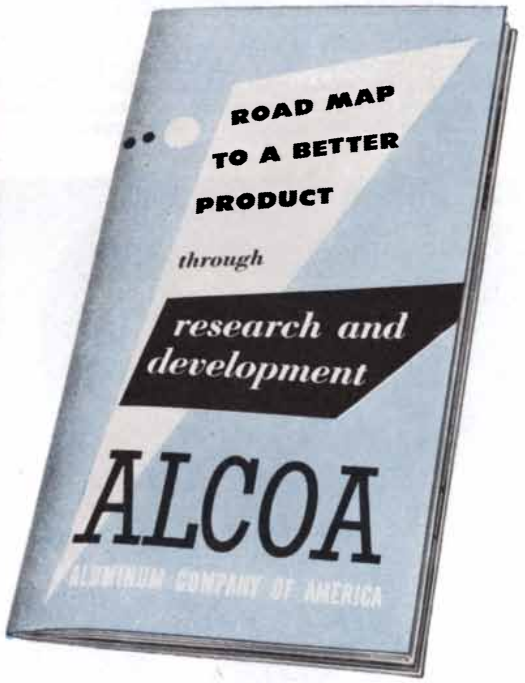

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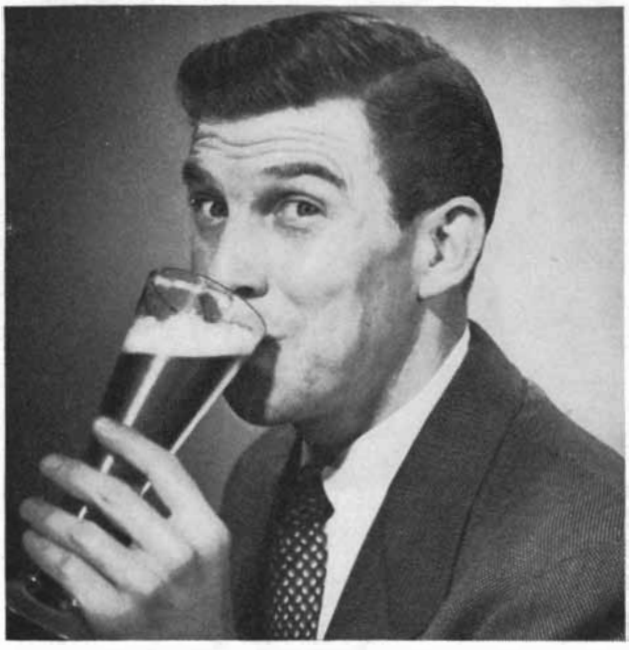

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THE CONTROL OF FLOWERING

What makes a plant grow flowers instead of stems and leaves? Although the mechanism is not entirely understood, the study of it makes possible some interesting advances in agriculture

by Aubrey W. Naylor

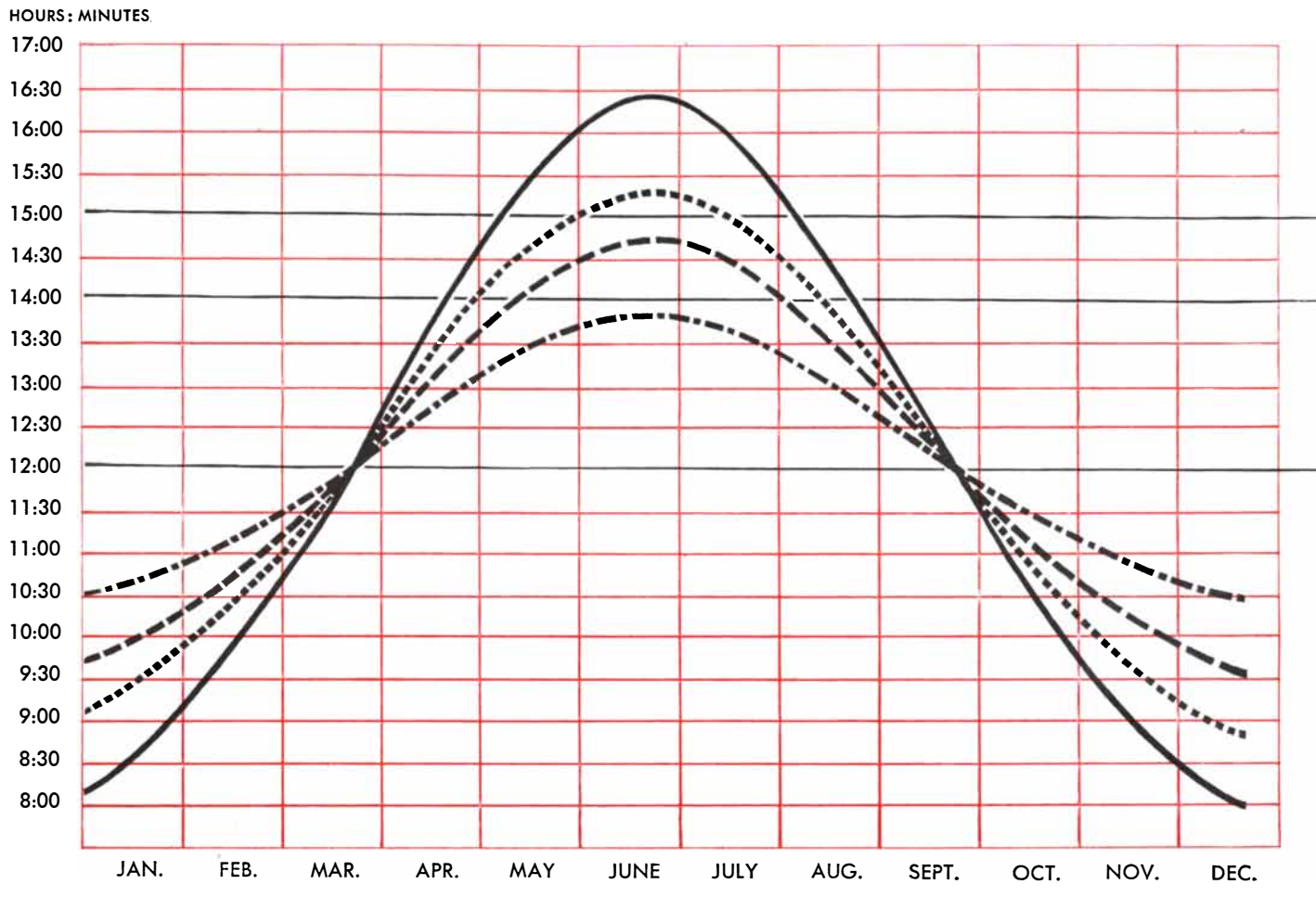
THE FIRST CROCUS has bloomed, heralding spring. As the year advances, other plants, each in its own season, will burst into flower on a predictable schedule. The calendar of blooms is so familiar that we take it for granted. But what is behind this predictability? Why not crocuses in July, or black-eyed Susans in April, or goldenrod in May?

Flowering represents a radical change in the physiology of a plant. Suddenly the plant turns from producing stems and leaves to making the blooms that will yield fruit and the seeds of reproduction. What master switch sets off this change? If we understood the mechanism that initiates plant flowering, we could envision some really breath-taking advances in agriculture and our control over nature.

Any study of the subject must begin with the environmental factors that govern a plant's development. Temperature, light, water and nutrition all play their parts, and clever gardeners and greenhousemen have long known how to force plants into bloom to meet deadlines by skillful manipulation of these influences. Their empirical methods have shed little light, however, on the physiological process that transforms a plant from the vegetative (foliage-producing) to the flowering state.

We know that a plant, like an animal, must reach a certain stage of maturity before it is ready to flower and reproduce. It takes fruit trees, for example, several years to begin bearing blossoms and fruit. A corn plant will not flower until it has produced a certain minimum number of leaves, the number depending on the variety of corn. There is a remarkable bamboo plant native to the mountains of Jamaica that carries the process of growing up to a strange extreme: 32 years after the plant is born, it flowers once and then dies. Its life cycle

PINEAPPLES in a field of the Hawaiian Pineapple Co., Ltd., are sprayed with naphthalene-acetic acid. This causes the plants to flower, and later to fruit, in concert. Because the plants in an untreated field flower erratically, their fruit must be collected at several different times. But a treated field can be harvested all at once.



LENGTH OF THE DAY determines when plants flower. The vertical coordinate of this diagram is the length of the day in hours and minutes; the horizontal coordinate, the months of the year. The four curves depict the annual change in the length of the day at four latitudes: that of Miami (26 degrees North), that of San Francisco (37 degrees), that of Chicago (42 degrees) and that of Winnipeg (50 degrees). The cocklebur requires 9 hours or more of darkness (*i.e.*, 15 hours or less of light) in order to flower. Thus in Winnipeg it has a long period of vegetative growth even after it is ripe to flower. In Miami, however, it flowers immediately when it is ripe to do so. In Winnipeg the buds of the cocklebur appear on about August 3, so late that frost will probably kill the plants

seems to be independent of the environment; transplanted to any other part of the world, the plant still blossoms on schedule at the age of 32 years, no earlier and no later.

What makes plants ripe to flower is not known. Occasionally a plant blooms ahead of schedule, just as an animal sometimes comes precociously to puberty. In animals precocious puberty can be induced by removing or impairing the pineal gland in the brain, which presumably changes the hormone balance of the body and accelerates sexual maturity. This suggests that hormones may have something to do with a plant's ripeness-to-flower.

INVESTIGATIONS to track down the physiological mechanism whereby a plant starts producing flowers have been carried out mainly along two lines, using two different tools to control flowering. The first is temperature. About 35 years ago the German plant physiologist Gustav Gassner discovered that he could influence the flowering of cereal plants by controlling the temperature of germinating seeds. One of the plants on which he experimented was winter rye. Winter rye is planted in the autumn, germinates during the winter and flowers the following summer. If it is planted in the spring, it fails to flower, remaining vegetative throughout the growing season. Gassner found, however, that by keeping the seed at near-freezing temperatures during germination he could make winter rye flower even when he planted it in late spring. This procedure was later adopted by plant breeders to transform winter cereals into spring types, and it became known as "vernalization."

At first it was thought that the low-temperature treatment changed a plant's general metabolism. But it developed that vernalization was a reversible process; that the change took place during a critical four-day period, after which it could not be reversed, and that rye seedlings could not be vernalized if they were undernourished. All this indicates that flowering depends on the formation of certain specific substances in the plant, rather than on an alteration in its general metabolism.

The second tool used to investigate flowering is the response of plants to the length of day—what is known as photoperiodism. This tool has been far more fruitful than temperature; it has been utilized by a great many investigators in a great variety of experiments, and it has already yielded some important practical results in agriculture.

THE FASCINATING story of photoperiodism goes back to a historic investigation more than 30 years ago by two workers in the U. S. Department of Agriculture—W. W. Garner and H. A. Allard. They wondered why the variety of tobacco called Maryland Mammoth was delayed in flowering when it was grown near Washington, D.C. It flow-

before their seeds mature. In Chicago the buds appear on about July 10, in good time for the seeds to mature. In San Francisco the cocklebur flowers shortly after it is ripe to do so. The dark requirement of the soybean and tobacco is also shown.

ered so late in the season that its seeds did not mature. The two investigators tried growing the plant under various conditions and explored many blind alleys before they discovered the answer: at the critical time the days were too long and the nights too short for these plants at Washington. Maryland Mammoth tobacco is a short-day plant, meaning that it begins to form flowers when the days are between 10 and 12 hours long. In the Washington growing season the days do not become as short as this until late in the summer. Consequently the tobacco plant, though ripe to flower long before, is delayed in receiving the necessary stimulus and so flowers very late.

Garner and Allard went on to test and confirm this discovery with many other species of plants. They found that plants fell into three general categories: short-day, long-day and indeterminate (not choosy as to length of day). Photoperiodism at once accounted for many things which had long puzzled botanists. It provided a reasonable explanation of why plants of a given variety, even though planted at different times, will nevertheless all flower at the same time, and why certain plants flourish in some latitudes and are practically absent from others.

Ragweed, for instance, starts making flowers when the day is just about 14.5 hours long. At Washington this length of day occurs around July 1, and the plant flowers and sheds its pollen by the middle of August. It has ample time, in other words, to form and scatter its seeds before frost comes. But there is little or no ragweed in northern Maine. There the long summer days do not shorten to 14.5 hours until after August 1. Ragweed, starting to form flowers after that date, would generally be killed by frost before its seed matured. Hence even if the wind or birds should bring ragweed seed to northern Maine, the plant could not establish itself there.

Conversely, a plant that thrives in the North may fail to flower in more southern latitudes where the spring and summer days are shorter. For instance, the rock-garden plant *Sedum telephium*, which needs a day of 16 hours or more, blooms very well in southern Vermont but will not flower in Virginia. This is a common experience of gardeners; attracted by a colorful plant during a trip, they may take it home to transplant in the garden, only to find that while it grows splendidly, it never produces anything but shoots and leaves. For this disappointing and puzzling result, sensitivity to the length of day is apt to be responsible.

There is a variety of wild sugar-cane which flowers only if the dark period is 10 to 12 hours long. Clearly under natural conditions this species would be confined to the Tropics. Spinach, on the other hand, would never flower or reproduce itself by seed in the Tropics, because it must receive 14 hours of light per day for a period of at least two weeks. And so it goes for many other plants.

THE DISCOVERY of photoperiodism's important role in limiting the range of plants was, of course, a matter of great consequence to agriculturalists. The U. S. Department of Agriculture now determines photoperiod requirements as a matter of routine before new plants are introduced. For instance, the various varieties of soybeans and onions are extremely sensitive to photoperiod; an individual variety may grow to its maximum only within a narrow belt of latitude as little as 150 miles wide and may fail as a crop if planted north or south of that region. Moreover, knowledge of photoperiod requirements is a great help to plant breeders. Sometimes they wish to cross two strains of plants that ordinarily flower in different months. By controlling the photoperiod in a greenhouse they can make the two strains flower at the same time and thereby fertilize each other. In this way breeders have obtained some valuable hybrid crop plants which could not be produced otherwise.

But photoperiodism has been most rewarding as a research tool. Very early the experimenters discovered a surprising fact. It seemed reasonable to suppose that if a plant required a certain length of day to flower, darkening the plant for part of the day should interfere with its flowering. This experiment was performed repeatedly, but nothing happened; the plants flowered just as if they had had a full day of light. Interruption of the nighttime period of darkness, however, told another story. Even a few minutes of illumination affected the plant's flowering. Thus when a short-day plant such as the chrysanthemum is illuminated for a few minutes in the middle of the night during the season when it normally would flower, it fails to bloom. On the other hand, a long-day plant such as pyrethrum can be made to flower in a short-day season when it would not normally do so, simply by exposing it to light for a short time at night. The critical factor in photoperiodism, then, is not the length of day but the length of night; strictly speaking, plants should be classified as long-night and short-night rather than short-day and long-day.

This information obviously has its practical uses. Flower growers, who used to delay chrysanthemum flowering for the late fall market by extending the daylight period with several hours of artificial light, now can achieve the same end and save a lot of current by illuminating the plants for a few minutes in the middle of the night.

More important, however, is the lead that this discovery has given in the investigation of the flowering process itself. Evidently the chemical reactions responsible for flowering go on in a plant at night. These reactions are sensitive to light. Other experiments show that they require carbon dioxide (or sugar sprayed on the leaves as a substitute) and depend on the quality (*i.e.*, wavelengths) of the light—all of which indicates that the photoperiodic reactions are in some way linked with photosynthesis. However, they appear to depend on some pigment other than chlorophyll as the light receptor.

WE COME BACK, then, to the main question: What is the chemical basis of flowering? Nearly a hundred years ago the great German plant physiologist Julius von Sachs suggested that the leaves of a plant produce "flower-forming sugstances" which travel to the growing points where flowers are gen-

COCKLEBURS exposed to flower-inducing light cycle (*yellow rectangles*) produced burs when only an eighth of a leaf remained on plant (*third from left*). Leafless plants and those exposed to other cycles did not flower.

BRANCHED COCKLEBURS further indicated that the plant was made to flower by a chemical originating in the leaves. One plant produced burs when only an eighth of a leaf on one branch was exposed to flower-inducing cycle.

GRAFTED COCKLEBURS also supported the leaf chemical theory. One plant flowered even when a piece of paper was placed across the graft between it and another plant exposed to the flower-inducing cycle (*right*).

erated. The first laboratory evidence to support his theory was discovered in 1934 almost simultaneously by several different groups of workers—J. E. Knott at Cornell University, J. Kuijper and L. K. Wiersum in the Netherlands and M. C. Cajlachjan in the U.S.S.R. Knott experimented with spinach, a long-day plant. He exposed the leaves to long photoperiods and covered the stem growing-point for part of the day so it was on a short photoperiod. The plants flowered as readily as if the whole plant had been on long photoperiods. When he reversed the procedure, giving the growing points long photoperiods and the leaves short photoperiods, the effect was the same as if the whole plant had been on short photoperiods—that is, the plant failed to flower. These experiments, confirmed and extended to other plants by the other workers, made it clear that the stimulus for flower formation must originate in the leaves. This strongly supported the idea that the stimulus was some kind of chemical regulator that moved from the leaves to the stem growing-points where flowers are formed.

Karl Hamner and James Bonner at the University of Chicago soon found even more convincing evidence. They did their work with cocklebur, a common noxious weed. This short-day plant is an ideal experimental tool for studying photoperiodism: it is sensitive to differences of less than 30 minutes in the dark period; a single nine-hour dose of darkness can induce it to flower, and it will survive considerable mutilation. Hamner and Bonner first stripped all the full-grown leaves from the plant and exposed the defoliated stem to nine-hour periods of darkness to see whether the plant would flower. It did not. But they found that when they left as little as one eighth of a fully expanded leaf on the stem, the plant did flower after exposure to the proper dose of darkness. By further experiments—forcing the plant to produce two branches, grafting shoots with leaves on the stem, and so on—they went on to show that the flower-inducing stimulus can travel up and down in the stem and across graft unions. They were also able to make a rough estimate of the rate of movement of the stimulus.

MANY OTHER investigators now took up the scent. Experimenting with a wide variety of plants, they demonstrated the activity of the flower-inducing stimulus in some striking ways. A nonflowering plant can be made to flower by grafting on to it a single leaf from a flowering plant, or even an isolated leaf that has been exposed to the proper amount of light. The stimulus can travel a considerable distance through several grafts. In one stunt six double-branched cocklebur plants were grafted together in series and all the leaves were removed except one at the

TOMATO PLANT grows a small head of flowers (*right center*) after treatment with 2,3,5-triiodobenzoic acid. This effect appears due to the fact that the chemical is an antagonist of auxin, the plant-growth hormone.

tip of the last plant. After this leaf was exposed to dark periods of the appropriate length, the whole series of grafted plants proceeded to flower in orderly sequence down the chain!

The flower-promoting stimulus is not special and different in each species of plant; apparently it is some general factor common to all plants. This is shown by the fact that a plant can be induced to bloom by a leaf graft from another variety, species, genus or even from another family of plants. There is a certain parasitic plant, growing underground on the roots of red clover, that apparently obtains the flower-inducing factor from its host!

How can the same factor cause flowering both in long-day and short-day plants, which respond so differently to light? One working hypothesis is that the factor is a substance which promotes flowering when it reaches a certain minimum concentration and inhibits flowering when it accumulates to a higher concentration. According to this theory, suggested by Harry Borthwick and Marion Parker of the Beltsville Experiment Station, a plant that is ripe to flower produces the active substance continuously, but the substance is unstable to light. In a long-day plant, the substance is somehow protected from destruction by light so that it does not fall below the minimum concentration needed for flowering; such a plant will flower even if exposed to light continuously. In darkness, however, the substance accumulates in the plant, and if the night is too long, it accumulates to the point where it inhibits flowering. When the plant is illuminated in the middle of the night, the light destroys the excess substance and enables the plant to flower. In a short-day plant, on the other hand, the flower-promoting substance is not protected from the destructive effects of daylight. Hence the plant needs a long period of uninterrupted darkness to accumulate enough of the substance to flower.

ALL IN ALL the evidence seems overwhelmingly in favor of the idea that a flower-promoting hormone does exist. The Russian worker Cajlachjan succumbed to the temptation to name the suspected substance "florigen." The potential value of this powerful substance, if indeed it exists, is so obvious that many attempts have been made to extract and isolate it from plants, in the U. S. and abroad. So far none has succeeded, though hopes have been raised several times. One of the difficulties is that no one knows just how such a substance should be introduced into a plant to promote flowering; hence experimenters cannot be certain whether they have failed to find the correct substance or simply failed to apply it properly.

Some investigators believe that plant hormones already known, rather than special "florigens," may be the agents responsible for the control of flowering. They argue that the growth-promoting hormones known as auxins may regulate flowering as well as vegetative growth.

One of the auxins is indole-acetic acid. It has been found that when the cocklebur plant is grown on long photoperiods, unfavorable for flowering, it produces much more indole-acetic acid than when it is on short photoperiods. This would indicate that the auxin inhibits flowering. There are some obvious

FERTILE TASSEL of corn produces large quantities of pollen. In the production of hybrid corn seed, where the pollen must come only from certain plants, such tassels must be removed from the rest of the plants by hand.

STERILE TASSEL resulted from treating the plant with the growth inhibitor maleic hydrazide. This suggests that the chemical could be used to eliminate the hand removal of tassels in the production of hybrid corn seed.

ways to test that conclusion: anything that neutralizes or destroys auxin in the plant should promote flowering, and an artificial increase in the plant's supply of auxin should suppress flowering. Experiments indicate that this is indeed the case. When cocklebur plants are treated with X-rays or certain chemicals that are known to destroy or counteract auxin, the plants flower more profusely than they would normally. On the other hand, treatment with auxins interferes with flowering. James Bonner and John Thurlow at the California Institute of Technology have prevented flowering in the cocklebur by treating the plant with indole-acetic acid, and the writer has greatly delayed flowering in plants by treating them with other auxins.

There is now good evidence that plants themselves produce natural substances which counteract auxins. These indirect indications point to the conclusion that flowering is regulated by the balance between the auxins and their antagonists in the plant.

WE ARE STILL far short of solving the mystery of what makes plants flower. It will take a great deal of investigation to determine just what substances are involved, how they are formed in the plant, and how they interact. Nevertheless, the information so far obtained has already made it possible to control flowering by chemical methods in a few plants.

One of these is the pineapple. This crop used to be expensive to produce, because the plants flowered and set fruit erratically, so that pickers had to come back to a field again and again to collect fruit as it ripened. Now all this has changed, thanks to the discovery that various substances, notably acetylene and naphthalene-acetic acid, can control the flowering of pineapple. Six to eight weeks after treatment a whole field flowers with amazing uniformity. As a result pineapple crops can now be harvested with all the techniques and machinery of mass production. The plants are usually treated with naphthalene-acetic acid, but this treatment has a drawback: the fruit-bearing stalks grow too weak and topple over. This can be corrected, however, by spraying the plants at the proper time with B-naphthoxyacetic acid. One of the leading investigators in the field, J. van Overbeek, observes wryly that the pineapple growers still are not satisfied: they want treatments that will make the fruits grow tailor-made to fit the cans!

Chemical control promises to make another dream come true. Hawaiian growers have long wished they could achieve large-scale production of the litchi nut, one of the most delicious of all tropical tree fruits. The litchi tree has been a poor performer in Hawaii; only about four per cent of the trees flower and bear fruit. Now it seems that

naphthalene-acetic acid may be the answer. In recent experiments it has been found that when litchi trees are sprayed with this growth substance at the end of September, about 88 per cent of the trees bear fruit. Development of this discovery may create a new industry in the Hawaiian Islands.

Some work has also been done with vegetable and grain crops. Among the promising candidates for control are lettuce and celery. The problem here is to prevent flowering, because lettuce and celery are grown for their vegetative parts (leaves and stalks) and lose their market value when they begin to go to seed. In the case of lettuce, experimenters have succeeded in delaying the development of seed stalks and flowers by treating the seeds of the plant with cold and a chemical at the time when they are germinating. In the case of celery, they have found one chemical treatment that retards flowering and another that accelerates it. Celery growers who grow celery for the table can use one, and those who grow it for seed can use the other. Tobacco is another plant in which it is desirable to prevent flowering, and some promising results have been obtained with that crop.

BUT OF ALL plants, perhaps the most important candidate for research on the control of flowering is corn, the No. 1 U. S. crop. Such research has already started, with two ends in view. One is to regulate flowering so that desirable strains which do not ordinarily flower at the same time can be crossed. The other is to sterilize corn tassels by chemical means. Growers of hybrid seed corn must sterilize the tassels to prevent plants from fertilizing themselves and reproducing their own kind; to produce the hybrid seed it is necessary to fertilize the plants with pollen from selected strains. At present the plants are generally detasseled by hand—an expensive operation. Chemical sterilization obviously would be much easier and less costly.

For both of the control purposes, promising experimental leads have already developed. Spraying with 2,4-D, the well-known weed killer, delays flowering in corn without harming the ear. And the tassel can be sterilized by treatment with the plant-growth inhibitor maleic hydrazide.

The results so far in the chemical control of flowering have been highly promising, in some cases even spectacular, and the future is bright. When the flowering process is fully understood, progress will, of course, be much faster. We may even be able to force into bloom plants that now flower rarely.

Aubrey W. Naylor is assistant professor of plant physiology at Yale University.

Valve castings by Walworth Company, South Boston, Mass.

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A New Microscope

Electrons or protons from a fine needle reveal the architecture of crystals and resolve individual atoms and molecules

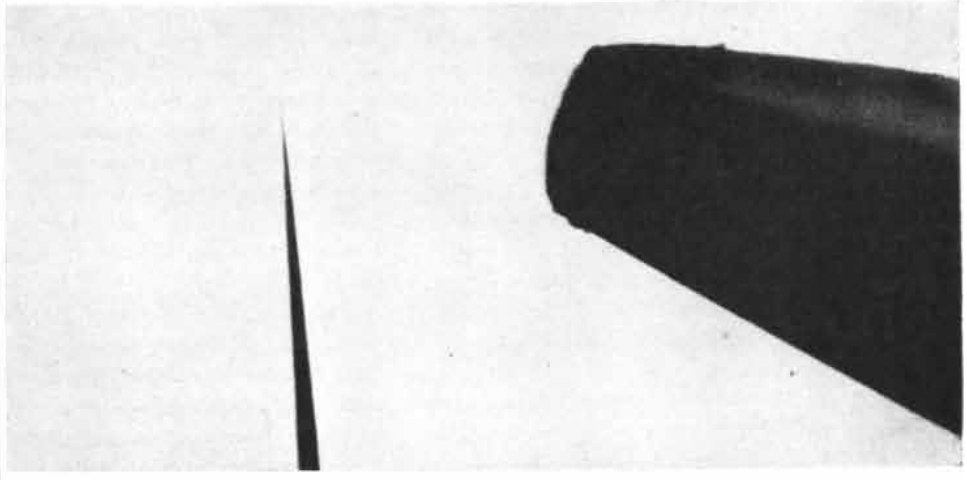
by Erwin W. Müller

SOME OF THE small blurred dots in the photographs on these pages are pictures of atoms. They were recorded by a simple, compact instrument called the field emission microscope, with which, for the first time, man can directly view matter down to molecular and even atomic dimensions.

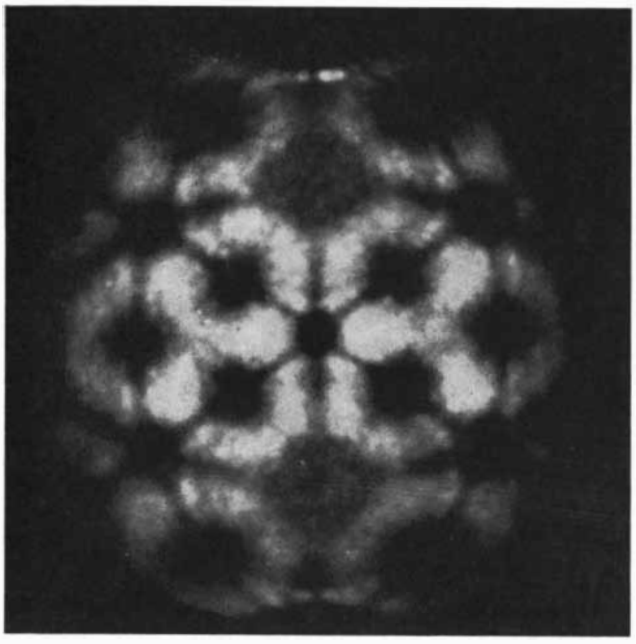
The microscope consists essentially of an extremely fine needle sealed into one end of an evacuated tube and pointing at a fluorescent screen at the opposite end. Its operation depends on the phenomenon known as field emission—the release of electrons from a cold metal surface under electrical pressure. When 5,000 volts are applied to the needle, creating a field strength of about 125 million volts per inch on its tip, electrons stream away from the tiny hemispherical tip in a direction almost perpendicular to the surface at every point. Thus the electrons map out on the fluorescent screen an enlarged picture of that surface. The picture is as many times larger than the needle point as the distance from point to screen is greater than the radius of the point. Using a needle with a tip radius of about four-millionths of an inch, such an instrument can produce magnifications of 100,000 to 1,000,000 times. The field emission is so strong that the picture is bright enough to be projected on a large screen in an auditorium and to be photographed with an ordinary motion-picture camera.

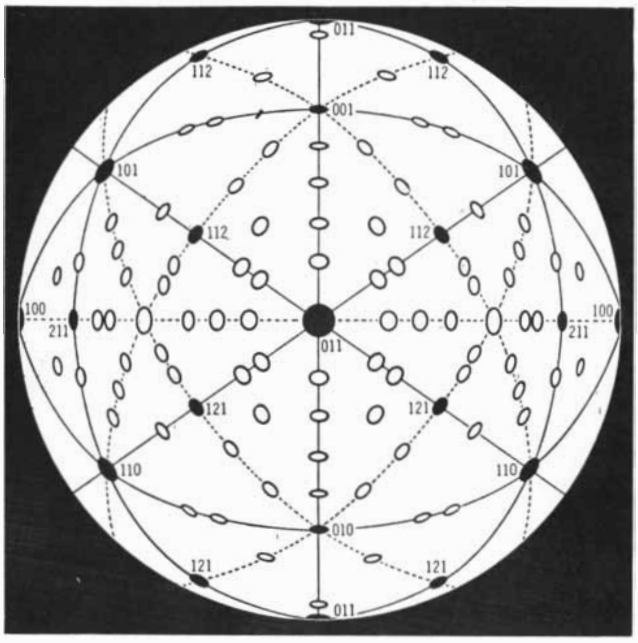
The mapping is not completely sharp, because electrons from any single point on the needle do not all come off in exactly the same direction but spread a little. The electron wavelength also sets a limit to the maximum sharpness attainable. For these reasons the field emission microscope cannot distinguish detail below about one ten-millionth of an inch. This resolving power is no better than that of the conventional electron microscope. But the great value of the instrument is its ability to make visible extremely thin layers of material on the needle surface.

The stage of this microscope is the needle point. When the metal point is bare, the picture on the screen represents the crystal arrangement of the atoms in the tip. When atoms or molecules of some other substance are deposited on the point, the electron emission from the

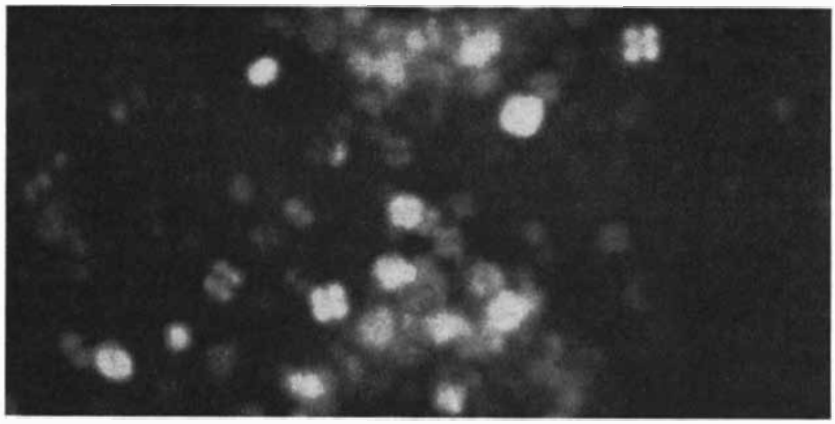


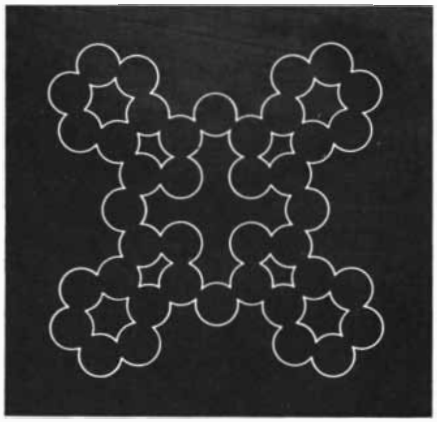
NEEDLE POINT, the "stage" of the field emission microscope, is shown in successively finer detail in the three pictures across the bottom of these two pages. Magnified 650 diameters under a light microscope (*left*), the fine point



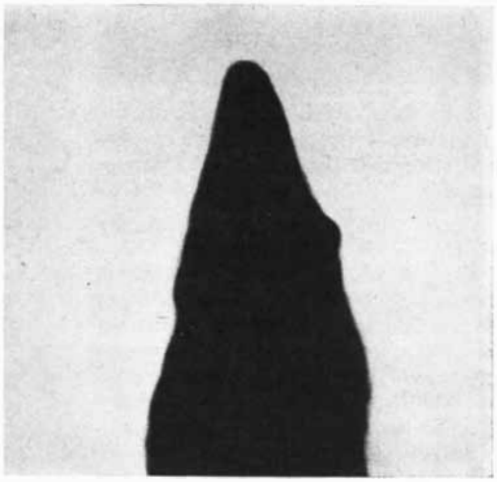


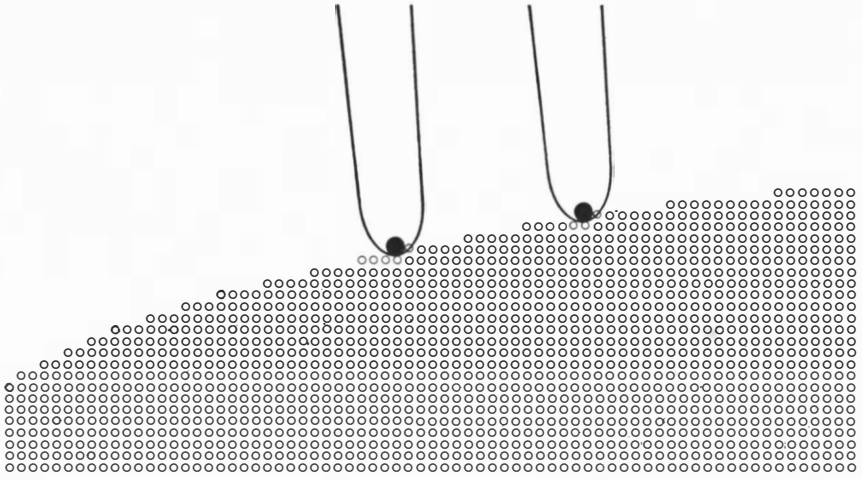
CRYSTAL STRUCTURE of the needle tip with a deposit of barium atoms (*small spots of light*) is revealed by the flow of electrons from its surface to a fluorescent screen (*left*). Dark areas correspond to faces from which fewer electrons are emitted. This photograph resembles a diagram (*right*) based on indirect evidence.



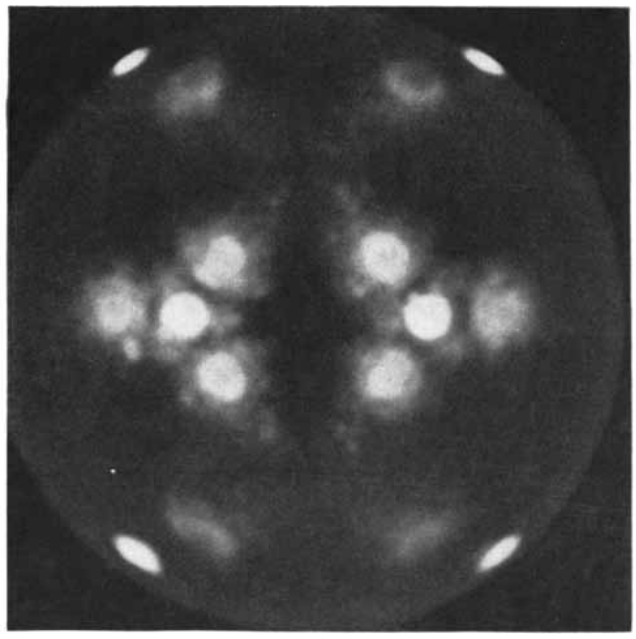


MOLECULES of phthalocyanin appear on the microscope screen (*left*) as clusters of dots similar to a four-leaf clover. Not only is the molecule visible, but also some of its structural detail; each "leaf" represents a cluster of its atoms. This molecular photograph strikingly confirms the diagram of its structure (*right*).

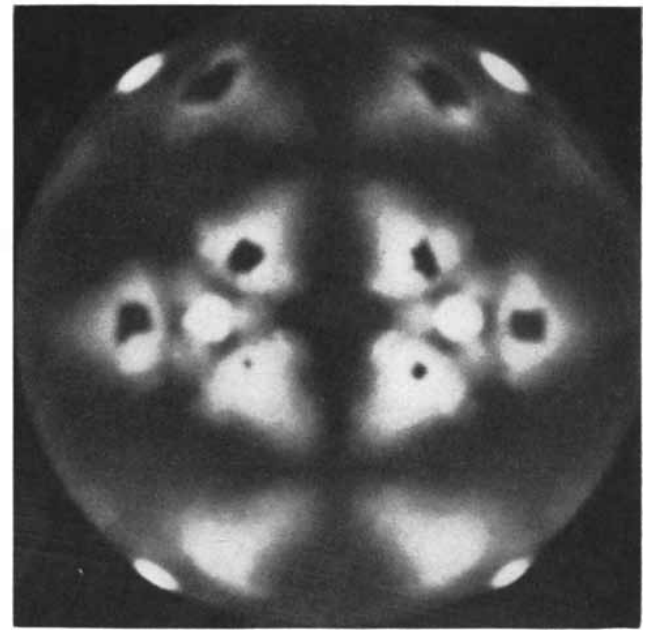




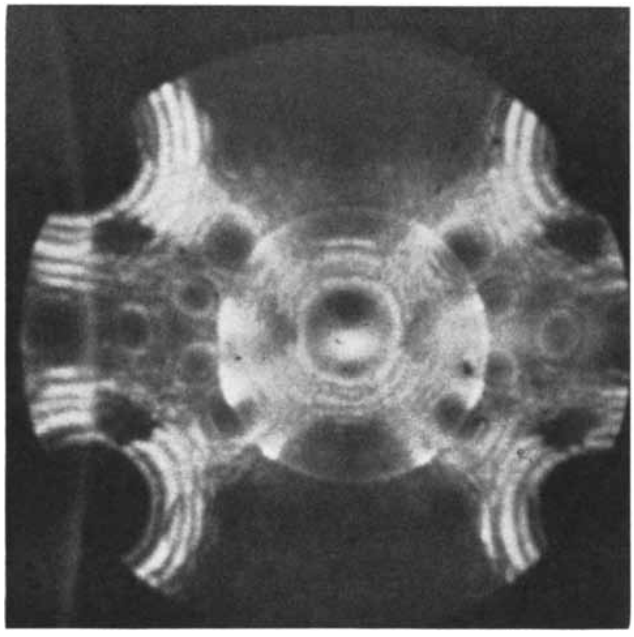
is compared with that of a common needle. In an electron micrograph (*center*), the hemispherical tip can be seen magnified 70,000 diameters. Diagram (*right*) shows cross section of tip crystal with its lattice steps. Two foreign atoms (*black*) produce relatively strong electron beams (*top*) that will make spots on the screen.



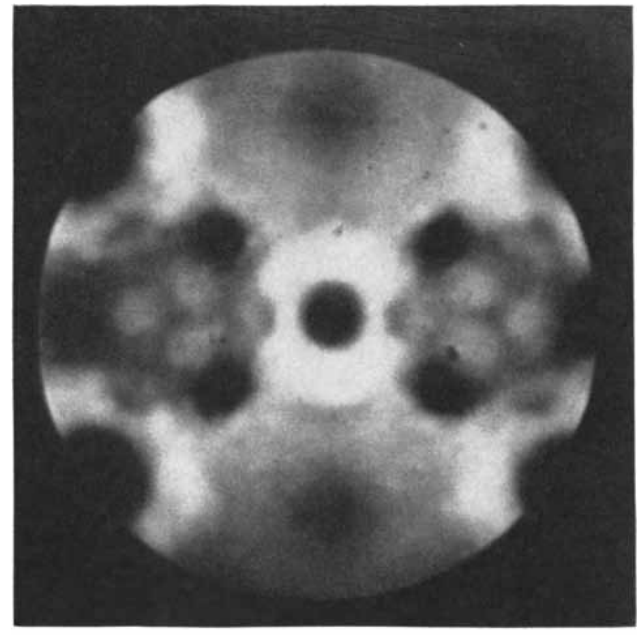
URANIUM OXIDE, building up into a monomolecular layer on the needle, produces bright spots because it tends to concentrate on certain faces of the crystal (*left*).



As the uranium oxide builds up to a double molecular layer (*right*), shadows appear in the bright spots because protruding oxygen atoms cut off flow of electrons.



POSITIVE ION microscope picture (*left*) shows detail in lattice structure of the needle tip. Curved stripes trace the contours of the lattice steps. The stripes are composed of distinguishable dots, each an atom of the needle. The electron picture (*right*) does not resolve the crystal steps nor distinguish the individual atoms.



region they cover is increased or decreased, depending on the nature of the substance and how the particles happen to lie on the needle surface. Thus we have light and dark areas on the screen which overlie the basic pattern of the tip and reveal the presence of the material we are studying.

With this instrument we can see a monomolecular layer of gas or liquid or even individual atoms and molecules deposited on the needle tip. We can study the behavior of different gases as they react chemically with each other or with the metal surface of the needle. We have watched the reduction of oxides by hydrogen, the burning of adsorbed carbon by oxygen, the decomposition of carbon monoxide on the crystal faces of a nickel tip. The needle substance may act as a chemical catalyst, so that the catalytic action of various materials can be studied by using needles made of those materials. To date we have used needles of platinum, tungsten, molybdenum, tantalum, iridium, zirconium, iron, copper and silver. We can study the catalytic action of nonmetallic substances by evaporating them onto the needle point.

The fact that the electron emission does not depend on the temperature of the needle allows us to observe the behavior of materials over a wide temperature range. We have studied reactions at 1,200 degrees Centigrade by heating the needle, and at minus 180 degrees C. by immersing the tube in liquid air. We can actually see the thermal agitation of molecules. By gradually varying the temperature of the needle, we can watch the changes in molecular behavior as an

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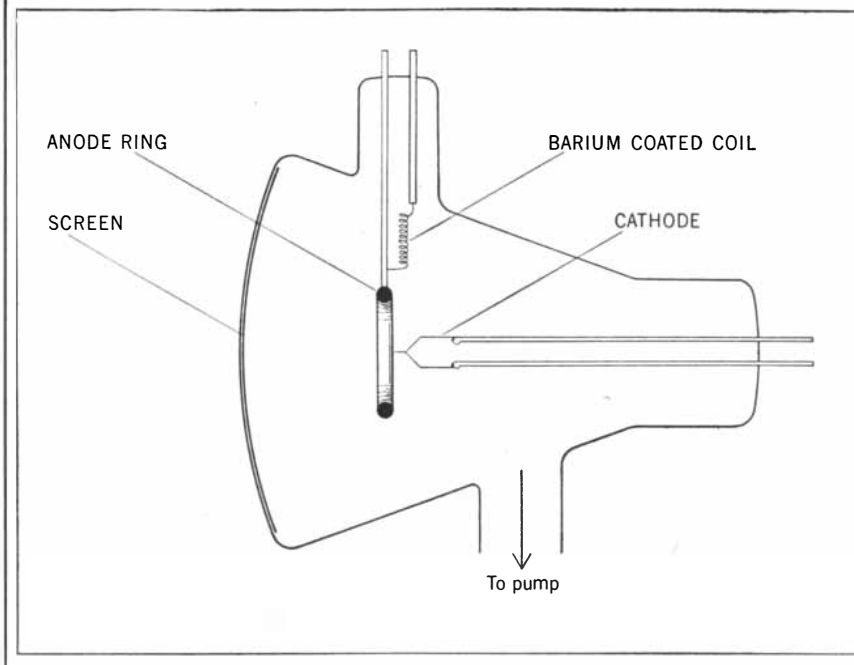


SCHEMATIC DRAWING shows simplicity of apparatus. Electrons from needle cathode are accelerated toward screen by the anode ring. Heated coil releases barium atoms for study. Pump maintains necessary high vacuum.

adsorbed substance passes from the gaseous to the liquid and finally to the solid state.

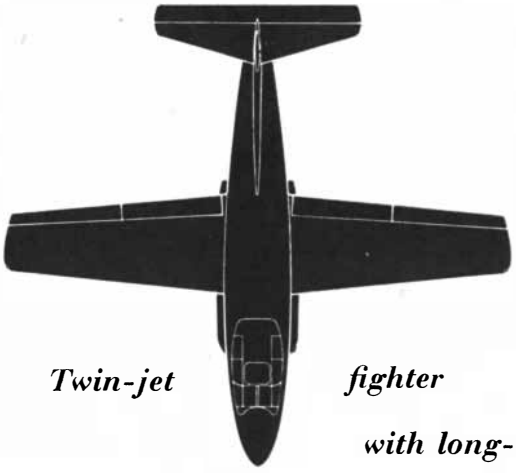
If we condense a very small number of large atoms, such as those of uranium, on the tip, we get a picture made up of separate blurred dots, each representing a spot approximately one ten-millionth of an inch in diameter. We assume that each dot represents an individual atom.

WE CANNOT hope to improve the resolving power of this instrument, because the electron wavelength and the spreading of the electrons are constants over which we have no control. Recently, however, the author has succeeded in operating the same microscope tube with positive ions instead of electrons. Positive ions spread less and have shorter wavelengths; hence they give much better resolution. They make possible a resolving power of approximately one hundred-millionth of an inch, which is fine enough to show the details of the arrangement of atoms in the needle-point crystal itself. On page 60 are two pictures of a needle point, one taken with electrons and the other with positive ions; the latter shows how much greater detail is possible.

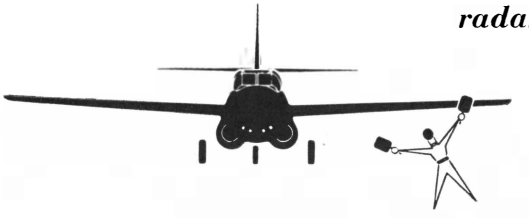
Metals themselves do not emit positive ions, so a new kind of emission had to be developed for this purpose. Ten years ago the author discovered that if a very high positive field, in the range of 750 million volts per inch, is applied, atoms adsorbed on the needle are torn off as positive ions. Since the area of the tip is only about one fifty-billionth of a square inch, the number of atoms that can occupy its surface at one time is very small. In order to get enough ions for even a faint picture on the fluorescent screen, about 100,000 layers of atoms must be torn off every second. To provide a big enough stream we had to arrange for a steady rain of atoms to fall on the tip, with new atoms replacing old ones almost as soon as they were torn off. This we accomplished by filling the microscope tube with hydrogen at a pressure of about one-millionth of an atmosphere. As atoms of hydrogen gas light on the needle point, they are torn off as protons and flow to the screen as a steady current, with new hydrogen continually replacing old on the point. We get a picture of the places where the ionization and tearing off of the hydrogen took place—in other words, a picture of the surface of the needle.

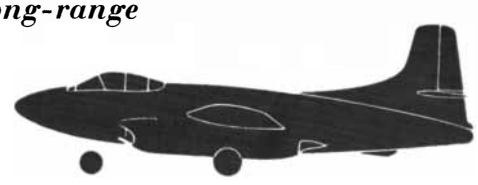
The brightest picture we can get is still rather faint, and it is difficult to photograph, since exposure times of about one minute are required. In this time we lose some details due to small movements in the picture which take place as the screen charges up. The best way to observe the screen is directly with our eyes, after they have been conditioned by a long period of darkness. But these difficulties will soon be overcome, and we have good reason to expect more interesting developments from this first method of observing a real crystal surface in atomic dimensions.

Erwin W. Müller is professor of physics at Pennsylvania State College.



Twin-jet fighter with long-range radar eyes





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INHERITED SENSE DEFECTS

Concerning color blindness, tone deafness and certain lesser-known shortcomings of men and animals

by H. Kalmus

ALL our purposeful behavior, all our awareness of physical "reality," all our ideas about the universe ultimately derive from data which our sense organs alone can provide: *"Nihil est in intellectu, quid non est in sensibus."* Thus for the biologist and the philosopher alike the study of the structure and function of the sense organs is of outstanding importance.

No two animals or people live in exactly the same world, for no two are precisely identical in sense perception. A fish and a snail in the same aquarium actually are living in quite different subjective environments. Because of the differences in their eyes, brains and locomotor systems, they receive totally different impressions from the same stimuli. The snail, having poor visual acuity, will not perceive a hand waved before the tank unless it casts a shadow, but the fish may see every finger. Similarly a blind person lives in a different world from one who sees; the environment of a man differs from that of a bat, for the reason, among others, that he cannot hear supersonic sound as a bat can; and so on.

We shall consider here some differences in sense perception that are inherited, that is, controlled by genes. In the main these differences can be determined only on the basis of the individual's own subjective judgment or his performance in carefully prepared tests, for nobody has yet discovered any morphological difference between, for example, normal and color-blind eyes or normal and tone-deaf ears.

Certain perceptual abnormalities do betray themselves by visible physical signs; some interesting examples of this occur in insects. Among insects there sometimes appear mutant individuals with white eyes, lacking the usual red and brown pigments. These deviant specimens respond to light, but they are unable to react to moving patterns. A white-eyed drone bee cannot find its way back to the hive, and a white-eyed housefly can readily be caught with the hand, because it does not perceive the movement.

In at least one species of fruit fly (*Drosophila subobscura*) this has rather interesting consequences. It has been found impossible to maintain a pure white-eyed stock of such flies, because white-eyed males and females of this species apparently do not find each other or at any rate do not sufficiently excite each other to mate. White-eyed mutants of other fruit-fly species can be bred successfully, however, as they can mate even in complete darkness.

Drosophila flies show another visible sign of a perception defect: absence of antennae, which carry the organs of smell. Flies with the gene responsible for this defect may have only one antenna or none, instead of the normal two, and their sense of smell is impaired.

Genetic sense differences also are known in various strains of mice and voles. Individuals of certain pure lines of laboratory mice, for instance, are seized with violent fits and may even die when they are exposed to high-pitched sounds, whereas mice of other strains are completely impervious to such treatment. These fits are in some ways very similar to certain types of human epilepsy.

THE CLASSIC example of inherited sense variations in human beings, of course, is color blindness, which was well covered in a recent issue of SCIENTIFIC AMERICAN ("Color Blindness," by Alphonse Chapanis; March, 1951). Whether individual color blindness occurs in animals other than man is not known. We do know that various animal species differ in color perception. Bees cannot see red and can distinguish only between orange, yellow-green and blue hues; on the other hand, they do see a small range of ultraviolet, which is invisible to man. Many birds have yellow or orange oil globules in their retinas, and it is supposed that this enables

them to see objects through a bluish haze better than other animals can. Some people believe that all dogs are color-blind; so far none has ever been trained to distinguish between colors. But this is still a moot question.

During blackout periods in the recent war it was discovered that many people are subject to night blindness. In a night-blind person the rods in the retina take an inordinately long time to become dark-adapted. Such people are quite helpless when they step out suddenly into a dark night, and they may remain unable to see for hours.

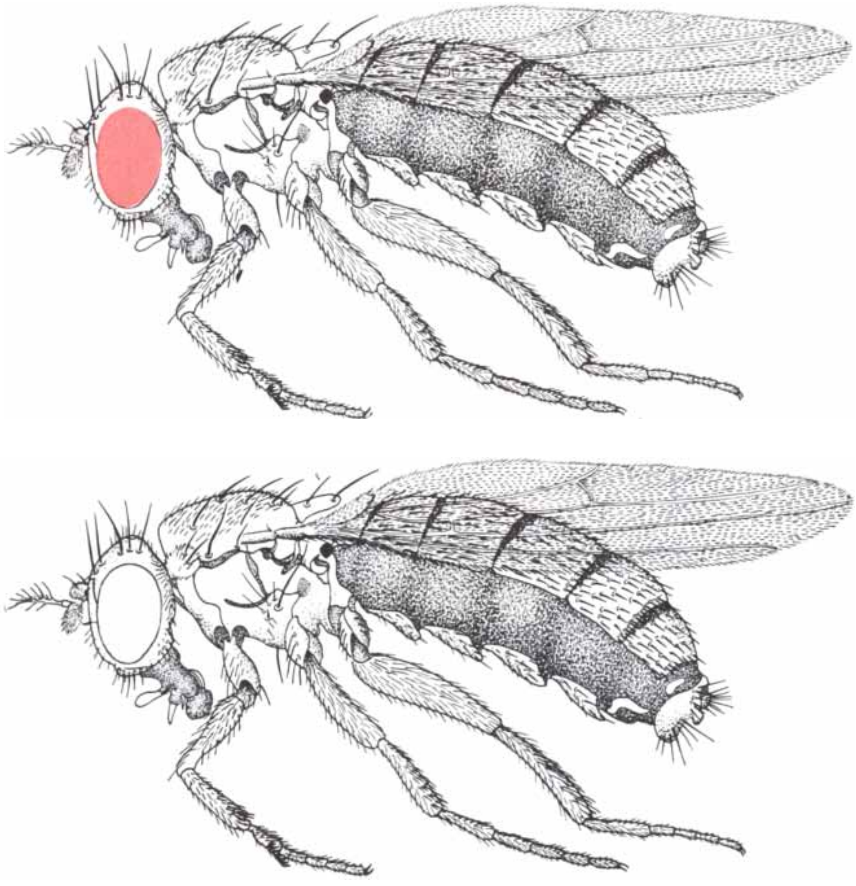
The defect exists in various forms, sometimes associated with eye disease of genetic origin, sometimes as an isolated trait. Some night-blind people can improve their dark-adaptation by taking large doses of vitamin A. Night blindness appears to be a sex-linked trait in some cases and linked to nonsex chromosomes in others.

TONE DEAFNESS, which I prefer to call tune deafness, is known to run in families. It is a familiar defect; almost everybody knows of friends who have been removed from a choral group because of inability to sing in tune, or who sing everything in a monotone or in the same off-key pattern, usually a distorted nursery melody. There is the famous story of the general at Queen Victoria's funeral who failed to rise for the national anthem.

We do not know for certain whether tune deafness is caused by a single gene difference or controlled by many genetic factors. It is possible that several types of tune deafness exist. The genetical analysis is complicated by the fact that the condition is by no means independent of upbringing. In societies where music is regarded as socially valuable, children are trained to overcome their tune deafness to some extent. In spite of their handicap they can sometimes, if pressed, achieve a reasonable proficiency on the piano. But probably no such person has ever learned to sing tolerably or to play the violin or flute without arousing violent reactions. In general it is unprofitable to make a tune-deaf child take music lessons.

Many tune-deaf people have an acute dislike for music, but others may genuinely enjoy listening to it, especially dance and symphonic music. They can appreciate the rhythm, intensity and polyphonic structure of music, even if not the harmony or melody. Needless to say, tune deafness has nothing to do with intelligence; tune-deaf people may be highly sensitive to other forms of art.

To determine whether an individual is tune-deaf is not easy. Self-ratings are



FRUIT FLY normally has a red eye (*top*). Some fruit flies have white eyes (*bottom*) and appear unable to perceive objects that are in motion.

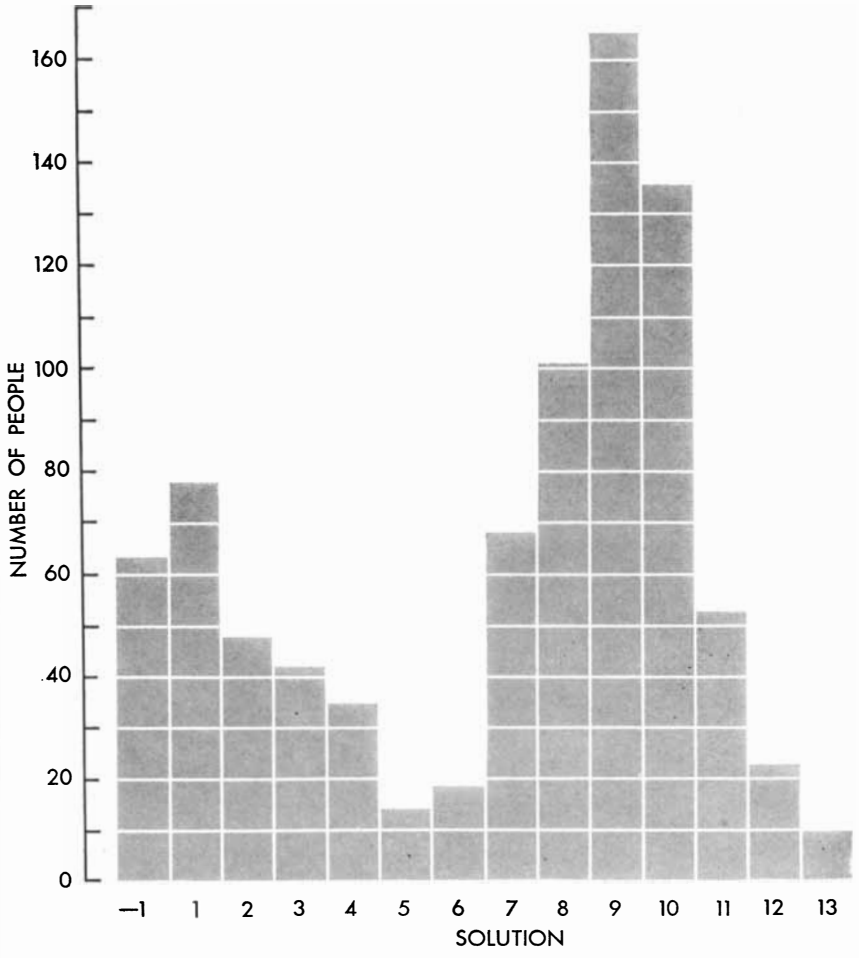
completely worthless. On the one hand there are assertive types, happily unaware of their atrocious performance, who insist that they have a perfect ear. On the other hand there are perfectionists who consider themselves tune-deaf because their singing or playing is slightly imperfect. Nor are the objective tests that have been devised altogether reliable, because test conditions are difficult to standardize and the effects of age and education cannot be separated.

Two points of view have been adopted concerning the physiology of tune deafness. One holds that it is primarily a defect in pitch discrimination or in perception of the melodic line. However, defective pitch discrimination, even where it exists, is probably not the whole story. Apparently auditory thresholds and the discrimination of intensity, length and "color" of sounds are not greatly impaired in tune-deaf people. The other point of view is that the individual notes of a melody are perceived more or less correctly but that their relationship is not accurately perceived. Tests to decide between those two possibilities unfortunately have not been decisive. People who are poor at recognizing melodies usually score low in pitch discrimination and in tonal memory.

Investigation has shown that the inability of tune-deaf people to sing correctly is rarely due to a motor defect but is as a rule caused by a defect in perception, or feedback.

An aspect of tune deafness on which one can only speculate is its possible effect on the history of music. A gene responsible for tune deafness, when brought in by marriage, can break the line of a musical family. This may very well have happened in the families of some famous composers. The family of Johann Sebastian Bach had for generations produced musicians, some of the first rank; 200 or 300 years ago the name Bach was synonymous with musician in Germany. But no great musical ability has been found among the numerous descendants of Johann Sebastian who now live in Germany and in North America.

Another defect on the higher level of perception that may be hereditary is the inability to read, known as dyslexia. People suffering from this defect may clearly perceive the individual letters of a word, but they cannot put them together. While every child experiences some such difficulty during an early phase of its school career, dyslectic children may never overcome it, in spite of



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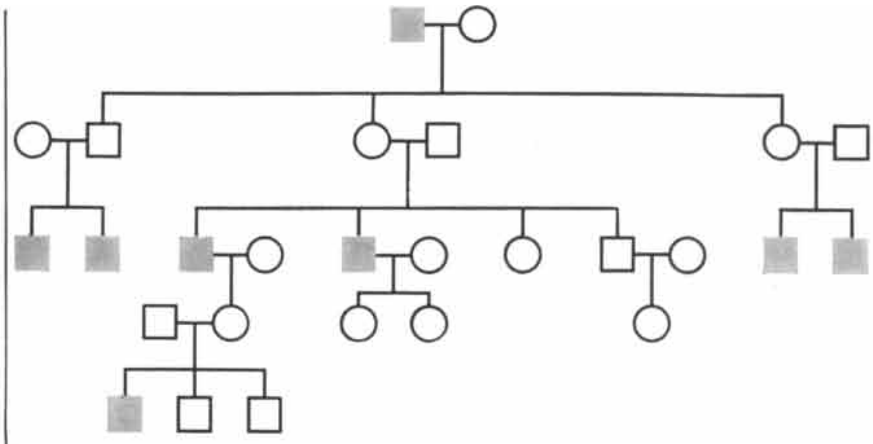


PEDIGREE of one kind of night blindness shows that males (*squares*) and females (*circles*) can transmit defect, but only males are affected by it.

high over-all intelligence. Inability to learn to spell correctly usually accompanies the inability to read.

FINALLY, perhaps most interesting of all, there are the recent discoveries about differences in the ability to smell and taste. Although the sense of smell is believed to be less acute in civilized man than in his forebears, it is still very sensitive and plays a large role in our eating, drinking and mating. Variations in sensitivity are wide. The perfumer, the teataster and the winetaster must have very good noses. At the other extreme we know there are people who completely lack ability to perceive any odor. Some can smell only vapors that cause pungent or stinging sensations, but these do not so much stimulate the olfactory end organs as irritate the trigeminal nerve in the nose. Total inability to smell is usually caused by infection or injury; only rarely does it affect more than one member of a family.

An interesting difference between men and women in odor perception has recently been described by some French authors. They claim that certain compounds which are related to the sex hormones are not perceived by men but have a musklike odor for adult women, especially during certain phases of the menstrual cycle. Confirmation of this is still lacking.

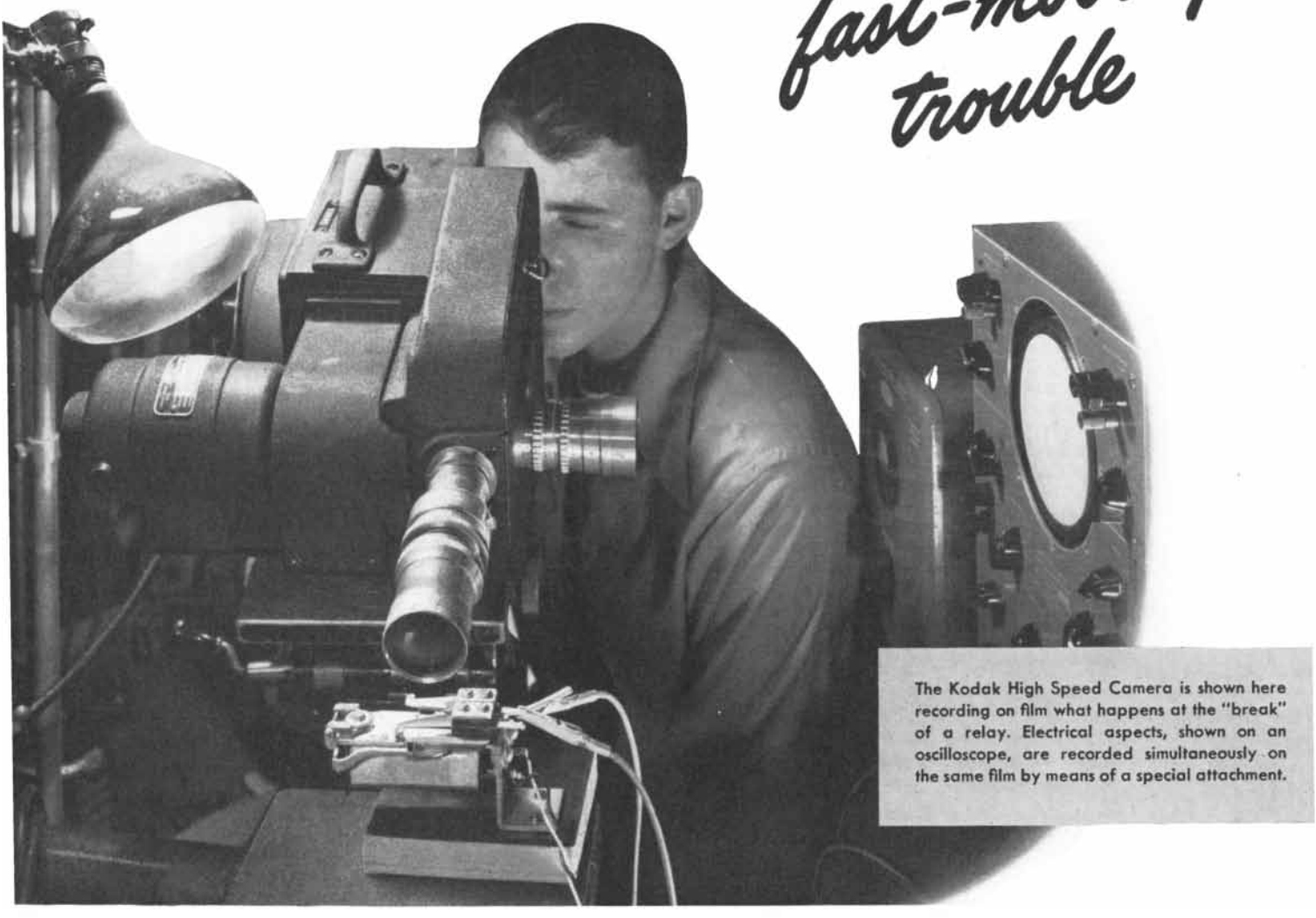
Some 20 years ago a chance discovery concerning the sense of taste started a long chain of investigations which have provided us with a most fascinating problem in sense perception, genetics and metabolism in general. The U. S. chemist Arthur L. Fox discovered that the crystals of a certain substance, phenylthiocarbamide (PTC), appeared very bitter to some people but tasteless to others. Using various dilutions of the substance in water, he found that the differences in tasting were graded. The range of minimum concentration tasted by various individuals varied by more than 10,000-fold. In general, however, people could be divided into two groups: tasters and nontasters. Whereas the distribution of taste thresholds for most other substances would show one peak, situated somewhere in the middle, the frequency diagram for PTC thresholds shows two, representing in effect the tasters and the nontasters.

It is perhaps worth while to describe in some detail how such threshold measurements are taken. Originally each person being examined was simply asked whether a series of given solutions tasted bitter or not, and the threshold was determined in this way. However, it soon developed that this purely subjective and verbal approach did not produce data worthy of statistical analysis. After some trial and error the following method emerged: The examiner first uses the old method to obtain a preliminary opinion as to the lowest concentration the subject can taste. Then a little of this solution is poured into each of four tumblers. These four are shuffled with four other tumblers containing only water, so that the subject does not know which contain the solution. He is asked to separate them according to taste. If he separates them correctly, the test is repeated with progressively weaker solutions until the subject can no longer detect the solution with any accuracy. This procedure yields more accurate results on actual ability to taste the substance.

THE percentage of people who cannot taste PTC varies greatly among different populations. In European, North American and Australian populations about a third fail to taste the substance in dilution; in many peoples of non-European origin the proportions of nontasters are much smaller. If this is a truly genetic trait, the gene for nontasting must vary in frequency from more than a half in "European" populations down to almost nil in certain isolated tribes. Some day, when the genetics of tasting are fully elucidated, it may be possible to trace human migrations by comparing taster frequencies.

The division of people into tasters and

This eye spots *fast-moving trouble*



The Kodak High Speed Camera is shown here recording on film what happens at the "break" of a relay. Electrical aspects, shown on an oscilloscope, are recorded simultaneously on the same film by means of a special attachment.

When trouble is hidden in a blur of speed too fast to see, the cause is hard to find. Here's the way to get the answer in a hurry without costly, tedious cut-and-try experimentation or theoretical analysis.

With the Kodak High Speed Camera, you can take up to 3200 clear pictures a second on 16mm film. When projected at normal speed, the film shows action slowed as much as 200 times—makes visual analysis quick and easy. And the films are available for study over and over.

This high speed "eye" is daily solving complex problems of design, production, and product performance—problems where usual methods of analysis would be slow and costly. One manufacturer projects high speed movies within two hours after they are taken—the solution to a problem is on the drawing board the same morning it is discovered. We'd be glad to send you, with our compliments, a folder showing how this company uses the Kodak High Speed Camera so effectively. Eastman Kodak Company, Industrial Photographic Division, Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

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nontasters of PTC poses a unique problem. In most cases of perceptual differences we can describe one class as normal and the other as abnormal. Color-blind people, for example, are a small minority. The nontasters of PTC, on the other hand, form up to one-third of our population, and the gene responsible for the trait must be more frequent than the taster gene, since it is present in many individuals without expressing itself. Under the circumstances it is impossible to say what is normal and what abnormal—whether one "ought" to taste PTC or not.

Nontasting has been held to be associated with various diseases, among them diabetes mellitus. The only condition on which there is any undisputed evidence is nodular goiter, which seems to occur somewhat more frequently in nontasters than in tasters.

PTC is by no means the only substance that divides people into tasters and nontasters. Most other compounds with the same carbon-nitrogen-sulfur group appear bitter to the same people and tasteless to the others. One of these thiocarbamides, known as "ANTU," is a powerful rat poison but is tolerated in relatively large doses by mice and men. Another is the substance called Antabuse, which is being used to fight alcoholism because it prevents the normal destruction of alcohol in the blood and produces very unpleasant aftereffects. Great caution is advisable, however, in administering such a drug.

IT APPEARS that the vast majority of the substances having dual taste thresholds inhibit the formation of thyroxine in the thyroid gland. Some of them, derivatives of thiouracil, are now widely used to treat overactivity of the thyroid. All this and other pieces of evidence would seem to support the idea that nontasting and goiter are somehow related. Endemic goiter has usually been attributed to lack of iodine in food and water. But some features of the occurrence of goiter remain unexplained, and it may well be that certain substances in food help account for the high incidence of the condition in given regions. Regional differences in the proportion of nontasters may be responses to specific differences in diet. Many points in this intriguing complex of problems are still obscure. We do not know, for instance, whether the ability or lack of ability to taste these substances has anything to do with food preferences.

All in all, even the small amount of work that has been done in the study of sense differences makes clear that it is a broad, important subject which should not be pursued piecemeal.

H. Kalmus is a geneticist in the Galton Laboratory of University College in London.

What GENERAL ELECTRIC People Are Saying

W. R. G. BAKER

Electronics Division

RADIO AND TELEVISION—WEAPONS OF TRUTH: The web of lies and deceit woven by the Kremlin is so tangled and so tenuous that the Communists must erect an iron curtain and must struggle continually to keep the truth from the peoples they dominate. They know they dare not admit the truth about the United States, about our standard of living, about our automobiles and homes and refrigerators, and particularly about our freedoms. They fear the truths carried by the powerful transmitters of the Voice of America, many built by and several operated by General Electric.

Lies and propaganda cannot live long where truth can be heard and seen. The sensitive ear and unblinking eye of radio and television are quick to detect the false note in the voice, or the sudden look of cupidity. A more effective weapon against propaganda than political censorship, through political selection of those events which are allowed to be reported by radio and television, would be the candid reporting of the radio microphone and television camera.

Radio has long listened and reported on governmental affairs, and it has become a past master at interpreting the world's events, although on occasion with too little reporting and too much interpreting. It is time that radio and television came of age, and lent their eyes and ears freely to the cause of communication of truth. Certainly the right of privacy is invaded if we turn on microphones and cameras during an inquisitorial congressional investigation in which no rebuttal is allowed, but this invasion of privacy stems not from the use of radio or television, but from the very procedures used by government.

Let us not forget that our government is a government by the people as well as for the people, and the closer we can come to an informed, enlightened democracy the stronger we will be against the forces of international gangsterism, or against predatory tactics by any group, clique or faction within our borders.

Radio Station WGY
30th Anniversary
Schenectady, New York
February 20, 1952

★

S. K. GUTH

Lamp Division

LIGHTING AND THE JOB: Workers often are expected to use expensive tools and machinery with the most primitive lighting and seeing conditions. The potentially efficient machinery cannot be utilized at its maximum efficiency because the workers are unable to see accurately, quickly and easily. Thus, another type of efficiency—human efficiency—needs to be considered in the over-all operation of a factory, office, or any area where work is being done.

We measure the efficiency of mechanical and electrical machines by the ratio of useful work done to the total—useful plus useless—work done. These machines have reserves which are available for emergencies. Human efficiency, on the other hand, usually is measured by the useful work done per hour or per dollar without any regard for the *total* human energy expended in performing the work. Such a criterion ignores consideration of wear and tear on eyesight, wastes human energy, and gives little or no thought to human reserve resources. Should not the human seeing machine be entitled to the same considerations as mechanical machines?

Conference on Occupational Vision
Rutgers University
November 1-2, 1951

G. E. HENRY

General Engineering Laboratory

ULTRASONIC CLEANING OF SMALL PARTS: Scientific interest in the varied and startling phenomena of ultrasonics inevitably leads to the question, "What are the applications?"

Ultrasonic cleaning is one of the best answers yet given to that question. Here is a method of removing oil, grease, chips, dirt, lapping compound, and many other contaminants from the surfaces of small precision work pieces at a rate hitherto unattainable, and to a degree of cleanliness that usually surpasses the most stringent industrial standard.

This is accomplished by beaming a high-frequency sound wave through the cleaning solvent or detergent solution, as the case may be, to the surface of the submerged work piece. The sound wave, usually, but not always, in the 300- to 1000-kilocycle-per-second range, is set up directly in the liquid cleaning bath by means of a vibrating quartz crystal. The crystal, in turn, is driven by an electronic oscillator.

Within certain limitations we can make superlative claims for this method. It is applicable to pieces of almost any material—to metals, glass, textiles, or molded products—and to pieces of practically any conceivable shape. We may even say that the more irregular the shape the better; ultrasonics is particularly good for getting at blind holes and capillary cavities. We confidently predict that the present decade will see many installations saving untold thousands of manufacturing dollars.

General Electric Review
March 1952

The Coriolis Effect

Everything that moves over the surface of the earth—water, air, animals, machines and projectiles—sidles to the right in the Northern Hemisphere and to the left in the Southern

by James E. McDonald

IT IS A curious fact that all things which move over the surface of the earth tend to sidle from their appointed paths—to the right in the Northern Hemisphere, to the left in the Southern Hemisphere. Since man has managed to make himself one of the most mobile of creatures, one might think that so ubiquitous an effect must long have been a matter of common knowledge. It has not been and still is not, even in this era of rapid speeds, which accentuate the sidling tendency. Probably few people realize that as they drive down a straight highway at 60 miles per hour this all-pervading drift would carry them off the road to the right at the rate of some 15 feet per mile were it not for the frictional resistance of the tires to any lateral motion.

This sidewise drifting tendency is called the Coriolis effect, after the 19th-century French mathematician G. G. Coriolis, who made the first complete analysis of it. The effect is due simply to the rotation of the earth, and it appears in all motions as soon as we refer those motions to any coordinate system fixed with respect to the earth (*e.g.*, the latitude-longitude grid).

There is really only one satisfactory way to obtain a vivid impression of the nature of the Coriolis principle. That is to go to a carnival. Every carnival worth the name has a Coriolian coordinate system: *viz.*, the merry-go-round. With only a few balls as laboratory equipment and two assistants, one on the merry-go-round with you and the other on the ground, you can carry out many interesting Coriolian experiments.

When the merry-go-round starts up, you begin a game of catch. Things will probably go very poorly for several throws (which is the reason for your taking the precaution of equipping yourself with several balls). The ball will seem to veer from its thrown direction in the most amazing fashion. Let us say the merry-go-round turns counterclockwise, as does the earth when viewed from above the North Pole. If it makes one complete turn in 10 seconds, and you throw the ball at a speed of 20 feet per second toward an assistant standing 15 feet from you on the merry-go-round, the apparently curving ball will miss the assistant by a little over six feet to the right. When you throw a ball to your other assistant, in the outer world off the merry-go-round, it will again seem to drift rightward. This time, however, by great concentration you may be able to fix your attention on the nonrotating framework of the outer world sufficiently to sense that the ball is really moving as it ought to move, and you may even make proper allowance for the merry-go-round's rotation so that the ball reaches your assistant's hands.

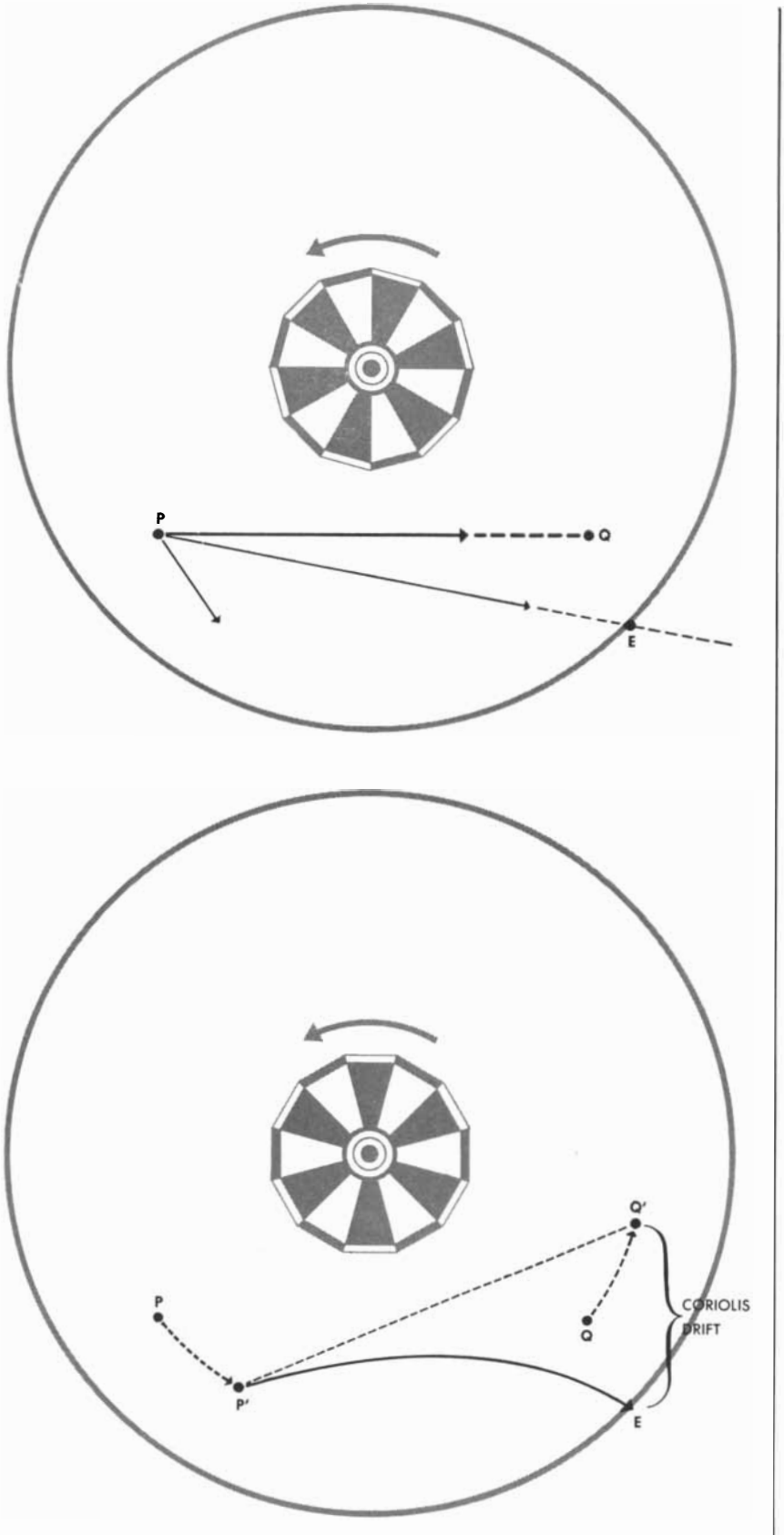
THE APPARENT strangeness of the balls' behavior in these experiments arises from the fact that almost inescapably you take the merry-go-round as your reference system, and in this system the laws of dynamics in their usual form simply do not hold. No such difficulties confront the assistant who stands out on firm ground. He is not so compelled to view these motions with respect to your rotating coordinate system. He will feel certain that the balls have at all times been moving in well-behaved fashion. If he has a little understanding of the problem, he may be able to explain to you that the drifting to the right which you seem to see is really due to the fact that your system is turning out from under the moving balls.

The earth is a spherical merry-go-round, and all of the Coriolis drifts we observe when we use terrestrial coordinate systems are due ultimately to the fact that the earth, like the merry-go-round, is always spinning out from under our dynamical systems. To be sure, there are certain subtleties that enter into some Coriolis effects, but at bottom the whole thing is just the merry-go-round idea. To an observer conscious of Newton's second law of motion, the apparent "acceleration" (deflection from a straight path) of an object moving over the earth suggests that some force is acting on it, and he is strongly tempted to speak of the Coriolis "force." For convenience, meteorologists and others who are concerned with the Coriolis effect do treat it as a force, and their equations work out all right. What they set down as a force in the Newtonian equation is actually a correction for the apparent acceleration. The pure dynamicist looks at it in a different way: he likes to regard these motions as occurring in obedient Newtonian fashion in what he calls "inertial space."

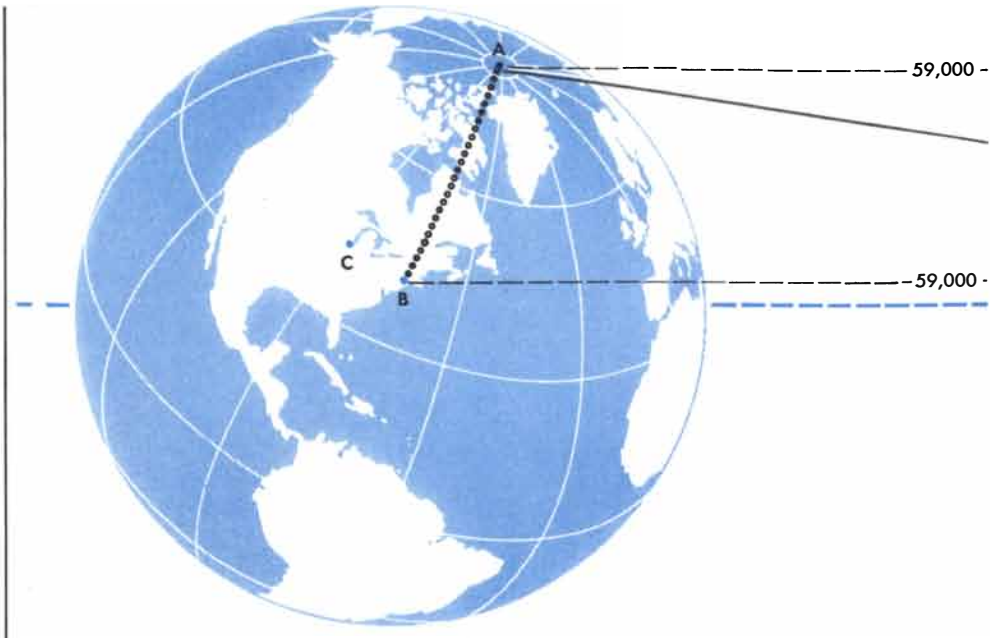
NOW let us look at some interesting examples of the Coriolis effect, as it applies to projectiles, flight, vehicles, ocean currents and even our weather. The Coriolis effect is greatest near the North and South Poles (where the earth turns most rapidly under a moving object) and decreases to zero at the Equator. The magnitude of the effect also depends directly on the speed of the moving object.

In middle latitudes of the Northern Hemisphere a bullet fired with a velocity of 800 feet per second at a target 400 feet away will drift one-tenth of an inch to the right (without considering wind effects or any other interference). That is, in the half-second during which the bullet is in flight, the rotation of the earth has shifted the bull's-eye by about one-tenth of an inch. This is not serious to a pistol marksman, but the effect can make quite a difference to a long-range gunner. A battleship gunner who takes dead aim at the bridge of a destroyer 20 miles away and fires a shell at 2,500 feet per second will miss the destroyer completely, because the lateral Coriolis drift will be more than 200 feet. In World War I the shells of the giant German gun called Big Bertha, which bombarded Paris from a firing site some 70 miles away, took three minutes to reach their destination, and they underwent a Coriolis drift to the right amounting to almost a full mile—an error for which the German ballistics experts carefully allowed.

For a really dramatic effect we can take the case of a rocket fired from the North Pole and aimed at, say, New York City. Assuming, for the sake of simplicity, that the rocket travels at a constant



MERRY-GO-ROUND EXPERIMENT demonstrates Coriolis drift. Seen from above, the merry-go-round rotates counterclockwise. In the top drawing a man at P attempts to throw a ball to a man at Q. The rotational motion of the man at P (*short arrow*), however, causes the ball to head in the direction PE. In the bottom drawing the man at P has moved to P′, the man at Q to Q′ and the ball crosses the edge of the merry-go-round at E. To the rotating observers on the merry-go-round the ball appears to have described a curve.



MISSILE flying from the North Pole (A) to New York (B) with a speed of a mile per second would land near Chicago (C) unless the Coriolis effect were taken into account. In the 55 minutes that it would take the missile to reach the latitude of New York the earth would have rotated on its axis about 15

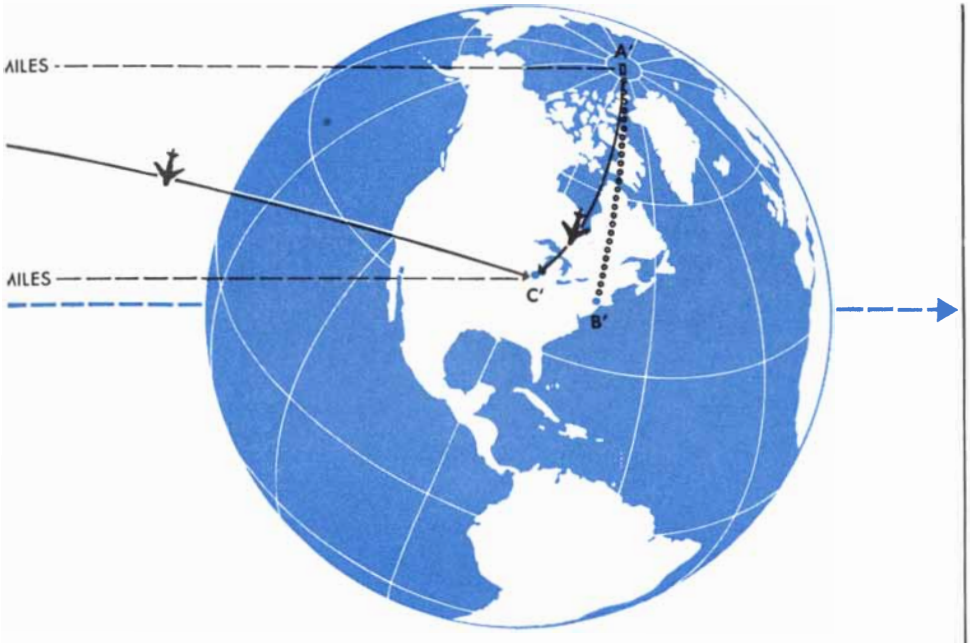
speed of a mile per second, it will be in flight for about 55 minutes. During all of this time the target, New York City, will be traveling at 18 miles per second through solar-system space (the speed of the earth's movement around the sun) and will also be turning with the rotation of the earth at the rate of 15 degrees of longitude per hour. As the result of these motions the rocket, at the end of 55 minutes, will come to earth in some cornfield in northeastern Illinois, not far from Chicago!

The earthbound observers who have been plotting the apparent path of this rocket with their radar network will say that it traced out a graceful curve which started out straight south in the longitude of New York City, but veered steadily westward, arriving in Illinois from a direction about 11 degrees east of north. A less provincial observer out in interplanetary space will see that the effect is entirely a result of the earth itself having turned out from under the moving rocket.

This is an idealized case; in actual situations the Coriolis effect is much less evident, because other forces such as air resistance, neglected in this example, also act on moving objects. Furthermore, the motion of a projectile fired from any place on the earth other than the Poles would be influenced not only by the Coriolis effect but also by the initial impetus from the circumpolar rotation of the launching site.

An airplane experiences Coriolis drifts which would lead to astonishing errors in long flights if no compensation were made for them. A jet fighter that set out on a great-circle heading from Chicago to New York and flew at 600 miles per hour without changing its heading would miss New York by several hundred miles to the south (assuming no allowance for any wind). And if the same pilot tried to fly in a similar way from Seattle to New York, he would find himself down in South America by the time he crossed the meridian through New York! In actual flights a pilot continually banks his plane slightly leftward, in our hemisphere, to compensate for Coriolis drift. It should be noted that, large as these deviations due to the rotation of the earth are, they are still small compared to the effects of cross-winds normally encountered in actual flights. The pilot's Coriolis corrections are thus obscured by the jockeying necessary to compensate for wind drift. To compensate for the Coriolis drift and keep a 20,000-pound jet fighter on a straight terrestrial course at 600 miles per hour requires a leftward force of about 55 pounds in middle latitudes of the Northern Hemisphere. This the pilot manages by manipulation of the plane's wings.

Railroad cars are much more massive, so the Coriolis reaction in their case is greater. A 500-ton locomotive moving at 60 miles per hour develops a lateral pressure on the rails amounting to about 300 pounds in middle latitudes. This has given rise to the story that the wheels on trains wear unevenly. Such a result could hardly be detected on coaches or freight cars, which for railroading reasons have no definite right or left sides, and the Engineering Department of the Union Pacific Railroad has informed the author that even in the case of locomotive wheels the difference of wear on the



degrees and traveled along its orbit some 59,000 miles. Within the coordinate system of the earth the missile would appear to describe the trajectory A′C′. Within the coordinate system of the sun and all the planets, it would appear to describe the path AC′ (*gray line running diagonally across these two pages*).

flanges of the right and left wheels is too small to be measured.

WHY IS SO universal (one should say, "so terrestrial") an effect not readily apparent in our everyday activities? The answer is that for many moving objects the tendency toward a lateral drift is quite easily counteracted as the motions proceed. Thus in the case of the car speeding down the highway at 60 miles per hour, the potential 15 feet of shift per mile is prevented by the frictional resistance of the tires to lateral motion.

A walking man makes corrections for the Coriolis effect easily and quite unconsciously. On frictionless ice that prevented his making any small lateral corrections (but somehow still permitted him to walk!) a man walking at four miles per hour would drift from his intended straight path by about 250 feet at the end of one mile. Lost polar explorers are reported to have a strong tendency to circle steadily toward the right near the North Pole and to the left near the South Pole; this may very well be due to the Coriolis effect, which is about 50 per cent stronger at the Poles than in middle latitudes. It is said that even the penguins in the Antarctic waddle in arcs to the left, but this the author will have to see to believe.

AMONG ALL the physical phenomena in which the Coriolis effect plays a role, the most striking is the weather. Were it not for the Coriolis effect, winds on the earth would rush directly from higher-pressure areas to lower-pressure ones, and no strong "highs" or "lows" could develop. Hence there would be no opportunity for the build-up of the intense cyclones and the large anticyclones that control and give variability to our weather, and our weather would be much less changeable than it is. This is precisely the situation in the Tropics, where the Coriolis effect is zero or very small. In that almost Coriolis-free belt any atmospheric pressure differences produced by heating of the air at the ground are quickly smoothed out, and the region has well earned the name of "the doldrums." Hurricanes and typhoons never form closer to the Equator than about five degrees of latitude.

Away from the Equator, however, the case is very different. There the Coriolis acceleration causes winds to veer around and blow at right angles to the pressure gradient, instead of parallel with it. The result is the pattern of strong lows and highs and circular movement that is responsible for changes in our weather.

On other planets, where the angular velocity of rotation is different from that of the earth, the Coriolis effect is correspondingly different. Jupiter and Saturn must have very marked Coriolis effects, because each rotates about two and a half times more rapidly than does the earth. Their atmospheres of hydrogen, methane and ammonia must have very steep pressure gradients, if their winds compare in strength with ours. In contrast, the atmosphere of Venus is probably very calm, because Venus rotates much more slowly than the earth—perhaps once in about 30 terrestrial days.

Just as the motions of the atmosphere

exhibit the Coriolis effect, so also do the more ponderous movements of the great ocean currents. To simplify the picture a bit, let us assume that the density of the sea is uniform. The oceans are not perfectly level, for the winds shift the waters and give them a gentle relief. Since water flows downhill, the natural tendency of the oceans' water is to flow from regions where the mean sea-level is relatively high to those where it is lower. But as soon as the water tries to move in so forthright a fashion, the Coriolis drift causes the moving water to veer off to the right (in the Northern Hemisphere). Eventually the currents flow steadily along the contour lines, with the water surface sloping upward to the right as one looks in the direction of flow. In practice, of course, internal eddy-stresses within the ocean and the winds blowing across the sea surface modify this trend. But the general rule still holds.

Lest the reader mistakenly conclude that he should have spotted these oceanic hills and valleys on his last sea voyage, it should be mentioned that the total difference of mean height across even the fastest-moving parts of the Gulf Stream system is only about a foot and a half in some 80 or 90 miles. Even this modest slope is only partly due to Coriolis effects, the remainder resulting from the sort of horizontal density gradients we have agreed to overlook. Yet, slight as such surface slopes may be, they constitute a major factor in the dynamics of the ocean currents.

PEOPLE ON the Pacific Coast are well acquainted with certain other consequences of the Coriolis acceleration, though not many realize this is the cause. Coriolis drift is mainly responsible for the notorious California fogs and the coldness of the water on California's beaches. Off the California coast, where the prevailing winds are from the northwest, the wind stress and Coriolis drift generally combine to make the coastal waters sidle off in a southwesterly direction. As water is transported away from the shore toward the southwest, the deficit must be made up somehow. The water moving offshore is replaced by water rising from below. This upwelling brings up water from cold strata lying at depths as great as several hundred feet. As a result there is a cool strip of water along the California coast, superimposed, in fact, on the already cool California Current flowing down from the north. In summer the warm moist Pacific air streaming in from the northwest is cooled by the coastal water, and this is what forms the fogs for which California regrets to be famous. A similar situation prevails off the coast of Peru and parts of the western coast of Africa.

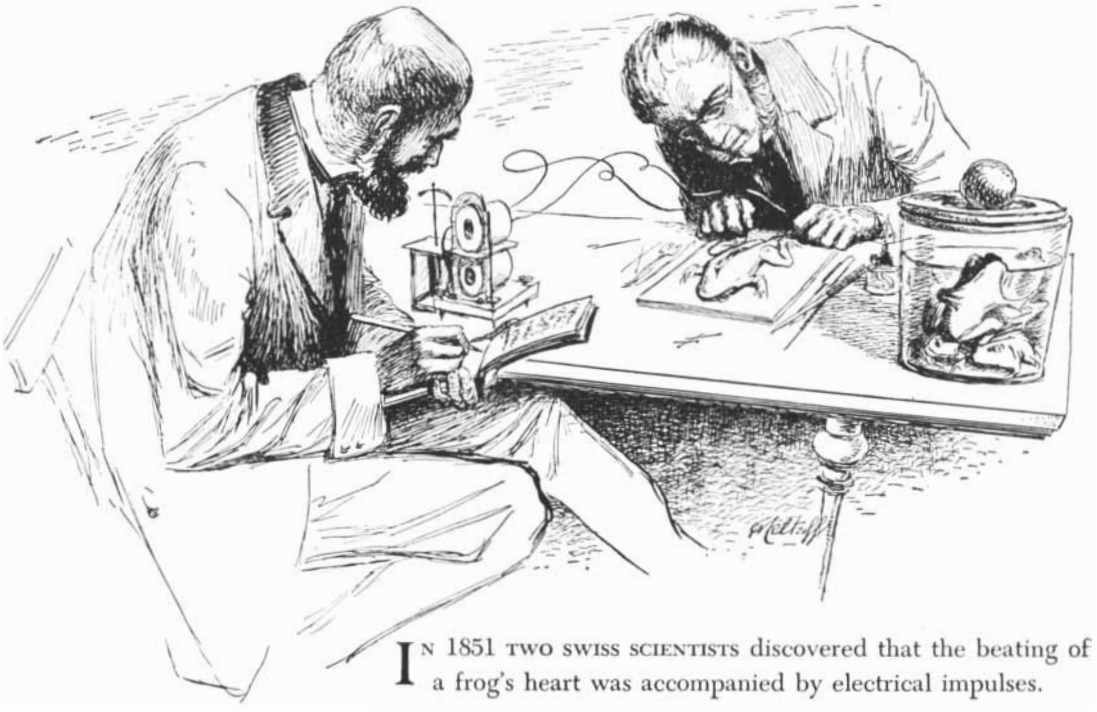
Some geologists believe the Coriolis effect causes a river to erode one of its banks faster than the other. The Russian scientists P. A. Slavsov and Karl von Baer reported that river valleys in Siberia tend to have steep walls on their right side and gently sloping walls on their left side. Similar asymmetries have been observed in some Alaskan rivers, in the Missouri River and in a number of streams on Long Island. This supposed effect of the Coriolis drift is sometimes called Baer's law. But students of the effect have not all been willing to attribute it to the Coriolis influence. Even in a river a mile wide flowing at the fast rate of five miles per hour in middle latitudes of the Northern Hemisphere, the Coriolis drift to the right would pile up the water only a little more than one inch higher at the right bank than at the left bank. Possibly such a slight difference in height might cause significant differences in erosion over geological periods of time, but the question is still unsettled.

This is as good a place as any to correct the persistent misconception that the Coriolis acceleration causes the water to run out of a washbowl in a clockwise direction in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. The Coriolis influence is so small at the velocity of water in a washbowl, the time involved is so short and other factors are so numerous (hands, noncircular bowl-shapes, and so on) that one may feel sure the Coriolis effect is never in control here. This is regrettable, because if it were, a washbowl would constitute a useful analogue of a cyclone in the atmosphere.

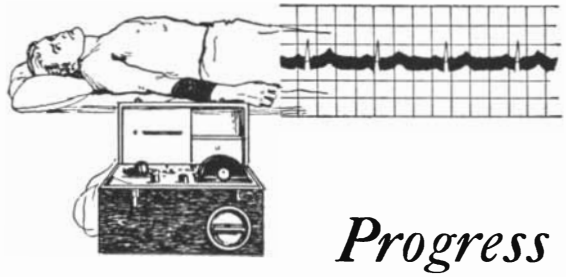
WE SHALL consider one more possible case of a Coriolis effect. There is a theory that some birds may be guided in their migrations by sensitivity to the Coriolis acceleration and to geomagnetic latitude. H. L. Yeagley of Pennsylvania State College has recently studied this amazing theory in an effort to determine the navigating techniques of the homing pigeon.

When a bird flies at constant ground speed in the Northern Hemisphere, its Coriolis acceleration toward the right grows greater the farther north it flies. Yeagley suggests that if, through some delicate sensory organ, the bird can detect slight differences in this acceleration, and can combine this information with an accurate estimate of its ground speed, it may be able to sense its geographical latitude. If, at the same time, another sensory organ with the necessary electrical properties senses differences in the minute electromotive forces generated by virtue of the bird's motion through the earth's magnetic field, then this plus the bird's estimate of its speed would provide a basis for sensing geomagnetic latitude. Now, since the magnetic poles of the earth are displaced some 20 degrees from the geographical

Milestones in *heart* research



IN 1851 TWO SWISS SCIENTISTS discovered that the beating of a frog's heart was accompanied by electrical impulses.



THEIR DISCOVERY WAS A MILESTONE in the development of today's electrocardiograph. By charting the electrical impulses of the human heart, this instrument provides important guidance in the diagnosis of heart conditions.

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Scientists believe we are on the verge of great new discoveries about the heart and circulation.

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poles, the parallels of geomagnetic latitude form a grid with the parallels of geographical latitude, and with this grid it is theoretically possible to navigate.

Most physicists would regard the theory as of very low *a priori* plausibility. Even assuming that a bird's senses are so delicate that it can detect the tiny differences in Coriolis acceleration and magnetic field, these cannot be translated into latitude until the bird has compared each effect with a very precise estimate of its ground speed. Furthermore, the bird must somehow allow for the effect of cross-winds, which is normally much greater than the Coriolis drift. As if this were not enough, the bird would have to defy relativity theory, which says that it could not distinguish the effects of the normal atmospheric electric field from those induced by the bird's motion through the earth's magnetic field. Yet despite these difficulties, certain features of Yeagley's theory seem to have been borne out by his extensive studies with homing pigeons.

If further research should confirm the magnetic-Coriolis theory of bird navigation, the solution of this deep mystery of the animal world will be rather more astonishing than the original mystery. It would certainly be startling to learn that this effect has been used by generations of golden plovers and Arctic terns to hold true to their courses as they fly over thousands of miles of trackless oceans.

Whether the birds are really that clever or not, we may be quite sure that they inexorably tend to drift as they fly. All things that move over the surface of our spinning earth, whether birds, winds, rivers, ocean currents, explorers, cars, trains, bullets or rockets, are inevitably subjected to this effect as we view them in our terrestrial coordinate systems. Even when man gets away from his planetary home and stakes out better-behaved coordinate systems in interplanetary space, he will not be able to omit consideration of the Coriolis effect from his dynamics. For the solar system itself, along with all its near neighbors, is slowly but surely rotating around the hub of our galaxy, some 30,000 light-years away. Undoubtedly a precise analysis of the waddling of Antarctic penguins would show not only Coriolis effects due to the earth's circumpolar rotation, and similar but smaller effects due to our planet's annual circuit around the sun, but also a tiny Coriolis drift due to the stately whirl of our solar system about the center of the galaxy.

Here we find ourselves in somewhat the same situation as Archimedes with his earth-moving lever—all *we* need to demonstrate our point is a suitable coordinate system.

James E. McDonald is assistant professor of physics at Iowa State College.

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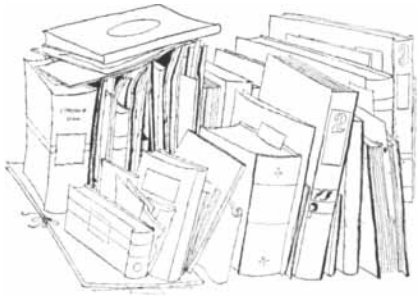
PROOF OF VALUE. Newark, N. J., cab driver Albert Cornell with his Plymouth taxi. Like the many other Plymouth taxis in hundreds of cities and towns, this car operates day and night in rain, shine, snow, sleet and heaviest city traffic. A car has to be tough to stand up under such a grind. The engineering skill that built such faithful performance into Albert Cornell's cab puts the same kind of hard-working value into all Chrysler-built cars.

SECRETS OF LONGER LIFE. That solid-looking metal bearing at left actually contains a myriad of tiny pores, each holding a supply of oil. This *Oilite* metal is used for bearings in hard-to-reach spots and other places in your car. *At right* is a "mirror" of tough metal, *Superfinished* by a special process which keeps wear of moving parts to a minimum. These two Chrysler Corporation developments, examples of practical imagination at work, are big reasons for the extra value in Chrysler-built products.



BOOKS

Two historical works: one on the ether and the other about Babylonian science

by I. Bernard Cohen

THE EXACT SCIENCES IN ANTIQUITY, by O. Neugebauer. Princeton University Press ($5.00).

HISTORY OF THE THEORIES OF AETHER AND ELECTRICITY: THE CLASSICAL THEORIES, by Sir Edmund Whittaker. Philosophical Library ($12.00).

THESE BOOKS represent two important but wholly different types of writing on the history of science. One is the attempt of a specialist who has devoted a lifetime of research to a small but crucial area to make accessible to general students of science and history information hitherto available only in difficult monographs and articles. The other is a survey of a broad field, written by a mathematician and physicist with historical insight and a philosophical bent. The first book is replete with new information, much of it discovered by the author. The second contains no new information that would alter current notions, but it does provide a readable and reasonably complete account of the development of ideas in a most important segment of physical thought.

Neugebauer's book deals mainly with Babylonian mathematics and astronomy. Our textbooks tell us that only two "facts" are certainly known about Babylonian exact science. One is that the Babylonians discovered the precession of the equinoxes and the other is that they determined that eclipses of the sun or of the moon occur at intervals of 223 months. Neugebauer shows that both of these ideas are wrong. It was the Greek Hipparchus who first discovered the precession of the equinoxes, and the discovery of the 223-month eclipse cycle was credited to the Babylonians only through a misinterpretation by Edmund Halley, the 17th-century British astronomer.

On the other hand, the Babylonians did make a number of important contributions to mathematics and exact science which anticipated the Greeks. They possessed enormous skill in dealing with numbers and worked out tables of squares, square roots, cubes, cube roots, sums of squares and cubes, reciprocals, and fractional ratios which enabled them to solve such complex problems as cubic equations of certain types, exponential functions used in the computation of compound interest, and so on. They knew and applied the "Pythagorean" theorem "more than a thousand years before Pythagoras."

Recognition of the important mathematical achievements of the Babylonians does not mean that we should cease to admire the achievements of Euclid and other Greek mathematicians. But Neugebauer suggests that we must re-evaluate the Greek contributions. Plato, for example, has been credited with many original ideas although, Neugebauer insists, his "contributions to mathematical knowledge were obviously nil." Furthermore, "Plato's doctrines undoubtedly have had great influence upon the modern interpretation of Greek sciences. But if modern scholars had devoted as much attention to Galen or Ptolemy as they did to Plato and his followers, they . . . would not have invented the myth about the remarkable quality of the so-called Greek mind to develop scientific theories without resorting to experiments or empirical tests."

One of the most interesting chapters of Neugebauer's book is a thrilling record of the steps by which our knowledge of the earliest exact science has been uncovered by a small band of devoted scholars, of whom the author is the outstanding living representative. Neugebauer writes in a vivid and trenchant style. Although some technical portions of the book are difficult to read, the important points are everywhere made clear. The reader should be warned that the title is somewhat misleading; this book is not a comprehensive history of "the exact sciences in antiquity" (Greek science has been well covered elsewhere) but "a survey of the historical interrelationships between mathematics and astronomy in ancient civilizations." As a history of the ancient mathematics and astronomy that was not produced by the classical Greeks, it is a magnificent creation.

Whittaker's history of the ether and electricity lacks the tendentious qualities that give Neugebauer's book such vitality. It is rather a sober and straightforward account of the main contributions in physics from the time of Descartes to about 1900, just before the birth of quantum theory and relativity. The book was originally published in 1910; this is a comprehensive revision. The author plans a second volume covering physics since 1900.

I know of no other history of electricity which is as sound as Whittaker's. On the other hand, much research has been done in the history of science in the 40 years that have elapsed since he first wrote the book, and in many places the text of this new edition could have been improved had Whittaker kept abreast of scholarly investigations in the history of physics.

Since this book deals with "the classical theories," one wonders whether the author intends in the second volume to consider the development of 20th-century physics in terms of "nonclassical" theories of the ether, particularly in view of P. A. M. Dirac's recent attempt to revive the ether concept in a new form. Whittaker points out that when the ether fell out of favor, interplanetary space became "vacuous." In this sense the vacuum had but one property, namely, that of electromagnetic wave propagation. "But with the development of quantum electrodynamics, the vacuum has come to be regarded as the seat of the 'zero-point' fluctuations of electric charge and current, and of a 'polarisation' corresponding to a dielectric constant different from unity. It seems absurd to retain the name 'vacuum' for an entity so rich in physical properties, and the historical word 'aether' may fitly be retained."

Sir Edmund is well known to physics students as the co-author of the "Whittaker and Watson" textbook and as the author of a great treatise on dynamics which has provided a classical background to quantum mechanics. In recent years he has turned his mind and pen to philosophical and theological matters, as in *Space and Spirit* and the Tarner Lectures *From Euclid to Eddington*. All those who have found stimulation from his works will read this informative and accurate history with interest and profit. They may, like the reviewer, regret that Sir Edmund has not altered the style of 1910, which was heuristic and expository and did not allow him an opportunity for philosophical reflection or summing-up. The final chapter, indeed, ends so abruptly that the reader's first reaction is that the binder lost a section of the book. Evidently the second volume will follow closely upon this one. We look forward to the second part with anticipation that it will help to illumi-

nate the general problems of current physics, just as this volume illuminates the progress of physics in the past 300 years.

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

LETTERS OF BENJAMIN RUSH, edited by L. H. Butterfield. Princeton University Press ($15.00). Mr. Butterfield, one of the editors of the great Princeton edition of Jefferson, here presents a meticulously edited collection in two volumes of more than 650 letters of Benjamin Rush, whose extraordinary career as a physician, psychiatrist, politician, educator, reformer, controversialist and patriot marks him as an outstanding American figure of the 18th century. The letters, which span 70 years (1761-1831), express Rush's vigor and originality and are couched in a delightful style. They evidence his contentiousness and pugnacity, his capacity for making enemies and his enduring loyalty to those he loved and respected, his "deadly earnestness," his uncompromising dedication to principle in all his activities, his disdain of vulgar opinion. "Expect to be persecuted for doing good," he advised Noah Webster, "and *learn* to rejoice in persecution." He wrote to John Adams that "during the whole of my political life I was always disposed to suspect my integrity if from any accident I became popular with our citizens for a few weeks or days." He had a Jefferson-like interest in everything under the sun, from clinical medicine to "psychiatry and forestry, veterinary science and the ventilation of ships, penology and chemistry." The letters also reflect his selfless devotion to his patients, his fabulous energy and restless creativity, his consecrated sense of social responsibility, his willingness to offer opinions on subjects as diverse as the origin of the prehistoric mounds in the Ohio country and "how a young woman should comport herself after marrying a widower with five children." The book is an exemplary work of scholarship, and anyone interested in biography, the history of science, or the ways of society in the Revolutionary period will enjoy it.

SOCIAL EVOLUTION, by V. Gordon Childe. Henry Schuman, Inc. ($3.00). In these lectures Professor Childe deals with the question: Is there a firm analogy between social and organic evolution? In anthropology, as he points out, archaeology plays the same role as paleontology does in zoology. It is from the study of material remains that preliterate societies must be reconstructed and their culture pieced together; by "culture" is meant not merely

their tools, equipment, weapons and houses but also their "social institutions, superstitions and behavior." The evidence is both "fragmentary and ambiguous," and the reconstruction poses intellectual problems of the subtlest and most difficult kind. Childe, one of the foremost specialists in prehistory, concludes in this closely reasoned and succinct survey that the hope of establishing a firm analogy between social and organic development must be abandoned. The Darwinian formula of variation, heredity, adaptation and selection can, with certain modifications, "be transfered from organic to social evolution, and is even more intelligible in the latter domain than in the former." Yet the differences between social and organic change are no less significant. The crucial distinction perhaps is that inventions and ideas are transmitted from one society to another, whereas there is no counterpart of this "diffusion" in biological evolution. Moreover, a cultural change may be established within a human population in a single generation; a mutation in a population of "even such a quick-breeding species as mice" would very likely take many generations to make itself felt. Childe's book is not always easy to read, and some of the conclusions impress one as forced and artificial, yet altogether it is an impressive and even fascinating analysis by a master of the subject.

TODAY'S SCIENCE AND YOU, by Lynn Poole. Whittlesey House, McGraw-Hill Book Company, Inc. ($2.75). This is a collection of science snapshots by the producer of the television program called "The Johns Hopkins Science Review." The topics include the electron microscope, isotopes, diffraction gratings, research on disease, insecticides, geochronology and "human engineering." Illustrations are supplied by Jeanne Bendick. The book, evidently based on TV scripts, shows pretty plainly why Mr. Poole's program, though a worthy effort with occasional interludes of high merit, so often fails of its mark. There are too many long and dreary monologues.

HIPPOCRATES ON INTERCOURSE AND PREGNANCY, translated by Tage U. H. Ellinger. Henry Schuman, Inc. ($2.50). This is a translation of *On Semen* and *On the Development of the Child,* two of the books in the famous collection known as the Hippocratic Corpus. The books, probably composed about 500 B.C., are not by the great Hippocrates of Cos, experts believe, but by a physician of the rival Cnidian school who has been called the first embryologist. They are achievements of considerable scientific importance and exceptional literary quality. Along with the usual range of fancies and doctrinal gibberish, they present brilliant descrip-

tions and conjectures about various aspects of heredity, plant growth, embryology and the physiology of reproduction.

THE PHOTOGRAPHIC STUDY OF RAPID EVENTS, by W. D. Chesterman. Oxford University Press ($5.00). A monograph on the various recording devices and methods for photographing such events as explosions, bird and insect flight, the air-flow past moving projectiles, the performance of underwater weapons, the motion of parts of high-speed tools. A number of remarkable plates illustrate what has been accomplished in this field of research.

PALEONTOLOGY AND MODERN BIOLOGY, by D. M. S. Watson. Yale University Press ($4.00). The Silliman Lectures for 1937 delivered by the Jodrell Professor of Zoology, University College, London. Professor Watson discusses what the study of fossil vertebrates contributes to our understanding of the history of life and the mechanism of evolution. A book for specialists of the sciences named.

PALOMAR: THE WORLD'S LARGEST TELESCOPE, by Helen Wright. The Macmillan Company ($3.75). The story of the 200-inch Hale telescope from its conception to its completion. A well-written, accurate and authoritatve book. The author, an astronomer, had access to the records of the remarkably large number of people who participated in the building of the great instrument.

THINKING: AN INTRODUCTION TO ITS EXPERIMENTAL PSYCHOLOGY, by George Humphrey. John Wiley & Sons, Inc. ($4.50). It is Dr. Humphrey's belief "that the history of the psychology of thinking consists largely of an unsuccessful revolt against the doctrine of association." His book records the criticisms of and the experimental attacks on this doctrine as well as the revisions which have been made in it over the centuries. An unusually readable, lucid and fair analysis of a complex topic, this volume is likely to be the standard reference on the psychology of thought for many years to come.

BASIC PSYCHIATRY, by Edward A. Strecker. Random House ($3.75). A readable account of the major features of modern psychiatry by one of its leading practitioners and teachers. Not a profound book, but one designed to increase public understanding of mental illnesses by communicating some facts about them in a simple, nontechnical and interesting manner.

INDUSTRY AND TROPICAL HEALTH. Published by The Harvard School of Public Health for The Industrial Council for Tropical Health ($10.00). These are

the proceedings of the First Industrial Tropical Health Conference held at Harvard in 1950. The purpose was to permit various industries conducting operations in underdeveloped areas of the world to report on their experiences in carrying out health and medical programs for the benefit of their workers and their families. Representatives of business concerns dealt with health problems in the Middle and Far East, tropical America and Africa; various specialists discussed the organization of industrial health services, the use of antibiotics in the Tropics, the control of infectious diseases, accident and health hazards and kindred topics.

PROCEEDINGS OF A SECOND SYMPOSIUM ON LARGE-SCALE DIGITAL CALCULATING MACHINERY. Harvard University Press ($8.00). Here are 39 papers presented in September, 1949, at a symposium held at the Computation Laboratory, Harvard University. The range of topics illustrates the rapid development of theory and practice in this comparatively new and intriguing branch of study, as well as the challenging possibilities that lie ahead. Among the subjects were various new types of computers; computational problems in physics, aeronautics and applied mechanics; the use of computers in psychological, economic and social research; the value of computation devices as models and as "springboards for new experiments" in general physiology; the electrostatic memory tube called the "Selectron." There is an interesting concluding paper by Louis Ridenour on the future of computing machinery.

HERBERT H. DOW: PIONEER IN CREATIVE CHEMISTRY, by Murray Campbell and Harrison Hatton. Appleton-Century-Crofts, Inc. ($3.50). A brief and somewhat pedestrian biography of a chemist, inventor and manufacturer who, in the familiar American tradition, starting with a tiny plant in which bromine was extracted from brine, built up one of the country's great industrial concerns, many of whose hundreds of products have contributed significantly to the technical and economic progress of this century.

RADIOISOTOPES: INDUSTRIAL APPLICATIONS, by G. H. Guest. Pitman Publishing Corporation ($4.50). Dr. Guest, formerly head of the Health Radiation and Isotopes Branch of Canada's atomic energy project, presents a convenient survey of the already large and rapidly growing field of industrial uses of radioisotopes. Simply written and effectively illustrated, this is a book for the general reader as well as the industrial scientist.

A HUNDRED YEARS OF PHYSICS, by William Wilson. The Macmillan Company ($3.50). A survey by the

Emeritus Professor of Physics in the University of London of the developments of this science from 1840 to the present. Wilson describes, among other things, the evolution of thermodynamics, electromagnetic theory, special and general relativity, the emergence of the quantum theory, the conduction of electricity, atomic physics. There is also a final chapter on astrophysics and modern cosmological speculation.

Also Noteworthy

ECLIPSES OF THE SUN, by Samuel Alfred Mitchell. Columbia University Press ($6.50). For the fifth edition of this standard work, Dr. Mitchell, director emeritus of the Leander McCormick Observatory at the University of Virginia, has condensed the historical chapters, eliminated material about his travels in the early part of the century to various parts of the globe on eclipse expeditions, and revised the text so as to include discussion of the latest solar problems and the methods devised to attack them.

THE THEORY OF ATOMIC SPECTRA, by E. U. Condon and G. H. Shortley. Cambridge University Press ($11.00). A reprint with minor corrections of an important work first published in 1935, which retains its value and authority despite the fact that the authors have been unable, by reason of other duties, to incorporate advances in the field over the past 15 years.

RADIATIONS FROM RADIOACTIVE SUBSTANCES, by Sir Ernest Rutherford, James Chadwick and C. D. Ellis. Cambridge University Press ($11.00). All who are interested in the subject of radioactivity will be grateful to the Cambridge University Press for making available in characteristically handsome format and at comparatively moderate price this reprint of a classic work of modern science.

AN INVESTIGATION OF THE LAWS OF THOUGHT, by George Boole. Dover Publications, Inc. ($4.50). A reprint of a work which first appeared in 1854, a classic of pure mathematics and symbolic logic. Strangely enough, this is the first American edition of this famous book and the publisher is to be thanked for making it available, at moderate cost, to students, scholars and libraries.

LONDON ESSAYS IN GEOGRAPHY, edited by L. Dudley Stamp and S. W. Woolridge. Harvard University Press ($5.00). Seventeen essays on various aspects of geography gathered in a memorial volume for the late Rodwell Jones, a leading British geographer, and one time head of the Joint School of Geography at Kings College and the London School of Economics.

THE AMATEUR SCIENTIST

About the banding of birds and the cooperative building of a telescope

Conducted by Albert G. Ingalls

SAMUEL JOHNSON, an opinionated man on any subject, had a theory that swallows, like frogs, spent the winter hibernating in the mud at the bottom of rivers and lakes. Unlike many of his pronouncements, this one was not delivered purely off the cuff; the irascible doctor actually conducted experiments. He captured a number of swallows and cemented bits of colored cloth to their tail feathers. He later recovered some of the marked feathers at the water's edge and triumphantly produced them as proof of his theory.

The good doctor overlooked the fact that birds molt their feathers, but his approach to the scientific problem was not entirely without merit. Bird-marking is today a large and fruitful enterprise. At the turn of the present century Danish ornithologists hit upon the scheme of tracing the travels of wild birds by banding them with a ring of light metal fastened loosely around a leg. A serial number and other information is marked on the band, and whenever a bird is recovered, the information is reported to a central clearing house. The system was soon adopted throughout the world.

Banded eaglet in nest

In the U. S. the sponsorship of bird-banding, started by the American Bird Banding Association, was taken over in 1920 by the Federal government. The project is now a branch of the Fish and Wildlife Service, with headquarters at Patuxent Research Refuge, Laurel, Md. It is under the direction of the biologist Seth H. Low.

Nearly six million birds have been banded since the U. S. program started; some 300,000 to 400,000 are tagged each year. A total of some half a million marked birds have been recovered. There are about 2,000 cooperating bird-banders, professional and amateur.

The object of bird-banding is to collect scientific data on the migration, dispersal and age of wild birds. It helps in the study of such characteristics as homing instinct, mating habits, navigation ability, flyways and related patterns of behavior.

Since only a small fraction of marked birds are recovered, it is desirable to band large numbers of them and to station banders and observers over the widest possible area. Hence the amateurs are strongly encouraged to take up this avocation.

It is an activity that can be pursued in the bander's own back yard or can take him afield on rugged adventure. It costs very little in cash and pays richly in diversion and discovery. All bird-banders must be licensed, because the trapping of wild birds without a license is prohibited in the U. S. Any citizen 18 years of age or over may apply to the Fish and Wildlife Service for a license. The applicant must prove that he can identify the various species and subspecies of birds and must give as references the names of three people with recognized ornithological qualifications.

Upon meeting these requirements the bander is issued a Federal permit and a supply of numbered aluminum bands of assorted sizes—free of charge—together with record forms and instruction pamphlets. He must then apply for a local permit in any state where he expects to do banding. He supplies his own traps and incidental equipment. At least once a year he must report to the Bird Banding Office, giving prescribed data on each bird he has banded or retaken.

Trapping and banding a bird without injuring it is an art, and no novice should undertake it without expert guidance. Two of the foremost bird-banding experts in the U. S., according to Lorene McLellan of Philadelphia's Academy of Natural Sciences, are John A. and Mabel Gillespie of Glen Olden, Pa. Mrs. Gillespie says that the precise number of years she has been a bander is outside the scope of this article, but in evidence of her experience she proudly exhibits a photograph of a common tern which she and her husband banded in New Jersey on August 5, 1923.

The Gillespies advise that one convenient way to band birds is to do it while they are still in the nest and unable to fly, but they must be sufficiently developed to hold a band that will be large enough when they are fully grown. This method is particularly suited for banding birds that nest in colonies and for eagles, ospreys and other birds of prey. For songbirds, ground-feeders and some wildfowl, bird-banders use a different technique, resorting to guile and temptation. They bait traps of various designs with tempting food. A bird that feeds on the ground, such as the native sparrow, readily follows a trail of food into a trap. Some banding traps are constructed on the principle of the maze; some are like funnel fish-traps; some have a trigger arrangement which closes the entrance automatically when a bird enters. There are also types of traps for catching birds that do not usually run on the ground. Properly conducted, trapping does birds no harm. Traps are never left "set" when the bander is absent, so that much of the time birds run in and out, feeding freely.

"Birds live in a world full of constant danger and surprise," say the Gillespies. "The experience of being trapped, if

Banded grackle

they are deftly handled and quickly released, is less disturbing to them psychically than an encounter with a cat. Within a few minutes the experience is all but forgotten. The birds usually remember the food, however, and this memory often brings them back. Sometimes a bird walks into a trap again within five minutes after it has been released. Now and then one retraps itself so persistently that it becomes a nuisance."

Banding a bird after it has been caught may be a painful experience—to the bander, not the bird. Some tough-looking specimens, such as the blue jay, usually submit with little struggle. On the other hand, cardinals and the seemingly meek purple finches may attack with a ferocity that sends the bander away nursing a blood blister. Eagles, according to the Gillespies, belie their fearsome reputation; the parents will flutter timidly at a distance of 50 feet or more, uttering feeble, unconvincing cries, as a bander climbs to their nest and casually places numbered bands on the legs of their young. But watch out for their cousins, the ospreys! A collaborator of the Gillespies, Frederick C. Schmid, once was nearly knocked out of a tree by an osprey which left the deep trail of its talons across his face.

As each bird is tagged, the bander records the serial number, the date, the kind of bird and if possible its sex and weight, and the location where it is banded. When a banded bird is recaptured, alive or dead, its recovery is reported through the Fish and Wildlife Service to the original bander. Thus a bander gradually accumulates case histories on individuals of many species. The record files of the Gillespies contain many hundreds of cards, some of which trace migratory cycles extending over periods as long as 15 years.

Few small birds survive longer than two years in the wild state, although their maximum expectancy is believed to be 9 to 12 years in nature and 18 to 20 years when protected in captivity. Mortality is appallingly high among young birds: generally 60 to 80 per cent in the first six months. Consequently most banders prefer to invest the extra time and effort required to band adults; the chances of recovering grown birds are much better.

More than 600 species of birds have been banded in the U. S. Mallard ducks lead all the others: banders have marked about half a million of them. After the mallard duck in order come the chimney swift, common tern, pintail, herring gull, song sparrow, robin, starling and purple grackle. Amateur banders account for about two-thirds of the banding activity, the remainder being done largely by government technicians and professional ornithologists.

Even a relatively low percentage of recovery can yield significant and sometimes dramatic information about bird migrations. From recoveries of just half a dozen birds it has been learned that the arctic tern nests in the Arctic Circle and winters in the Antarctic, an annual round trip of at least 25,000 miles!

One of the four flyways of the Canada goose

Migration takes many forms. Some species follow relatively narrow routes; others range half a continent or more. There are birds that never travel farther than between a valley and its neighboring hill. The cardinal does not migrate at all; it makes every effort to acquire a small, exclusive territory for itself, and if the climate permits, it stays there as long as the place suits it.

The Gillespies have given much study to the mating and nesting habits of backyard birds. One of their case histories concerns a pair of house wrens they banded one spring. After the wrens had raised a brood and the fledglings had left the nest, the female became interested in a second male which had been hopefully building a nest nearby, and she mated with him to produce a second family that summer. The next spring the female returned to the Gillespies' birdhouse and again started the season with a banded male they suspected to be her first mate of the preceding season, though they could not catch him. The male soon abandoned her, leaving her to raise the brood alone. Again she found a second mate and raised a second family. Late in July the Gillespies caught her first mate nesting two blocks away. He returned to one of their birdhouses the next summer, but the female did not appear again. Two or three years seems to be the average life span for a house wren.

"One year," said the Gillespies, "we tested the homing instinct of a female cowbird. A cowbird, like the European cuckoo, builds no nest and lays her eggs in the nests of other birds. She is not lacking, however, in a homing or maternal instinct. We carried our cowbird to various places some distance away from the nest several times and each time she returned promptly after we released her. Once she was released in the center of Wilmington, Del., 20 miles from home, and she was back in our trap within three hours. The late William I. Lyon of Waukegan, Ill., sent a banded cowbird to be released in Denver, Col. Twenty-five days later it was back in Waukegan. Many believe that performances of this kind are confined to homing pigeons. Actually many wild birds demonstrate a much stronger homing instinct than do the highly trained pigeons."

A by-product of bird-banding is the opportunity to collect and study parasites. Mites, flies, ticks and lice can easily be removed from the birds while they are being handled. One bander whose brother specialized in research on malaria was able to help by taking blood smears of migratory birds, thus providing information on how malaria may be spread by bird carriers.

The Gillespies have found especially thrilling the banding of ospreys, or fish hawks, which have the fierce nature usually attributed to the American eagle. They have banded 457 ospreys and have

heard from 70, an unusually high percentage. Forty were reported dead within a few months of the time when they were banded as nestlings. Some were found near their birth sites several seasons later. Osprey nestlings banded in July are usually well on their way South by fall. But one osprey was found in Florida less than seven weeks after it was banded, whereas his brother was still in Pennsylvania at Thanksgiving time.

"While we welcome reports of the travels of ospreys," say the Gillespies, "we regret that information generally comes only through their untimely deaths. They feed exclusively on fish and are no menace to the farmer but are often killed because they are mistaken for eagles. One of our ospreys, shot by a farmer in West Virginia, made local newspaper headlines: 'Eagle Killed by Local Hunter.'

"Our most unusual recovery was that of an osprey banded in Cape May County, N. J., on July 16, 1939. It covered 6,837 airline miles between that time and December 16, 1939, when it finally encountered a bullet in Rio de Janeiro. We feel sure that it did not fly in a beeline but probably followed coastlines and explored riverways, so its total distance must have been much greater than the airline routes.

"Our bird-banding work has been rich in unusual and varied experiences. There is nothing like the excitement of a nesting colony, where the air is full of flashing wings and wild screams, and young birds are everywhere about. Our activities have taken us to unfrequented beaches, deep woodlands and vast marshlands. We have enjoyed contacts with all sorts of people, not only in this country, but throughout the Americas and West Indies."

Anyone who finds a banded bird, dead or alive, will greatly assist the work of ornithologists by sending the band or its number to the Fish and Wildlife Service, along with a statement of the circumstances of the finding. The report should be made to the Bird Banding Office, Patuxent Research Refuge, U. S. Fish and Wildlife Service, Laurel, Md. Give your name and address, the date and the location where the bird was found. If you caught the bird alive, release it with its band; if the bird is dead, remove and flatten the band and send it in with your report. The Service will inform you of the known history of the bird, and notify the bander of the recovery. Many bird-banders make it a custom, when they get a notification from the Service, to write to the finder.

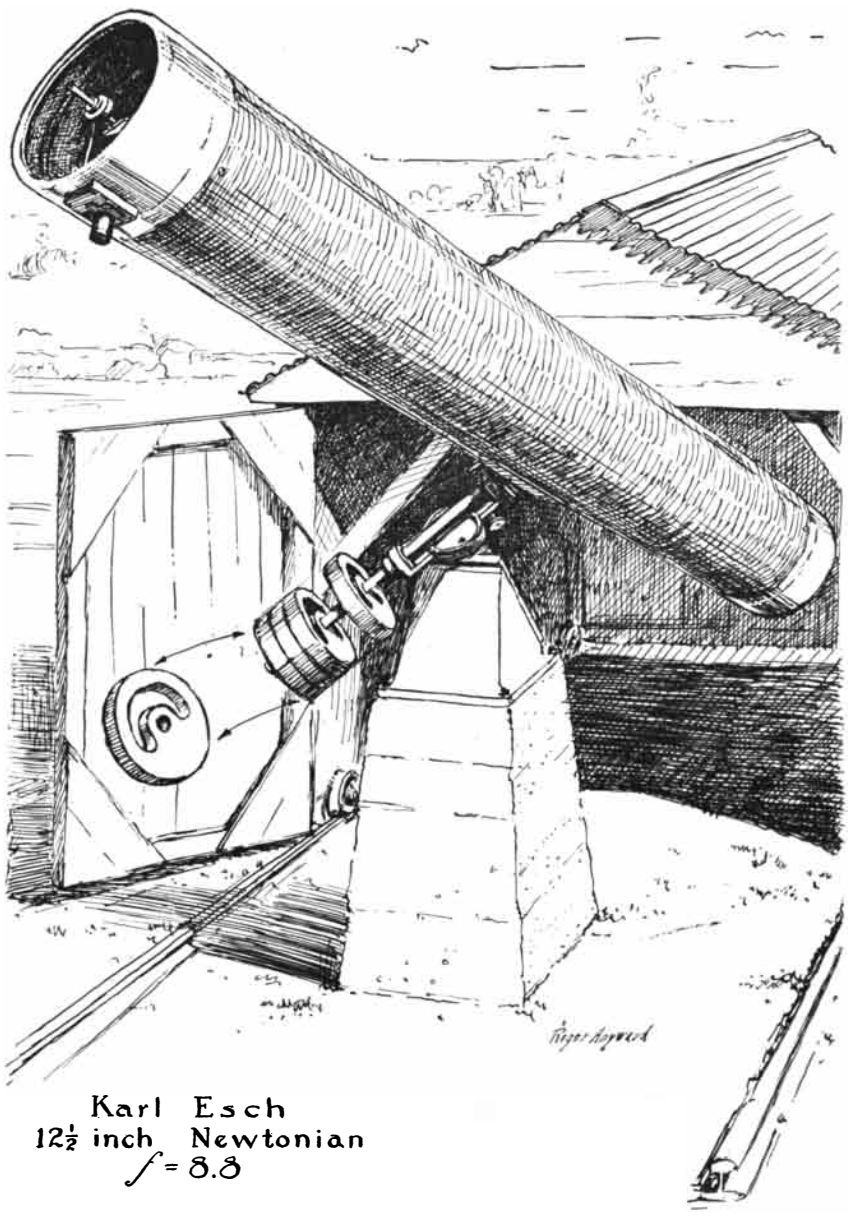
ORIGINAL but sound features mark the 12½-inch reflecting telescope shown in Roger Hayward's drawing on pages 89 and 90. The telescope was built by Karl Esch of Cherryvale, Kan., with the assistance of his relatives and friends. Esch discovered this department while studying engineering at Independence Junior College, became interested in telescopes and chose telescope making as a project in laboratory technique. He planned to make the typical beginner's six-inch size, and wisely set about it by cornering every person in Cherryvale, population 2,956, who might throw any light on the art. This led to the unexpected discovery of a 12½-inch Pyrex mirror that had lain for 22 years in a trunk. Perhaps noting the gleam in Esch's eye, the widow of the mirror's maker practically gave it to him. Esch and his physics instructor, W. L. Gillmore, found that the focal ratio of the mirror was $f/8.8$, and sent it away to be aluminized.

This windfall set the size of Esch's first telescope somewhat large. Fortunately he enjoyed a number of advantages. Although he was only 19, he had worked four years in a foundry run by his uncle, Hermann Esch, and had pottered about in its pattern shop. Thus he could make the patterns for several of the key parts and cast them in aluminum. His older brother, Robert Esch, a pattern designer, pattern maker and machine designer, helped him with the pattern work. A family friend, Charles Jones, whose hobby is fine work on a lathe, was also eager to help. Esch writes: "I humbly consider myself fortunate to have such resources. I have never met anyone who was not anxious to help with a practical suggestion. I am now convinced that all persons are interested in the heavens."

Though Esch had much help, he had only five months to complete his project before graduation. (The local newspaper reports that he did so as valedictorian of his class.) Actually it required the spare time of three additional months to finish the job; a total of 800 man-hours were expended by all its participants. The 15-page report that Esch turned in at Independence Junior College was entitled "Hours Spent and Problems Encountered in the Frantic Effort to Produce a Telescope."

Esch "inherited" a 120-pound 1⅞-inch shaft with roller bearings from an old boring mill, and this became his polar axis. The declination axis is 1 7/16 inches in diameter. The eccentric counterweights for balancing the tube on both its axes were the idea of his brother Robert. Jones "spent unaccounted hours at his lathe," Esch writes, "meticulously finishing all the castings for the telescope, and many hours were contributed by half a dozen others." He also gives credit to *Amateur Telescope Making*.

Telescope builders who do not slight the assistance of others have their reward: they are often suspected of soft-pedaling their own part. The correspondence between this department and Esch shows that his telescope was



The work of a Kansas family

planned and built under pressure. He was preoccupied with studies in chemistry, calculus, physics and surveying; yet he was able to infect his family and parts of two communities with enthusiasm for the project.

Esch continues: "The supreme thrill came with the first look through the telescope only four days before I entered the University of Kansas as an engineering physics major in September. Never have I witnessed more spectacular sights than those of brilliant, jewel-like, blue-white, orange or red stars, or chummy doubles, or the Milky Way. I found Jupiter and watched the change of position of its satellites with fascination. I was able to show all who aided me in the project, including my instructors, neighbors, friends and friends' friends, glimpses of what is above. Even my dog Mortimer attended. To make these wonders visible to others is indeed satisfying."

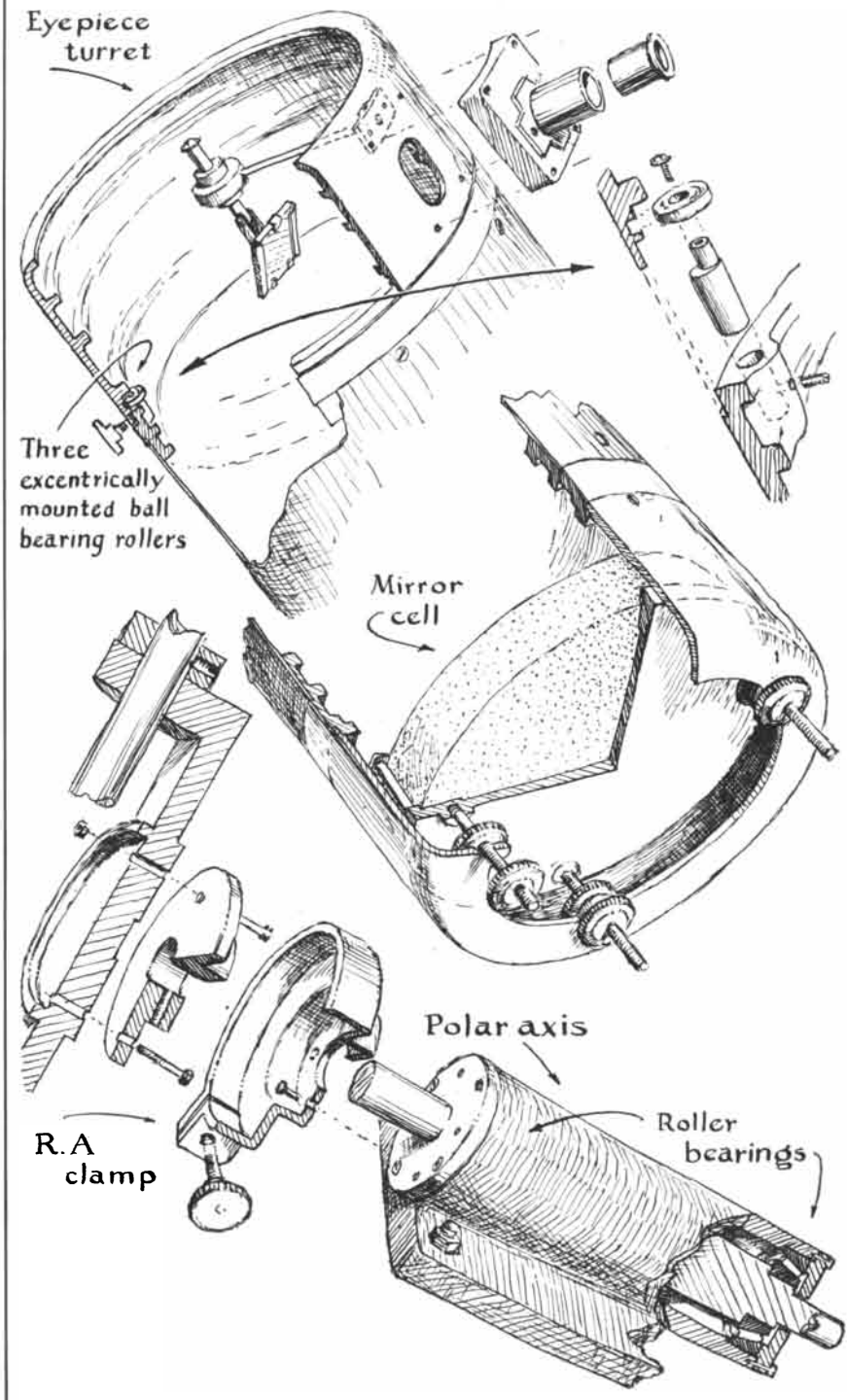
The support of the diagonal mirror in Esch's telescope is interesting. It is a single 3/16-inch radius rod held by a setscrew. Esch says that the support is stable and easy to adjust. Approximate collimation of the telescope required only an hour and a half, a fussy job that can last a lifetime, or shorten one's life. The washer at the top of the half-inch axial rod prevents the accidental dropping of the diagonal on the mirror.

The eyepieces of Esch's telescope are mounted on a rotating turret head. This arrangement is becoming more fashionable because it provides easy access to the eyepieces, but unless it is carefully made the eyepieces will not be properly collimated. And unless the turret head rotates smoothly and easily, and continues so throughout the life of the tele-

scope, its use will be much like wrestling with a bear. The Esch turret head is a 14-pound aluminum casting 14⅝ inches in diameter revolving on three equally spaced ball-bearing rollers. Each roller is on an excentrically mounted stub shaft, as shown in the upper right-hand corner of the drawing below. This feature, the design of Robert Esch, makes it possible to assemble or disassemble the turret. A lock-screw permits the observer to fix the turret in the most comfortable position. The internal ribs of the turret casting prevent it from warping out of round and binding against the rollers.

After alterations in the pattern for the turret casting, the same pattern was used to cast the mirror cell. The mirror rests on the inner rim of an aluminum plate. If a camera is affixed to the eyepiece end of the telescope, three one-pound lead counterweights may be screwed on the projecting ends of the cell-adjusting screws to balance it.

The 8½-foot tube of the telescope is made of 16-gauge cold-rolled steel welded and painted black inside. The



Details of the Esch telescope

total weight of the telescope is about 350 pounds. It rests on a concrete pier "which must weigh all of 40 tons," said Esch just after mixing and pouring the makings. The roll-off housing of the telescope measures 8 by 12 feet; in its design Esch was helped by his father, W. D. Esch.

Esch's last words might well be the motto of the telescope maker, who, unlike the burnt child, scarcely ever shuns the fire. Says Esch: "I think I can build a better one." Months after describing his first effort, he wrote that he had been watching the making of a new 27-inch reflecting telescope at the University of Kansas, where he has been studying astronomy as well as physics. He invited his father and brother to study it. "When they went home," Esch writes, "my brother's boss, Ivan Marrow, became so excited that he gave the time and lumber to make a pattern for a larger tube saddle and his foundry for casting it. New axes three inches in diameter are being substituted for the old, with ball bearings from truck axles. The telescope is to be equipped with setting circles and a drive. I am also grinding a 10-inch mirror to round out my apprenticeship."

IN THIS department last October F. A. Luck told how to make a simple apparatus for collimating a binocular. Unaware of this article, a professional scientific instrument maker undertook to collimate a friend's binocular by the "look, blink, look" method and wrote: "After looking at my target I became so dizzy and goggle-eyed that I walked straight against the side of the house." The Luck article was sent to him. His reply: "I made the Luck rig. Without it I would never have got the binocular collimated. It worked wonderfully well."

MANY telescope users regularly obtain the annual 80-page *Observer's Handbook* published by the Royal Astronomical Society of Canada, 3 Willcocks St., Toronto, Ont., at 40 cents. It contains data on the planets and the sky for each month, lists of brightest stars, clusters and nebulae, with finding coordinates and many other data useful to observers. *The Handbook of the British Astronomical Association,* published at 303 Bath Road, Hounslow West, Middlesex, England, at five shillings (about 70 cents), contains similar but not identical data.

RECENTLY the proposal was made that the many amateur astronomical disciples of Russell W. Porter combine to erect a memorial at his grave at Glenmere near Port Clyde, Me., where he lived for a number of years and began making telescopes. Unfortunately for this proposal, Porter made it abundantly clear while living that he wished his ashes to lie in an unmarked grave.

INDEX OF ADVERTISERS

MAY, 1952

AIRESEARCH MANUFACTURING COMPANY, DIVISION OF THE GARRETT CORPORATION 61
Agency: J. Walter Thompson Company

ALLEN-BRADLEY COMPANY 53
Agency: The Fensholt Company

ALUMINUM COMPANY OF AMERICA 46-47
Agency: Fuller & Smith & Ross, Inc.

AMERICAN CYANAMID COMPANY BACK COVER
Agency: Hazard Advertising Company

AMERICAN OPTICAL COMPANY, INSTRUMENT DIVISION 55
Agency: Baldwin, Bowers & Strachan, Inc.

AMPEX ELECTRIC CORP. 42
Agency: E. W. Shafer & Co.

BAKELITE COMPANY, A DIVISION OF UNION CARBIDE AND CARBON CORPORATION 39
Agency: J. M. Mathes, Incorporated

BAKER & ADAMSON PRODUCTS, GENERAL CHEMICAL DIVISION, ALLIED CHEMICAL & DYE CORPORATION 56
Agency: Atherton & Currier, Inc.

BECKMAN INSTRUMENTS, INC. 57
Agency: Dozier, Eastman and Company

BELL TELEPHONE LABORATORIES 7
Agency: N. W. Ayer & Son, Incorporated

BENDIX AVIATION CORPORATION, FRIEZ INSTRUMENT DIVISION 38
Agency: MacManus, John & Adams, Inc.

BERKELEY, EDMUND C., AND ASSOCIATES 64

BOEING AIRPLANE COMPANY 75
Agency: N. W. Ayer & Son, Incorporated

BOOK FIND CLUB, THE 3
Agency: Roeding & Arnold, Incorporated

BRUSH DEVELOPMENT COMPANY, THE 10
Agency: The Griswold-Eshleman Co.

CARBOLOY DEPARTMENT OF GENERAL ELECTRIC COMPANY 44
Agency: Brooke, Smith, French & Dorrance, Inc.

CHRYSLER CORPORATION 79
Agency: N. W. Ayer & Son, Incorporated

CONSOLIDATED VULTEE AIRCRAFT CORP. 83
Agency: Barnes Chase Company

CRUCIBLE STEEL COMPANY OF AMERICA 14
Agency: G. M. Basford Company

DOUGLAS AIRCRAFT COMPANY, INC. 63
Agency: J. Walter Thompson Company

DOVER PUBLICATIONS, INC. 82, 84

DOW CORNING CORPORATION 37
Agency: Don Wagnitz, Advertising

DU PONT, E. I., DE NEMOURS & CO., INC. 35
Agency: Batten, Barton, Durstine & Osborn, Inc.

DUREZ PLASTICS & CHEMICALS, INC. 36
Agency: Comstock & Company

EASTMAN KODAK COMPANY 69
Agency: Charles L. Rumrill & Co., Inc.

EDMUND SCIENTIFIC CORP. 89
Agency: Walter S. Chittick Company

EITEL-McCULLOUGH, INC. 65
Agency: Conner-Jackson-Walker-McClure

FENWAL, INCORPORATED 48
Agency: James Thomas Chirurg Company

FUNK & WAGNALLS CO. 82
Agency: Albert Frank-Guenther Law, Inc.

GENERAL ELECTRIC COMPANY 71

GENERAL ELECTRIC COMPANY, APPARATUS SALES DIVISION 1
Agency: G. M. Basford Company

GENERAL ELECTRIC COMPANY, X-RAY DEPARTMENT 43
Agency: Klau-Van Pietersom-Dunlap Associates, Inc.

GILSON SLIDE RULE CO. 64

GRAPHIC CALCULATOR COMPANY 65
Agency: Harold F. Lewis Advertising Company, Inc.

HEILAND RESEARCH CORPORATION, THE 76
Agency: Ed M. Hunter & Co.

HEWLETT-PACKARD COMPANY INSIDE BACK COVER
Agency: L. C. Cole Company

HILLYER INSTRUMENT COMPANY, INC. 6
Agency: Renner Advertisers

ILLINOIS TESTING LABORATORIES, INC. 54
Agency: The Buchen Company

JAEGERS, A. 89
Agency: Carol Advertising Agency

LEITZ, E., INC. 40, 92
Agency: Kelly, Nason, Incorporated

LEMAR SCIENTIFIC CORPORATION 90
Agency: Harvey Epstein Advertising, Inc.

LINGUAPHONE INSTITUTE 84
Agency: Kaplan & Bruck, Advertising

LOCKHEED AIRCRAFT CORPORATION 85
Agency: Hal Stebbins, Inc.

MELETRON CORPORATION 62
Agency: Welsh-Hollander Advertising

MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIVISION 12
Agency: The Aitkin-Kynett Co.

NORTHROP AIRCRAFT, INC. 58
Agency: West Marquis, Inc.

NORTON COMPANY, THE 2
Agency: James Thomas Chirurg Company

OXFORD UNIVERSITY PRESS 82
Agency: Denhard, Pfeiffer & Wells, Incorporated

PEERLESS CAMERA STORES 66
Agency: Newmark's Advertising Agency, Inc.

PFAUDLER COMPANY, THE 67
Agency: Charles L. Rumrill & Co., Inc.

POLAROID CORPORATION 4
Agency: Batten, Barton, Durstine & Osborn, Inc.

PRATT & WHITNEY AIRCRAFT, A DIVISION OF UNITED AIRCRAFT CORP. 9
Agency: Geyer, Newell & Ganger, Inc.

RADIO CORPORATION OF AMERICA, SPECIALIZED EMPLOYMENT DIVISION 41
Agency: J. Walter Thompson Company

REVERE COPPER AND BRASS INCORPORATED 45
Agency: St. Georges & Keyes, Inc.

SANBORN COMPANY 74
Agency: Meissner & Culver, Inc.

SORENSEN & COMPANY, INC. 70
Agency: Moore & Company, Inc.

SPONGE RUBBER PRODUCTS COMPANY, THE 11
Agency: Conklin Mann and Son

STATHAM LABORATORIES 68
Agency: Western Advertising Agency, Inc.

UNION CARBIDE AND CARBON CORPORATION INSIDE FRONT COVER
Agency: J. M. Mathes, Incorporated

UNITED BINOCULAR COMPANY 66
Agency: E. H. Brown Advertising Agency

UNITED STATES STEEL COMPANY 5
Agency: Batten, Barton, Durstine & Osborn, Inc.

UNITED TRADING COMPANY 84
Agency: Lloyd Advertising, Inc.

VICTOREEN INSTRUMENT COMPANY 73
Agency: The Carpenter Advertising Company

VIRGINIA SMELTING COMPANY 8
Agency: Gray & Rogers, Advertising

WHITE, DAVID, SALES COMPANY 88
Agency: Klau-Van Pietersom-Dunlap Associates, Inc.

WILEY, JOHN & SONS, INC. 81
Agency: Waterston & Fried, Inc.

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful. The lists are not intended as bibliographies of source material for the articles. The references selected will provide supplementary information.

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