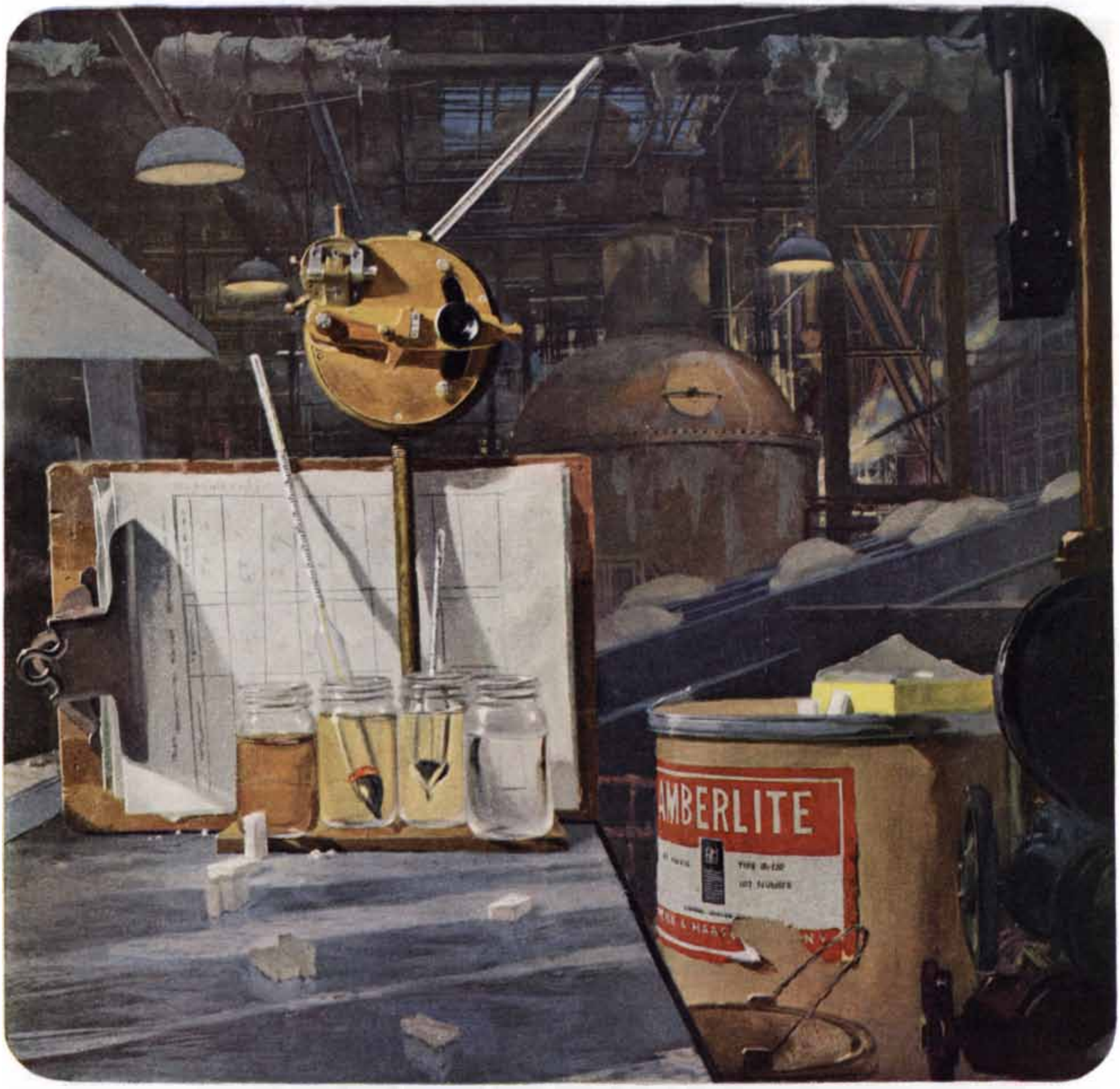
SCIENTIFIC AMERICAN

THE FORM OF CITIES

FIFTY CENTS

April 1954



Sugar by the ton: 99.99% pure

There aren't many chemicals—let alone foodstuffs—as chemically pure as sugar prepared from sirups treated with Amberlite® ion exchange resins. These resins remove ash from cane sirup solutions, cut down sugar loss in molasses, yield sugar of the highest quality.

Other products, too, benefit from proper treatment with the Amberlite ion exchangers. Soft curd milk for infants may be produced from cow's milk, for example. Stabilized cream and condensed milk, readily soluble in hot drinks, may be prepared. Crude glycerin can be converted to C.P. grade by an ion exhange process.

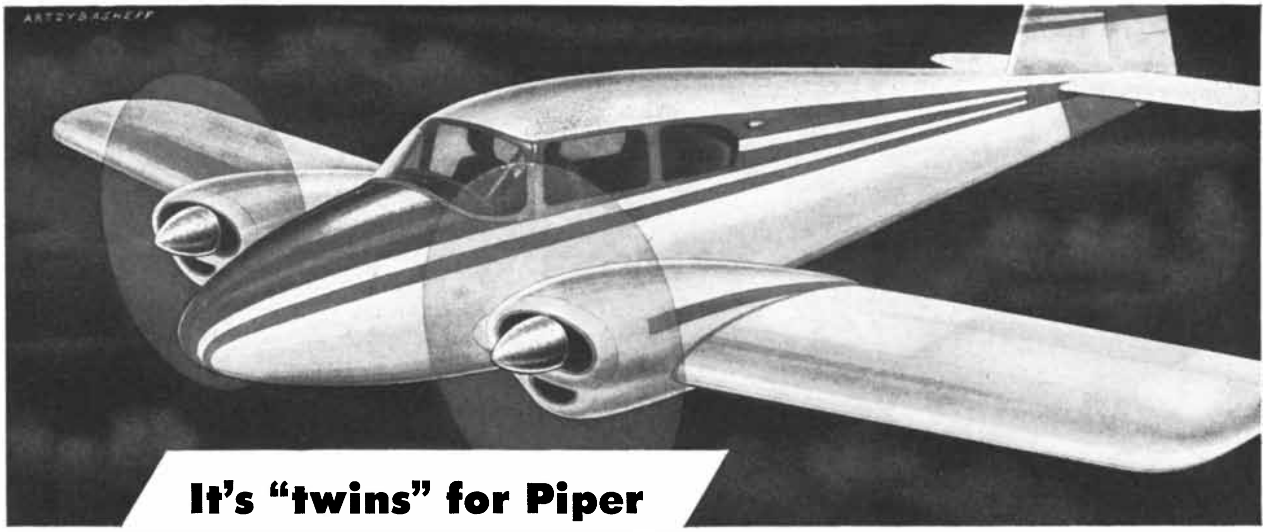
The list is long. Gelatin, amino acids, fruit drinks, bland sirups from fruit wastes, vitamins, dextrose sirups, and others may be purified at low cost by means of Amberlite ion exchange.

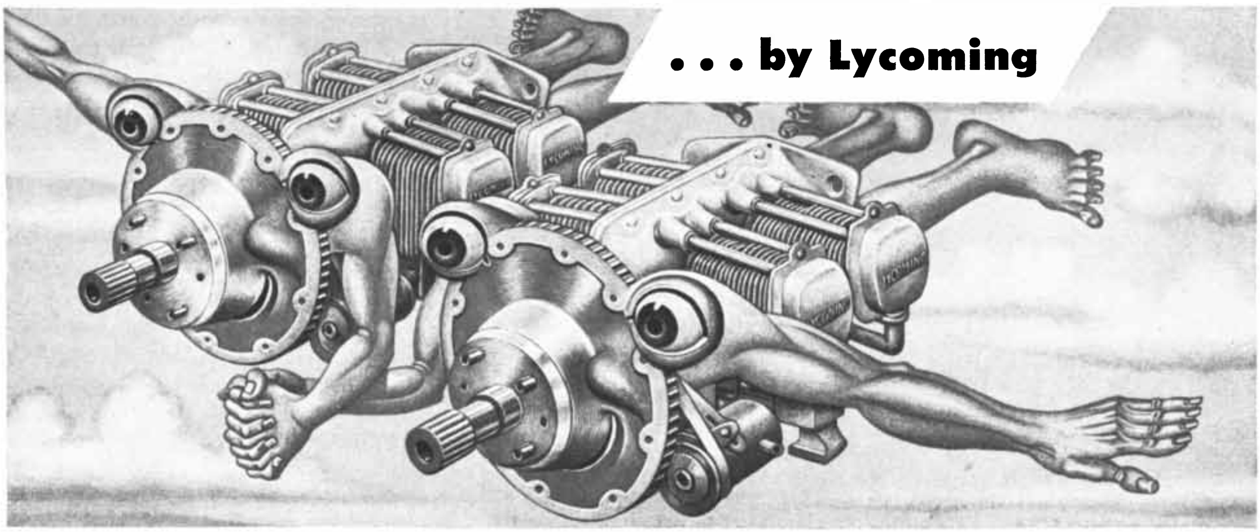
Why not write us about your problem . . . ask us about Amberlite ion exchange resins? Take this opportunity to find out why, in ion exchange, the *right* way is the *Amberlite* way.

Ask for "Amberlite Ion Exchange," 16 pages of technical information on the applications for ion exchange in industry.

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION, PHILADELPHIA 5, PENNSYLVANIA





This is the Piper Apache . . . the all-new executive plane that brings new economy to the twin-engine field while maintaining high standards of safety and dependability.

It is powered by two proven Lycoming 150-h.p. air-cooled engines designed especially for the Apache. These power plants provide an improved horsepower-weight ratio, new compactness . . . and are so powerful that the Apache can safely fly and land with a full load *on one engine alone.*

We suggest a test flight in the Piper Apache for a new experience in air travel.

Just off the press! "THE LYCOMING STORY". . . 40 interesting, illustrated pages that give you information about the many Lycoming services listed below. Write for it on your letterhead.

Aircraft Engines
Industrial and Tank Engines
Engine Overhaul
Generating Units

Turbine Engineering and Research
Engineering Design and Development
Hardened and Ground Precision Parts
Gears and Machine Parts

Complete Assemblies
Heat-Treating and Plating
Steel Fabrication
Castings
Boilers

FOR RESEARCH • FOR PRECISION PRODUCTION
LOOK TO **Lycoming**

DIVISION OF AVCO MANUFACTURING CORPORATION — STRATFORD, CONN.
Manufacturing plants in Stratford, Conn., and Williamsport, Pa.

LETTERS

Sirs:

As a science teacher I was very much interested in Fletcher G. Watson's article "A Crisis in Science Teaching" (SCIENTIFIC AMERICAN, February). From my observations of some 14 years as a teacher of science and mathematics, I think that the situation is even more alarming than Dr. Watson indicates, and relief is nowhere in sight. Although he states the existing situation quite well, and ably analyzes future trends, he nowhere sinks his teeth into the real problem: the cause and the remedy. He almost does this near the end of his article when he states: "Considering the meager rewards of teaching, either social or financial, one wonders why anyone chooses to become or remain a teacher."

In my own school we have quite a number of teachers of science and mathematics who hold engineering degrees, some of us with master's degrees. Nearly all of us have done some graduate work both in our specialties and in education, and this is quite common in the secondary schools of my city. What is the reward for all this scholarship and devotion to duty? Today we find ourselves in the bottom third of the nation's income groups! . . .

We with engineering degrees entered teaching during the depression years. Since employment by industry of engineers and scientists has picked up, we have not been able to recruit new teach-

Scientific American. April, 1954; Vol. 190, No. 4. 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 Martin M. Davidson, Advertising Manager, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y.

Subscription correspondence should be addressed to Circulation Manager, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y.

Change of address: Please notify us four weeks in advance of change. If available. kindly furnish an address imprint from a recent issue. Be sure to give both old and new addresses, including postal zone numbers, if any.

Subscription rates for U.S.A. and possessions: 1 year, $5; 2 years, $9; 3 years, $12.50. Canada and Latin America: 1 year, $6; 2 years, $10; 3 years, $14. All other countries: 1 year, $8; 2 years, $12; 3 years, $16.

What do <u>YOU</u> want to protect?

1. FOOD PROCESSORS in all fields call on Fenwal THERMOSWITCH® thermostats to "take care" in many vital operations: bakers use them to guard humidity and temperature of dough . . . these units control the heat-sealing temperature for tea bags and frozen food packages . . . even monitor the water bath temperature for washing eggs. *Design* makes the THERMOSWITCH resistant to vibration, corrosion and dirt.

2. SCHOOLS and other public and commercial buildings entrust fire detection to Fenwal DETECT-A-FIRE units incorporated into alarm or release systems. They operate on the new Rate-Compensation-Actuated principle, which means they alarm *instantly* when the temperature of the surrounding air reaches the danger level. This means safe and economical protection for life and property.

3. FABRICS, HATS, SHOES — in the manufacture of all these, Fenwal THERMOSWITCH units are used. They control temperature in the rollers of fabric finishing machines, in the ironer that shapes hat brims, in the heated forms that smooth linings into shoes. Throughout industry THERMOSWITCH units are solving problems of temperature control — at lower costs.

4. THIS ENGINEERING LABORATORY at Fenwal lays the groundwork for quality products. It first assures *exactness* of engineering model specifications and establishes the specifications for future, daily quality control. Fenwal engineers are constantly creating better devices to help protect products and processes, people and property. Why not send us your problems? Fenwal Incorporated, 304 Pleasant St., Ashland, Mass.

Fenwal

ELECTRIC TEMPERATURE CONTROL AND DETECTION DEVICES

PROTECTING PRODUCTS AND PROCESSES . . . PROPERTY AND PEOPLE

ers with the same qualifications, and we veterans cannot be expected to carry the increasing burden indefinitely.

One cannot criticize capable young people if they choose careers which are more highly respected and more rewarding. They are not fools. If they were, we shouldn't want them as teachers. They are intelligent enough to select careers which offer them more, "socially and financially," and with the least expenditure of effort, anxiety and time on their part. . . .

Dr. Watson points out that the standards for science teachers throughout the country as a whole are low, and that at the same time there is a critical shortage of teachers. Obviously we cannot raise our standards if we already have difficulty finding people to fill the jobs. The only logical procedure is to make the rewards much greater in order to attract more people. Then we can raise the standards as high as we please. There are always people who are willing to aim high if it is worth while. A first step in attracting capable young people to the teaching profession, and holding on to the ones we have, is offering them more money. That is only the first step.

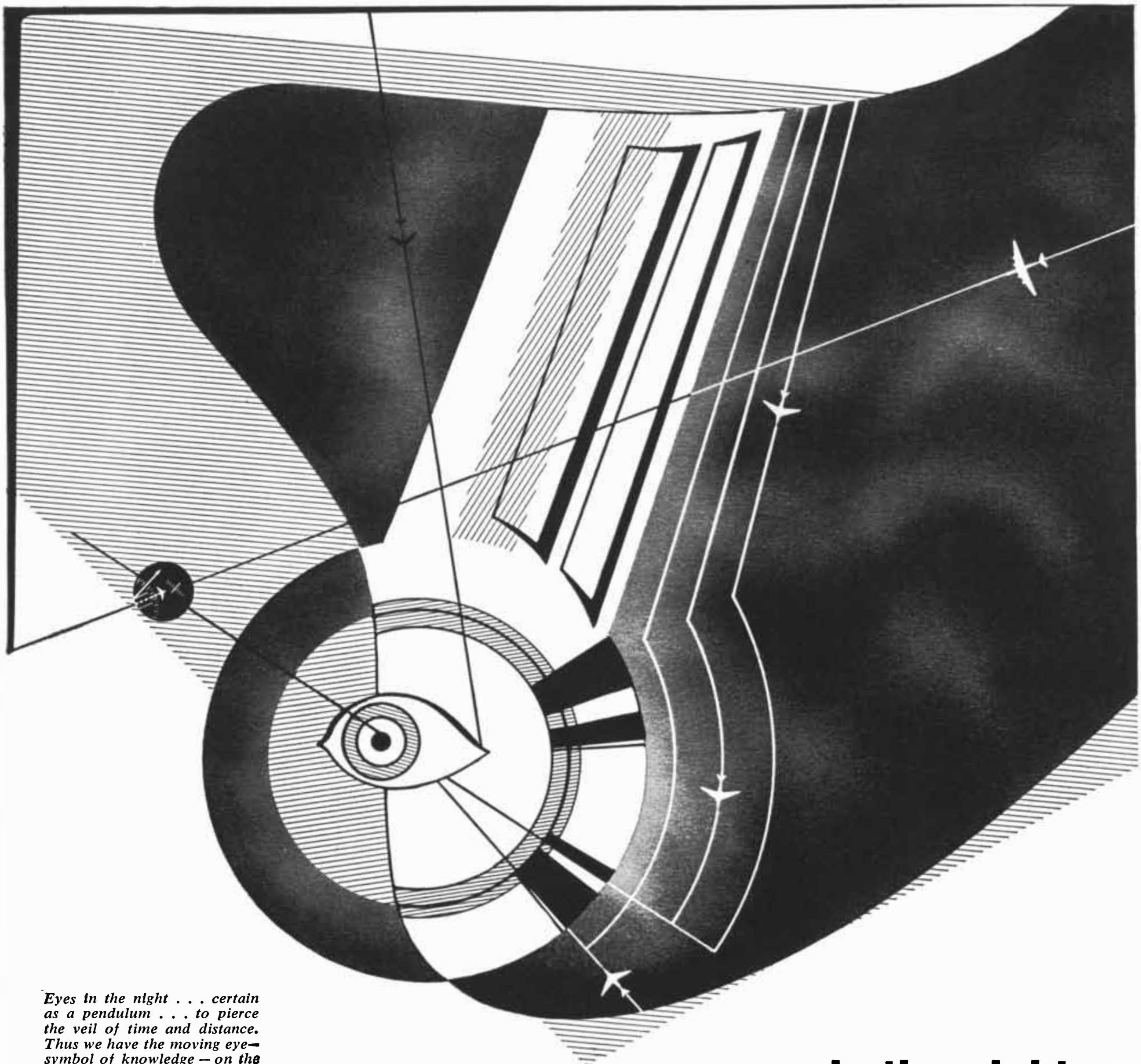
PETER S. PAPPAS

Flushing, N. Y.

Sirs:

I was pleased to see Fletcher G. Watson's article dealing with the crucial problems of high school science education. Those of us who teach in the high schools have been aware for some time that education is at the crossroads, and that further neglect of its serious problems will cause irreparable damage to our welfare.

The key problem of salaries was pointed up for me when a prize "G" pupil (not so hot) came back to school recently to visit his teachers. This pupil had been a nuisance to everyone. He had failed miserably in most of his courses. He viewed school as a place to have a good time. He was disruptive in class and shortened the life expectancy of most of his teachers. Yet here he was, proudly telling me of his job as a bottler in a brewery at $93 a week. And what of his teachers? After four years of college and a fifth year for a master's degree or equivalent (now required in New York City high schools) the teacher would have to start as a substitute making $60 a week, serve for several years before the grueling examination for regular teachers would be passed,



Eyes in the night . . . certain as a pendulum . . . to pierce the veil of time and distance. Thus we have the moving eye—symbol of knowledge — on the ever predictable pendulum.

eyes in the night

The victory over time and darkness is certain with Kollsman instruments. Certain because of our quarter century dedication to accuracy in controls and instrumentation.

Today our activities encompass four fields:

AIRCRAFT INSTRUMENTS AND CONTROLS
OPTICAL PARTS AND DEVICES
MINIATURE AC MOTORS
RADIO COMMUNICATIONS AND NAVIGATION EQUIPMENT

Our manufacturing and research facilities . . . our skills and talents, are available to those seeking solutions to instrumentation and control problems.

kollsman INSTRUMENT CORP.

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF *Standard* COIL PRODUCTS CO. INC.

and then go on as a regular teacher for another eight years or so until our "G" pupil's salary level would be reached.

Can we honestly tell our pupils that it pays to have an education? Advantages of greater cultural values from a college education, better citizenship, etc., cut little ice with the young folk. Why should they study when the "rewards" for education are so meager? The pupils see this and loaf in school. The teachers see it and strive to get out. College graduates see it and go elsewhere.

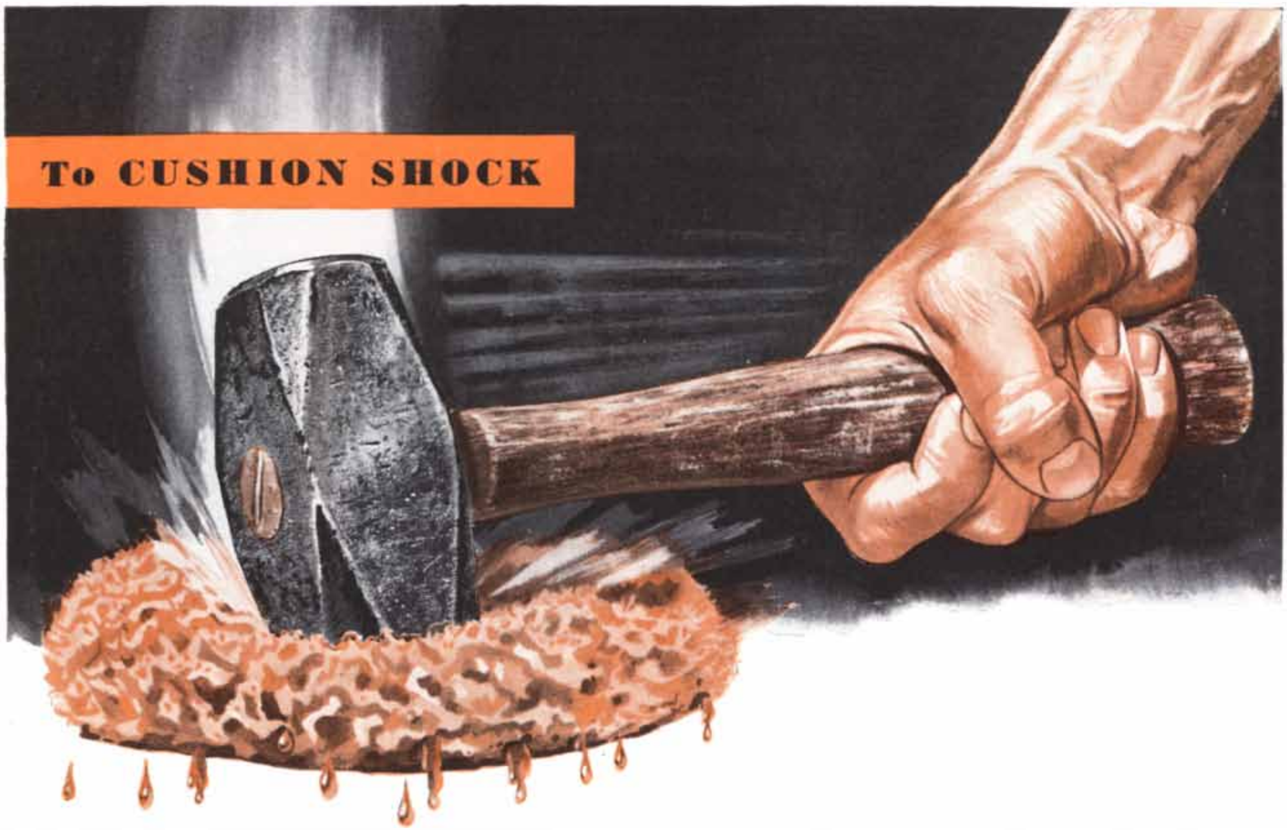
Along with this major factor is a continuous decline in teaching conditions. Leaking roofs, peeling paint, leaky plumbing are common in many schools (certainly in New York). In the science field it shows up as a gradual elimination of laboratory work in the high schools. Schools are so crowded that laboratories are soon used for regular classrooms. In short order the gas jets disappear, faucets come off, closet doors come loose and the "laboratory" becomes a shambles. In the school at which I teach about half of the science classes meet in rooms that have no water or gas. Electrical outlets have been improvised. Many of these "science" rooms have regular wooden desks instead of demonstration tables.

Coupled with this growing physical deterioration is a deterioration in student quality. I do not know the cause of this deterioration. Perhaps it is the growing "amuse me" attitude engendered by television and "comics." Perhaps it is caused by defective educational procedures (at all levels) in which the pupil is permitted to get by with little or no work. It is not uncommon for us to get pupils from lower-level schools who are two or three years retarded in reading or arithmetic and whose grades in these subjects are 85 or 90. When they come to us, the pressure is there for us to do the same, otherwise a majority of the pupils would have to be failed. Bright pupils with good potential tend to be lost in this shuffle, and to come through high school with high grades for little or no effort.

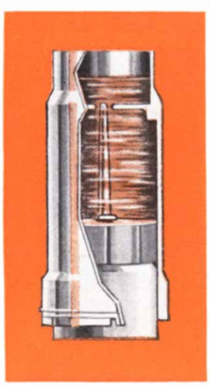
It is obvious to me, and to most teachers, that the public will wake up one day aghast at the results of years of neglect of the fundamental problems of education in a democracy. It would be far wiser for men of public stature to begin to tackle the roots of this problem now before the deterioration is permitted to proceed much further.

HYMAN RUCHLIS

Brooklyn, N. Y.



How we can sponge up unwanted impact with Drops of Oil!



Whatever your product—if it is subjected to unwanted impact, that impact may cost you money. Our knowledge of impact-absorption can be important to you.

Perhaps it is destructive vibration; perhaps crushing impact. We know how to control both with impact absorbers using air and oil, or oil alone, engineered for precise control.

The world's largest "impact absorbers" are the landing gears we make for giant aircraft. They cushion tons crashing to earth at tremendous velocities. The principles we apply work as well absorbing pounds as they do tons. Size is no obstacle—biggest, smallest, or in-between. Our skill has made us the world's largest manufacturer of this kind of product.

These facilities and knowledge are ready for your engineers to draw upon.

Write for the booklet which will give you a brief idea of these facilities and typical product applications.

CLEVELAND PNEUMATIC
TOOL COMPANY
Dept. D-4 • Cleveland 5, Ohio

BALL-SCREW MECHANISMS • AIR-OIL IMPACT ABSORBERS

World's Largest Manufacturer of Aircraft Landing Gear

To MOVE with less EFFORT

Combining the screw with balls makes Cleveland Pneumatic's patented ball-screw actuator drive with as little as 10% friction . . . compared to as much as 65% for ordinary screw drives. You can cut the weight of a drive system, reduce its space, lessen its cumbersomeness, increase its control accuracy, and provide pin-point positioning. Let our engineers work out your ideas for our ball-screw mechanisms.

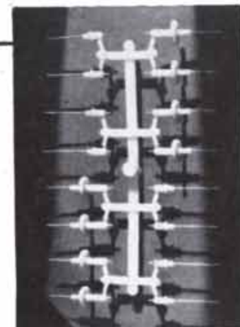
A TECHNICAL REPORT from Du Pont

● *Properties and uses of Du Pont nylon resin*

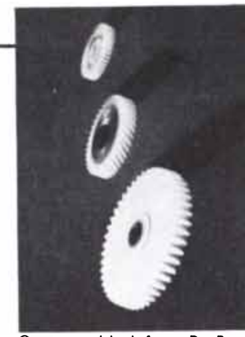
Nylon is the name for a family of polyamide resins developed by the Du Pont Company, all of which are related in composition. This group of compounds features extreme toughness, abrasion resistance, form stability at high temperatures, strength in thin sections, lightness in weight, chemical resistance and easy moldability.

On the opposite page are detailed the outstanding properties of one of the Du Pont nylon molding powders, a general-purpose nylon. By using the unique combination of properties this Du Pont nylon offers, engineers and designers have been able to develop many new design and product improvements. Six of nylon's many thousands of applications, serving practically every industry, are shown here.

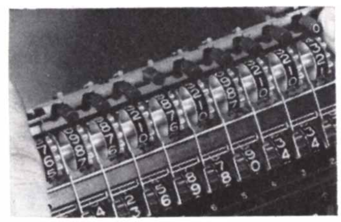
Have you and your company considered general-purpose Du Pont nylon in terms of your own product design problems? For additional information on the properties, applications and processing of this unique engineering material, mail in the coupon today.



Blood-donor and receiver needles as they come from the mold illustrate how Du Pont nylon is readily molded around metal inserts.



Gears molded from Du Pont nylon have excellent resistance to abrasion, provide quiet operation, and may be produced economically by injection molding.



Counter dials with integral gear, and other parts of this calculating machine are molded of Du Pont nylon. The nylon parts cost much less than parts replaced . . . give quiet, smooth operation.

Coil forms of Du Pont nylon offer an excellent example of the molding of thin and intricate yet tough sections. Du Pont nylon has good dielectric properties for electrical applications.

This complex molding is the tension pulley on a yarn-tension brake for textile machinery. Du Pont nylon provides resiliency and strength in thin sections.

Du Pont nylon is an ideal material for translucent lenses, such as this one. Du Pont nylon is heat-resistant, won't discolor, eliminates breakage during assembly and use.

Du Pont **NYLON**	**ALATHON***	**LUCITE***	**TEFLON***
Tough	Polyethylene Resin	Acrylic Resin	Tetrafluoroethylene Resin
Abrasion-Resistant	Excellent Dielectric Properties	Clear, Transparent	Heat Resistance
Strong in Thin Sections	Flexibility and Toughness	Outdoor Durability	Chemical Inertness
Form Stability	Tasteless, Odorless, Non-Toxic	Unlimited Range of Colors	Dielectric Properties
	Excellent Water Resistance	Ability to Pipe Light	Non-Sticky Characteristics

**Trade-mark of E. I. du Pont de Nemours & Co. (Inc.)*

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

TYPICAL PROPERTIES* OF DU PONT NYLON

MECHANICAL

MECHANICAL			METHOD
Tensile strength,	−70°F.	15,700 p.s.i.	D-638-46T
	73°F.	10,900 p.s.i.	D-638-46T
	170°F.	7,600 p.s.i.	D-638-46T
Elongation,	−70°F.	1.6%	D-638-46T
	73°F.	90%	D-638-46T
	170°F.	320%	D-638-46T
Modulus of elasticity	73°F.	400,000 p.s.i.	D-638-46T
Shear strength		9,600 p.s.i.	D-732-46
Impact strength, Izod	−40°F.	0.4 ft.-lb./in.	D-256-47T
	73°F.	1.0 ft.-lb./in.	D-256-47T
Stiffness,	73°F.	250,000 p.s.i.	D-747-48T
Flexural strength	73°F.	13,800 p.s.i.	D-790-45T
Compressive stress at 1% deformation		4,900 p.s.i.	D-695-44T
Creep in flexure		90	**
Hardness, Rockwell		R 118	D-785-48T

THERMAL

THERMAL		
Flow temperature	480°F.	D-569-48
Coefficient of linear thermal expansion per °F.	5.5×10^{-5}	D-696-44
Thermal conductivity	1.7 B.T.U./hr./sq.ft./°F./in.	—
Specific heat	0.4	—
Deformation under load at 122°F. and 2000 lb./sq.in.	1.4%	D-621-48T
Heat-distortion temperature, 264 lb./sq.in.	150°F.	D-648-45T
Heat-distortion temperature, 66 lb./sq.in.	360°F.	D-648-45T

ELECTRICAL

ELECTRICAL			METHOD
Dielectric strength, short time		385 V/MIL	D-149-44
	Step-by-step	340 V/MIL	D-149-44
Volume resistivity		4.5×10^{13} OHM-CM.	D-257-46
Dielectric constant,	60 cycles	4.1	D-150-47T
	10^3 cycles	4.0	D-150-47T
	10^6 cycles	3.4	D-150-47T
Power factor,	60 cycles	0.014	D-150-47T
	10^3 cycles	0.02	D-150-47T
	10^6 cycles	0.04	D-150-47T

MISCELLANEOUS

MISCELLANEOUS		
Water absorption	1.5%	D-570-42
Flammability	self-extinguishing	D-635-44
Specific gravity	1.14	D-792-48T
Average mold shrinkage	0.015 in./in.	—
Compression ratio	2.1	D-392-38
Resistance to weathering	good	—
Basic color	light cream, translucent	—
Resistant to:	esters, ketones, common solvents, alkalies, weak acids	
Not resistant to:	phenol, formic acid, concentrated mineral acids	

*Some of the physical properties are dependent on the moisture content of the nylon which may be as high as 2-2.5% under normal exposure.

**Term "creep in flexure" is a measure of the deformation under a prolonged standard load. Results here represent mils deflection in 24 hrs. of a 1/8″ x 1/2″ bar, 4″ span, center-loaded flatwise to 1,000 lb./sq. in., minus the initial deflection.

Note: This table shows the typical property data for Du Pont nylon FM-10001.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department,
Room 364 Du Pont Bldg., Wilmington 98, Delaware.

Please send me more information on Du Pont nylon resin: Uses ☐; Processing Techniques ☐; Properties ☐. I am also interested in receiving more information on: Du Pont "Teflon" tetrafluoroethylene resin ☐; "Alathon" polyethylene resin ☐; "Lucite" acrylic resin ☐.

Name ____________________

Title ____________________

Firm Name ____________________

Street Address ____________________

City ____________________

State ____________________

Type of Business ____________________

50 AND 100 YEARS AGO

SCIENTIFIC AMERICAN

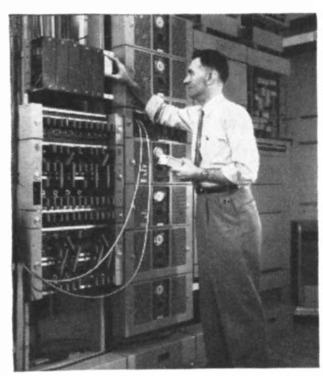
APRIL, 1904: "The recent sailing of the Panama Canal Commission for the Isthmus on their first visit of inspection, coupled with the announcement from Paris that the suit of the Republic of Colombia against the Panama Canal Company has failed, must bring home to the people of the United States the conviction that the long-deferred construction of the canal across the Isthmus is at last about to commence. Accompanying the commission were Dr. Col. William C. Gorgas and Dr. Louis La Garde, of the United States Army, and Dr. Ross, of the Navy, who are to have supervision of the sanitary arrangements on the Isthmus."

"Uranium is one of the rare metals for which there is a limited demand. The present world's consumption amounts annually to about 300 tons of uranium ore, yielding from 3 to 13 per cent of the metal. For several years Colorado has supplied the United States output, nearly all of which goes to Europe. France, England and Germany are the principal markets."

"In the report of the Marine Hospital Service of Vera Cruz on yellow fever the announcement is made that the parasite causing yellow fever has at last been discovered. The remarkable work recently done in Cuba by the late Major Walter Reed and his colleagues convicted the mosquito of the spread of yellow fever. This important work was done despite the fact that the actual cause of yellow fever, the germ itself, was not known. Several previous investigators, including Surgeon General Sternberg, thought they had found it, but subsequent study disproved this. According to the Vera Cruz commission their microbe is a form of protozoon, similar to the malarial parasite, and not an ordinary bacterium."

"To the many methods of purifying, modifying and preserving milk must now be added a process for *homogenizing* it so that it will keep almost indefinitely without change in its physical condi-

WHAT TIME IS GREEN?



To keep colors true in television, signals must be kept on one of the world's strictest timetables. Equalizers that correct off-schedule waves are put into place at main repeater stations of the transcontinental radio-relay system.

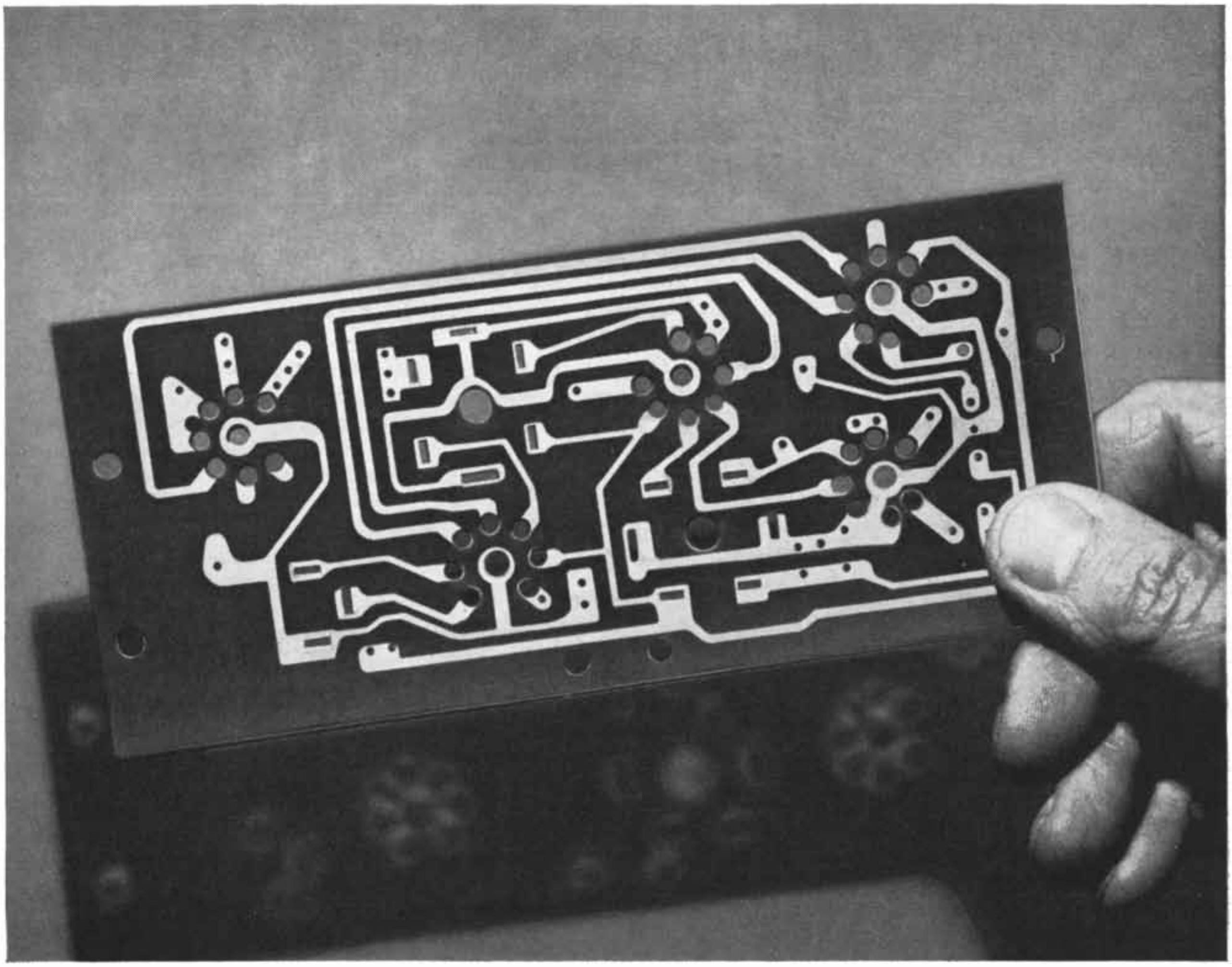
tion. The process has been perfected and patented by Gaulin of Paris, and is coming into use in Europe. It is designed to reduce all the fat globules in milk to a very minute size, by means of pressure and concussion."

"E. Salvioni has devised and accurately examined a microbalance which consists of a thin thread or very thin ribbon of glass or other material, fixed at one end and placed in a closed case; the case also contains a number of small weights (the larger of platinum wire, the smaller of silk thread) which, with the aid of a handle, can be placed on the flexible thread or ribbon. The flexure of the thread when loaded is observed by means of an ocular micrometer. A glass thread 10 centimeters long, and one of two tenths of a millimeter in diameter, will support by flexure a weight of more than 100 milligrammes, and, if provided with an optical arrangement which magnifies 100 times, will serve to weigh to one thousandth of a milligramme."

"A correspondent, Hudson Maxim, writes us about a new theory of radio-activity. He says, 'Some time ago I discussed the subject of radio-activity with Mr. Francis I. du Pont of Wilmington, Del., a noted inventor and expert practical chemist. This subject has always been of intense interest to him, and it is to him that we are indebted for the new theory. It is his opinion that radio-active substances are catalytic agents; that radium is a very powerful catalytic agent; that radio-activity is a form of catalysis, and that the action which radium has upon surrounding bodies is due to this cause.' "

SCIENTIFIC AMERICAN

APRIL, 1854: "The great Expedition which was sent out to survey the Isthmus of Darien, for the purpose of constructing a ship canal, has turned out to be a disastrous failure so far as the possibility of executing such a work is concerned. Surveying parties were sent out by the American, French and British governments, all working in unison, but moving on different lines. Now this splendid scheme, in which three great nations indulged such hopes, for uniting the Atlantic and Pacific by a short-cut, is dashed at once to pieces. Nothing now remains for us, then, but a railroad, to shorten the distance—commercially—to



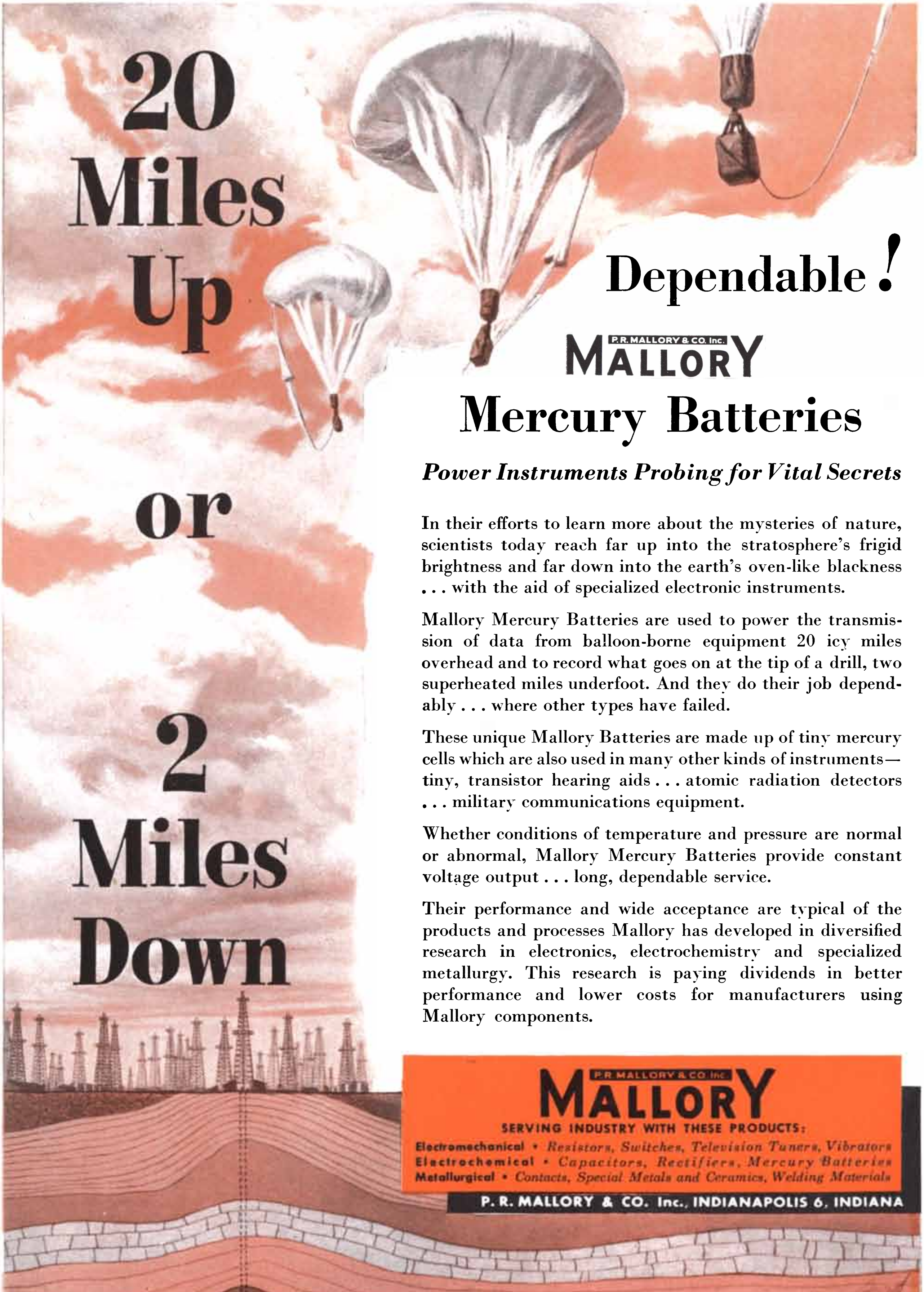
our Pacific possessions, and the sooner one is constructed so much the better for our country."

"Courage in the battle-field is celebrated in history and in song, but little is said of the courage exhibited in pursuing scientific investigations, though often displaying more real elements of bravery than ever were called into action in war. It is said that when Arago and Dulong were employed by the French Government to make experiments upon the subject of the construction and safety of steam boilers, the task executed by the two philosophers was one of as much danger as difficulty. The bursting of boilers, to which they were constantly exposed in a limited locality, was more hazardous than that of shells upon a battle-field, and, while military officers who assisted them—men of tried courage in the conflict—grew pale and fled from the scene, the savants proceeded coolly to make their calculations and to observe the effects of temperature and pressure upon boilers almost at the very point of explosion."

"Lieutenant Maury, whose authority in the department of science to which he has devoted himself is held in universal respect, has satisfied himself on the practicability of establishing a submarine telegraphic communication between America and Europe, by the way of Newfoundland and Ireland. He says that from Newfoundland to Ireland the distance is 1,600 miles, and throughout the whole way the bottom of the sea seems to be a plateau which has been placed there for the special purpose of holding the wires of a submarine telegraph—so deep as to be beyond the reach of icebergs and drifts, and so shallow that the wires may be readily lodged upon the bottom."

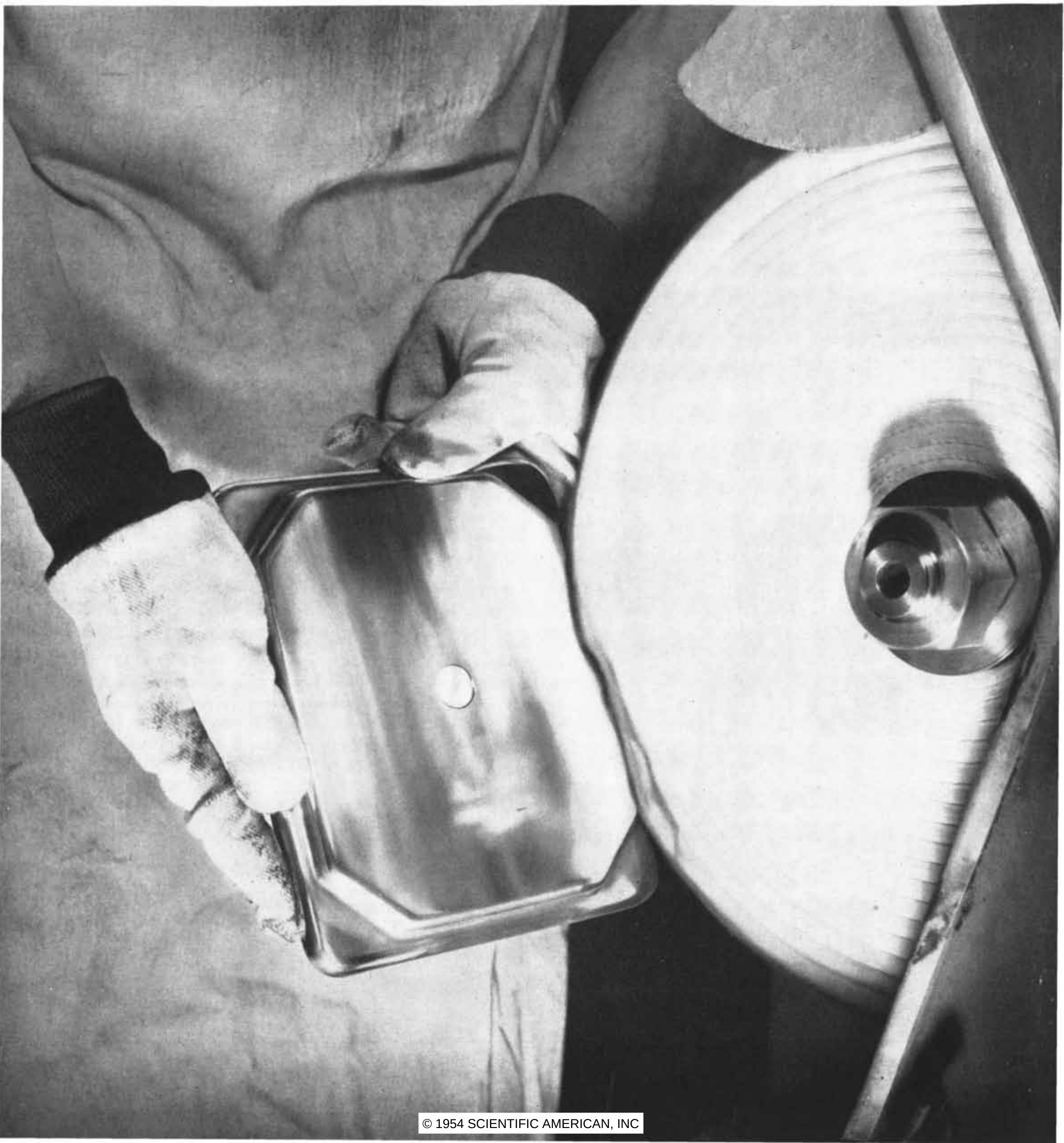
"The deepest sea soundings yet effected were made on the 30th October last, by H.M. Ship *Herald*, in the course of a passage from Rio de Janeiro to the Cape of Good Hope. It was not until 7,706 fathoms of sounding line had run off the reel that the sea bottom was reached."

"We learn from the testimony taken in the remarkable case of the explosion of the steamship *Kate Kearney* that the common manner of stopping leaks in steamboat boilers is to throw in them horse dung, ropes chopped fine, potatoes, meal, &c. Sometimes lead is melted and poured in the holes, and sometimes wooden pegs answer the purpose."


20 Miles Up or 2 Miles Down
Dependable!
P. R. MALLORY & CO. Inc.
MALLORY
Mercury Batteries
Power Instruments Probing for Vital Secrets
In their efforts to learn more about the mysteries of nature, scientists today reach far up into the stratosphere's frigid brightness and far down into the earth's oven-like blackness . . . with the aid of specialized electronic instruments.
Mallory Mercury Batteries are used to power the transmission of data from balloon-borne equipment 20 icy miles overhead and to record what goes on at the tip of a drill, two superheated miles underfoot. And they do their job dependably . . . where other types have failed.
These unique Mallory Batteries are made up of tiny mercury cells which are also used in many other kinds of instruments—tiny, transistor hearing aids . . . atomic radiation detectors . . . military communications equipment.
Whether conditions of temperature and pressure are normal or abnormal, Mallory Mercury Batteries provide constant voltage output . . . long, dependable service.
Their performance and wide acceptance are typical of the products and processes Mallory has developed in diversified research in electronics, electrochemistry and specialized metallurgy. This research is paying dividends in better performance and lower costs for manufacturers using Mallory components.
P. R. MALLORY & CO. Inc.
MALLORY
SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical • Resistors, Switches, Television Tuners, Vibrators
Electrochemical • Capacitors, Rectifiers, Mercury Batteries
Metallurgical • Contacts, Special Metals and Ceramics, Welding Materials
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

Look What's New In Metals

Anaconda develops a brass that's easier to polish...offers new and better electrical wires and cables . . . and gets down to "pay-dirt" in new Nevada copper mine

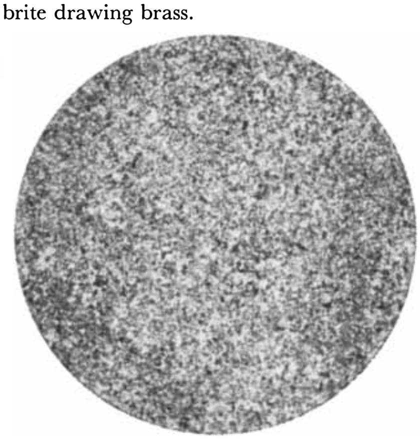


NEW TYPE OF BRASS MAKES POLISHING EASIER. How important is polishing on brass? Plenty! Every day, manufacturers of stamped and drawn brass products make millions of lipstick holders, vanity cases, fishing lures, automobile parts, building hardware items. But to "finish" these products for lacquering, or for bright nickel or gleaming chromium plate, they must be polished. And that operation is expensive—often costs more than the metal itself!

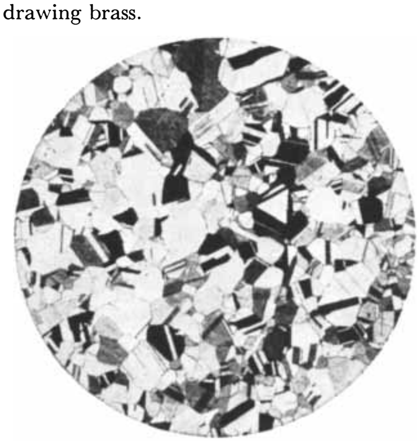
Now, for the first time, these manufacturers are being offered a new type of brass—Formbrite*. This ductile and readily formed metal differs from ordinary brass by having a superfine grain structure. That makes polishing easier and faster—often cuts the cost in half. And Formbrite makes a more lustrous, more attractive, more scratch-resistant product, too. No wonder it is rapidly becoming a favorite with consumer and manufacturer alike.

***FORMBRITE** is registered in the U. S. Patent Office. It was developed and is sold by The American Brass Company, an Anaconda subsidiary.

75x magnification of superfine-grain Formbrite drawing brass.



75x magnification of ordinary, coarse-grain drawing brass.



DO YOU DO THIS TOO OFTEN? Inadequate wiring is usually at fault when circuits overload. Don't blame the appliance . . . don't use an oversize fuse! See your electrical contractor. Anaconda Wire & Cable Company has developed new wires—many insulated with modern plastics—to help him replace and add to outgrown circuits most economically. Plenty of copper—always the No. 1 metal to carry electricity—means plenty of wire to rewire U. S. homes and factories.

WHEN it's made of metal, you can count on Anaconda and its manufacturing subsidiaries to find new and better ways to meet U. S. needs. They supply products as varied as Everdur® Copper-Silicon Alloys for boat fastenings...zinc-plated and synthetic-covered flexible *steel* conduit for wiring . . . *copper* and *aluminum* signal wire for railroads . . . *copper* sheets for roofing.

Progress—through better products for U. S. industry and U. S. consumers—is the aim of Anaconda and its subsidiaries. As part of a fully integrated business working with *many* metals, each is better able to achieve this aim . . . *today and tomorrow.* 54273

ANACONDA

PRODUCERS OF: Copper, zinc, lead, silver, gold, platinum, cadmium, vanadium, selenium, manganese ore, ferromanganese, superphosphate and uranium oxide.

MANUFACTURERS OF: Electrical wires and cables, copper, brass, bronze and other copper alloys in such forms as sheet, plate, tube, pipe, rod, wire, forgings, stampings, extrusions, flexible metal hose and tubing.

"ANACONDA" IS A REGISTERED TRADEMARK

THIS IS A SEVEN-TON BITE OF COPPER ORE! Since opening day in November 1953, these big electric shovels have been working at Anaconda's new open-pit mine at Weed Heights near Yerington, Nevada. The ore is being blasted and trucked to the adjoining treatment plant. There it is crushed and leached, after which the ensuing copper-rich precipitate is shipped to Anaconda's Montana plants for smelting and refining. "Yerington" is the nation's newest copper mine.

THE AUTHORS

ABRAHAM STONE ("The Control of Fertility"), director of the Margaret Sanger Research Bureau and vice president of the Planned Parenthood Federation of America, is a medical pioneer in the field of human fertility. This is his second appearance in these pages; he reviewed Simone de Beauvoir's book, *The Second Sex*, in the April, 1953, issue. A constant traveler to international conferences on parenthood, marriage and family education, Stone attended three last year, in India, Stockholm and Lisbon. He is one of the vice presidents of the International Planned Parenthood Federation. In addition to these activities and his private practice as a physician, he is associate professor of preventive medicine at New York University's Bellevue College of Medicine, an editorial board member of the journals *Fertility and Sterility* and *Marriage and Family Living* and author of the widely used *A Marriage Manual.*

FRANK A. BROWN, JR. ("Biological Clocks and the Fiddler Crab") is chairman of the Department of Biological Sciences at Northwestern University. His most recent research work has been in the relatively new field of persistent biological rhythms. Every summer he and his family of four trek to the Marine Biological Laboratory at Woods Hole, Mass., where most of his work on fiddler crabs was done. For several years he directed a course in invertebrate zoology at the Laboratory; he is now an executive member of its board. A native of New England, Brown was drawn into biology by a stimulating teacher at Bowdoin College, from which he graduated in 1929. His doctor's degree is from Harvard (1934). His early work was on response mechanisms in animals, particularly with reference to light and its regulatory effect on color. He is also an authority on crustacean endocrinology and the physiology of vision in lower animals. Brown is president-elect of the Society of General Physiologists.

WILLARD F. LIBBY ("Tritium in Nature") is the originator of the well-known radiocarbon method for determining the age of old organic materials, as well as of the newer tritium method which he describes in this issue. Now 45, he was born in Colorado, raised on a ranch near Santa Rosa, Calif., and entered the University of California in

CORNING GLASS BULLETIN

FOR PEOPLE WHO MAKE THINGS

3-WAY glass grounds electricity, conducts it, and fights off heat rays . . . Glass gun shoots oil . . . An introduction to solving some materials problems.

3-way glass

E-C glass is a PYREX brand glass panel (or tube) permanently bonded on one side with a thin (20-millionths inch) transparent coating that conducts electricity. (The E-C stands for Electrically Conducting.) Run a current through it and you get an efficient heating element. Ground it and it drains off charges of static electricity, as any metal would. (But you can *see through* the E-C glass). Let it stand by itself, with or without electrical or ground connections, and E-C glass reflects infrared heat rays.

E-C radiant glass panels drying lacquer on plastic sheets.

Since 1950 we've worked with a number of customers on applying E-C glass, quite successfully, as a heating element in space heaters, home appliances and industrial drying equipment. (It's especially useful where an uniformly distributed heat flow is wanted.)

One of the most recent applications is shielding certain elements of IBM's new electronic calculator from static that might disrupt the workings of this remarkable abacus.

And a well-known steel producer has erected a curtain of E-C glass between shear pulpit operators and the intense heat of the fiery steel bars moving through the shear. (About 60% of those sizzling infrared rays bounce off the E-C curtain.)

Not every day, but every now and then, some manufacturer, bent on new product development or old product improvement, shoots a question at us, "What about this E-C glass of yours?"

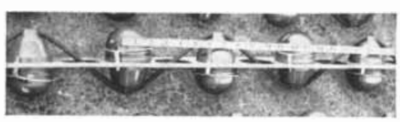
▼ We're always glad to tell people what we know that's pertinent to their problems. And we'll be glad to tell you, too, if you're interested. Just check the E-C square in the coupon below.

glass gun

Nobody would have believed five years ago that a gun made of glass could shoot anything, but today the oil industry is using glass guns to shoot holes in heavy steel oil well casings to release trapped oil pools miles deep in the ground, making run-out wells produce profitably again and even bringing some dry holes to life.

These guns are called glass jet perforators. They contain shaped explosive charges and a 4-inch charge will cut a neat hole through six inches of steel without leaving even a burr.

McCullough Tool Company of Houston, Texas, was far from happy with the containers for their shaped charges. After considerable experimenting with various metal containers, McCullough asked, could we design and manufacture a glass container that would stand the tremendous pressures involved, but completely disintegrate after the charge exploded? (Metal containers left debris in the well which often clogged valves and pumps.)



Up to thirty or forty glass jet perforators are mounted in series on a metal strip for lowering into oil well casing.

How we found the answer in PYREX heat-resisting glass perforators may interest you even if you don't own an oil well. It illustrates another instance where we were able to help a customer find a successful answer to a design and engineering materials problem.

▼ An article in the October-November 1953 Corning GLASSMAKER tells the story in detail. Just check the appropriate square on the coupon below and we'll be glad to send you a copy.

solving problems

If you've been wrestling with a materials problem that still refuses to lie down long enough for the count, we encourage you to thumb a few informative pages that describe briefly and succinctly some of the things other people are doing today with glass.

In a matter of only a few decades glass has changed from a simple, fragile material of limited utility into a versatile material whose uses are unnumbered. You'll glimpse something of the meaning of this conversion by remembering that glass can now be made as light as cork or heavier than iron, hard as steel or soft as cotton, thin as tissue or thick as a wall; that it can be fragile or strong, a conductor of electricity or an insulator, a selective transmitter or absorber of radiation in the infrared or the visible, the ultraviolet or the X-ray regions of the spectrum, *as required*.

There may be an idea or two for you in these 48 pages of informative but nontechnical reading about some of the things people are doing these days with glass.

▼ This parade of antithetical utilities roughly indicates the flexibility and versatility of modern glass. If any of them suggest a possible answer to that stubborn problem of yours and you'd like to modernize your information about glass, quite painlessly, the few pages we mentioned three paragraphs ago make up an illustrated booklet we'd like to send you. Just make your mark in the "Glass and You" square and mail the coupon to us.

If the items covered on this page don't seem to bear on any problem of yours, we may have the information you need at our fingertips. We'd like to hear from you.
▼

CORNING GLASS WORKS
CORNING, N. Y.

Corning means research in Glass

CORNING GLASS WORKS, 30-4 Crystal Street, Corning, N. Y.

Please send me more information about E-C glass ☐; a copy of the Oct.-Nov. '53 GLASSMAKER article ☐; "Glass and You" ☐.

NAME________________ TITLE________

COMPANY________________

ADDRESS________________

CITY__________ ZONE____ STATE________

1927, bent on becoming a mining engineer. He soon shifted to chemistry and obtained his doctorate in that subject. Then he taught at Berkeley for eight years. In 1941, while working under a Guggenheim fellowship at Princeton University, he was drawn into the group working with Harold C. Urey at Columbia University on atomic bomb problems. After the war he moved to a professorship at the University of Chicago and into its new Institute for Nuclear Studies. He has received many honors, including election to the National Academy of Sciences in 1950. His first book, *Radiocarbon Dating*, was published in 1952. He wrote an article entitled "Hot Atom Chemistry" for SCIENTIFIC AMERICAN in March, 1950.

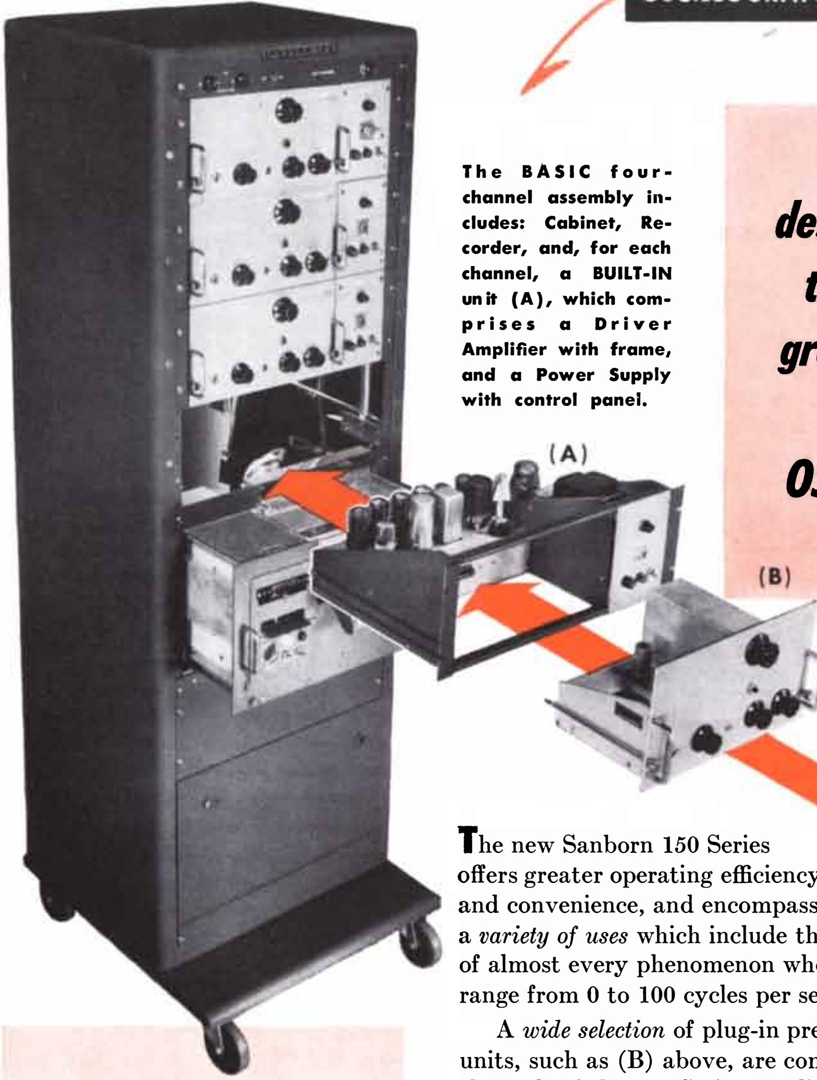
KEVIN LYNCH ("The Form of Cities") is assistant professor of city planning at the Massachusetts Institute of Technology School of Architecture and Planning. His interest in the form of cities goes back to his eighth-grade days in Chicago, where he remembers drawing up "house plans" and a "slightly sketchy one-sheet plan" for the whole city. Lynch has crowded both academic and practical studies into a few years. After two years in Yale University's School of Architecture, he joined Frank Lloyd Wright's group of apprentices in 1937. Later he spent a year in civil engineering at Rensselaer Polytechnic Institute, a year with the architects Schweikher & Lamb of Chicago and five years in the Army. He graduated from M.I.T. in 1947, put in a year as a city planner in Greensboro, N. C., and then returned to M.I.T. to teach. He is 35, the father of three small children.

LAWRENCE P. LESSING ("The Late Edwin H. Armstrong"), a member of the editorial board of this magazine, was for many years a friend and admirer of the great electronics engineer and radio inventor.

L. V. HEILBRUNN ("Heat Death") has studied the colloid chemistry of protoplasm ever since his Ph.D. thesis at the University of Chicago in 1915. "Call it lack of originality, if you will," he says. "I prefer to think of it as steadfastness of purpose." He is one of two editors of *Protoplasmatologia*, an international treatise now in publication in Vienna, and the author of a book on the chemistry of protoplasm which was published in Berlin in 1928 and is now a collector's item. He also wrote a text, *Outline of General Physiology*. Born in Brooklyn, N. Y., in 1892, Heilbrunn had his under-

SANBORN 150 SERIES
OSCILLOGRAPHIC RECORDERS

A NEW design concept that brings even greater versatility to industrial OSCILLOGRAPHIC RECORDING



The BASIC four-channel assembly includes: Cabinet, Recorder, and, for each channel, a BUILT-IN unit (A), which comprises a Driver Amplifier with frame, and a Power Supply with control panel.

You have a CHOICE of readily interchangeable, plug-in Preamplifiers (B) for EACH channel, as described below.

The new Sanborn 150 Series offers greater operating efficiency and convenience, and encompasses a *variety of uses* which include the accurate recording of almost every phenomenon whose frequency spectrum lies in the range from 0 to 100 cycles per second.

A *wide selection* of plug-in preamplifiers, or "front end" units, such as (B) above, are completely interchangeable in any or all channels of the 150 Series amplifier section, where they simply plug in to the driver amplifier and power supply, (A) above, which are already in place.

Available plug-in Preamplifiers include: AC-DC, CARRIER, SERVO-MONITOR, DC COUPLING, LOG-AUDIO, and LOW LEVEL. Blank plug-in assemblies are also available for users to make input circuits for special measurement problems.

And, there are the popular Sanborn advantages: a high torque movement (200,000 dyne cms per cm deflection), direct *inkless* recording in *true rectangular coordinates*, and provision for code and time markings.

A new catalog on Sanborn Oscillographic Recording Systems and their components will be sent gladly on request.

OTHER SANBORN IMPROVEMENTS

- **Extended frequency response.**
- **Improved regulated power supply.**
- **Individual stylus temperature control for EACH channel.**
- **Improved, single control, paper speed selector. Nine speeds — 0.25 to 100 mm/sec.**
- **Recorder slides out, if desired, for better view of recorded events, or for notations on record (illustrated at right).**
- **Improved control of input signals by use of 1, 2, 5 ratios on attenuator.**

SANBORN COMPANY
INDUSTRIAL DIVISION

195 MASSACHUSETTS AVENUE
CAMBRIDGE 39, MASS.

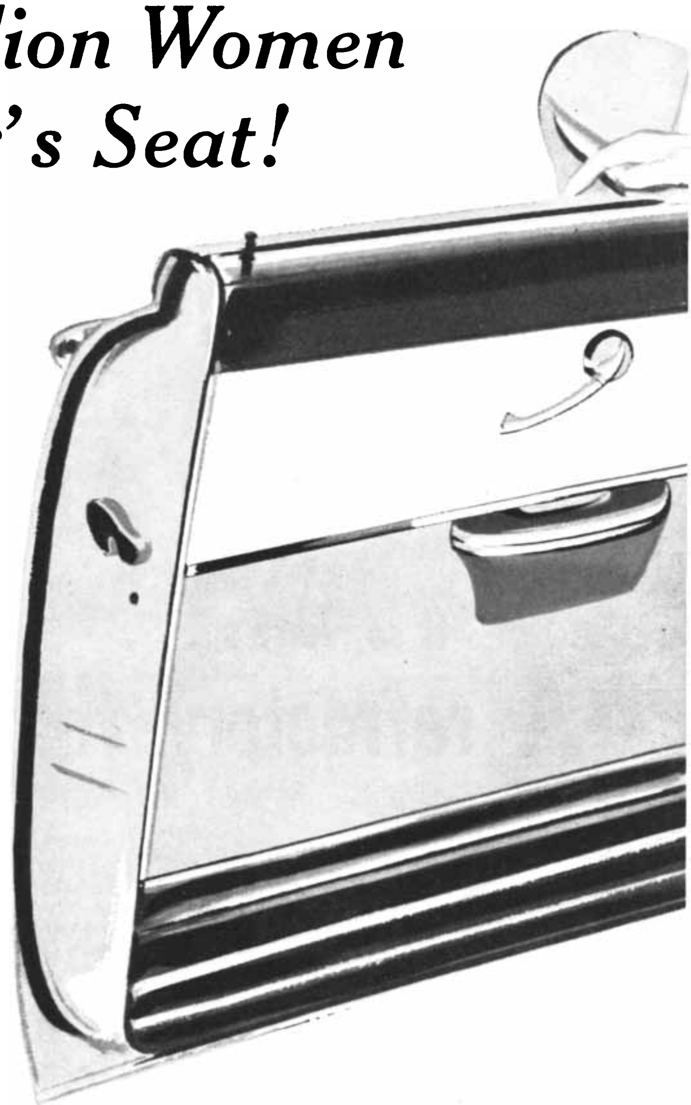
graduate training at Cornell University. Since 1929 he has been a teacher at the University of Pennsylvania, training many prominent figures in general physiology. He still occasionally plays basketball, touch football, softball and, more recently, handball.

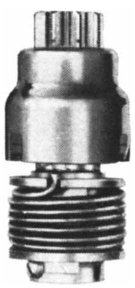
KATHLEEN M. KENYON ("Ancient Jericho") was director of excavations at the famous Biblical city of Jericho in 1952. She has been an indefatigable digger since 1929, when, at the age of 23, she assisted in excavations by the British Association at Zimbabwe, Southern Rhodesia. Her first independent digging was done at the Jewry Wall site at Leicester, England, in 1936, and she has directed excavations at many sites in England and the Middle East. Born in 1906, the daughter of the late Sir Frederic G. Kenyon, she was educated at Somerville College, Oxford. Since 1948 she has been lecturer in Palestinian archaeology at the University of London, and since 1951 director of the British School of Archaeology in Jerusalem.

HANS HAHN ("Geometry and Intuition"), who died of cancer in 1934 at the age of 55, was a talented Viennese mathematician, teacher and researcher. He had a strong bent toward the philosophical relationship between logic and mathematics, as this excerpt from one of his best works shows. After receiving his degree from the University of Vienna in 1902, he published papers and worked in seminars with many mathematical giants of the day. In 1905 he took over Otto Stolz's post at the University of Innsbruck. During the First World War, in which he served in the Austrian Army, he was severely wounded and decorated for bravery. Shortly thereafter he returned as professor to the University of Vienna.

A. E. MIRSKY, who in this issue reviews C. D. Darlington's *The Facts of Life*, has been a leading biochemist at the Rockefeller Institute for Medical Research since 1930. Born in Flushing, N. Y., he was educated at Harvard Medical School and at Cambridge University, where he took his Ph.D. degree under the late Joseph Barcroft. His early work was on hemoglobin. More recently he has worked on the chemistry of chromosomes, some details of which he summarized in a recent article in this magazine ("The Chemistry of Heredity," SCIENTIFIC AMERICAN, February, 1953). Last year he visited Africa to observe its tribal life and ponder the genetic enigma of race.

Famous Bendix* Starter Drive helped do away with cranking *and put 20 Million Women in the Driver's Seat!*





Small things bring great changes. Think what really happened in 1913 when the little but wonderfully ingenious Bendix Starter Drive became "the mechanical hand that cranks your car." By eliminating back-breaking cranking, the self-starter opened the car door to Woman's world.

The Great American Economic Revolution was under way and it hasn't stopped gathering momentum yet. Today nearly 20,000,000 women drive cars to places to spend an estimated 80% of the national take-home pay.

We are not claiming this would not have happened if it had not been for the wonderful Bendix Starter Drive; we simply point out that it did happen because this invention helped change the auto from a luxury for men only to the whole-family necessity it is today!

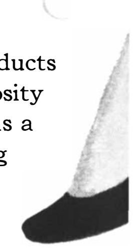
The Bendix Starter Drive also started Bendix Aviation Corporation—it was our first product. So many have been made, and so efficiently have they operated, that the "Bendix Drive" is a symbol of quality the world over.

Other Famous Bendix Names

Bendix Aviation makes scores of other quality automotive products with famous names—Stromberg* Carburetor, Bendix* Radio, Bendix-Eclipse* Brake Lining, Bendix* Brakes, Scintilla Magneto, Bendix* Power Steering, and Zenith* Carburetor are a few. Hundreds of other products for aviation, industrial and home use are turned out by our 25 manufacturing divisions.

You and Bendix

Because Bendix Aviation is more diverse in manufacturing and engineering experience than perhaps any other large corporation, our ability to serve other businesses is correspondingly greater, with products as complex as supersensitive temperature or viscosity control instruments, for example, or as simple as a new rattle-proof, rust-proof handle for carrying cases of all kinds which one of our divisions recently introduced, and which has enjoyed remarkable acceptance. Or it may be we have the technical answer to a processing problem that has been bothering your production a long time.



To find out all about Bendix Aviation Corporation and our ability to serve you, why not follow through with the suggestion at the right:

THE COVER

The hand-colored woodcut on the cover is an idealized view of Pisa in the 15th century. Pisa was a typical medieval city: a compact physical and social unit surrounded by a wall (*see page* 55). The original woodcut, from the *Nuremberg Chronicle* of 1493, is reproduced through the courtesy of the Metropolitan Museum of Art.

THE ILLUSTRATIONS

Page	Source
31-33	Bunji Tagawa
34-36	Eric Mose
37	Myron Davis
38	Herman Yagoda
39	Myron Davis
40-41	Irving Geis
54	Aero Service Corporation
56	Ewing Galloway
57	Ewing Galloway (*left*), Owen from Black Star
58-59	Fairchild Aerial Surveys, Inc. (*upper left*); Aero Service Corporation (*upper right*); Fairchild Aerial Surveys, Inc.
60	Aircraft Operating Co. of Africa, from Ewing Galloway (*top*); Fairchild Aerial Surveys, Inc. (*middle*); Aerofilms, Limited, from Ewing Galloway
61	John Tremblay
62	Hunting Aerosurveys Ltd., from Ewing Galloway (*left*); Compagnie Aérienne Française, from Ewing Galloway
63	Fairchild Aerial Surveys, Inc. (*left*); Aero Service Corporation
65	International News Photos
66-67	James Egleson
68	Columbia University
71	Paul Weller
72	L. V. Heilbrunn
74	R. W. St. Clair (*top*); Ethel Browne Harvey
78	Bunji Tagawa
84-91	James Egleson

What General Electric people are saying . . .

W. H. ROBINSON, JR.

Mr. Robinson is Manager of Advertising, Lamp Division

". . . A hairpin in a bottle," the first incandescent lamp made practical by Edison in 1879, began a chain of circumstances that brought our country and our way of life out of one world and into another.

For the principal difference between the America of today and that of 75 years ago is electricity—the energy, and the appliances and equipment that help the factory worker, the farmer, the homemaker—that relieve us of drudgery and make each hour of working time far more productive.

When Edison turned his inventive, but very practical, mind to the problem of electric light, he realized that it would not be enough merely to invent an efficient light source.

The job, as Edison saw it, was to perfect a lamp with long burning life, that could be manufactured in large quantities and offered at low cost. Large numbers of these lamps would have to be supplied with electric current from a single source—yet it must be possible to turn lamps on and off individually.

Thus Edison had to solve not only the difficulties that had balked other inventors. He also had to devise a method for satisfactory supply of current, which would have to be manufactured and brought to each lamp, ready for use at the customer's wish.

In other words, Edison conceived and created, in miniature, the entire electrical industry as we know it today. He could buy very little. Generators, wiring, sockets, switches—all had to be invented, designed, and manufactured.

The "hairpin in a bottle" that burned for 40 hours in Edison's laboratory in 1879 was far more than a better light than the world had yet known. It was also the starting point for the electric utility industry, the electrical manufacturing and the electrical construction industries, that make it possible for electricity to serve us today.

at The Electric League, Chattanooga, Tenn.

R. M. SWETLAND

Mr. Swetland is Manager, Illuminating Engineering Laboratory, Lighting and Rectifier Department

". . . Approximately 40,000 traffic fatalities have occurred on American roadways during 1953! About 60% of these—roughly 24,000—occurred at night. Experience, over many years, proves that fully one half of these night fatalities—some 12,000 lives—could have been saved by adequate roadway lighting—protective visibility.

The National Safety Council estimates the total economic loss, per traffic fatality, as $95,000. Thus 12,000 fatalities represent over 1.1 billions of dollars in such losses.

The American public now spends approximately $1.25 annually per capita for street lighting. It is reliably estimated that the doubling of this investment in protective street lighting (another $200,000,000) would *eliminate* this 1.1 billion in economic loss; that is, each $1 additional investment in roadway lighting saves over $5 in economic loss—plus its share in saving some 12,000 American lives.

Higher illumination levels will be needed to adequately protect future traffic flow—both vehicular and pedestrian. Luminaires giving increased light output, properly controlled, are being planned to meet these demands.

Systematically planned street lighting improvement programs pay attractive dividends in (a) merited illumination and protection for each type of roadway, (b) standardization of equipment, and (c) a maximum of protective visibility per $1 of investment.

A recent reliable poll of experienced street lighting engineers reveals that *only* about 7% of our lighted streets and highways now meet A.S.A. recommended illumination levels.

Thus, we're a long way from the street lighting saturation point.

at Yale University

G. S. BENNETT

Mr. Bennett is in the Electro-Mechanical Engineering Services Department, General Engineering Laboratory

". . . It has long been felt by many people, mostly those not in industry, that industrial ultrasonic applications would never be economical. This viewpoint was well put by W. T. Richards, writing in the Journal of Applied Physics for May, 1938.—"In fact, about 1932 there was a feeling in the air that anyone who manufactured anything, with the possible exception of horn buttons, was either installing a supersonic outfit or wishing he had the money for one. The chief beneficiaries of this movement were the electric power companies.—But the electrical production of sound waves is appallingly wasteful—they will be supplanted by more efficient mechanical devices.' Now the fallacy in this viewpoint is the confusion of the words "expensive" and "uneconomical." These are not synonymous—a very strong case can be made for the argument that the highest priced automobile is actually the most economical in the long run. In the same sense, an industrial ultrasonic installation is still expensive, but if a necessary operation can be performed which cannot be done in any other way, if a product can be improved, if time or space can be saved, the initially expensive installation can result in long-range economy. It is in this light that any industrial process must be considered, and in which ultrasonic is gaining acceptance.

at Michigan State College.

You can put your confidence in—

GENERAL ELECTRIC

Your business **is** in the Age of Electronics

Measure rotational speeds to *3,000,000* r.p.m.* without mechanical loading or connections

Electronic tachometers, counters, light cells—these are three of many new electronic test instruments industry now uses to speed engineering and improve manufacturing.

Easily used by non-technical personnel, such instruments simplify production and quality control by giving instantaneous and continuous indication of r.p.m. and acceleration, or serving as an automatic overspeed control. In your laboratory, these same instruments often provide information not otherwise obtainable.

Hewlett-Packard is a pioneer and world leader in electronic test instruments—basic measuring tools used throughout manufacturing, research, communications and military installations. Correct application of such instruments is of primary importance; Hewlett-Packard field engineers can recommend and provide the right instrumentation for your r.p.m. measurement or overspeed control problem. Why not write us about your problem today. You will receive a prompt reply.

hp

ELECTRONIC MEASURING INSTRUMENTS

The very high speeds of turbines, jet engines, grinding and dental equipment—even flea-power mechanisms—can be measured with 2% accuracy using -*hp*- electronic tachometers. For higher accuracy, 0.1% or better, -*hp*- electronic counters may be used. Speeds to 3,000,000* r. p. m. are measured safely, easily—even at remote locations—without loading or mechanical connection.

*Mechanically, this speed has yet to be achieved. But when it is, present-day -*hp*- instruments will measure it readily.

HEWLETT-PACKARD COMPANY

2908S PAGE MILL ROAD • PALO ALTO, CALIFORNIA

2870

SCIENTIFIC AMERICAN

Established 1845

CONTENTS FOR APRIL, 1954 VOL. 190, NO. 4

ARTICLES

DEPARTMENTS

Brig. General David Sarnoff, Chairman of the Board, Radio Corporation of America

Sees No. 1 wish come true!

Television Tape Recording by RCA Opens New Era of Electronic Photography

In 1956, RCA's General Sarnoff will celebrate his 50th year in the field of radio. Looking ahead to that occasion, three years ago, he asked his family of scientists and researchers for three gifts to mark that anniversary: (1) A television tape recorder, (2) An electronic air conditioner, (3) A true amplifier of light.

Gift No. 1—the video tape recorder—has already been successfully demonstrated, two years ahead of time! Both color and black-and-white TV pictures were instantly recorded on magnetic tape without any photographic development or processing.

You can imagine the future importance of this development to television broadcasting, to motion pictures, education, industry and national defense. And you can see its entertainment value to you, in your own home. There the tape equipment could be used for home movies, and—by connecting it to your television set—you could make personal recordings of your favorite TV programs.

Expressing his gratitude for this "gift," General Sarnoff said it was only a matter of time, perhaps two years, before the finishing touches would bring this recording system to commercial reality. He described this RCA achievement as the first major step into an era of "electronic photography."

Such achievements as this, stemming from continuous pioneering in research and engineering, make "RCA" an emblem of quality, dependability and progress.

RADIO CORPORATION OF AMERICA

World leader in radio — first in television

SCIENTIFIC AMERICAN
APRIL, 1954 VOL. 190, NO. 4

The Control of Fertility

The problem of balancing population with natural resources resides in the human reproductive cycle. The study of this cycle has suggested new ways in which it can be interrupted

by Abraham Stone

Interest in population and family planning is spreading rapidly today. Everywhere the need for individual couples to plan their families and for nations to plan their populations is receiving more recognition. There is a growing awareness that the economic welfare and future stability of the world may depend to a large degree upon a better balance between natural resources and human populations, between the fertility of the soil and the fertility of man, between human production and human reproduction.

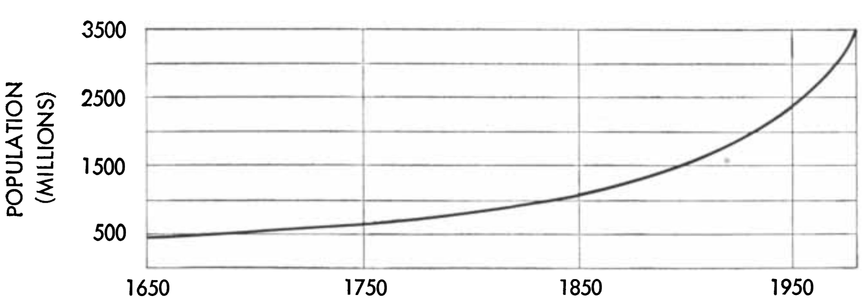
Until about 300 years ago the population of the world grew fairly slowly. Within the last three centuries, thanks in large measure to man's progress in the conquest of disease, the world population has multiplied fivefold, from an estimated 500 million in 1650 to nearly two and a half billion today. It is now growing at the rate of 25 million a year. With the elimination of epidemic diseases and the lengthening of the average life span, the rate is certain to increase.

Illustrative is the case of Ceylon, which I visited recently. In 1920 the birth rate of Ceylon was 40 per thousand population and the death rate was 32—a surplus of births over deaths of only eight per thousand. In 1950 the birth rate of Ceylon was still about 40, but the death rate had been reduced to 12 per thousand, due mainly to control of malaria. At its present rate of growth Ceylon's population will double within about 26 years. In Japan the population has increased from 55 million in 1920 to some 85 million in 1950, and is expected to reach 100 million within a decade or so. In India the population is about 360 million and is increasing by more than five million each year. No possible improvement of food production is likely to keep pace with such growth. "You can increase the resources of a people," said Alan Gregg of the Rockefeller Foundation recently, "you can double them, and still if you pay no attention to birth rate, the growth of population can catch up with the resources and start the whole problem over again."

Social, political and public health leaders in many countries are now seriously concerned with the population question and are taking active steps to disseminate family planning information in an effort to bring about a better balance between resources and populations. In attempting to introduce family planning measures, however, they are confronted with a major problem: the need for a contraceptive method which is simple, practical and within economic reach of everyone. In a recent journey around the world I was deeply impressed with the universal demand for a simplified method.

A contraceptive method has to meet three major requirements: harmlessness, reliability and acceptability. It should also be simple, practical, inexpensive and esthetically satisfactory to the people who use it. The best present methods, while harmless, reliable and fairly acceptable, are not sufficiently simple and inexpensive to be suitable for people in all cultures. Many physiologists and clinicians are now engaged in a search for a more practical and more universally acceptable contraceptive technique. Some of them are working on radically new approaches.

There are five stages at which conception may be prevented. For a pregnancy



WORLD POPULATION increased from an estimated 470 million in 1650 to 2.4 billion in 1950. The population predicted for 1980 (*last vertical coordinate on this chart*) is 3.5 billion.

to occur (1) an adequate number of spermatozoa must be deposited within the vaginal tract; (2) the sperm must enter the uterus and travel to the Fallopian tubes; (3) a mature egg must be ready in one of the tubes; (4) a sperm cell must unite with the egg; and (5) the fertilized egg must travel to the uterus and implant itself in the lining.

Most of the contraceptive devices employed at the present time are designed to prevent Step 2—entry of the sperm into the uterus. Some interpose a mechanical barrier to it (a condom or diaphragm); others a chemical one (douches, jellies, creams, tablets). Research workers are now giving much attention to the other steps in the fertilization process: sperm formation, egg formation, union of the sperm with the egg, implantation of the fertilized egg in the uterus.

The possibility of controlling fertility by preventing the formation or discharge of a ripe egg has been under study for a number of years. It has been found that frequent doses of the female sex hormone estrogen will inhibit a woman's ovulation. If a woman were to take one or two milligrams of diethylstilbestrol by mouth every day, she probably would not produce eggs for at least two or three cycles. The estrogen presumably suppresses the formation of the hormone gonadotropin, without which ovulation cannot occur. The inhibition of ovulation need not necessarily suppress menstruation. The taking of progesterone, another hormone from the ovaries, can induce menstruation even when no egg has been formed. Progesterone, like estrogen, can also prevent ovulation. Some 30 years ago it was discovered that the transplantation of ovaries from pregnant animals into other females made the latter sterile for a time. Many other investigators have since shown that injections of progesterone may inhibit ovulation.

Aided by grants from the Planned Parenthood Federation, a number of studies on the use of progesterone and allied steroids for the control of fertility are now in progress in a biological laboratory in the U. S. Animal experiments have given promising results, but the value of this method for human application remains to be determined. The reproductive mechanism is a very delicate apparatus, and obviously extreme care must be exercised with these powerful biological products. It will take years to test and evaluate the hormonal control of ovulation.

Like the formation of the egg, the production of sperm also may be suppressed temporarily by hormones—in this case by the male sex hormone testosterone. But because of the cost and possible side effects of large doses of testosterone, this method is not yet feasible for contraceptive purposes.

As for union of the sperm and the egg, there is some evidence that progesterone, administered to a female at the time of ovulation, may inhibit that too. This method, not yet tried in human beings, might provide a very simple contraceptive measure.

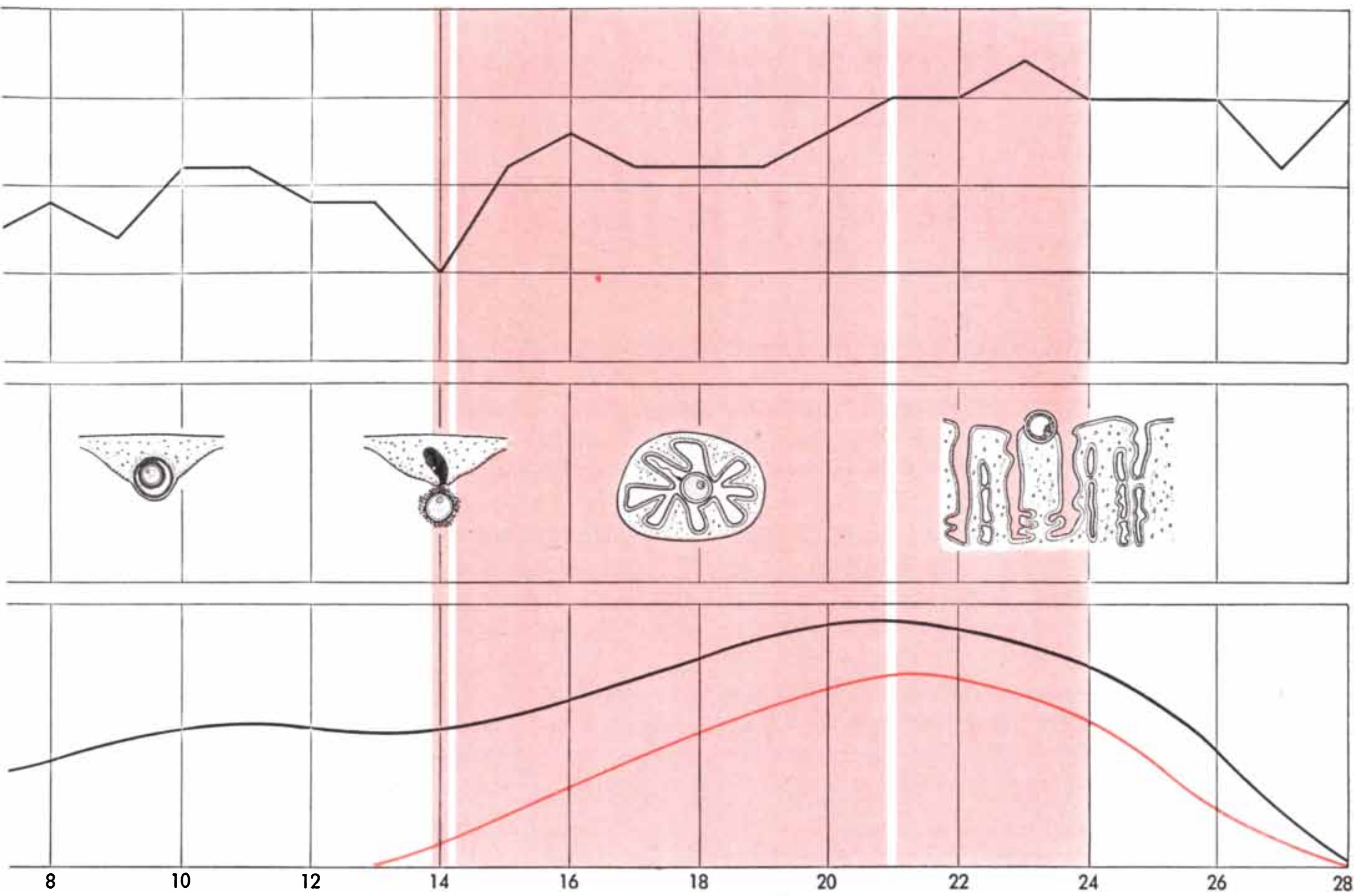
More work has been done on the prevention of fertilization by certain chemicals that counteract hyaluronidase, an enzyme which plays an important role in fertilization. When an egg is discharged from the ovary, it is protected by a company of surrounding cells which are believed to be held together by a cement-like substance of which the chief ingredient is hyaluronic acid. Spermatozoa carry the enzyme hyaluronidase, whose chief function, the theory goes, is to break up the guarding cells so that a sperm can penetrate the egg. It is therefore suggested that an anti-hyaluronidase substance, taken by the woman, should prevent spermatozoa from reaching the egg. Experiments with an anti-hyaluronidase called phosphorylated hesperidin are reported to have had some success, but they are far from conclusive, and it has not yet been shown that the continued use of such a substance would be harmless.

Even after the egg has been fertilized, there is still the possibility of preventing its implantation in the wall of the uterus, where the fetus must develop. The journey of the egg through the Fallopian tube to the uterus takes approximately four days. By means of one or the other of the ovarian hormones, it may be possible either to retard or to accelerate the passage of the egg, and thereby prevent its normal implantation and development.

Recently it has been discovered that withholding certain essential vitamins from a pregnant animal, or giving it vitamin antagonists, can stop the development of the fetus even after implantation. The studies have been carried on chiefly with a compound antagonistic to folic acid, a vitamin essential for embryonic growth. One of these so-called antifols has been used in a few experimental cases for interrupting pregnancies which endangered the life of the woman. It has also shown a contraceptive effect in mice and rats. This drug, however, must be considered with extreme caution, even more than the others. The antifolic compounds are highly toxic to the blood, and if the drug failed to stop the pregnancy, it might cause serious abnormalities in the embryo. Furthermore, the method raises an important ethical question; unlike the other contraceptive methods, it destroys a life already begun.

ZONES OF CONTROL of conception in the female are indicated by the colored bands through this chart of developments in the

Since time immemorial man has been using herbs and other plants supposed to prevent conception; there are records of more than 100 such plants in use by various peoples. The search for a simple, inexpensive method has revived interest in these, especially in a plant known as *Lithospermum ruderale*, which Indians of our Southwest are reported to have discovered. Last year the Planned Parenthood Federation brought together at a special conference in New York City a number of U. S. and Canadian investigators of this plant. They reported that extracts of dried Lithospermum have reduced fertility of both males and females in animals of many species. There is



monthly egg-producing cycle and fertilization. First is ovulation, which occurs on the 14th day after the period begins and is accompanied by a rise in body temperature. Second is the period in the oviduct, when fertilization is likely. Third is the implantation in the uterus. The curves at the bottom indicate the level of estrogen (*black*) and progesterone (*colored*) during the cycle.

some evidence that the extracts suppress the secretion of gonadotropins from the pituitary. Studies of the ingredients, the mode of action, possible side effects and the applicability of the drug to human beings are being pursued.

All in all, the goal of a so-called "birth control pill" is now emerging from the realm of theory to that of reality. Clearly such a method, providing lasting protection, eliminating the need for a mechanical or chemical device, and probably inexpensive, would greatly simplify the practice of family planning.

There is, however, a method which is far simpler: it requires no appliances or medication at all. It is the so-called "safe period" system. A woman matures one egg during each menstrual cycle. The consensus today is that the egg is ripe for at most a 48-hour period, and that human sperm cells also live no more than about 48 hours. The safe-period idea is based on the assumption that conception is possible only around the time of ovulation.

The chief problem is to determine the exact day on which ovulation occurs. From that knowledge it is quite simple to calculate the fertile and infertile periods. At present there are three practical methods available for determining ovulation time: (1) symptoms such as cramplike feelings in the lower abdomen, a slight vaginal discharge or tension in the breasts, which identify the time for a few women; (2) a woman's menstrual calendar—ovulation is believed to take place two weeks before the onset of menstruation; (3) the woman's monthly temperature curve—an abrupt rise in temperature that takes place in the middle of the month is believed to correspond closely to the ovulation time. A woman's "basal body temperature" (meaning the temperature on waking each morning) goes through a characteristic cycle each month. During the first two weeks or so after menstruation the temperature is at a relatively low level between 97 and 98 degrees Fahrenheit. Then in the middle of the month it commonly drops several tenths of a degree and the following morning abruptly rises a half to a whole degree. Sometimes the rise extends over two to three days. For the rest of the month the temperature stays between 98 and 99 degrees. It then drops a day or so before the onset of menstruation.

Urgently needed, however, is an even simpler and more definite indication of ovulation time. One possible indicator is the mucus in the cervix, which undergoes cyclic chemical changes. It has been suggested that a kind of litmus-paper test might be developed to show by a change of color when a woman is in the fertile or infertile period.

These are some of the lines along which research in contraception is currently being carried out. With the newly awakened public and scientific interest in the subject we may confidently expect more important developments within the near future. We are now on the threshold of the realization of long-sought simple techniques which will be acceptable to peoples in all cultures.

Biological Clocks and the Fiddler Crab

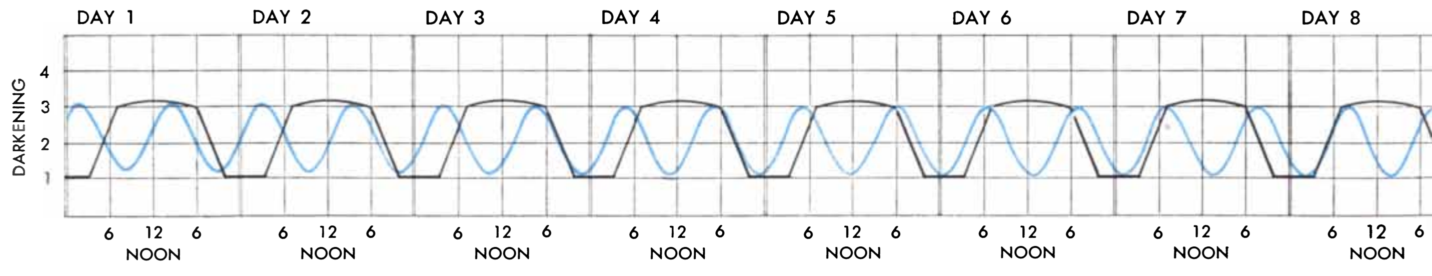
What is the mechanism that times the rhythms of life? The answer is sought in the regular changes of color and metabolism of a small inhabitant of the seashore

by Frank A. Brown, Jr.

Everyone knows that there are individuals who are able to awaken morning after morning at the same time to within a few minutes. Are they awakened by sensory cues received unconsciously, or is there some "biological clock" that keeps accurate account of the passage of time? Students of the behavior of animals in relation to their environment have long been interested in the biological clock question.

Most animals show a rhythmic behavior pattern of one sort or another. For instance, many animals that live along the ocean shores have behavior cycles which are repeated with the ebb and flow of the tides, each cycle averaging about 12½ hours in length. Intertidal animals, particularly those that live so far up on the beaches that they are usually submerged only by the very high semimonthly tides when the moon's pull upon the ocean waters is reinforced by the sun's, have cycles of behavior timed to those 15-day intervals. Great numbers of lower animals living in the seas have semilunar or lunar breeding cycles. As a result, all the members of a species within any given region carry on their breeding activities synchronously; this insures a high likelihood of fertilization of eggs and maintenance of the species. The Atlantic fireworm offers a very good example of how precise this timing can be. Each month during the summer for three or four evenings at a particular phase of the moon these luminescing animals swarm in the waters about Bermuda a few minutes after the official time of sunset. After an hour or two only occasional stragglers are in evidence. Perhaps even more spectacular is the case of the small surface fish, the grunion, of the U. S. Pacific coast. On the nights of the highest semilunar tides the male and female grunion swarm in from the sea just as the tide has reached its highest point. They are tossed by the waves onto the sandy beaches, quickly deposit their reproductive cells in the sand and then flip back into the water and are off to sea again. The fertilized eggs develop in the moist sand. At the time of the next high high tide, when the spot is again submerged by waves, the young leave the nest for the open sea.

Almost every species of animal is dependent upon an ability to carry out some activity at precisely the correct moment. One way to test whether these activities are set off by an internal biological clock, rather than by factors or signals in the environment, is to find out whether the organisms can anticipate the environmental events. The first well-controlled experimental evidence on the question was furnished by the Polish biologist J. S. Szymanski. In experiments conducted from 1914 to 1918 he found that animals exhibited a 24-hour activity cycle even when all external factors known to influence them, such as light and temperature, were kept constant. During the succeeding 20 years various investigators, especially Orlando Park of Northwestern University, J. H. Welsh of Harvard University and May-



CHANGES OF COLOR in the fiddler crab are plotted for 16 days. The black curve represents the changes that take place with the day. Every morning the crab gets darker; every evening it gets lighter. The blue curve represents the changes that take place with

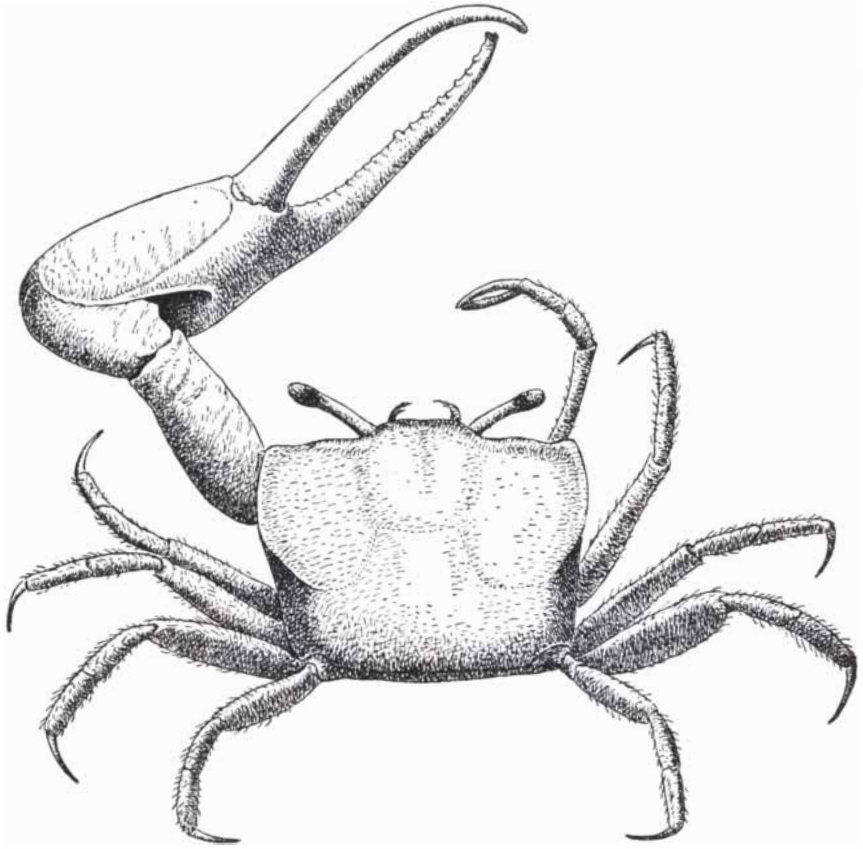
nard Johnson (currently in the U. S. Navy), demonstrated that comparable rhythmic processes persisted in many insects, in crustaceans and in mice. Persistent daily rhythmicity has been found in animals ranging from one-celled protozoa to mammals. And the Austrian biologist Karl von Frisch, using a slightly different approach, discovered that bees could be trained to come to a feeding station at the same time on successive days but not at different times—a finding which suggested that bees have an internal daily cycle.

In homing or migration, bees, ants and birds use at least to some extent what is called "the light-compass reaction." They keep the sun at a fixed angle with respect to the long axis of the body. If the sun is to be an accurate direction guide for a bird during a long flight, the bird of course must make continual corrections for the sun's movement across the sky. Gustav Kramer in Germany recently studied the orientation of starlings in enclosures illuminated by an artificial sun kept in a fixed position. He found that the birds systematically shifted their orientation during the day at the usual rate of correcting for the rotation of the earth.

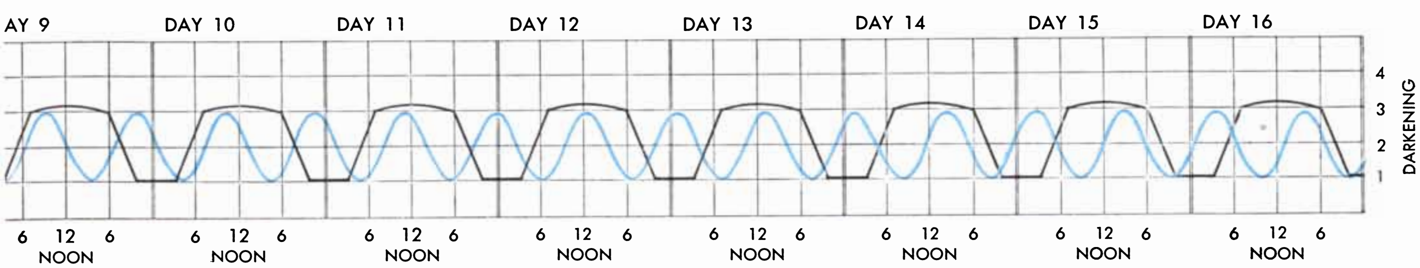
My own interest in the general problem of the time-measurement mechanism was aroused some years ago by certain findings which suggested that the biological clock was more or less independent of temperature. Cold-blooded animals appeared to hold rather precisely to a 24-hour cycle regardless of the temperature at which they were kept. Logic, too, argued that the clock must be impervious to temperature variations. Yet how could an internal mechanism be unaffected by temperature? All the known physiological processes, and the chemical processes underlying them, are accelerated by increases in temperature. If the clock was a metabolic one, temperature-independence would indeed be a unique property.

Starting with this temperature question, I undertook a series of studies in which I was assisted by my graduate students. Among the assistants have been H. M. Webb, M. I. Sandeen, M. Fingerman, G. C. Stephens, W. J. Brett, M. N. Hines and M. F. Bennett. The studies were carried out mainly at Woods Hole, Mass. As an experimental animal we wanted one which was cold-blooded (*i.e.*, whose body temperature varied with that of the surroundings) and which had a clear-cut and easily measured daily behavior pattern. We found an ideal animal in the common fiddler crab, which shows a striking daily cycle of variation in body color. Throughout the day the animal's skin is dark; in early evening it becomes pale; and around daybreak it begins to grow dark again. The daytime darkening of course serves the function of protecting the animal from the bright sun and from predators. Black pigment in the skin cells disperses through the bodies of the cells to make the animal dark; when it concentrates in the cell centers, the skin becomes paler.

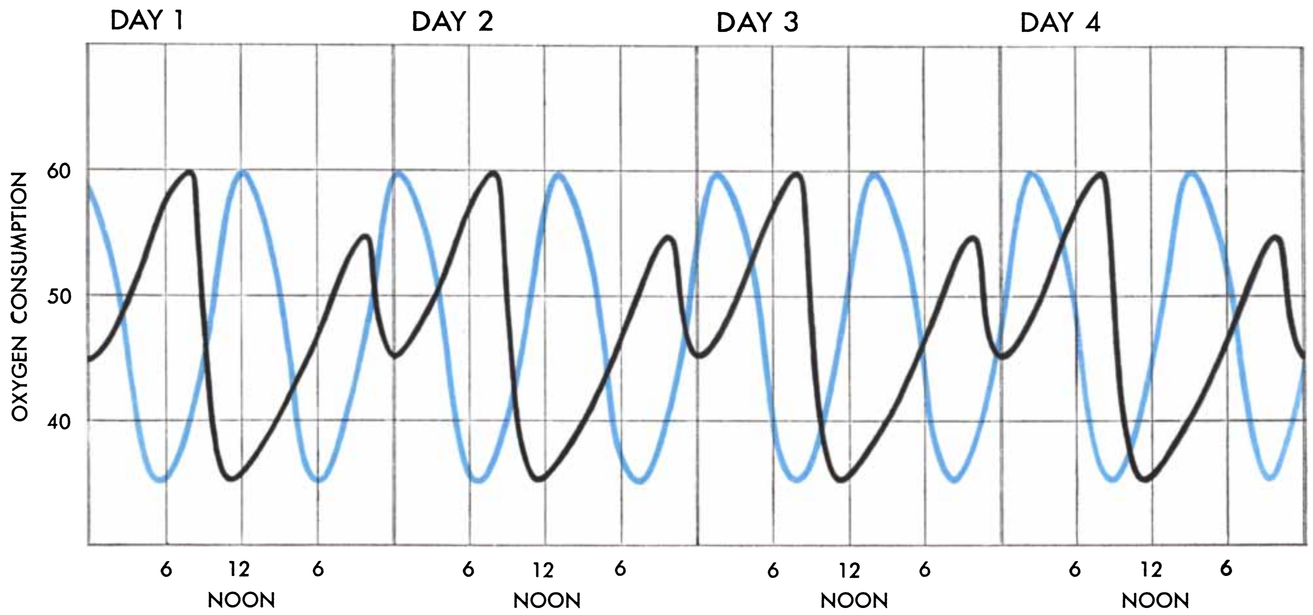
A quantitative method of determining the average stage of dispersion of the pigment at any given time of day was developed. By placing a large group of animals in a photographic darkroom at constant temperature and then sampling



FIDDLER CRAB gets its name from the fiddling motions made by the male with its oversized left pincer. This drawing shows the crab somewhat larger than its natural size.



the tides. At low tide the crab gets darker; at high tide it gets lighter. Every day the tidal rhythm gains about 50 minutes on the daily rhythm. Hence the curve of the tidal rhythm bears the same relationship to that of the daily rhythm every 15 days.



OXYGEN CONSUMPTION of the fiddler crab is plotted for four days under constant conditions in a laboratory respirometer. The black curve represents the daily change in oxygen consumption. The blue curve indicates the tidal change in oxygen consumption.

the group from time to time, it was possible to follow the persisting daily variations in the pigment cells.

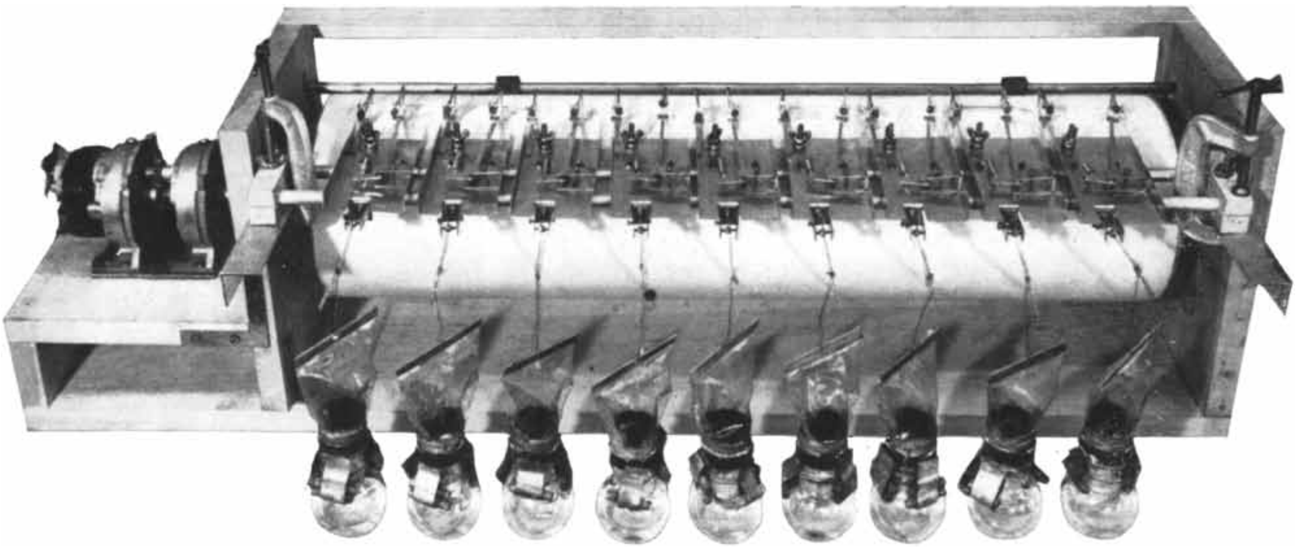
In two months of observation the rhythm of color change faithfully followed the day-night cycle, whether the temperature was kept at 26 degrees, 16 degrees or 6 degrees centigrade. The clock could not have gained or lost more than a few minutes in the two-month period. If, however, the temperature was reduced to near freezing during the 24-hour cycle, the color clock changed. For example, when the water in which the crabs were kept was chilled to 3 or 4 degrees C. for six hours and then was warmed quickly to room temperature again, the rhythm of color change was set back by approximately a quarter cycle. In other words, the clock appeared to have been stopped or greatly slowed down during the period of low temperature and to have resumed its normal rate afterward. It now ran regularly on the 24-hour cycle but was six hours slow. By such low-temperature treatment it proved possible to set the cycle any desired degree out of phase with the normal one.

The clock can also be reset by changes in illumination at sensitive times in the daily cycle. Fiddler crabs which have been kept in very bright light continuously for about 10 days stop changing color. But they retain a rhythm of sensitivity to stimuli which can reset the clock. If, for example, these rhythm-inhibited animals are placed in a darkroom either at 12 noon or 6 p.m., they resume their original day-night color cycle. If they are placed in the darkroom at 6 a.m., their rhythm is set forward by about a quarter cycle. If animals with a normal rhythm are illuminated on three consecutive days from midnight to 6 a.m., the clock is set back by about a quarter cycle. It can be set back another quarter cycle if the same animals are exposed to light from 6 p.m. to midnight on three successive days. But the latter treatment will have no persistent effect unless it is preceded by the first. One can also reverse the phases of the rhythm by a few periods of illumination by night and darkness by day. It is even possible to change the normal 24-hour cycle. Prolonged exposure to 32-hour "days" of alternate light and darkness will cause the crabs' clock to run on a cycle of 96 hours—the smallest common denominator of the imposed 32-hour and the normal 24-hour cycles. But as soon as the crabs are returned to constant darkness they revert to a 24-hour day.

Within the general daily rhythm of the fiddler crab's gross color change there is a certain amount of variation in the degree of daytime darkening. And this varies with the time of day. Sometimes the crab is darkest in the morning, sometimes at noon, sometimes in the afternoon and occasionally both early in the morning and early in the evening. The time of greatest darkening tends to occur about 50 minutes later each successive day. Now it is common knowledge that high and low tides in any given locality also occur about 50 minutes later each day. We found that the maximum darkening of the crabs in our laboratory came at about the time of day when the tide was low in the place where they had been collected. In other words, at the very same time that crabs on the beach were taking on their darkest hue as protection from the sunlight and predators, their captured relatives in the laboratory, who had been kept in a darkroom for as long as a month, also were becoming their darkest.

This suggests that the fiddler crab has a 12.4-hour metabolic rhythm coinciding with the tide intervals, as well as a 24-hour one. The two rhythms coincide in phase about every 15 days; that is, a low tide at 9 a.m. is followed by one at the same time about 15 days later. It was found that the crabs in the photographic darkroom also had their darkest hour at the same time of day at 15-day intervals. The tidal rhythm, like the daily one, is remarkably precise. Fiddler crabs from Woods Hole were kept in the darkroom side by side with crabs from Martha's Vineyard, where low tide comes four hours later in the day. The Vineyard crabs turned their darkest just four hours later than the Woods Hole crabs! The 15-day tidal rhythm turned out to be independent of temperature, as the 24-hour cycle is, and it could also be reset similarly by shifting the illumination periods.

All these studies required around-the-clock observations, with one investi-



RESPIROMETER has one vessel for each crab. Atop each vessel is a plastic bag containing oxygen. When the bags are suspended in water, the bags collapse as the oxygen is consumed. The changing buoyancy of the vessels is recorded on drum in background.

gator spelling another. Nearly half a million separate observations were made and analyzed in the tidal study alone. To reduce the tedium we looked for an index, other than the pigment changes, which could record the rhythms continuously and automatically. The rate of oxygen consumption by the crabs seemed suitable, for we had good reason to suspect that this was regulated by the same hormones that were responsible for the color changes and it was also to be expected that the crabs would use more oxygen at low tide, when they run about to feed.

A very simple, automatic, continuously recording respirometer was invented. It consisted of a sealed glass flask, with materials to absorb carbon dioxide and other gaseous wastes eliminated by the crabs, and a fine hypodermic needle which went through the rubber stopper to an oxygen-filled plastic sack. The whole was suspended in a bath and acted as a "diver." Changes in the weight of the diver were measured by a delicate spring scale from which it was suspended, and they were recorded on a slowly moving strip of paper. A crab was placed in each flask. As fast as it used up the oxygen in the flask air, fresh oxygen flowed down from the sack to replace it, and the diver became correspondingly heavier. For every cubic centimeter of oxygen used by the crab, the diver increased in weight by one gram.

On a daily basis the oxygen consumption by the crabs was lowest at noon, rose gradually until around 10 in the evening, then dipped until about midnight and after that climbed slowly to the day's highest point at about 8 in the morning. In the 15-day tidal rhythm the highest consumption rate came just before the time of low tide and the lowest about the time of high tide. The peak rate of course tended to occur when low tide came at approximately 8 a.m.

Other work in progress in our laboratories now suggests strongly that the quahog and some marine snails have mechanisms like that of the fiddler crab for the accurate measurement of times of days, tides and moon phases. And by experiments on the little fruit fly *Drosophila* Brett has been able to show that such biological clocks are inherited.

New fruit flies usually emerge from the pupal to the adult stage shortly after daybreak. But when Drosophila eggs develop entirely in darkness, from the laying of the eggs through the pupal stage, they show no special tendency to emerge when daylight comes. Yet if a group of fly larvae being raised in darkness are exposed to light for even as brief a period as one minute, the mature flies will tend to emerge (several days later) at a time of day which is correlated with the time of day when they were given the light flash. The most reasonable interpretation of this is that a fly larva has an inherent 24-hour clock and that the flash of light, acting as a daybreak signal, sets all of the clocks in a population of larvae for the same time.

What sort of mechanism can account for the biological clock? The most popular hypothesis has been that it is purely metabolic. Once set, the clock continues to run at its characteristic rate and independently of all external influences. A change in conditions can stop, slow or reset the clock but does not change its rate. The main difficulty is to explain how a metabolic clock can maintain such uncanny precision over a temperature range of more than 20 degrees C. An alternative hypothesis which fits all the known facts equally well is that the mechanism is one which can perceive some kind of physical force in the environment hitherto not known to affect living organisms. This hypothesis suggests that the experimental changes do not reset the basic clock but rather shift the specific behavior pattern. Experiments now in progress should yield a decision between the two hypotheses.

In their measurements of various physiological processes modern biologists have been plagued by an unpredictable factor they call random individual variability. Judging from the studies of the rhythmic behavior of the fiddler crab and other animals, it seems reasonable to venture that much of the "random" variation will turn out to be quite orderly and predictable in terms of specific cycles. The development of an accurate, temperature-independent internal clock is so useful in helping organisms to adapt to their environment and to maintain their stability that in all probability it will be found to be universal among living beings.

Tritium in Nature

The heaviest isotope of hydrogen is made not only by man in nuclear reactors but also by cosmic rays in the atmosphere. Its radioactive atoms can be used to trace natural processes

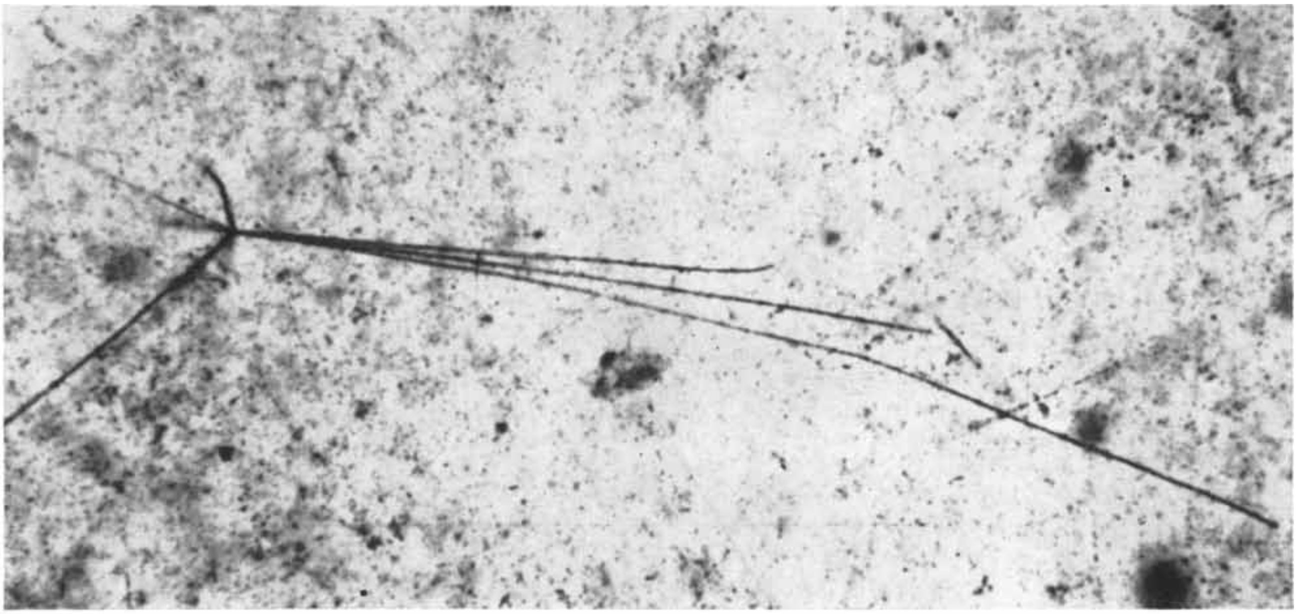
by Willard F. Libby

Tritium is one of the new things under the sun discovered by modern physics. Until less than a decade ago men did not know it existed. It was discovered first as a synthetic product of nuclear transformations in a reactor; then it was detected in nature. We are concerned with it here not as a possible fuel for hydrogen bombs but as a natural phenomenon.

The finding of tritium in nature was not easy. The total amount on our planet is about two pounds, and most of that is in the oceans, so diluted as to be beyond detection. In all the inland waters and the atmosphere of the earth there is a total of about one ounce of tritium. The waters have only about a third of that. But thanks to its radioactivity and to modern techniques of analysis it is possible to measure accurately the tritium in a single gallon of river water.

Why bother to hunt down this infinitesimal substance? The answer is that tritium (radiohydrogen), like radiocarbon, may be an excellent tracer for studying natural processes. With it we can date plant products, such as wine, which originally took up tritium in the water from the soil. Tritium in nature discloses valuable information about the cosmic rays. And tritium in the earth's precipitation may tell us a good deal about the great movements of air and moisture over the face of the globe.

Tritium is hydrogen of mass three (a proton and two neutrons). Chemically it behaves, of course, like ordinary hydrogen; it combines with oxygen to form molecules of water. The richest natural sources of tritium are rain and snow. Without doubt it is produced by cosmic rays when they hit the atmosphere. There are at least two reactions by which tritium might be formed in the air. Cosmic rays produce many neutrons in the atmosphere. When a fast neutron hits a nitrogen atom, it parts the atom into a carbon 12 and a tritium atom. The other reaction yields tritium as a fragment of an atomic disintegration. Cosmic rays of very high energy sometimes hit an atom so hard that they produce a "star" of fragments flying in all directions; tritium nuclei are among the products in this debris. It seems likely that both processes, and perhaps others, contribute to the production of tritium, as the cross section for capture of neutrons by nitrogen in the air probably is



TRITIUM NUCLEUS or triton is produced in a special photographic emulsion exposed at high altitude by Herman Yagoda of the National Institutes of Health. The "star" at left is a lithium nucleus in the emulsion disrupted by a cosmic ray coming in from the upper left. The three tracks running from left to right were made by a proton (*top*), a deuteron (*middle*) and a triton (*bottom*).

too low to account for the production of all the tritium by this process alone.

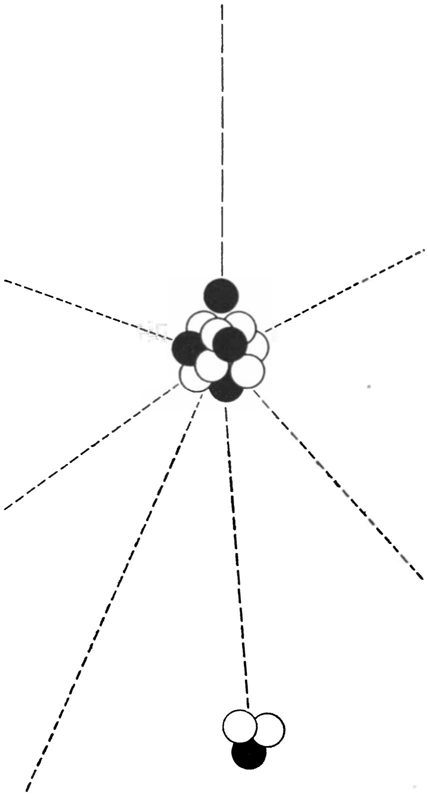
How can one estimate the amount of tritium on the earth, or the rate at which it is being produced? The method is based on this reasoning. Most of the tritium made by the cosmic rays must form water in the atmosphere. This water probably falls and reaches the oceans before any appreciable fraction of the tritium is lost by radioactive decay: the half-life of tritium is 12.5 years and its average total lifetime 18 years. Therefore the rate at which the oceans receive tritium must be nearly equal to the total rate of production. We must calculate the amount that falls into the oceans directly as rain and the amount that flows in from the continents by way of rivers. The calculation is complicated by the fact that the intensity of cosmic radiation varies with latitude on the earth; it is about four times as great at the latitude of Chicago, for instance, as at the Equator. Since the tritium probably mixes vertically faster than it does horizontally, we should expect the tritium content of rains to show corresponding variations with latitude.

Let us see how the calculation on this basis comes out. We take the rainfall at Bergen, on the coast of Norway, as typical of ocean rains at that latitude. According to the measurements, the tritium content of the rainfall there is $.8 \times 10^{-18}$ tritium atoms per ordinary hydrogen atom (that is, the proportion is less than a billionth of a billionth). Now we must make two corrections, one for latitude and one for rainfall rate, to translate the Bergen sample into a world-wide average. In this way we deduce that the average tritium content of sea precipitation is .54. Multiplying by the total annual ocean rainfall (a little more than 30 inches), we obtain the total amount of tritium that falls directly into the oceans. To add the tritium flowing in from the rivers, we used measurements taken in the Mississippi River, where the tritium content was found to be 5.2×10^{-18}. We correct this figure for the latitudinal factor, obtaining a world-wide average of 3.3 for the tritium content of land rainfall. The average total runoff from all the continents into the oceans is some 11.4 inches of water per year. From these figures the amount of tritium entering the sea from the rivers can be calculated. Now we can compute the average rate of production of tritium over the whole earth: it comes to about .1 tritium atoms per square centimeter per second.

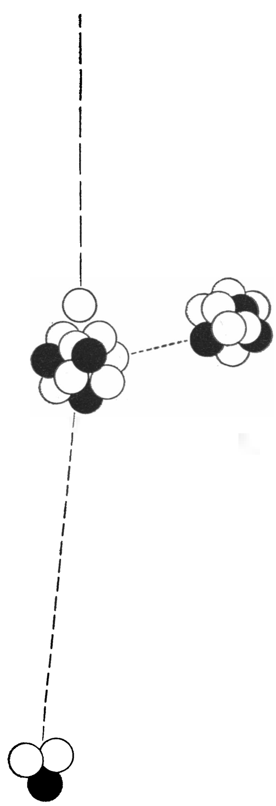
The production at any location also

GEIGER COUNTER is used to measure the tritium content of water at the University of Chicago. The sample is placed within the array of Geiger tubes at right center. The tubes are heavily shielded against extraneous radiation. Door is lowered when counts are made.

WATER SAMPLES are piled at the side of the University of Chicago laboratory. Some of the samples are rainwater, some river water and some lake water. Beneath the table at the right is a case of wine. The tritium in as little as a gallon can be measured accurately.



COSMIC RAY PROTON can hit a nitrogen nucleus (*center*), break it into several fragments including a tritium nucleus (*bottom*).



COSMIC RAY NEUTRON can also hit a nitrogen nucleus (*center*), cause it to decay into nuclei of carbon 12 (*right*) and tritium.

can be computed, of course. For instance, at Bergen, where the annual rainfall is some 35 inches, the tritium production is found to be .15 atoms per square centimeter per second.

The tritium content of water is measured by a lengthy process which involves first concentrating, or "enriching," the proportion of the isotope. At least a gallon is needed for measurement. Before the tritium content can be counted accurately by a Geiger counter the tritium in a sample of natural water must be concentrated by a factor of at least 10,000. It is concentrated by electrolysis in a manner similar to that in which heavy water is made. In electrolysis ordinary hydrogen is dissociated more readily than the heavier isotopes. Both deuterium (hydrogen 2) and tritium (hydrogen 3) are concentrated, but the enrichment of the latter is more than twice as great. Its degree of enrichment is calculated from the measured enrichment of deuterium. Some tritium of course is lost, but under good conditions about half of the tritium in the sample is still left even after 30 gallons of water have been reduced to one cubic centimeter. After enrichment the sample is reduced with zinc to hydrogen gas and its radioactivity is measured in a Geiger counter equipped with devices to cancel out gamma and cosmic rays.

Sheldon Kaufman and the author have completed an assay of precipitation and lake and river waters in the Mississippi Valley region which will shortly be published in detail. The tritium contents of these samples, plus a few from other places, are listed in the table on page 42. The same table also shows the tritium content of some vintage wines. The map on the opposite page gives the calculated average tritium content of waters at several representative points in the Northern Hemisphere.

One important fact disclosed by these figures is that the tritium assay of ocean rains is much lower than that of inland precipitation. This is to be expected, for several reasons: (1) water which rains back into the sea has been in the air for a much shorter time, and therefore has had a shorter exposure to cosmic rays than that which moves in over the land before it precipitates; (2) water evaporated from the sea should have no appreciable amount of tritium, because the isotope is so diluted in the ocean; (3) on the other hand, rain falling on the land is not diluted and hence should accumulate tritium in each successive re-evaporation and fall.

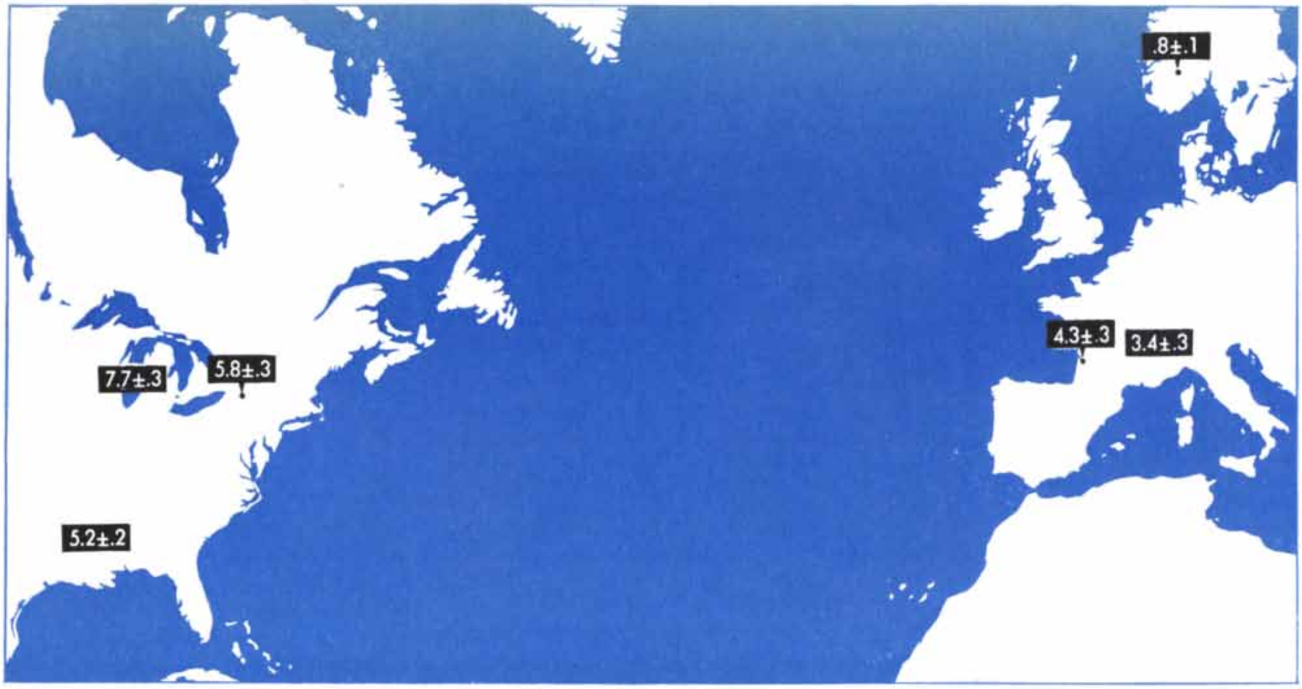
Thus we are not surprised to find that Mississippi Valley rains have some six or seven times as high a tritium content as rains on Hawaii or the seacoast of Norway. Wines from the Rhône and Bordeaux regions of France have only about half as much tritium as waters of the Mississippi, which is much farther inland. In general, the closer to the seacoast, the less tritium there is in the rain. As more observations are made, we shall also expect to find that waters on the western slopes of continents have less tritium than those on the eastern slopes, because of the prevailing westerly winds.

The wide variability of Chicago rains —which ranged from about 1 to 66 tritium atoms on our index—is rather surprising. It seems to indicate that the water in some of the rains had been rained out on the land and re-evaporated many times. The Chicago tritium fall also seems to have a seasonal cycle. It is generally highest in the fall and winter months. This seems to correlate with the fact that in those months Chicago gets most of its moisture from the distant Pacific, and in spring and summer from the Gulf of Mexico.

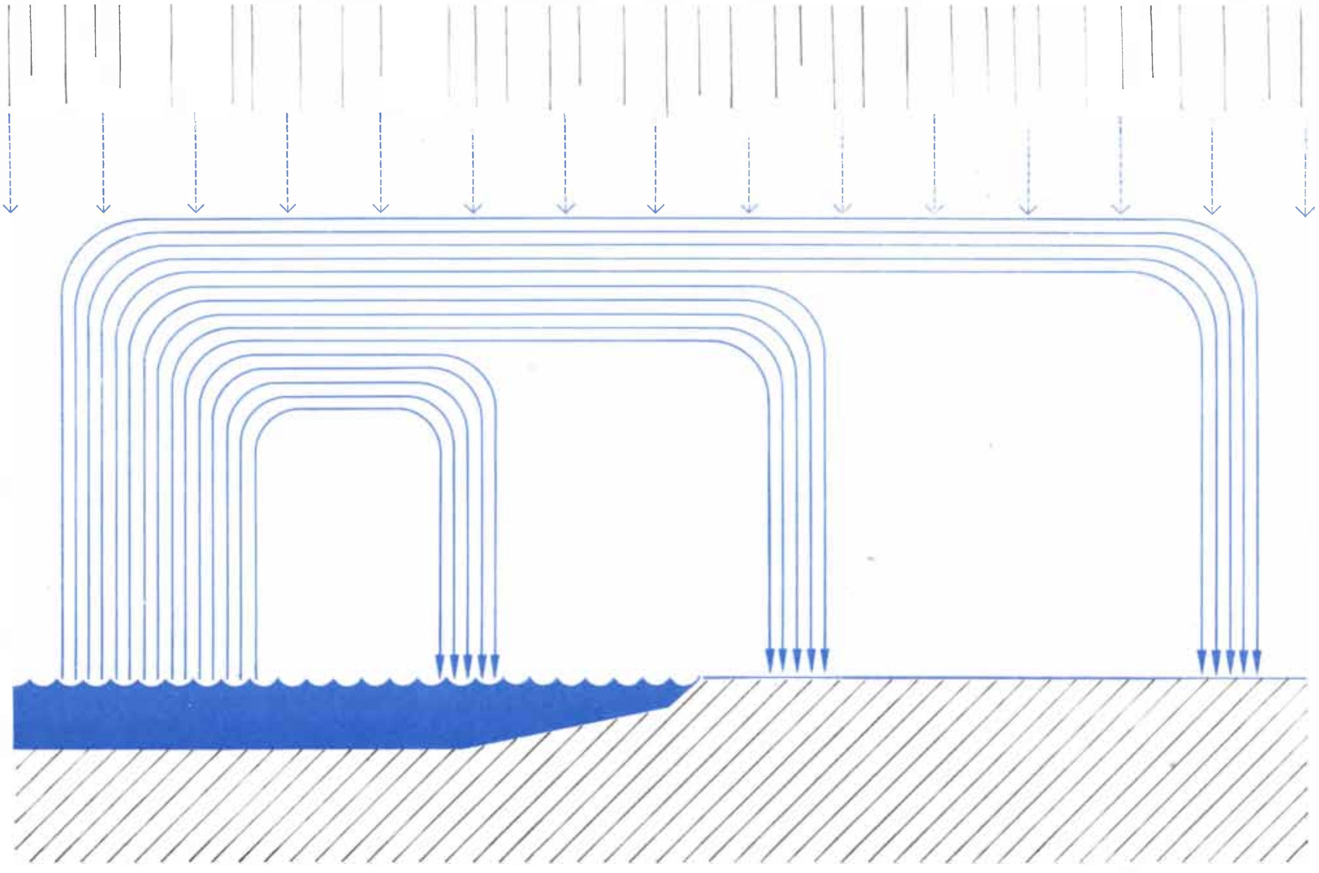
Knowing the rate of production of tritium, we can write an equation which makes it possible to calculate how long moisture has been in the air—from the time it is evaporated from the ocean until it falls as rain. On the basis of a rough estimate of the average amount of moisture in the atmosphere and a tritium assay of oceanic rain, we have calculated that water stays in the air over the ocean for an average of about nine days.

Ignorance of meteorology has made it difficult for Dr. Kaufman and the author to draw many useful conclusions from our tritium observations. It seems obvious, however, that this may become a helpful meteorological tool. It may also be of practical importance in water-supply problems, for tritium assays can reveal, for instance, how long underground reservoirs store water.

When tritium decays, it gives off a beta particle and becomes helium 3. This is undoubtedly the major source of helium 3 on the earth; some may be made by the smashing of atoms by cosmic rays and some by natural fission and other processes in the earth's radioactive rocks, but the total production of helium 3 probably is no more than twice that from tritium created in the atmosphere. Now the earth's atmosphere contains about 80 million million atoms of helium 3 per square centimeter of surface. Considering that the cosmic rays



TRITIUM CONTENT of water varies roughly with the distance from the ocean of the point from which the sample was taken. The numbers on this map are tritium atoms per 10^{18} hydrogen atoms. The samples, from left to right, were: Mississippi Basin water; Lake Michigan water; Naples, N. Y., wine; Gironde Valley, France, wine; Rhône Valley, France, wine; Lake Mösvann, Norway, water.



TRITIUM VARIATION is explained by this chart. At left is the ocean; at right, the land. The black lines at the top are cosmic rays; the dotted blue arrows, water vapor containing tritium. Some of the water evaporated from the ocean (*solid blue lines*) falls as rain (*arrows*) on the ocean, some near the coast, some inland. The farther the evaporated water travels, the more tritium it contains.

SAMPLE			TRITIUM CONTENT
CHICAGO RAINS AND SNOWS			
MAY 11, 1951	RAIN	3.81 INCHES	33 ± 2
OCTOBER 14, 1952	RAIN	.70 INCHES	20.4 ± .7
NOVEMBER 17, 1952	RAIN	.31 INCHES	37 ± 3
NOVEMBER 18, 1952	RAIN	.70 INCHES	66 ± 1
NOVEMBER 22-25, 1952	RAIN	1.13 INCHES	19 ± 1.5
DECEMBER 2, 1952	SNOW	.29 INCHES	13 ± 1.2
JANUARY 6, 1953	SNOW	.05 INCHES	7 ± .5
JANUARY 23, 1953	RAIN	.32 INCHES	9 ± 1
FEBRUARY 11, 1953	RAIN	.03 INCHES	5 ± .7
FEBRUARY 16, 1953	SNOW	.19 INCHES	11 ± 1
FEBRUARY 20, 1953	RAIN	.94 INCHES	3.3 ± .3
MARCH 3, 1953	RAIN, SLEET AND SNOW	.38 INCHES	9.4 ± 1
MARCH 7, 1953	SNOW	.18 INCHES	9.6 ± .8
MARCH 12, 1953	RAIN	.98 INCHES	4.8 ± .2
MARCH 14, 1953	RAIN	1.05 INCHES	1.2 ± .2
MARCH 18, 1953	RAIN	.13 INCHES	7.9 ± .3
MARCH 21-22, 1953	RAIN	.06 INCHES	3.1 ± .13
MARCH 31, 1953	RAIN	.07 INCHES	9.5 ± .4
WEIGHTED AVERAGE			5.5
FAYETTEVILLE SNOW			
JANUARY 23, 1953		1.17 INCHES	5.5 ± .6
HONOLULU RAIN			
MARCH 26, 1953		TRACE	.61 ± .1
MISSISSIPPI RIVER WATER			
JANUARY 29, 1953		ROCK ISLAND	2.5 ± .3
FEBRUARY 6, 1953		ROCK ISLAND	3.7 ± .4
FEBRUARY 24, 1953		ROCK ISLAND	4.4 ± .2
JANUARY 31, 1953		ST. LOUIS	5.6 ± .6
FEBRUARY 4, 1953		ST. LOUIS	4.5 ± .6
FEBRUARY 10, 1953		ST. LOUIS	6 ± .9
FEBRUARY 20, 1953		ST. LOUIS	6.4 ± .5
FEBRUARY 4, 1953		MEMPHIS	6 ± 1
FEBRUARY 8, 1953		NEW ORLEANS	4.7 ± .3
WEIGHTED AVERAGE			5.2 ± .2
SANGAMON RIVER WATER			
AUGUST 6, 1953		DECATUR	1.15 ± .08
ARKANSAS RIVER WATER			
MARCH 20, 1953		CONWAY	3.12 ± .1
LAKE MICHIGAN WATER			
JULY 7, 1952		JONES LABORATORY TAP WATER	1.4 ± .3
FEBRUARY 13, 1953		JONES LABORATORY TAP WATER	1.73 ± .06
1941		OAK PARK HOT WATER HEATER	.62 ± .06
NEW YORK STATE WINES			
VINTAGE 1940		WIDMER'S RIESLING	3.20 ± .2 (6.6 ± .4)
VINTAGE 1946		WIDMER'S RIESLING	3.63 ± .16 (5.4 ± .3)
VINTAGE 1952		WIDMER'S RIESLING	5.3 ± .3 (5.6 ± .3)
RHÔNE VALLEY WINES			
VINTAGE 1929		HERMITAGE	1.13 ± .38 (4.3 ± 1.4)
VINTAGE 1942		HERMITAGE	2.15 ± .25 (3.92 ± .4)
VINTAGE 1947		HERMITAGE	2.15 ± .28 (3 ± .3)
VINTAGE 1951		HERMITAGE	3.4 ± .4 (3.8 ± .5)
GIRONDE VALLEY WINES			
VINTAGE 1928		CHATEAU LAUJAC	1.16 ± .16 (4.6 ± .7)
VINTAGE 1934		CHATEAU LAUJAC	1.16 ± .3 (3.3 ± .9)
VINTAGE 1939		CHATEAU LAUJAC	2.6 ± .4 (5.6 ± .9)
VINTAGE 1945		CHATEAU LAUJAC	2.7 ± .18 (4.2 ± .3)

TRITIUM MEASUREMENTS made in the University of Chicago laboratory are listed. Tritium content is tritium atoms per 10^{18} hydrogen atoms. The average for Chicago rains and snows is weighted according to the amount of precipitation from December to March. The average for Mississippi River water is weighted according to the inverse square of counting errors. The Oak Park water heater had been sealed for about 12 years. The tritium content of wines is corrected in parentheses for its decay since the wines were bottled.

produce an average of about six tritium atoms per square centimeter of the earth's surface every minute, and assuming that they have been producing at this rate for hundreds of millions of years, it becomes plain that much of the helium 3 formed on the earth has disappeared. The only way it can disappear is to escape completely from the earth, because helium 3 does not decay and it cannot react chemically with other elements. From our knowledge of the production rate of tritium we can calculate the rate at which helium 3 escapes from the earth. The calculation indicates that the average time a helium 3 atom remains on the earth is between 30 and 60 million years.

This computation gives us a means of checking whether cosmic rays have really been bombarding the earth at a constant rate through eons of time. Helium 4, the more common helium isotope, is constantly being produced by radioactive decay of uranium and thorium in the earth. It, too, escapes from the atmosphere into space—a little more slowly than helium 3 because it is slightly heavier. Since the production rate of helium 4 and the amount of it in the atmosphere are known approximately, its escape time can be estimated. It turns out that this escape time is about equal to that calculated for helium 3 on the basis of our assumption of a constant rate of production. This agreement supports the idea that cosmic radiation has been raining upon the earth for a long time at about the present rate.

The dating of agricultural products by their tritium content is based on the fact that after a plant has been harvested and has lost contact with rain or snow, its age can be measured by the decline in the tritium content of its water. Through the kindness of several vintners we were able to obtain substantial samples of wine from various localities to assay for tritium. These assays [*see table at left*], when related to the tritium content of rain in the respective localities, agree fairly well with the known ages of the wines. Of course any old water, including that which has been standing in enclosed tanks, can be dated in the same way. Because of the relatively rapid decay of tritium, the dating span is limited to about 30 years.

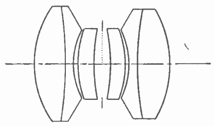
The fact that tritium can be measured in such extreme dilutions makes it an excellent tracer material—one which should have many industrial applications. Tritium is one of the cheapest isotopes to make and one of the safest to handle.

Kodak reports to laboratories on:

Ektar lenses for 70mm cameras . . . making the selection of scientific photographic materials easier for you and us . . . refluxing fats

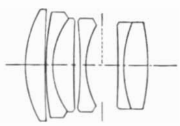
The new lenses

It is conceivable that these three lenses are going to usher in a new phase in camera design. Whether they will or not depends on the eagerness with which designers attack the problem of 70mm film.



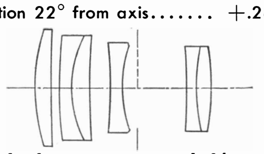
Kodak Ektar Lens, 2½-inch f/4.5

back focal length	52.63 mm
length	23.00 mm
field to corners of 70mm frame	70°
distortion 23.1° from axis	+.065 mm
distortion 33.5° from axis	+.254 mm



Kodak Ektar Lens, 4-inch f/2.8

back focal length	73.81 mm
length	41.69 mm
field to corners of 70mm frame	48°
distortion 18° from axis	+.18 mm
distortion 22° from axis	+.28 mm



Kodak Ektar Lens, 8-inch f/4

back focal length	153.98 mm
length	77.15 mm
field to corners of 70mm frame	24°
distortion 7.5° from axis	+.035 mm
distortion 12° from axis	+.144 mm

Image quality of these lenses is good, very good indeed—so extraordinarily good that the 70mm negatives are probably fairly close for over-all detail content to big negatives made by many an acceptable lens of considerably longer focal length. Rarely has a designer so freely been given his head, and rarely has one tried so hard and succeeded so well in working out a series of lenses with the sharpest imagery for one fixed picture area.

Since we are also a manufacturer of film, you might think that we wouldn't have wanted him to try so hard to make 70mm film do the work of wider film. However, we decided long ago that that kind of thinking was no way to get ahead in the business world.

Sorry, we're not in a position to sell you one *of these lenses. We* are *prepared to enter into negotiations for the manufacture of quantities of them to individual mounting specifications. Address inquiries to Eastman Kodak Company, Special Products Sales Division, Rochester 4, N. Y. Have you ever thought of us as a contract shop for optics?*

Catalog

There is a tradition in our sales department to encourage correspondence on business that looks like small potatoes to the average cost accountant. Unaware of the historical relationship between us and the scientific user of photographic materials, he might well question the exchange of two or three long letters leading up to a recommendation that an order be placed with a dealer for one dozen 1″ x 3″ *Kodak Autoradiographic Plates, Type No-Screen,* retailing at $1.66.

Noble as this outlook may be, we are now making an attempt to save time and stationery for the scientist and ourselves through the medium of a booklet that summarizes the facts about the various materials, familiar and obscure, which we offer for scientific photography. If it does nothing else, it should at least suggest useful questions to ask.

Covered are our offerings in the following categories: 1) for general photography and photomicrography, 2) for the specialized recording of radiation, 3) for general spectrochemistry, 4) for the deep ultraviolet, 5) for the infrared, 6) for autoradiography and nuclear particle tracks, 7) for electron imagery, 8) for the finest image detail, 9) for modifying spectral distribution, 10) for attenuating light, 11) for other photographic techniques.

"Kodak Photographic Materials and Light Filters for the Laboratory" is the title, and Eastman Kodak Company, Industrial Photographic Division, Rochester 4, N. Y., are the people who hope to lighten their correspondence load by sending a copy of it to you free.

Fats for feed

Advertising, not the kind you are reading now but the big-time outpourings, convinces millions of ladies that plain soap is *démodé*, that synthetic detergents are the thing. Frantic scrabbling ensues to find a market for the 700 million pounds of tallow and grease by which the nation's production exceeds its consumption. Agencies and institutions concerned with our agricultural welfare conceive the notion of the entire animal industry as a vast chemical operation in which the less desired product—fat—may be refluxed to create more of the desired product—meat. A long series of nutritional experiments shows that it's mere folklore to regard herbivores as creatures that eat vegetable materials only. The reflux or feedback idea, besides sounding highly scientific, also fits in with the farmer's instinctive desire for self-sufficiency.

The statistics are impressive: if only one percent of all feeds sold contained 5 to 8 percent of stabilized animal fat, the farmers would use up all the fat they can't sell for soap.

Now, we learn that at the University of Nebraska, they have "fed out" one lot of steers on standard rations and an equivalent lot on a mixture including tallow. Both lots brought the same price, but the fat eaters had a glossier appearance and cost $1.18 less per cwt gain. Experiments elsewhere with chicken feeds containing up to 8 percent stabilized animal fats have produced chickens indistinguishable from those on standard diets.

"Stabilized" brings us to our part. Fat goes rancid in feed with commercially inconvenient rapidity, making it unappetizing to animals and possibly dangerous to them. "Tenox R," our butylated hydroxyanisole, added in minute amount during rendering, keeps the fat unaltered in mixed feeds for at least one year's storage at room temperature. Since we don't know of a better way to stabilize fats in feeds, the news from Nebraska and elsewhere excites us.

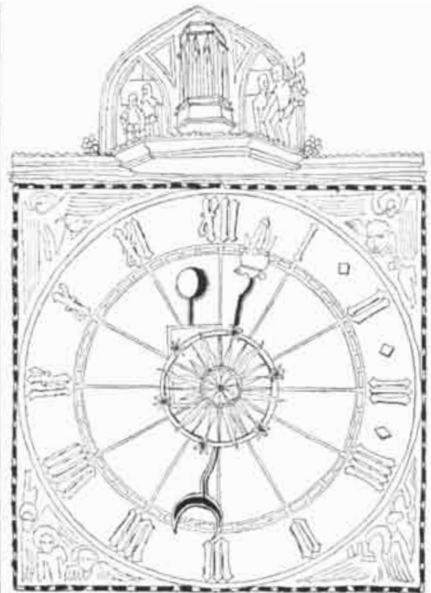
Whether you are a nutritionist, a chemist, a rancher, or a renderer, you can get into a discussion on the economics of fat stabilization by writing Eastman Chemical Products, Inc., Chemicals Division, Kingsport, Tenn. (Subsidiary of Eastman Kodak Company).

Price quoted is subject to change without notice.

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

Kodak
TRADE-MARK

SCIENCE AND



Atomic Energy Law

In a special message to Congress President Eisenhower requested changes in the Atomic Energy Act to reflect "the nuclear realities of 1954." His specific suggestions:

Permit the exchange with U. S. allies of "such tactical information as is essential to the development of defense plans and to the training of personnel for atomic warfare."

Allow the Atomic Energy Commission to release restricted data on industrial applications to friendly nations and make fissionable materials available for industrial and research use in those countries.

Authorize U. S. citizens and business firms to participate in atomic energy projects in foreign countries.

Relax restrictions against private ownership or lease of fissionables.

Permit private ownership and operation, under license, of reactors.

Liberalize patent provisions, principally by "expanding the area in which private patents can be obtained to include the production as well as utilization of fissionable material." Patent holders should be required "for a limited time" (possibly five years) to license their inventions to others, so that "the limited number of companies which now have access to the program cannot build a patent monopoly."

Recognize "degrees of sensitivity" in personal security clearance, so that unskilled workers on an atomic energy project may be cleared without extensive investigation.

Transfer the responsibility for weapons security from the AEC to the Defense Department.

Allow publication of weapons information which the Defense Department and the AEC believe would not endanger national security.

Washington observers doubt that Congress will act on the President's proposals during this session. The Joint Congressional Committee on Atomic Energy is reported to be hopelessly divided over a group of proposed amendments previously submitted by the AEC.

Military Insecurity

While the U. S. Army was having its troubles with Senator Joseph McCarthy last month, the Navy was accused by scientists of being "dilatory, uncertain and panicky in handling security questions." L. W. McKeehan, a Yale University physics professor and retired Naval Reserve captain, voiced the charge in an open letter to the Defense Department printed in *Science*.

McKeehan, who directs an "urgent defense project" at Yale, said that delays in clearing scientists have slowed up his work and damaged the public interest. "The most trivial facts or rumors turned up in routine investigations," he said, "hold up clearances for long periods. Security officers will not discuss a case with either the contractor or the individual involved until the entire investigation has been finished." He mentioned three scientists, needed on his project, whose cases have been pending for more than a year. With the permission of these persons he gave their names as Ray W. Jackson, a Canadian citizen; Carl W. Miller, professor of physics at Brown University, and Miss Virginia Withington, an engineer and a lieutenant in the Naval Reserve.

"I suspect," McKeehan concluded, "that the same malady affects the Army and the Air Force. I think the reasons for this deplorable situation are sufficiently well known not to need discussion here."

Scotch Verdict

That gamma globulin can prevent or alleviate poliomyelitis was "not demonstrated" in 1953, according to 20 experts who were asked by the U. S. Public Health Service to evaluate last summer's results. They found that the mass injections given the children of 23 communities yielded too little clear-cut

THE CITIZEN

information to decide whether they had done any good, because in most instances the peak of the local epidemic had passed. The committee declared flatly that inoculation of household contacts of known polio cases had been ineffective.

The National Foundation for Infantile Paralysis disagreed with the verdict on the effect of mass inoculations. It recalled that in its controlled tests of 1951 and 1952, conducted by William McD. Hammon, "the results were 80 per cent effective for a limited period of time." This year the Foundation will make available three million doses for mass inoculations.

Hammon, who was a member of the PHS evaluation committee, filed a minority report. He believes that the inconclusive results of the uncontrolled 1953 program were neither surprising nor significant, and that they did not prove the giving of GG to family contacts is ineffective.

Geophysical Year

Scientists all over the world are now laying plans for a concerted study of our planet which will begin three years hence. From August, 1957, to December, 1958, observers at various points on the globe will be making coordinated observations of the continents, the oceans, the atmosphere, and the sun and stars. This International Geophysical Year (IGY) will be the third such program. In 1882 and again in 1932 scientists cooperated in "Polar Years" which emphasized arctic research.

IGY is a project of the International Council of Scientific Unions. The Council's committee for the undertaking is headed by Sydney Chapman, British geophysicist. The committee's vice president is Lloyd V. Berkner, a specialist in terrestrial magnetism and now president of Associated Universities, Inc., which runs Brookhaven National Laboratory.

U. S. participation in the IGY is being planned by a committee set up under the auspices of the National Academy of Sciences and the National Research Council. Joseph Kaplan, professor of physics at the University of California at Los Angeles, is chairman. The committee has drawn up a preliminary schedule of activities and has submitted a budget to the National Science Foundation, which will eventually ask Congress for the necessary funds. The U. S. part in the project will be a multimillion-dollar undertaking.

The study will come at a time of maximum solar activity, and many of the investigations will center on solar effects. The fields of inquiry will include meteorology, latitude and longitude determinations, terrestrial magnetism, the ionosphere, the aurora and airglow, cosmic rays, glaciology, solar activity, rocket exploration of the upper atmosphere and oceanography.

The committee has asked for suggestions from scientists as to specific studies that should be made.

Weather Ships

The U. S. has decided to continue on a slightly reduced scale its support of the network of North Atlantic weather stations. Instead of withdrawing all its servicing ships, as the Government had announced, it will cut their number from 14 to 11 and the financial subsidy from $13.6 million to $9 million. The total cost of the program is to be divided into two parts, with 80 per cent prorated according to the number of commercial transatlantic flights made by each participating country and 20 per cent allocated on the basis of weather and other benefits. One of the 10 stations will be dropped.

Stature and Geography

The farther from the Equator you were born and raised, the bigger you are likely to be. This fact has been confirmed in some new studies by Marshall T. Newman, anthropologist with the Smithsonian Institution.

Carl Bergmann, a 19th-century German biologist, predicted that members of a species of warm-blooded animals living in cold climates should be larger than those in warmer. (A bigger individual has less skin area in proportion to total volume and so less tendency to dissipate body heat.) "Bergmann's rule" had never been extensively tested in the case of man. Newman tabulated the body sizes of North and South American Indians and Eskimos. His maps show conclusively that these men and women become larger the farther they live from the tropics. He also checked the second most generally dispersed animal in the New World—the puma. These cats also seem to follow the rule.

Newman points out that the geographical differences in human stature can hardly be hereditary, for man has not been established in the New World

Spare Parts for Human Bodies...
Vacuum Freeze-Dried Arteries

Bones, arteries and other tissues are dried in Stokes vacuum freeze-drying equipment at U. S. Naval Medical Center, Bethesda, Md.

Human arteries, bones, and other tissues, quickly frozen, freed of moisture under vacuum, keep indefinitely at room temperature until needed in surgery.

The vacuum freeze-drying equipment used in this work — first developed commercially by Stokes — is one of the world's great life savers. Blood plasma, several of the mycins, hormones and antibiotics; anti-venoms for snake bite, live vaccines for the prevention of devastating diseases among chickens and hogs . . . all these must be processed by vacuum freeze-drying.

Vacuum freeze-dried products retain potency and volatile constituents for years at room temperature. They have remarkable solubility and reconstitute rapidly to the characteristics of the natural material.

Stokes experimental and test laboratories have been working on vacuum drying processes for 50 years . . . are ready to help with your low-temperature drying problems.

Three important Stokes brochures will be helpful to manufacturers who have heat-sensitive products to be dried. Write for any or all of the following technical brochures (1) Freeze-Drying in Industry, (2) Laboratory Freeze-Drying, (3) Vacuum Drying.

F. J. Stokes Machine Company
Philadelphia 20, Pa.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment long enough to have incorporated them into his genes. As a matter of fact, the effect may show up in a single generation. Children born to U. S. nationals living in Panama have been found to be significantly smaller than their contemporaries in the U. S., even though their diet and living conditions are just as good in Panama.

"Man is not a precisely fixed organism," Newman concludes, "but comes into the world with a considerable physical leeway for adaptation to the environment in which he finds himself."

An Even 100

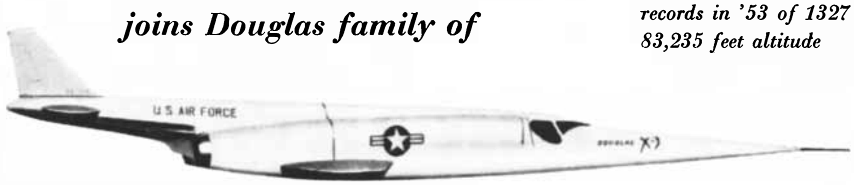
Elements 99 and 100 have been added to the periodic table. Scientists at the University of California made number 99 in their 60-inch cyclotron and number 100 in the Materials Testing Reactor at Arco, Idaho. Other groups, working on classified projects, also have prepared these elements, and the question of priority is unsettled.

The California work was done by members of Glenn T. Seaborg's laboratory. In 1945 Seaborg predicted that the transuranium elements would form a homogeneous chemical group much like the rare earths. Elements 95 through 98 (americium, curium, berkelium and californium) fell into the periodic table under the rare earths, just where Seaborg had said they would, and now 99 and 100 come neatly into line. Ninety-nine goes under holmium, element 67, and has properties like those of holmium; 100 goes under erbium, number 68. This prediction of properties is very handy, because the new artificial elements are made in such minute quantities and are mixed with so many other products of nuclear reactions that chemists could hardly hope to find them without a good idea of what to look for.

Element 99 was made by bombarding uranium 238 with nitrogen nuclei. In the reaction, nine nuclear particles were absorbed to give a nucleus with an atomic weight of 247. The new atom, like all transuranium elements, is radioactive; it decays by emitting an alpha particle and has a half-life of 7.3 minutes. Element 100 was manufactured by "fattening up" plutonium with neutrons in a two-stage process. Plutonium 239 was put into the reactor, where some of its atoms soaked up 13 neutrons and were converted to californium 252. Then the sample was taken out and the pure californium extracted. This was put back into the reactor, where it absorbed two more neutrons to bring its weight to 254. It then underwent two beta decays,

Skyrocket—set world records in '53 of 1327 mph, 83,235 feet altitude

Stiletto-shaped twin jet joins Douglas family of



high-speed research aircraft

Skystreak—world speed record 1948, 650 mph

—the supersonic Douglas X-3

Now to the record-breaking Skystreak, the Douglas Skyrocket and the record-holding carrier-based Skyray, add this important experimental plane—the Douglas X-3.

Performance is secret, but a little can be told. Longer, heavier than a DC-3 transport, X-3 flies on wings smaller than a DC-3's tail—using conventional jet engines for *sustained* flight. X-3 has already contributed basic facts on insulation, refrigeration, and the use of heat-resistant *titanium*, while its payload of research instruments has been used to study the stresses and strains of flight at supersonic speeds.

Design of X-3 is another example of Douglas leadership in aviation. *Faster and farther with a bigger payload* is a basic Douglas rule.

Enlist to fly with the U.S. Air Force

Depend on *DOUGLAS* First in Aviation

converting neutrons to protons, and its atomic number rose from 98 to 100.

The rare earth series extends to element 71. Since element 100 falls under 68, three more transuranium elements would complete the series. Chemists believe, however, that these will have such short half-lives that they may be very difficult or impossible to detect, even if they can be made.

Better than Ivory Soap

W. G. Pfann of the Bell Telephone Laboratories has developed a simple method of refining metals and some other materials to unheard-of purity. The process is already being used to make germanium for transistors which is 99.99999999 per cent pure.

"Zone melting" is the name of the method. Impurities in a substance almost always have different solubilities in the solid and liquid states of that substance. Usually they are more soluble in the liquid. If a small section of the material is melted, impurities will move into the liquefied part from the neighboring solid portions. Pfann's technique consists in moving a solid bar slowly through induction coils which successively melt narrow sections of the bar. As the molten region moves down the bar it accumulates impurities and "sweeps" them down to the end. By repeating the process enough times, almost all the impurities can be deposited in a small end-section which is then cut off. The concentrated impurities can be analyzed and identified.

Zone melting will make it possible to study the properties of really pure metals and the effects of adding precisely measured quantities of adulterants.

Anatomy of Viruses

Only a few years ago seeing a virus at all was considered quite a feat. Today virologists are beginning to probe the internal structure of viruses. In *The Physics of Viruses* the biophysicist Ernest C. Pollard recently drew some theoretical diagrams of viruses showing a central body like a cell nucleus and two outer layers with membranes. Now a group of researchers at the Columbia College of Physicians and Surgeons report that they have seen viruses very like those in Pollard's drawings.

They were working with herpes simplex virus in chick embryo cells. Slicing the preparation into ultra-thin sections, they cut through a number of virus particles so that the cross section could be seen in an electron microscope. Some of

NOW—the modern successor to the galvanometer

the new

ElectroniK

Null Indicator

If you use galvanometers, you'll be interested in the new *ElectroniK* Null Indicator. For here, at last, is the lab man's ideal d-c null balance detector . . . completely free from all the limitations of galvanometers.

It's easy to use—no "loss of spot" from excess signal; bridge balancing operation is simplified.

It's self-protecting—will take heavy over-loads without damage.

It's vibration-proof—undisturbed by nearby traffic or machinery.

It goes anywhere—needs no leveling or special mounting; plugs into 115-volt 60-cycle line; small case fits readily into experimental set-ups.

It's stable—holds steady zero after warm-up.

It's fast—indicates in less than one second; ideal for production testing.

It's sensitive—suitable for use with high precision measuring circuits.

The *ElectroniK* Null Indicator is priced within reach of any budget. It will be a valuable asset to your lab. Write today for complete information.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Instrumentation Data Sheet No. 10.0-12.**

electrical characteristics

INPUT IMPEDANCE
1500 ohms

CURRENT SENSITIVITY
0.6 x 10^{-9} amperes per millimeter

VOLTAGE SENSITIVITY
1 microvolt per millimeter

OPERATING VOLTAGE
115 volts, 60 cycles

H HONEYWELL

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

the viruses were inside the nucleus of the embryo cell, others were in the cytoplasm. The scientists believe that new virus particles begin their development in the nucleus and finish in the cytoplasm. The nuclear viruses showed up as solid spherical bodies, either bare or with one surrounding layer and membrane. The particles in the cytoplasm, which presumably were fully developed, had a central body surrounded by two lighter layers contained in a pair of concentric membranes.

The Columbia scientists, Councilman Morgan, Solon A. Ellison, Harry M. Rose and Dan H. Moore, disclosed their findings in a letter to *Nature*.

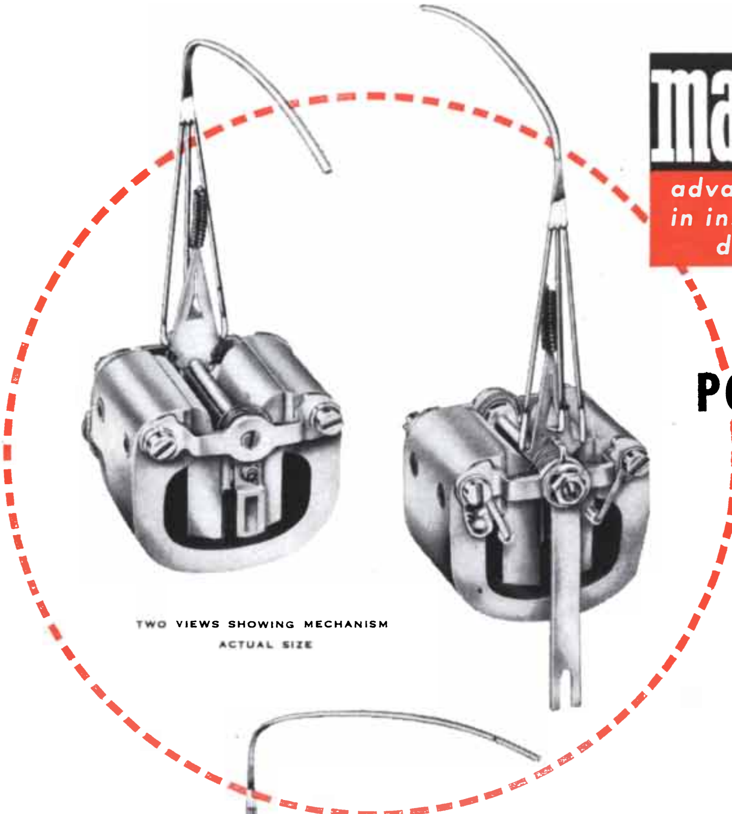
Helpful Defect

The blood condition known as sickle cell trait has long been a puzzle to geneticists. They reason that because of the simple way it is inherited, and because it can produce a fatal disease, natural selection should have wiped it out. Yet in the susceptible populations it remains very widespread. Now A. C. Allison, a British pathologist, has found a likely explanation. He reports in the *British Medical Journal* that sickling provides considerable immunity against malaria, and suggests that this gives it a high survival value in malarial areas.

Sickling is not dangerous unless it affects most of the hemoglobin, in which case it can cause fatal anemia. It is now believed that sickle cell anemia comes from inheriting genes for this trait from both parents, while the trait itself may be transmitted by one parent.

Allison reasoned from its persistence that the sickling trait must carry with it some unrecognized competitive advantage. He observed that the condition is most prevalent in areas where malaria is widespread. Sickling is very common in Africa and India and is known to occur in Italy and in certain parts of Greece. Allison examined the children of a small African village and found that 46 per cent of the non-sicklers were infected with malaria, as against only 28 per cent of the sicklers. Furthermore the non-sicklers tended to have more severe cases. He then inoculated 15 adult sicklers and 15 non-sicklers with malaria parasites. Fourteen of the non-sicklers came down with malaria but only two of the sicklers.

Thus the persistence of sickle cell trait seems to be the result of a balance between the pressure of malaria, which tends to increase the frequency of the gene, and that of sickle cell anemia, which tends to eliminate it.

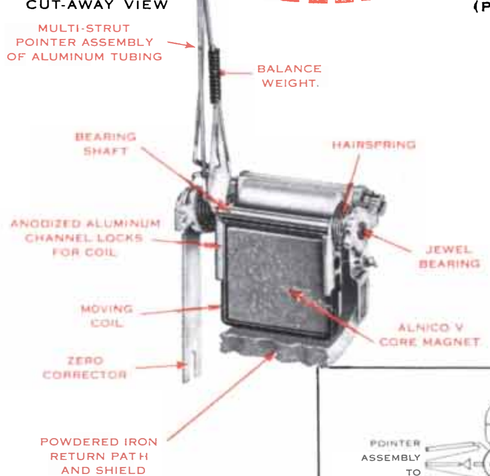


TWO VIEWS SHOWING MECHANISM
ACTUAL SIZE

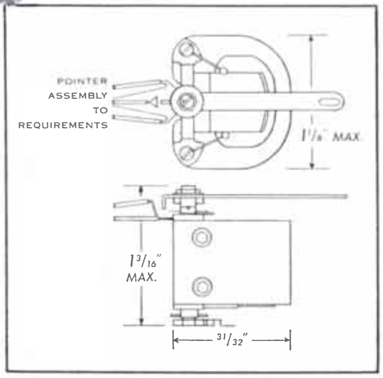
marion
advancement in instrument design

POWERFUL MOVING COIL MECHANISM HAS GYRO-LIKE STABILITY

CUT-AWAY VIEW



(PATENTS PENDING)



The Marion Type MEP-1 meter mechanism was designed to develop highest possible torque for a given volume of magnetic material. Its high torque, heavy eddy current damping and low relative inertia provide unusual performance characteristics simulating the stability of a gyro, in like environment. Already it is setting new and higher standards for reliability in moving coil indicating mechanism design for aircraft application, where the influence of vibration and rapid attitude changes on pointer indication are significant factors.

The gyro-like stability of the MEP-1 mechanism results from its unique mechanical design. An end-pivoted coil assembly, with a one piece bearing shaft and precise mechanical assembly operates in a self-shielded magnet structure which produces approximately 6000 Gauss in a single air gap. When the end-pivoted moving coil, of long turning radius, operates in a magnetic field of such strength, substantial gains in torque and eddy current damping are realized. This great torque, combined with relatively light weight, permits unit bearing loadings substantially lower (i. e. larger pivot and jewel radii) than heretofore normal.

MECHANISMS BY MARION

Although developed expressly for application in aircraft navigational instruments, many of the MEP-1 characteristics make it desirable for use as the sensitive element in control devices where it is required to initiate a control function. It is one of a number of Mechanisms by Marion that extend the field of moving coil mechanism application where previously size, weight or performance characteristics prevented their use.

Marion Electrical Instrument Company,
416 Canal Street, Manchester, N. H.

Reg. U. S. Pat. Off.

marion meters

MANUFACTURERS OF RUGGEDIZED AND "REGULAR" METERS AND RELATED PRODUCTS

THE FORM OF CITIES

A city is the characteristic physical and social unit of civilization. It possesses size, density, grain, outline and pattern. The people who live in it shape these properties and are shaped by them

by Kevin Lynch

The world's first cities arose between 4500 and 3500 B.C. in the valleys of the Tigris-Euphrates, the Nile and the Indus. The coming of the city marked a sudden alteration in the character of human existence: with it came the invention of writing, the specialization of labor, the acceleration of technology and the beginnings of science. Today in every advanced country the city is man's principal way of organizing his living space. In the U. S., for instance, two thirds of the population lives in cities, and by the year 2000 some 80 or 90 per cent may do so.

We are increasingly aware of the effects of the city's physical form on the human activities that go on inside it. In making decisions as to how to build, enlarge or renew this complicated piece of equipment, we are faced with many controversial issues and questions to which neither history nor planning theory have yet given us final answers.

Take, for example, the question of city size, a key issue in planning theory today. It was an important question for the Greek philosophers, who were concerned with the conditions under which a city-state becomes a healthy political and social unit. "Ten people would not make a city, and with 100,000 it is a city no longer," wrote Aristotle. In the 20th century attempts have been made to control or reverse the growth of the metropolis, notably in the cases of London and Moscow.

In a city of what size can we produce most efficiently, best facilitate cultural development, live the most satisfying lives? Let us consider some examples, taken on an ascending scale of size of population.

WASHINGTON depicts a problem of city planning. Its rectangular grid provides convenient building sites but poor communication. Its radial avenues provide good communication but inconvenient building sites.

Size

The little town of Ortonovo in the foothills of the Italian Apennines has a population of some 500 people. Beautifully set on the point of a mountain spur, it depends for its living on olive groves that stretch down the steep mountain slopes. It is closely related to its countryside, intimate and protective. Everyone knows everyone else; gossip is strong. More a village than a town, it means social security for the inhabitants and charm for the visitor. It also means isolation and poverty of life. The village settlements of Neolithic man may almost have reached this size.

Ancient Priene, a planned Greek city of Asia Minor, had in the fourth century B.C. a population of about 5,000. Its temples, agora and stadium give evidence of an organized cultural life, though still on a provincial scale. Presumably nearly all its inhabitants were at least acquainted with one another by sight and its leaders knew each other well. Man's first cities were of this order of size. In modern terms the size of Priene corresponds closely to the "neighborhood unit," a separate residential district equipped with all the basic daily services except employment. Those who favor this type of unit assert that it would assure services within reasonable distances and would reestablish a sound social structure in our great anonymous metropolitan areas. Its opponents argue that 5,000 is already too large a number for any real intimacy, and too small for cultural life in modern terms.

When we come to a town the size of Greensboro, N. C., with 70,000 people, we begin to approach a city as we think of one today. Greensboro deals with the entire Piedmont region and sells some of its products throughout the U. S. The citizens of such a city no longer are generally acquainted with one another but often meet friends on the downtown streets. A specialized cultural life appears, and so do contending social divisions. There is a reasonable variety of jobs and shopping facilities. Public services—police protection, health, education—approach an efficient size. Such towns, once the backbone of American life, still figure deeply in our literature and our popular attitudes, expressed either as nostalgia or revolt. Planning theorists of classical Greece apparently thought this was about the right size for a city—large enough to be self-sufficient for the purpose of living the good life but small enough to allow the citizens to know one another's personal characters. Some modern city planners refer to this size as "ideal."

The next jump is represented by Italy's world-famous Florence, whose population is 350,000. Its size brings to its inhabitants a new freedom and a marked economic and cultural variety. It exerts a strong influence on its region and has a characteristic flavor all its own. Its contributions to man's culture have been tremendous. Although the city is big and anonymous, its whole central area is familiar to all its citizens. The open countryside is 10 minutes away by motorbike, within walking distance in some directions. This size may be near or just over the optimum for efficient urban services. It provides a good variety of economic opportunity. Some problems of urban congestion begin to appear. Many theorists believe, however, that this is the optimum city size for modern society.

Finally we come to the world metropolis: New York, say, with its 13 millions. Here is a tremendous concentration of specialties and specialists, a vast economic and physical network. Products of any kind can be produced or purchased; activities of all types can be found. The city environment completely encompasses the citizen; rural land is far away. There is high stimulus in such a city, and cultural innovation proceeds at a rapid rate, setting the pace for the world. Only 10 cities on earth approximate this size: New York, Chicago, London, Berlin, Paris, Moscow, Leningrad, Tokyo, Shanghai and Buenos Aires. The problems of congestion here appear in acute form, and the city is attacked for its anonymity, loneliness and social disorganization. But it is also defended with equal fire as an efficient structure in a market economy. What is required, say its advocates, is not its abolition but restructuring into more manageable units.

The optimum size for a city is difficult to reduce to a formula. Any principle must be tempered by the purpose and character of the city, its location and the society for which it is built. The definition of a "big" city has changed with history. Lagash in ancient Sumer had 20,000 people; Babylon under Nebuchadnezzar had 80,000; Periclean Athens, perhaps 200,000. Carthage during the Punic Wars was a city of 500,000; imperial Rome, a metropolis of a million.

A factor importantly related to a city's size is its population density: the number of persons occupying a given unit of city ground. Florence, because of its relatively high density, can have green hills close to its center and work places within walking distance of its homes. The endless spread of Los Angeles is a product of low density and a large population.

Density directly affects the life of the city-dweller, since it controls the bulk and height of buildings, the living space inside and out, even the light and air. If the city's size is often beyond our rational control at present, its density is determined daily by every act of construction or regulation.

Density

We can weigh our experience with various densities just as we have compared size. At the lower end of the scale is a town with a density of about 1,000 persons per square mile. This verges on rural land; it would be the density of a community of single-family houses on lots of an acre or more. Few cities have densities this low; one of the few examples is Canberra, the capital of Australia. It is a planned town, set out in 1913 by Walter Griffin, a U. S. architect chosen by international competition. His aim was a plan in the grand manner, with plenty of open space and room for expansion. Its ultimate density was to be 3,000 to 4,000 persons per square mile, but it is still only 500, and the town of 20,000 occupies an area seven by five miles. In Canberra the minor roads have a 100-foot right of way; the major roads, 200 feet. Shops are a mile or more from most homes, and many people must travel five miles to work. The open areas are distances to overcome rather than countryside to enjoy. Densities of this order mean waste of land and inevitable problems of transportation and social cohesion. Only wealth and two cars per family can begin to overcome the difficulties.

At 3,500 persons per square mile we approach the density of a typical U. S. suburb, with single houses on generous lots. This is the American dream becoming reality: a home of one's own, a measure of privacy and freedom, room for the children to grow in. Surveys indicate that more than 60 per cent of our population would prefer to live in areas like this. (There are some large cities with densities of this order, Los Angeles for an example.) The present impulse toward the suburbs is too strong to be denied. Yet it raises important problems: the giant mushrooming of cities, long travel times to work, the impracticability of frequent bus service because of the population dispersal, some isolation of group from group, insufficiency of social stimuli. Many of those who move out from the city remark on the loneliness of outer suburbia.

At 10,000 persons per square mile we reach an urban structure in which the dominant residential type is group housing: row houses, two-family houses and the like. Baltimore and Washington are cities of this order; Chicago is just above it (average over-all density: 16,000). A city that has been planned for a 10,000 density is the new English town of Harlow. There are still private gardens, but the layout is tighter and more economical than in single-family suburbs, with

SIZE of a city deeply influences the character of life at its center. These views of four U. S. cities suggest the change of this character with size. At the left is Johnson, Vt., representing cities with a population of about 500. Second from the left is Maquoketa,

greater visual and social cohesion. Efficient public transport, even rail transit, can be supplied. Theoretically each of the jumps in density we have reviewed reduces travel time to work by 75 per cent. But in a great metropolitan center an average density of 10,000 still means a substantial journey from the periphery to the center. And in a land-starved nation such as England it may be wasteful of land. Few cities of the past were so dispersed, for defense was paramount and transportation primitive.

At 35,000 persons per square mile we come to crowded walk-up apartments three and four stories high. Florence (among the older cities) and the central areas of most of our own major cities are in this range. Congestion begins here: it spells a more difficult environment for growing children, a surrender of light and air. Yet there are also positive values: better social intercourse, a strong feeling of "urbanity," short journeys to work or to the open country, efficient mass transportation. If we waive direct access to the ground, modern design can meet this density and satisfy basic standards by the open use of six-story and nine-story elevator apartments.

At 100,000 per square mile, the upper end of our scale, we find the most congested parts of Manhattan, the modern city of Damascus, the slums of Naples or of ancient Rome. Such concentrations are formed by densely set elevator apartments or hopelessly dark and overcrowded tenements. There is loss of privacy, light, air, circulation, recreational space. Minimum standards cannot be met at this scale today without the use of 40- to 60-story buildings, suspended open spaces such as balconies and terraces, tiered circulation and parking areas. Such a metropolis may be tolerable at the center only for certain special individuals.

We cannot pick any one density as "best." Below a certain point acute difficulties of physical and social communication appear; above another point come inescapable problems of congestion. Within the tolerable range are various types of development which may be better for different social groups. Above all, there is a close relation between appropriate density and total size. A low density, excellent in a small town, may impose a cracking strain on the circulation of a big one.

The act of setting or changing densities directly influences the character and functioning of a city. In most medieval cities fundamental changes came as the population gradually increased within static city walls. Gardens disappeared, houses were packed together and upper floors were added, leaning out over the streets. This happened again when immigrants poured into the tenements of Boston and New York; the sanitary and safety problems took on new and alarming proportions. Conversely, the depopulation of cities at the beginning of the Dark Ages left them disorganized and decaying. Our contemporary flight to the low-density suburb is raising its own problems of obsolescence and communication.

The arrangement of the city's parts is just as important as its size and density. Every city, however small or primitive, shows a certain specialization in the way it uses structures and space. There are separate places for residence, trade, ceremony, production, recreation. Specialization is carried far in modern cities, and this is one of the chief sources of their power and effectiveness. The extent and distribution of such specializations in a city give it a "grain" or texture —a pattern of work places and housing, of large and small dwellings, of segregation or non-segregation of racial groups. The pattern of differentiation may promote or thwart efficiency, reduce or aggravate conflicts. It is so important that a city planner normally begins his design with a plan for the distribution of special uses.

Grain

Some of the primitive city types have relatively little differentiation or pattern. The "city villages" of West Africa and some towns of the Middle East are cases in point. Production is carried on in the home, mixed with some agricultural occupations. Buying and selling may go on there, too, or may spread out indiscriminately along the streets. Houses of all kinds are mixed together; there are few distinct focal points. It is difficult to perform large-scale functions, to locate any particular activity or to service it easily. Such a town astonishes and confuses a visitor from our own cities, which, though often called chaotic, represent a much higher level of organization.

The medieval city had a well-developed sorting-out of uses. Craftsmen often lived over their shops, but there

Iowa, representing cities with a population of about 5,000. Third from the left is Greensboro, N. C., representing cities with a population of about 50,000. Fourth from the left is New York, representing world cities with a population of more than five million.

were sharp cleavages on occupational and class lines. There was a street of butchers, another of ironmongers; locations were controlled by guilds or the city. Sometimes the city had a rigidly enforced ghetto, separate precincts for clergy or lawyers. It had one or more precise focal points: the market square, a cathedral or a castle. Rich and poor might live close together but grouped by guilds or dominant families. On the other hand, Florence had a section of workers' houses across the Arno River; imperial Rome had a similar "poor" district on the far side of the Tiber which persists to the present day.

The "grain" of a medieval city was relatively fine and sharp. The Florentine ghetto occupied a small city block, and abutted directly on the market center. Street names changed from block to block, or even in mid-block, according to the trade or family occupying the frontage. Producers were in close contact with their fellows of the same trade, and comparative shopping was easy. Areas adapted to special uses had strong emotional associations with their activity, be it weaving or worship. The fine grain, the small areas, provided easy accessibility, good social contact and great visual richness.

This medieval organization, however, has features against which we rebel: the fixed definition of a man's position in society, the restrictive control over the productive process, the segregation of the ghetto—though we have our own examples of these today. The fine grain, too, can develop frictions. Medieval Paris made repeated efforts to move the butchers out of the center of town. A convent in 14th-century Béziers protested against nearby tanneries producing "infected air." In addition, small areas may prevent growth and efficient development of a specific activity. Florence's celebrated textile-finishing industry was carried on in dark, cramped shops, with the goods stored on floors above, difficult to handle and exposed to ruinous fires.

Modern cities exhibit differentiation on a much broader scale. The grain is coarse rather than fine. For instance, Chicago has a large Negro section on the South Side, an extensive upper middle class housing area in its North Shore suburbs. Manhattan has a section for the garment industry, a long avenue of department stores and so on. Such large-scale differentiation may have marked advantages. Residential areas can have quiet local streets, with open areas for children and family life. Factory districts can be supplied with rail and road connections; interdependent industries can be kept in close proximity. Both types of area may have room to grow and to develop without interference from other uses.

In U. S. cities the boundaries between areas are generally blurred and indistinct. This indecisive physical transition can be painful: blighted housing mixed with outworn factories or stores; the notorious belt of decay which borders the major commercial center; tense areas on the edge of a racial ghetto where a struggle between expansion and containment goes on constantly. To avoid such conflicts contemporary designers try to make boundaries as sharp and frictionless as possible. Thus in a new town such as Harlow, industry is concentrated in two areas, separated from the residential sections by topography and wide open spaces. Shops are placed in marked-off centers. Even the residential areas are broken up by wide greenbelts. The patterns resemble those of ancient towns which conquerors divided to forestall conflicts. An example is Peking, with its Chinese and Manchu cities, and separate quarters for the emperor, noblemen and commoners. Kahun, the ancient construction camp for the Egyptian pyramids, had a wall separating the workmen from officials. Shanghai is divided into "foreign" and "native" settlements.

Indeed, broad segregation may make population groups hostile strangers to one another, place necessary facilities beyond easy reach and overload transportation systems. In the suburbs the lack of nearby neighborhood stores is a common complaint, and the public library may have little patronage because it is beautifully isolated in a "civic center." Thus segregation is a matter of controversy in planning theory. The need for specialization is accepted, but there is sharp disagreement over how far it should go. For example, heavy industry must be kept in its own area, but is it wrong to put certain light industries in the midst of housing? Each use must be examined to see why its functioning calls for a special area, since segregation is not a good in itself. No reasoned stand can be made for residential division by race, for example, yet this is still a common practice even in new developments.

Some of the argument over specialization can be resolved if each use is studied to find the minimum cluster that will give functional efficiency for that use. For example, houses for families with small children may best be grouped in clusters, so that the young may have

DENSITY of a city varies with the character of its building. These aerial views of four U. S. cities illustrate how this character affects density. At the




upper left is an area in Barrington, N. J., with a population density of about 3,500 per square mile. At the upper right is an area in Philadelphia with a density of about 10,000 per square mile. At the lower left is the well-planned Fresh Meadows project in Flushing, N. Y., with a density of about 35,000 per square mile. Last is a New York slum area with a density of about 100,000 per square mile.

GRAIN of a city refers to the texture of its functional differentiation. At the top is Kano in Nigeria; it has little differentiation. In the middle is a part of Akron, Ohio; the large factory is poorly differentiated from a residential section. At the bottom is Harlow in England; its residential section in the center is clearly differentiated from other areas.

playmates (and the adults, fellow-sufferers), but it may be wrong to extend such an area beyond a square mile, forming a one-class section from which it is not easy to escape.

Shape

Besides size, density and grain, there is the matter of the shape of cities. Even the silhouette of a city tells us a great deal about its living quality. The old cities usually were roughly circular or rectangular in outline, with a sharp boundary commonly marked by a wall. Such is the medieval town of Lucca or a great city like Peking. The compelling motive was protection—the carving out of a special environment in an alien world. In the Etruscan ritual of city-founding, the first act after consulting the omens was to cut a furrow marking the new city boundary. For centuries towns were built first by throwing up a wall, then filling in with development.

Beyond its defensive value, the compact mass is a logical form when it is not too large. The center is close to all sectors of the periphery; the town has a solid, visible unity. It is particularly delightful when the countryside can readily be seen, giving the sense that it can be entered easily. The English city of Bath, ringed with green hills, is a fine example of this.

As the population grows, the compact shape begins to exhibit difficulties. Growth must occur by crowding within or by annular accretion, like the growth rings of a tree. Unlike a tree, however, the center cannot be left to die. It must continue to function, and its obsolescence is increasingly difficult to remedy. It becomes a critical problem to serve the spreading mass with transportation. The open country recedes farther and farther away.

A second city form is the long, narrow ribbon, usually lying along a road or river. The typical "street village" is a good example. The road or river is the primary fact, and the town has developed along it. Topography also may dictate this shape, as in coastal towns or in a settlement like Colle di Val d'Elsa, on a narrow ridge in Italian Umbria. The linear city rarely grows very large. An exception is Stalingrad, which developed this way partly because of the importance of river transport to it and partly for theoretical considerations. On a regional scale the ribbon form may take in a string of towns, such as the urban "corridor" running from Springfield, Mass., through New

York and Philadelphia to Washington.

The advantage of the linear shape is that all structures are close to the main line, and readily accessible in terms of time or effort, given efficient transportation. Expansion can go on indefinitely, without losing touch with the open country. Louisiana parishes and many New England settlements were laid out in this way, requiring a minimum of road to service farms which ran back in deep strips. In Colle di Val d'Elsa most houses front directly on the main street and have green landscape at their backs. Easy communication and closeness to rural land are the motivations behind theoretical proposals of this type. An example is the *Ciudad Lineal* of the 19th-century Spanish engineer Raphael Soria, based on a trolley line. Similar proposals were made by Arthur Comey of the U. S. in 1923 and more recently by the noted French architect Le Corbusier.

Overextension of the linear form risks throttling the main artery, particularly if too much local movement and access to the road is allowed. On a giant scale it cuts the countryside into the kind of isolated patches which may now be seen in the environs of big cities. There is an inherent lack of focus in this form, a lack of centers around which identification and activities can group themselves. Yet on a smaller scale or for particular uses this ancient form has value today.

The shape of a metropolis is something else again. From a central mass extend long arms of development. It is often likened to a star or an octopus, depending on one's emotions. This stellar shape is a natural one for peaceful communication cities, growing from within outwards along fast rail lines or high-speed roads. It is markedly the outline of Chicago.

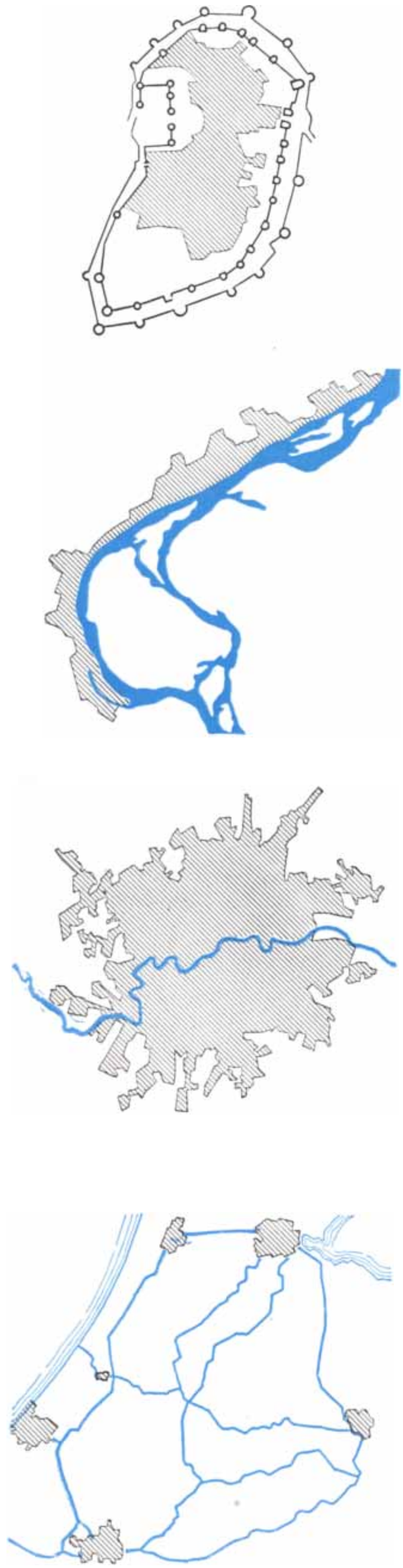
The star shape combines a strong center with the advantages of linear extensibility and close contact with open country between the fingers. If open land is brought in close to the center, then the entire mass can be "aerated" without destruction of convenience or urbanity. Copenhagen's new regional plan has taken this shape. It is advocated by the U. S. planner Hans Blumenfeld in his *Theory of City Form*. Its inherent problems are the difficulty of moving around the circumference, of avoiding the overtaxing of the single center and of seeing the city as a whole. If this form today is associated with overloaded radial highways, blurred boundaries, the gradual melting of houses into scattered dwellings, unoccupied subdivisions and roadside stands, these defects can be prevented by good design and regulation. The blundering fringe which is our first sight on approaching a modern metropolis is the visual evidence of a careless, indecisive relation of the city to rural land.

Each of these city shapes has its problems, particularly as the urban complex grows to great size. For such a complex a new form, called the "constellation," has been proposed. Many separate units, distributed over a large region, would be held together by a web of fast transportation lines. If one unit is clearly dominant and the others are connected with it radially, we have the "satellite" form proposed by the English reformer Ebenezer Howard. Or there might be several more or less equal but specialized centers, each supporting the others, as in the "regional city" of the planner Clarence Stein.

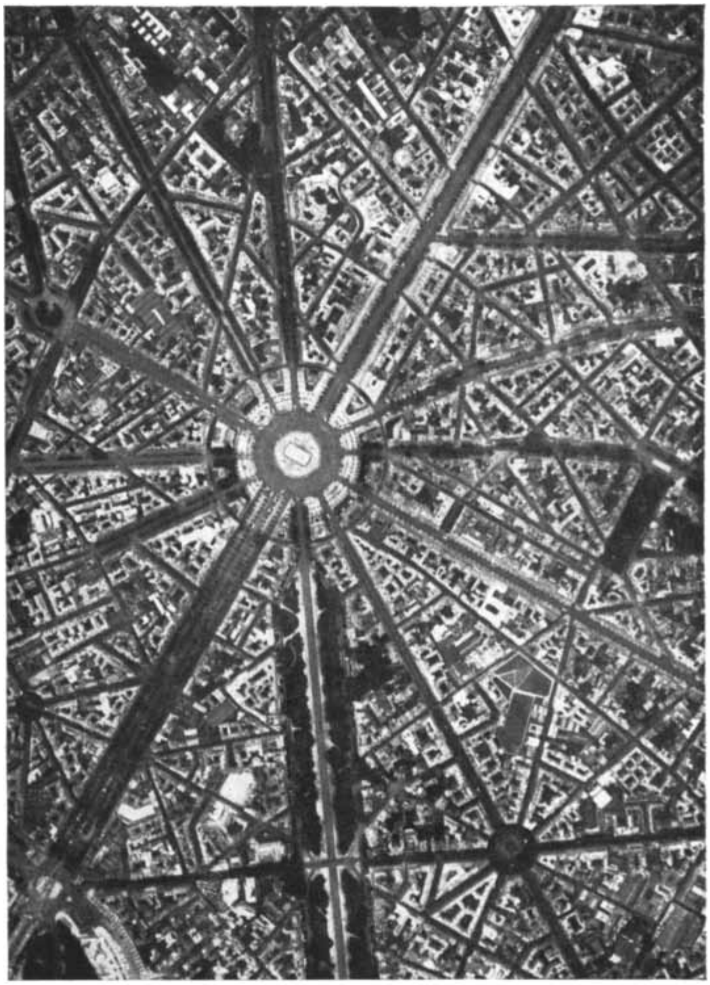
There are no large, thoroughgoing examples yet of the constellation form. A few satellite units have been built, principally near London; the new town of Harlow is one of these. Elsewhere we may see suggestive forms, as in the Boston or Copenhagen regions, where peripheral small towns, anciently independent, have been drawn into the expanding influence of a big city. In some heavily urbanized regions we find close groupings of independent cities, as in the Dutch ring Amsterdam-Haarlem-Hague-Rotterdam-Utrecht or the German cluster Wiesbaden-Frankfurt-Mainz-Darmstadt. Or we may see the form struggling to be born in some of our metropolises, where shopping and employment centers are moving out into the suburbs. The form presupposes fast, flexible transport systems. It would presumably retain the advantages of the great metropolis and yet avoid congestion. Growth and special areas can be provided for, and close contact with open land can be regained. Most city planners today probably hold some variant of this form as their objective.

There are still other possible forms which await imaginative study. Cities might be conceived in a ring shape, with open centers. Or one might turn the old pattern inside out, putting residence on the inside and normally central functions on the periphery, as suggested by the planner Alexander Klein, now working in Israel.

A big city of course resists rapid and sweeping changes. The physical and social investment in its existing structures is too high. Yet growth and change occur perpetually. There is constant opportunity for decisions which in time



OUTLINE types are compact (Carcassonne in France), linear (Stalingrad), star (London), constellation (Haarlem, Amsterdam, Utrecht, Rotterdam, The Hague, Leiden).



PATTERN refers to the organization of space within a city. Here it is illustrated by aerial photographs. At the left is the ancient Syrian city of Erbil; built atop a mound, it has an intricate "capillary" pattern. Second from the left is Paris around the Arc de Triomphe;

could completely reorganize the shape of the city.

The Internal Pattern

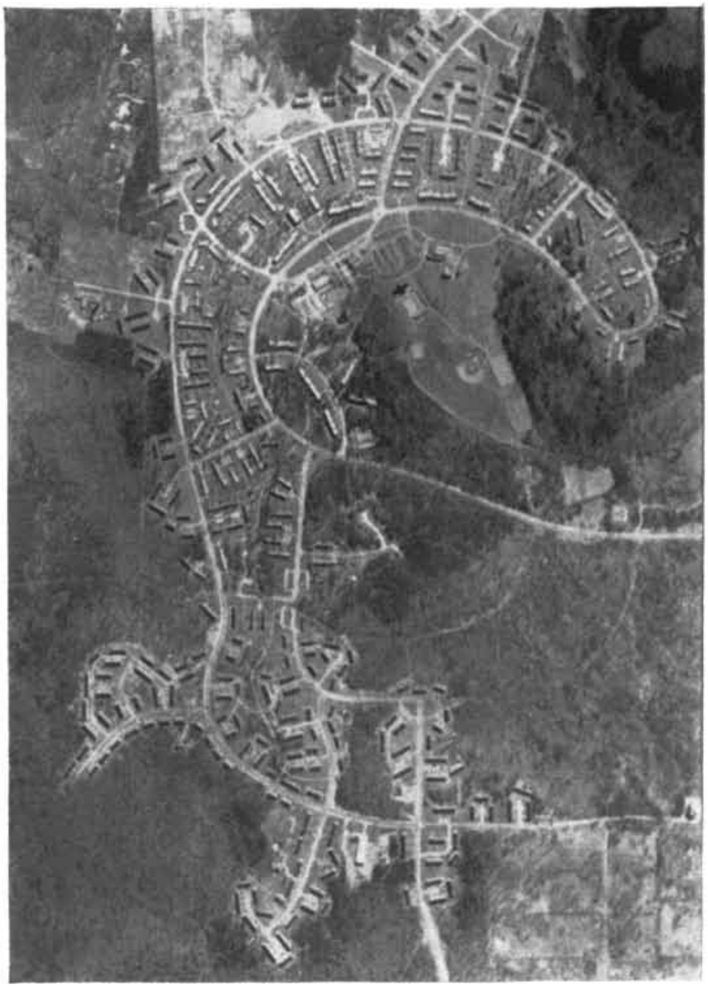
Every city has its intimate inner pattern: the streets, squares and other openings that make buildings accessible and livable. In ancient cities and those of North Africa today the pattern is highly irregular. Buildings or high-walled private gardens are dominant: the public way is simply the land left over. This intricate capillary mass may be perforated occasionally by larger open spaces for gatherings, exchange or ceremonials. Where such a system is not too extensive, it may have its values. There is visual fascination in its intricacy. Its very complication protects the citizen from violent weather, from heavy traffic, or from the sudden foray of an enemy. But over any large area it poses tremendous difficulties of movement, unity and living standards. The agonies of circulation in ancient Rome and the desperate efforts to alleviate them are a matter of historical record.

Equally ancient is the pattern of enclosure in which buildings are wrapped around the community heart; there are ring streets with few breaks into the center. The ring village is a form natural to small settlements in warlike periods. The modern residential or shopping court repeats it. Its modern values are not military defense but social intimacy, segregation of traffic and visual satisfaction. It is difficult to apply on a large scale, although organization of a city as a system of courts of various sizes has been suggested.

More important for city planning today is the axial pattern of streets leading to and from important centers. It is a pattern made for movement. Indeed, the earliest instances, in Egypt and Babylonia, seem to have been designed for religious processions. The axial pattern may appear as a very simple linear arrangement, or be expanded into a spindle consisting of a bundle of parallel roads. Berne is such a city. In Rome the axial lines are scattered irregularly through the city. In many cities the main lines converge from several directions on a center or crossing, or are organized in a perfect radial form. Karlsruhe is a classic example of this axial geometry, which pervaded the ideal city plans of the Renaissance and Baroque periods.

The advantages are obvious. It is easy to locate one's self in such a city if the lines are not too numerous. The long vistas may be imposing, as from the Arc de Triomphe in Paris, or infinitely dreary, as in Chicago. Converging lines have the disadvantage of producing triangular plots, difficult to develop efficiently, and of making intersections hazardous. Yet the axial form is so natural to great cities with dominant centers that city plans repeat it again and again.

A common alternate method of street arrangement is the grid. Although it could take other forms, such as triangular or hexagonal, in practice the grid has always been rectangular. It has very



its dominant pattern is radial. Third from the left is a small section of New York; its pattern, like that in most of the city, is the rectangular grid. Fourth from the left is the Resettlement Administration town of Greenbelt, Md.; it has a free pattern of open spaces.

ancient roots. The Bronze Age villages of northern Italy were laid out in a clear rectangular grid and so was the ancient Indus city of Mohenjo-Daro; Greek colonial cities, Roman camps and medieval towns such as Villeneuve-sur-Lot were all planned on it. It has been the preferred form for new communities. It is systematic, easy to lay out and provides equal, rectangular building sites. It allows a numbering system for easy location. The motives for choosing a grid may be philosophic, as in Peking, where it was adopted to promote regularity and harmony in a city conceived to be the center of the universe, or they may be strictly utilitarian, as when the Commissioners laying out Manhattan in 1811 rejected circles, ovals and stars and decided that "strait-sided and right-angled houses are the most cheap to build and the most convenient to live in."

Among designers there is now a reaction against the grid, mainly because of its lack of adaptability and its "monotony." It causes difficulties on irregular ground, as in San Francisco and Priene. When diagonal motion must be applied over it, as in Washington, it produces confusing intersections and awkward pieces of land. If used unthinkingly, it may allot the same kind of ground for factories as for homes, the same width for main arteries as for local streets. Sensitive design can avoid this, but not without departing from a uniform grid. The impression of monotony arises in part from the lack of necessary specialization; it is not inherent in the pattern.

Another pattern of interior space developing in modern towns makes open spaces instead of buildings dominant, with the building masses as isolated points. Examples may be found both in new low-density suburbs and in relatively high-density "open" developments. Modern transportation allows dispersal of the city and also demands more ground area for its facilities. At the same time modern building technology permits tall, concentrated structures which free the land around them.

This pattern provides a new freedom of movement and of use of the ground. Yet towering buildings set on open ground may have only an illusory advantage if over-all densities remain high and the open spaces are overloaded. In certain sections, particularly shopping and office areas, there is both a technical and a psychological need for concentration which the open pattern cannot supply. The sense of urbanity and the function of the city as a meeting place for large numbers would be destroyed if an entire city were given over to this new pattern. The new town of Harlow, for all its open-space advantages, has a "flat" taste. The modern city requires a rhythmical balance between enclosure and openness, concentration and freedom.

Size, density, grain, outline, pattern—all are basic aspects of the city's physical form. All have a powerful effect on the quality of life that goes on in it. Decisions about them must be faced with increasing frequency as we rebuild and enlarge man's peculiar environment.

The Late Edwin H. Armstrong

The tragic death of the principal creator of modern radio occasions this brief review of the trials and tribulations and achievements of an independent inventor in the U. S.

by Lawrence P. Lessing

When Edwin Howard Armstrong jumped from a 13th-floor window of River House in New York City on February 1, there died one of the authentic innovators of our time. He had conceived the three basic circuits upon which rests the whole of modern radio communications. The first is the regenerative feedback circuit (1912) which took wireless telegraphy out of the spark-gap, crystal-detector stage into continuously amplified sound; the second is the superheterodyne (1918), which underlies all modern radio and radar reception; the third is wide-band frequency modulation or FM (1933), a novel system of high-frequency broadcasting which excludes noise and is the core of developments in high-fidelity sound.

Though Armstrong received many professional honors and large financial rewards, he was not the stereotype of a great American inventor. He was born in New York City in 1890, the son of John Armstrong, who was for many years U. S. representative of the Oxford University Press. In this comfortable, bookish household, later removed to a big house in Yonkers, young Armstrong was soon absorbing the stories of Watt, Volta, Hertz, Tesla and Marconi, devouring the works of Michael Faraday, who remained his lifelong idol, and rigging wireless contraptions in the attic like other young "hams" of the day. At Columbia University, to which he commuted from 1909 to 1913 on a red Indian motorcycle, he entered electrical engineering and came under the inspiring teacher Michael Pupin. From his early teens he had shown an urge to go beyond textbooks into the unknown. He made his first great invention while still a junior at Columbia; his second while still in his twenties, serving as an Army Signal Corps Major in France. At the war's end he returned to Columbia to teach, experiment and eventually take over Pupin's chair, a position which, with its precious freedom to investigate, he never relinquished.

Armstrong's early inventions, vital to the lusty new radio industry, brought him almost immediate wealth. In 1912 his father had refused him $150 with which to file a patent application on his feedback circuit, asking him to wait until he was graduated. In 1913, when he filed the patent, he would cheerfully have sold it for $10,000 and a job. None of the big communications companies made an offer. Right after the war, however, the Westinghouse Electric & Manufacturing Company offered him $530,000 over 10 years for both his regenerative and superheterodyne patents, and he sold them. (Later the government forced the radio industry to pool all electronic patents, and the right to license them for radio uses was centered in the new Radio Corporation of America.) In 1922 Armstrong sold a lesser invention, the super-regenerative circuit, to R.C.A. for $200,000 and 60,000 shares of R.C.A. stock, which was later raised to 80,000 shares for consulting services, making him the largest individual stockholder in the corporation.

Armstrong, then 32, went to Europe, lived expensively and brought back a Hispano-Suiza to indulge his love for fast cars and to dazzle R.C.A. President David Sarnoff's secretary, Marian MacInnis, whom he was courting. One windy night, to impress her, he impulsively climbed to the top of the 400-foot transmitter tower of the new radio station WJZ in 42nd Street. Armstrong and Miss MacInnis were married in 1923, and on their honeymoon to Palm Beach he carried the first portable radio, built for the occasion.

Despite behavior that suggests an F. Scott Fitzgerald novel, Armstrong remained a serious professor of electrical engineering, with more than a touch of worldly shrewdness (he sold most of his R.C.A. stock at a peak price of $114 a share before the 1929 crash). He was of the same breed as the Wright brothers: practical, thorough, soundly trained, tenacious in defense of his ideas and his rights. If he was less successful in establishing his claims to fame, this may have been due partly to the fact that he was never his own best advocate and that while the Wrights' achievements were soon visible in large, shining vehicles riding the skies, Armstrong's were as invisible as the radio waves carrying a song. His major accomplishments were contained within the vacuum tube.

In 1939, when I first met Armstrong, he was at the height of his long battle to establish FM. In 1935 he had demonstrated FM before the Institute of Radio Engineers and in months of successful tests in R.C.A.'s facilities atop the Empire State Building. Getting no action from the industry and finding himself stalled by the Federal Communications Commission on a license to erect an experimental FM station of his own, he threatened to take it to a foreign country. In 1937 he was allowed to build a full-scale FM station, in which he invested $300,000, at Alpine, N. J. In the next two years he gave demonstrations of FM's superior radio quality to all who would listen.

The demonstration I attended started with a briefing in his Columbia laboratory, from whose walls two portraits of Faraday looked sternly down; afterward Armstrong drove us first to Alpine and then far out on Long Island to the house of a friend who had an FM receiver. When the set was turned on, the Alpine program came in out of a blank silence, as if there were no receiver at all. Armstrong telephoned an assistant at Alpine: "Suppose we have a few tricks first, John." A match was struck, a glass of water poured, a gong tapped, and all were reproduced on Long Island with utmost faithfulness. Then a pianist began a Mozart sonata, and there issued from the black box such full, natural tones as had never been heard. FM broadcasts were repeatedly recorded at this location with the same steady, limpid clarity through thunderstorms and other atmospherics that make ordinary radio an affront to the ear more than half the time.

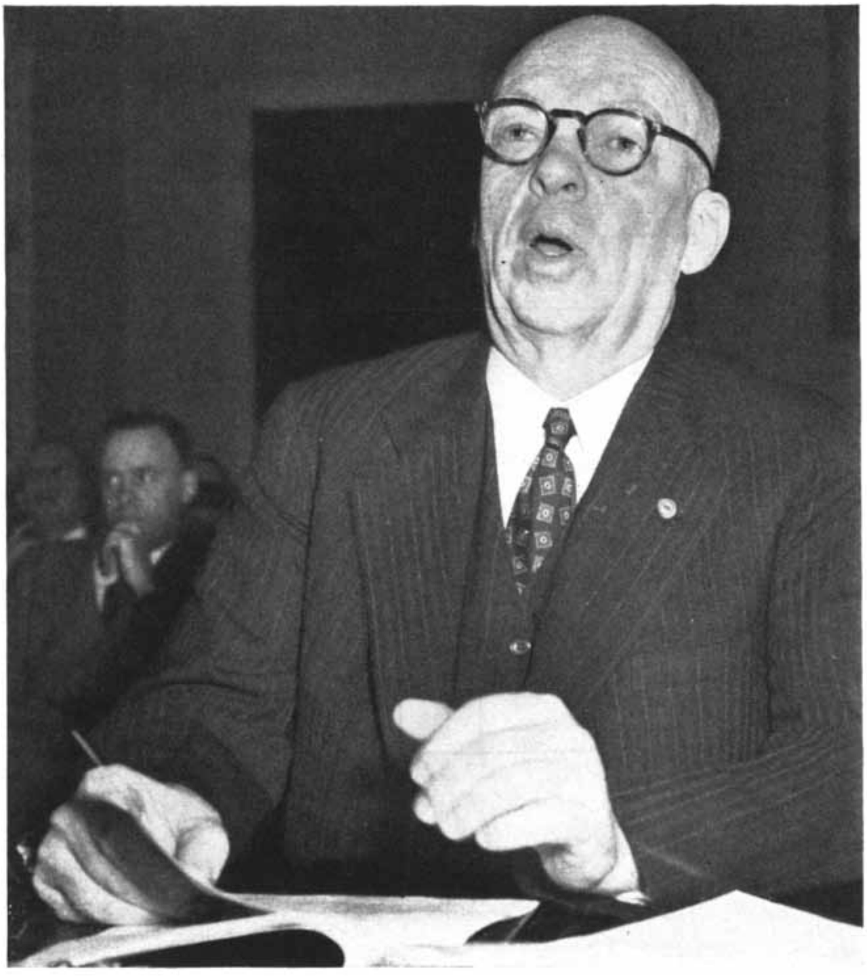
Short-wave FM was not merely a tonal advance but a different broadcasting system. It made possible many more radio stations and networks than could ever be crowded into the limited long-wave radio bands. The inventor offered the FM patents only for licensing, not for sale. He was determined to administer FM himself in order to control its quality. Regular radio, to his sensitive ear, had had its technical standards steadily lowered by the overcrowding of stations in limited frequencies and by a flood of inferior receivers. Naively, he was shocked by the stony silence and opposition with which most of the radio industry greeted FM. The industry coldly informed him that the public was not interested in high fidelity, and moreover, with television just on the horizon, that FM had come too late. Armstrong never forgave this rebuff.

Like his model Faraday, whose discoveries founded the electrical industry, Armstrong was an original, non-mathematical thinker in electromagnetic waves. He shied at equations, not because he was ignorant of mathematics but because he preferred to think first in physical terms of particles, currents, frequencies, circuits, then to reduce his observations to mathematics. Too many discoveries had been put off by figures which said they were impossible. His forte was the sharp analysis of ambiguous physical phenomena. He was never so happy as when flying in the face of some accepted theory or confounding an unimaginative engineer. His deepest reverence was for "the laws of nature." Though his discoveries were not as basic as Faraday's, they went far beyond narrow invention.

This is well illustrated in his working out of the regenerative circuit. In 1883 Thomas Edison observed a mysterious effect. Experimenting with a plate inserted in an incandescent lamp, he noticed that when he connected the plate to the positive terminal of a battery, a current leaped across the space between the lamp's hot filament and the plate. Edison passed over the phenomenon as insignificant. It took until 1904 for an English physicist, Sir John Fleming, to puzzle out the "Edison effect" and put it to use in the Fleming valve—the first electronic tube. It had two elements: a filament and a plate. Two years later, in the U. S., Lee De Forest added a third element—a metal grid between the filament and the plate which could control or modulate the current across the space by small voltage changes on the grid. He thereby created essentially the electronic vacuum tube of today.

Its possibilities for radio were not realized at the time. Again a tiny effect was observed, which De Forest passed over and failed to explain. When the tube was tuned to a certain frequency in a circuit, it emitted a faint, long-drawn whistle. In 1911 young Armstrong found the answer. Like a dozen more eminent investigators he was searching for a means of amplifying wireless signals, which were then too weak for effective transoceanic communication. Testing and analyzing the tube's performance, Armstrong came to the startling discovery that, properly hooked up, it was a powerful amplifier. The whistle De Forest had heard had been the tube imperfectly amplifying. When the tube's electrical output was purposefully fed back on the input line to the grid in an endless loop, it multiplied weak incoming signals hundreds of times. When, later, Armstrong allowed it to amplify beyond a certain value, the tube began sending out its own oscillating, high-frequency radio waves. In 1914 Armstrong wrote two historic papers fully delineating the regenerative feedback principle and plotting the first curve—now an engineering commonplace—showing how the vacuum tube really worked.

His next two inventions, which came in short order, were of the more striking "accidental" sort. He was led to the

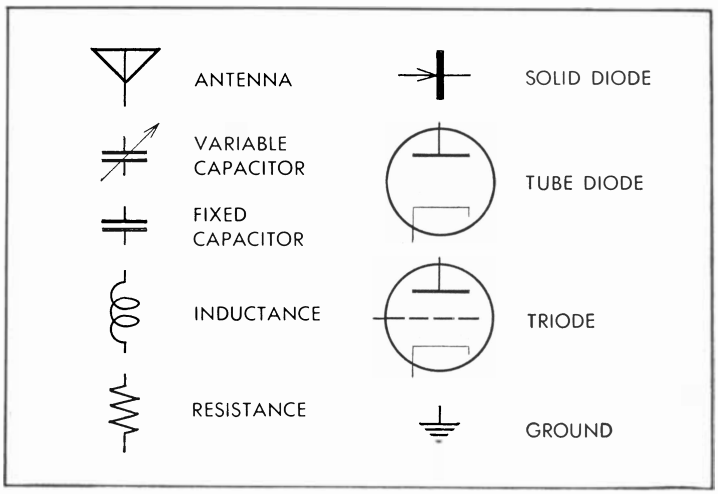


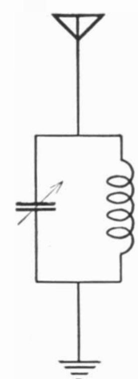
ARMSTRONG was born on December 18, 1890, and died on February 1 of this year. This photograph was made in 1948 as he testified before a Congressional committee on FM.

superheterodyne by a mathematical dispute over a circuit called the heterodyne. He solved the problem by experimental means, and its solution, plus two chance observations on unrelated military problems, suggested a circuit which would overcome feedback limitations and give thousandfold amplification. The next invention was pure chance. While resetting his regenerative apparatus to prove that a patent lawyer had garbled a law of nature, he suddenly pulled in an amazingly loud signal. This proved after some days of analysis to be super-regeneration, now used in special military and police systems. "Ninety-nine out of 100 experimenters," said his co-worker Alan Hazeltine on presenting him with the Edison Medal of the American Institute of Electrical Engineers in 1942, "would have failed either to notice the effect or to find its cause."

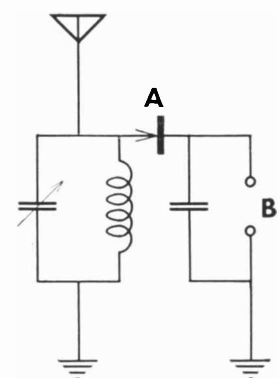
FM came at the end of a dogged, 20-year search in which Armstrong had chased many will-o'-the-wisps. Static in radio is essentially the same electrical phenomenon as the radio signal itself: *i.e.*, amplitude-modulated waves of varying power. Hence it is extremely difficult to keep static out of AM radio, even with heavy power and ingenious filters. Searching for a way around this impasse, Armstrong about 1925 found a way to transmit signals by varying not the power but the frequency of the waves. Many experimenters had tried this and pronounced it unworkable for radio use. But all had attempted to employ FM like AM radio, transmitting it on as narrow a band of frequencies as possible for sharp tuning. Armstrong conceived the idea of allowing the frequencies to swing over a wide band. This not only made FM workable but allowed for the full frequency range of the human voice and music. The band width required put FM up into the more spacious, relatively un-

The wiring diagrams below depict in simplified form the evolution of

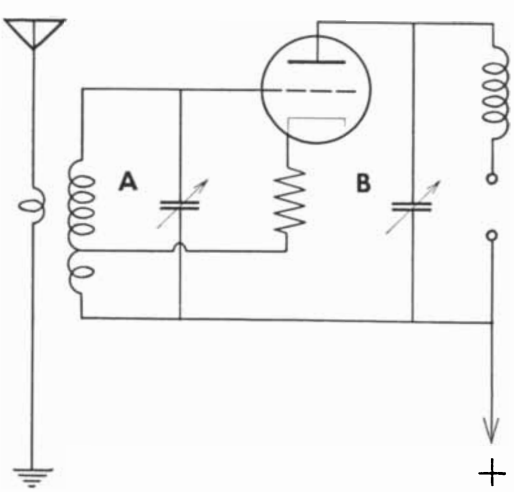




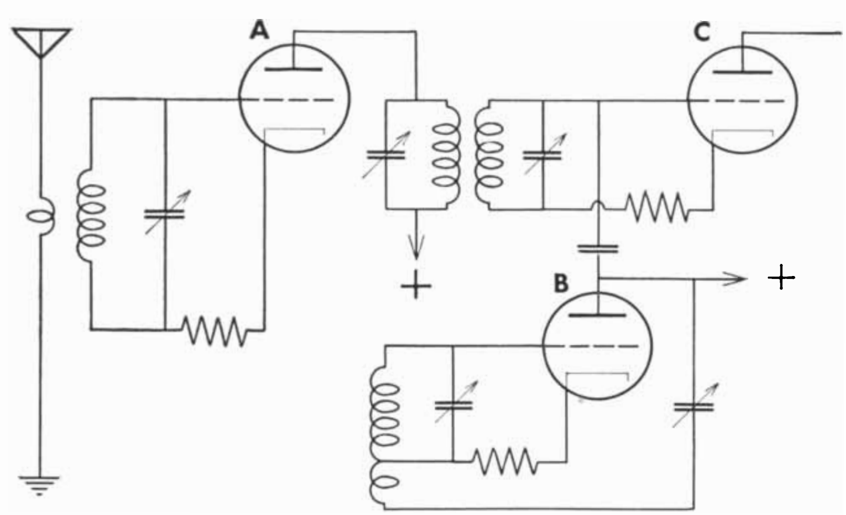
TUNED CIRCUIT is resonant to frequency of an incoming signal.



CRYSTAL (A) detects signal, *i.e.*, changes it to direct current for the output (B).



SUPER-REGENERATIVE CIRCUIT amplifies radio signal so much in circuit A that the tube begins to oscillate. The oscillation is quenched by circuit B.



SUPERHETERODYNE CIRCUIT is quieter and more selective of frequencies than the super-regenerative. Incoming signal is amplified in circuit A. Circuit B generates oscillations of a frequency differing from that of the in-

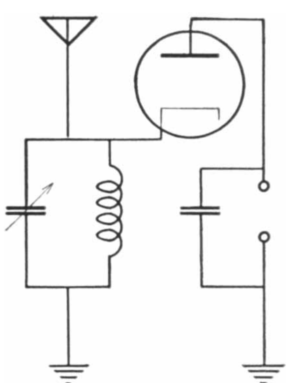
tenanted ultrashort waves, where there is less static to deal with.

In essence Armstrong's solution was to employ a type of electromagnetic wave not normally found in nature. Generated by a specially designed transmitter and sent to a special receiver, it forms a closed system into which normal static cannot break. Since the signal's amplitude is held constant, FM can operate on a small fraction of the power of AM radio with a clarity unmatched by the most powerful clear-channel stations. Its range, however, is limited to not much farther than the horizon.

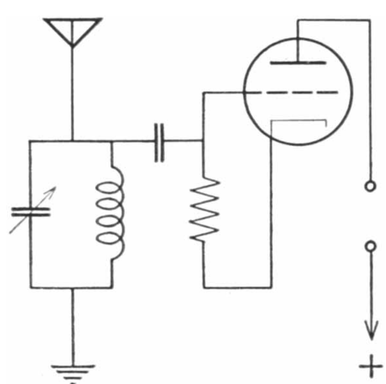
Most of Armstrong's life work was done in the arena where the patent and research departments of great corporations contend for advantage. He had an early baptism of litigation. In 1914, shortly after Armstrong filed his feedback patents, De Forest applied for patents on a similar system called the "Ultraudion" circuit. Armstrong received his patents in 1914, De Forest in 1924. For 12 years a violent battle was fought in the courts. The radio industry first backed Armstrong's patents, which it owned, then switched to De Forest's, which it also owned but which had an additional 10 years to run. Armstrong carried the case alone up to the Supreme Court, seeking vindication. The Court, following the technical facts with difficulty, found for De Forest. Shaken and emotionally distraught, Armstrong returned to the I.R.E. a citation and medal it had awarded him in 1917. The organization refused to take it back. In 1941 and 1942 two technical juries, after again reviewing the case, awarded Armstrong the Franklin medal and the A.I.E.E. top medal for his three major inventions.

FM was to give Armstrong an even worse legal headache. In 1940 the Federal Communications Commission awarded to FM radio the frequency band it had previously given to experi-

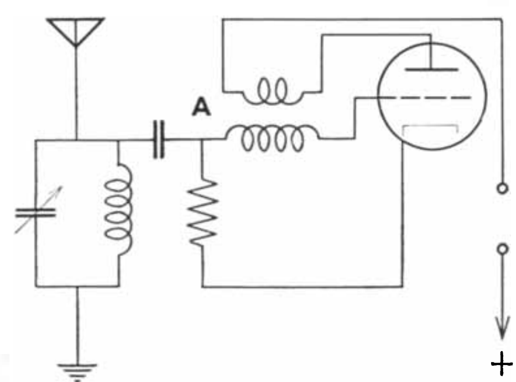
radio from the crystal detector to wide-band frequency modulation



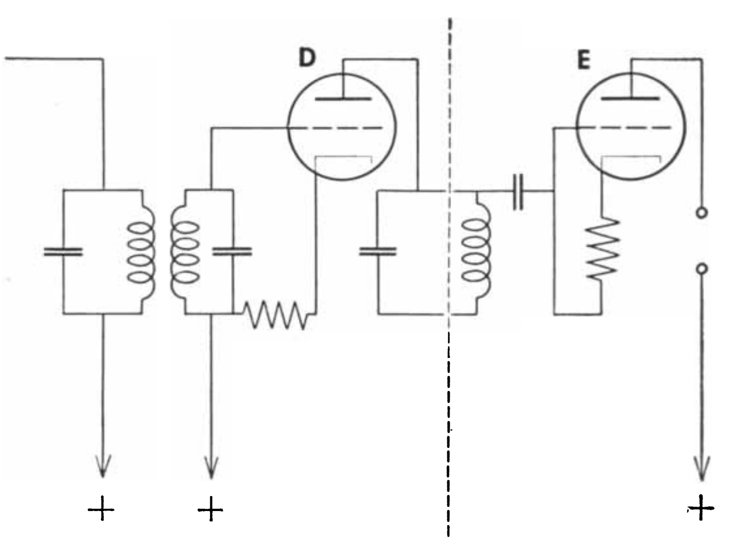
TUBE DIODE has the same function as crystal diode. Neither device amplifies the radio signal.



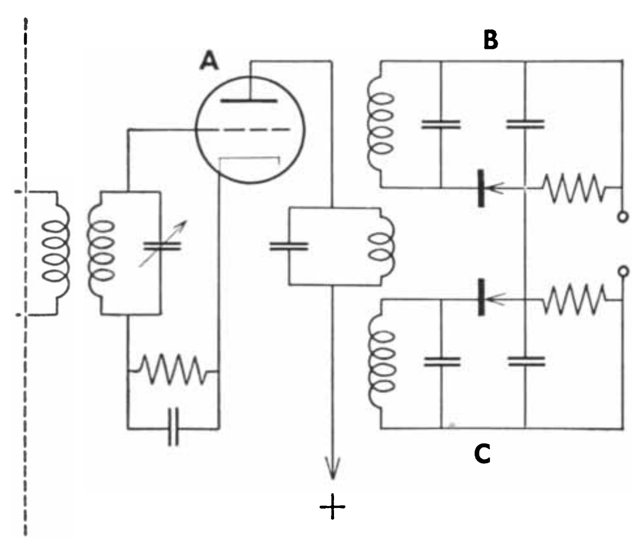
TUBE TRIODE adds grid to diode, modulates large local current in pattern of radio signal. It amplifies signal about 100 times.



REGENERATIVE CIRCUIT feeds some of the amplified current back through the grid by means of coils (A). It amplifies signal about 1,000 times.



coming signal. The two frequencies are mixed in circuit C. The resulting beat frequency (the difference between the two frequencies) is amplified in circuit D. It is finally detected in circuit E.



WIDE-BAND FM CIRCUIT is the same up to the dotted line. Circuit A limits amplitude of signal. Circuit B is tuned to higher frequencies; circuit C, to lower. Their output is mixed.

TOWER and radio station were built by Armstrong at Alpine, N. J., to work with FM.

mental television, moving the latter to a higher frequency. In addition, it ordered all of television's audio circuits to be changed to FM, as they are now. Soon 40 FM stations and 500,000 sets were operating. The large AM networks added FM facilities.

After World War II (during which FM served in most of the mobile short-range military communications) the F.C.C. dealt FM broadcasting two severe blows. It moved the broadcasting to higher bands, making all transmitters and sets obsolete, and, on an AM network suggestion, it drastically cut the allowable station power in order to limit each station to a "single market" area. This hurt small networks of independent FM stations, which had been relaying programs by air from one station to another. Nevertheless, by 1949 there were more than 600 FM stations on the air, and high-fidelity radio has now become a $300-million-a-year business.

Throughout all this, only a few manufacturers paid Armstrong royalties on his FM patents. Most set-makers used a type of FM (the "ratio detector"), first heard of in 1946, which Armstrong charged was merely a cut-rate, inferior version of his invention. He brought suit. The suit has dragged on in pre-trial hearings for five years.

Bitterest of all to Armstrong was the fact that FM showed no signs, as he and others had predicted, of supplanting AM radio. The AM networks merely duplicated their AM programs on FM, developed few if any live programs for FM standards and failed to develop independent advertising revenue from FM outlets. Small, independent FM stations, isolated in single markets, had rough sledding economically and, therefore, artistically, and many went out of business. Armstrong himself anonymously put up some $1,200 a month for high-fidelity toll lines between Washington and Boston to hold the old FM Continental Network together for such programs as the Library of Congress' chamber music series. He also kept his old Alpine station going. This station operated for 16 years at a cost of more than $1 million. Last month, after his death, it was shut down.

Armstrong's life was a mixture of great achievement and of nagging adversities which finally killed him. Perhaps he might have been happier if he had followed Faraday's example of renouncing the financial exploitation and rewards of his discoveries. Yet if he had not pressed FM, it might still be only a document in the Patent Office. He, like Marconi toward the end of a busy life, looked longingly and prophetically at the microwaves, in which he was certain there were discoveries yet to be made, but his trials did not give him time.

At the end he was weary of the battle. I talked with him late last December. His basic FM patent was running out. His suit showed every sign of outlasting the De Forest action. He would not be consoled by the slowly growing popularity of FM and the high-fidelity idea. He had placed great hope in a new F.C.C., but that was gone. He had a sense of failure such as often creeps in upon the best and most creative minds.

In his big, lonely apartment overlooking the East River Armstrong wrote a last letter to his wife (who had gone off to Connecticut because he refused to retire and relax). His funeral in the Fifth Avenue Presbyterian Church was attended by his Columbia University associates, some of the world's leading electronic engineers and the captains of the radio industry he had founded. "Greatness," said Ralph Waldo Emerson, "is a property for which no man gets credit too soon."

HEAT DEATH

A brook trout perishes at room temperature; a frog, when one of its limbs is placed in warm water. Every animal has its own fatal temperature, determined by the stuff of its cells

by L. V. Heilbrunn

What is it that makes a man die of the heat—or a mouse, a fish or an insect? They all do die when the temperature of their bodies rises only a few degrees above normal. Of course there is a difference between a man and a mouse on the one hand and a fish and an insect on the other. Men and mice keep their body temperature reasonably constant. This is somewhat easier to accomplish for a man than it is for a mouse. The mouse, being much smaller, loses heat more rapidly and on a cold day has rather a hard time keeping its body temperature normal; in spite of its protecting fur, it doesn't always succeed. Both animals produce heat as a result of muscular activity, for when muscles contract they give off heat. When it is hot, our bodies must lose some heat if we are to survive. Sweating is a help. The mouse does not sweat, but it is cooled by evaporation from its moist mouth and lung surfaces.

The insect and the fish have no protection against the heat of their environment. Some fish will die at temperatures that seem cool to us. The heat any animal can tolerate depends on the temperature it normally lives at. Tropical fish can live in rather warmish water; a brook trout, which normally lives in cold mountain streams, cannot survive at ordinary room temperature. Marine fish accustomed to life in the cool ocean soon die in warmer water. On the other hand, fishes of shallow warm ponds and tropical fish can stand more heat. In some cases animals live their lives through in water just a degree or two cooler than the temperature which kills them. This is true of polyps which build coral reefs. Our own normal temperature is 98.6 degrees Fahrenheit. If a violent fever increases our temperature 9 or 10 degrees, we are sure to die.

Why is this true? Why is the stuff we are made of so sensitive to heat? The heat death of an animal, be it man or mouse, fish or insect, is due to the heat death of cells. What is it that makes a cell die when its temperature goes up a few degrees?

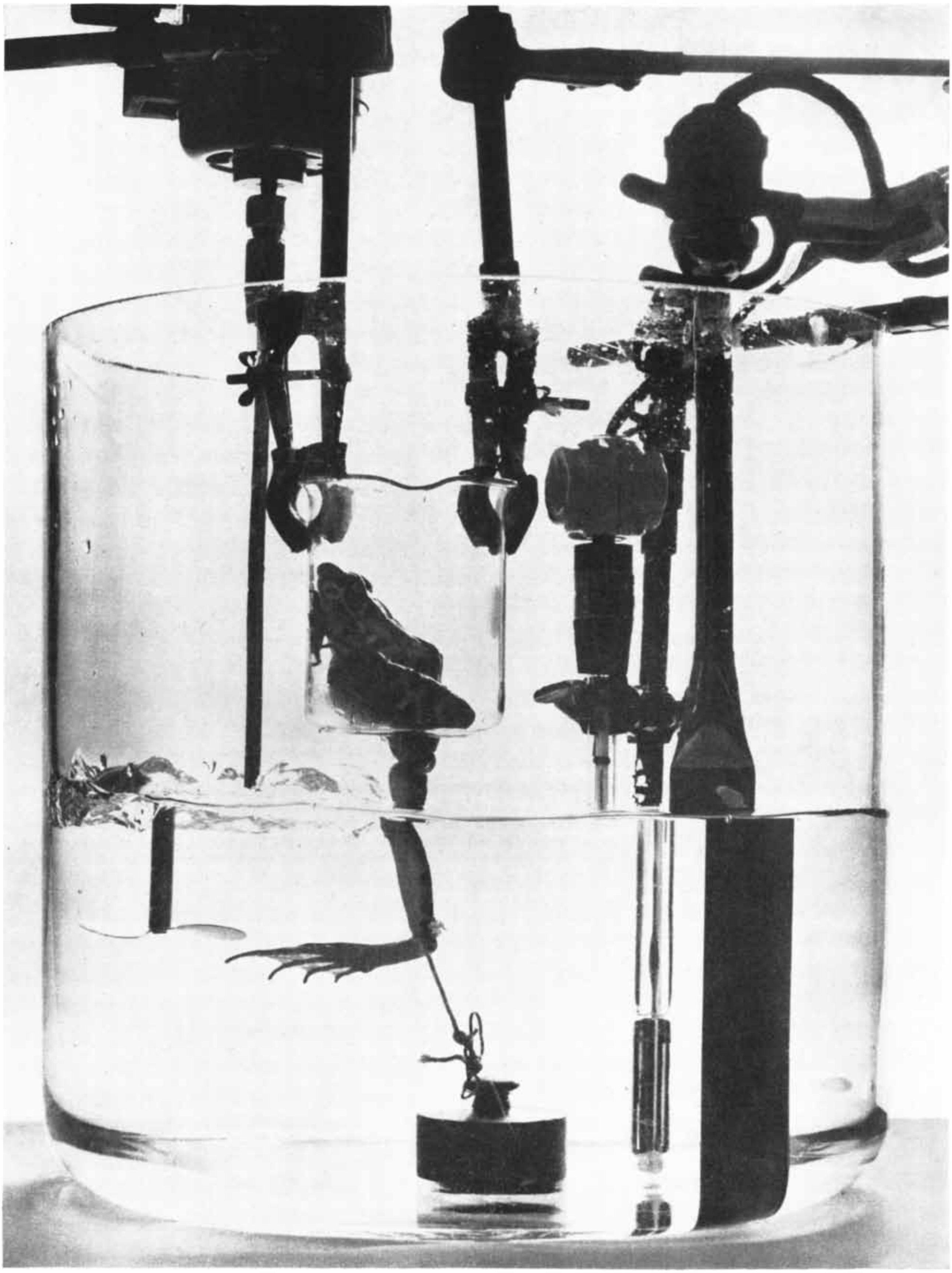
Typically a cell is a tiny fluid droplet consisting of a nucleus, a surrounding fluid in which are suspended numerous granules, and a firmer outer rim called the cortex. The chemical components of the cell are water, proteins, fats or fatlike substances, carbohydrates and salts.

In considering how heat kills a cell, we can well exclude the nucleus, for cells can live for quite a while even if the nucleus is removed from them. The main effect of killing heat on the cytoplasm of the cell is a marked stiffening of the fluid. This can be measured with a centrifuge. The most useful centrifuge for such tests is a hand-operated one whose tubes are whirled by means of a handle like that on an old-fashioned coffee grinder. A convenient cell on which to experiment is the egg of the sea urchin. A sea urchin egg has a great many granules evenly distributed throughout its protoplasm. In its normal condition, when the egg is subjected to a centrifugal force several thousand times gravity almost all its granules, being heavier than the rest of the protoplasm, move toward one end of the cell. But if sea urchin eggs are first heated to a temperature of 93 degrees F. for a few minutes, centrifuging will not move the granules at all. The main mass of the protoplasm has lost its fluidity and the granules are stuck in the stiffened mass.

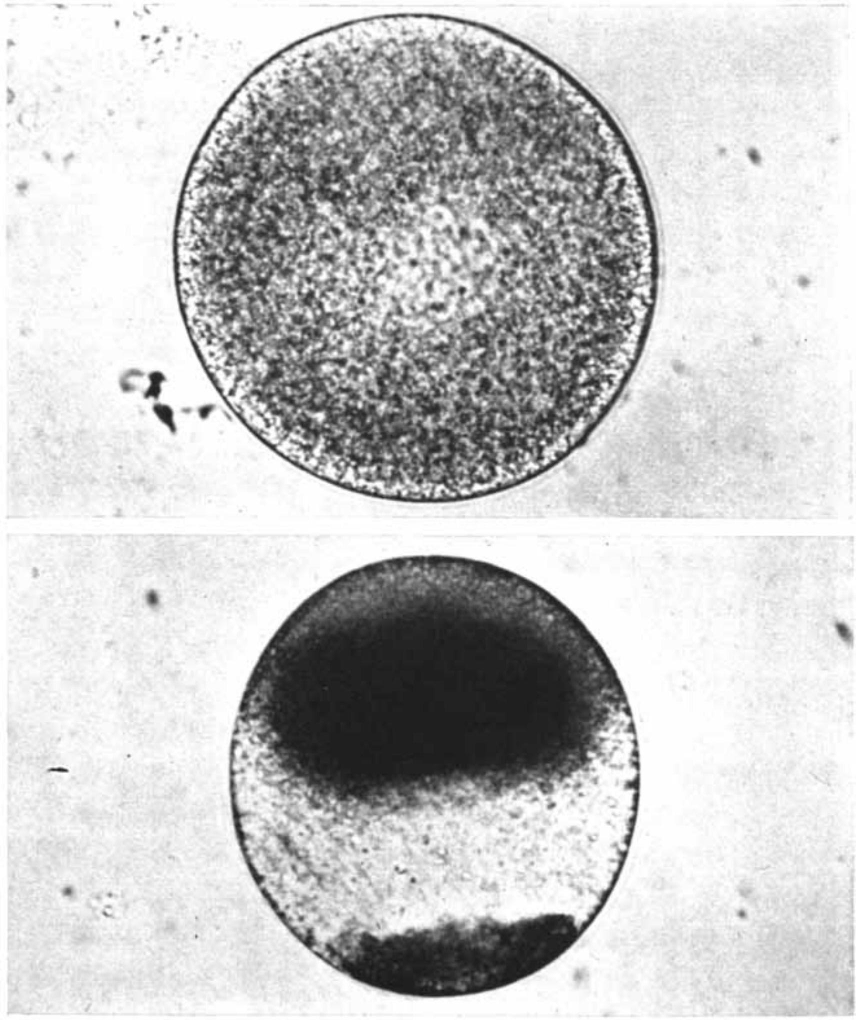
What causes this stiffening? The simplest explanation would be that the proteins of the cell have coagulated, exactly like the white of a boiled egg. But the proteins in egg white harden only at rather high temperatures—not at 93 degrees but at something closer to 212 degrees. Some proteins, it is true, may coagulate at lower temperatures, but there are cold-climate animals that die at 60 degrees, and one could scarcely talk about heat coagulation of proteins at that temperature.

If heat death is not due to coagulation of proteins, is it possible that other substances are primarily affected—and what other substances? There is a strong suspicion that fats and fatlike substances may be involved. Here is some of the evidence: There is a correlation between the melting points of the fats of various animals and the temperatures at which they die. Cold-blooded animals such as fishes ordinarily die at 70 to 80 degrees F. Birds and mammals do not die at temperatures below 100 degrees. Correlated with this is the fact that at room temperature the fats of fishes ordinarily are fluid (for example, cod-liver oil) while those of birds and mammals are solid (*e.g.*, chicken or beef fat). The same relation holds in plants. Those plants that live in more northern latitudes and are more sensitive to heat have fats which ordinarily are fluid at room temperature (for example, linseed oil), while the fats of tropical plants are often solid (for instance, cocoa butter). In general the melting points of the fats of northern plants are lower than the melting points of the fats of southern plants. This is true even of similar species growing in the north and in the south.

There is an even more striking fact than this. When an animal of a particular species lives at lower temperatures, its fats have lower melting points. Thus salmon living in northern waters have more fluid fats than those that live farther south. And this sort of thing can also



FROG'S LEG is immersed in water at 110 degrees Fahrenheit. Here the leg is tied off by a ligature and the frog shows no ill effects. When the ligature is removed, a substance produced in the leg by heat circulates through the rest of the body and the frog dies. Immersed in the water at the far right is a heating element. Next to it is a temperature-regulating device. At the far left is a stirrer.



EGGS OF CHAETOPTERUS, a marine worm, are photographed under the microscope. At the top is a normal egg; fine granules are distributed through its protoplasm. At the bottom is an egg that has been spun in a centrifuge; the granules have moved toward the periphery of the cell. If before it is centrifuged the egg is placed in oxalate or citrate solution, which removes the calcium in its outer layer, the granules pass out of it entirely.

be demonstrated in laboratory experiments. For example, if flies are raised at different temperatures, the warmer flies have more solid fats than those raised in the cold. An amusing experiment of this sort was done many years ago in Denmark. Two Danish physiologists kept pigs in woolen underwear, so that their skin temperatures were higher than those of their naked brethren. (Ordinarily the skin temperature of an animal is not constant and is lower than the body temperature.) When the cutaneous fats of the pigs in underwear were examined, they were found to have higher melting points.

This introduces an interesting possibility. Couldn't we perhaps change the constitution of the fats of an animal by changing its diet? Then if its fats became more solid, it should be able to resist heat more readily. It has long been known that if a pig is fed more solid fats, the fats in its body become more solid—this is a way of producing better bacon. Years ago a student of mine discovered that frog tadpoles which were fed beef had fats of higher melting points and were better able to resist heat than tadpoles which grew up on a fish diet. Later some Canadian biologists did more extensive experiments on goldfish. Goldfish that were fed lard were much more tolerant to heat than others raised on fish oil. Another way of doing the same experiment is to feed animals a diet rich in carbohydrates. An animal converts carbohydrates into fats with relatively high melting points. The Canadian investigators Louis-Paul Dugal and Mercedes Thérien demonstrated that rats fed a diet rich in carbohydrates were more resistant to heat. I have heard it said that people who work in the hot sun in the South like to drink sugar water. The

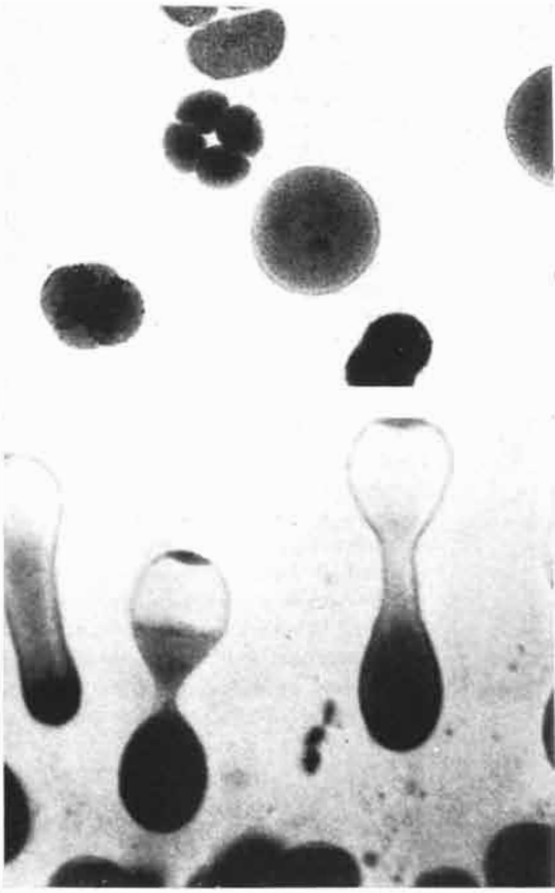
French army used to issue sugar to its troops in the tropics.

Actually little is known about what might be done to improve the ability of man to withstand tropical heat. The problem is an old one. The Romans wondered why their soldiers and colonists in Africa could not stand heat as well as the natives. With the world becoming ever more crowded, it certainly would be advantageous for the white race to discover ways of living comfortably in hot climates. Much has been done in the way of air conditioning, but one can hardly expect to live at all times in air-conditioned rooms. The late explorer Ellsworth Huntington once wrote: "The climate of many countries seems to be one of the great reasons why idleness, dishonesty, immorality, stupidity and weakness of will prevail. If we can conquer climate, the whole world will become stronger and nobler." Whether this is true or not, it is rather surprising that so little scientific effort has been expended to improve man's resistance to heat.

Let us return to our inquiry as to why heat kills cells. How does the fact that its fats become more fluid affect the life of a cell? The answer seems to lie in the cortex of the cell. The cortex contains fats and proteins, and bound to them chemically is some calcium. Apparently anything that tends to liquefy or dissolve the fats will loosen their bonds to calcium, with the result that calcium is released from the cortex into the interior of the cell.

Calcium is an extremely important element in the chemistry of the body [see "Calcium and Life," by L. V. Heilbrunn; Scientific American, June, 1951]. One of its vital functions is to act as a clotting agent. The stiffness of the cell cortex depends on calcium. This can be demonstrated by an experiment on the egg of the marine worm *Chaetopterus*. If the egg is placed in a solution of oxalate or citrate, which removes calcium, the cortex becomes so fluid that granules can readily be displaced from it. Calcium is necessary for the clotting of blood and of protoplasm. The normal activity of protoplasm depends on this clotting; for instance, if you inject a little calcium into muscle cells it produces a gentle clotting which causes the cells to contract. But the release of a large amount of calcium into a cell will cause severe clotting and death.

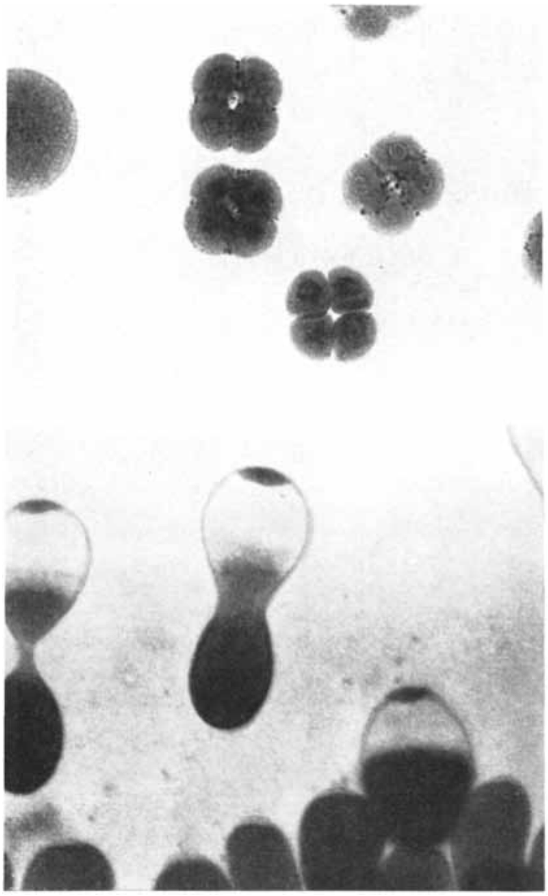
When a marine worm egg is exposed, even for a short time, to temperatures above those to which it is accustomed, the cortex loses its rigidity and the interior protoplasm of the cell becomes



EGGS OF THE SEA URCHIN are also photographed. At the top are normal eggs, some of which are dividing. Like the eggs of *Chaetopterus*, they contain evenly distributed granules. At the bottom is a photomicrograph of sea urchin eggs in a centri-

clotted. Presumably the heat releases calcium from its bonds to fat in the cortex and allows it to enter the interior protoplasm. Exposure of cells to a substance that dissolves fat, such as ether or alcohol, has the same effect. Indeed, we can fortify the effect of heat by adding one of these solvents to the treatment. This may be one reason why it is unwise for people in the tropics to drink alcohol to excess.

In an animal as complex as a mammal the situation is complicated by the fact that some types of cells are more sensitive to heat than others. And there are general interactions among the cells. Consider the rat. A rat cannot live at a temperature of 110 degrees F. The interesting point is that it dies just as fast if only its legs below the knee joint are immersed in water at that temperature as it does if its whole body is exposed to 110-degree air. The same is true of a frog. It seems that the cells killed by the heat produce a poison which affects the whole animal. If the circulation from the legs is tied off so that blood from



fuge turning at 10,000 revolutions per minute. Here again the granules move toward the periphery of the cell. If the cell is heated, the granules do not move at all. The bottom photograph was made by Ethel Browne Harvey of Princeton University.

the heated legs cannot go to the rest of the animal, the animal survives.

What is the poison produced by scalded or burned cells? This question has been asked by many scientific workers, but there is at present no definite answer. In my own work I have come to the conclusion that when the protoplasm clots, it produces a clotting enzyme, just as clotted blood produces the enzyme thrombin. The thrombin-like substance produced when cells are killed by heat (or other agents) passes by way of the blood to all parts of the body and can, I believe, cause the clotting or death of cells. But if this view is to be proved correct, much more experimental work needs to be done.

Surprisingly enough, the effect of heat on protoplasm has not been given the attention it deserves. A great deal remains to be learned. Perhaps work along these lines in the future will not only help us to understand the nature of living substance but may also be of help in solving problems that concern the welfare of the human race.

ANCIENT JERICHO

By digging through its layered remains archaeologists have found that it flourished 4,000 years before it fell to the Israelites. Indeed, it may be the oldest town in the world

by Kathleen M. Kenyon

And it came to pass at the seventh time, when the priests blew with the trumpets, Joshua said unto the people, Shout; for the Lord hath given you the city . . . and the people shouted with a great shout [and] *the wall fell down flat. . . . And they utterly destroyed all that was in the city . . . with the edge of the sword. . . . And they burnt the city with fire, and all that was therein.*

Jericho fell to Joshua and the Israelites sometime between 1400 and 1250 B.C. It had had a long, long history before that. Modern archaeologists are greatly interested in the site of this ancient city, for in addition to the romantic attraction of the Biblical story, the site has other claims to importance. There is reason to believe that Jericho may be the oldest town in the world, and we are finding there a wealth of material evidences of man's first steps toward civilization some 7,000 years ago.

The site of ancient Jericho today is a great mound—a heap entombing dead towns. It contains a series of cities, each built on the ruins of those that went before. The Arabian name for a mound formed of the accumulated remains of human occupation is *tell.* The Jericho tell has a great deal to say indeed; its lowest levels go back to Neolithic times —the late stone-age period when man first took the revolutionary step from a nomadic life of hunting to the settled life of agriculture and community building. From that step has sprung all human progress: the beginning of architecture, arts, crafts and manufacture, community organization, religion, laws, the invention of writing and ultimately civilization.

Although archaeologists have long been convinced that the Near East is the region where man first made the transition from a wandering to a settled life, the early stages of this transition have been shrouded in the mists of time. There are plenty of human artifacts from the Early Bronze Age in the Near East, but very few from the Neolithic period that preceded it. When, during the latter part of the 19th century and the early years of the 20th, archaeological expeditions began to explore the site of

EARLY NEOLITHIC houses of Jericho had curved walls such as those at left center in this excavation. Running from upper left to lower right are the stones of a Neolithic city wall, probably the oldest in the world. At the left is the base of a later structure.

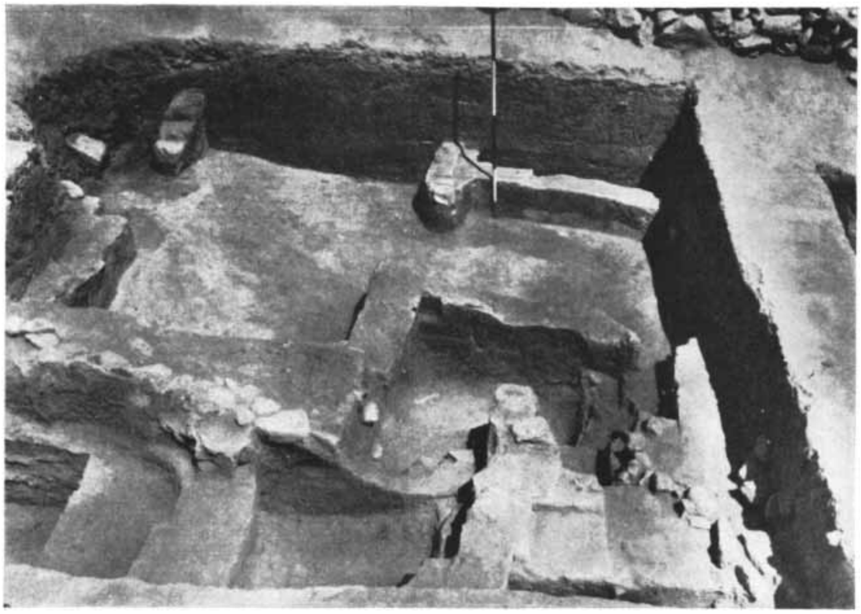
ancient Jericho, there was no suspicion that a prehistoric period lay beneath their spades. Their object was primarily to investigate the story of the capture of Jericho by Joshua's people, to date that event and thereby to throw light on the date of the first Israelite settlement in Palestine.

Between 1930 and 1936 the archaeologist John Garstang, of Liverpool University, carried out a series of deeper and more thorough excavations at Jericho. Far down in the mound, beneath the debris of Early Bronze Age cities, he found some flints and building remains which showed that men had occupied the site in the Neolithic age. His discoveries aroused in some archaeologists a keen desire to investigate the deep Jericho levels further.

The Second World War delayed this investigation. During the 20-year period between the two world wars Palestine in general had been the scene of much archaeological activity, principally by British and U. S. expeditions. Palestine is an area with a remarkably small written history, apart from the Bible. Very few ancient written records of the country have survived, and its history has had to be built up piece by piece from the results of excavations. These have yielded a consecutive history of Palestine from very early times, which has been set down in books such as *The Archaeology of Palestine and the Bible*, by William F. Albright of The Johns Hopkins University.

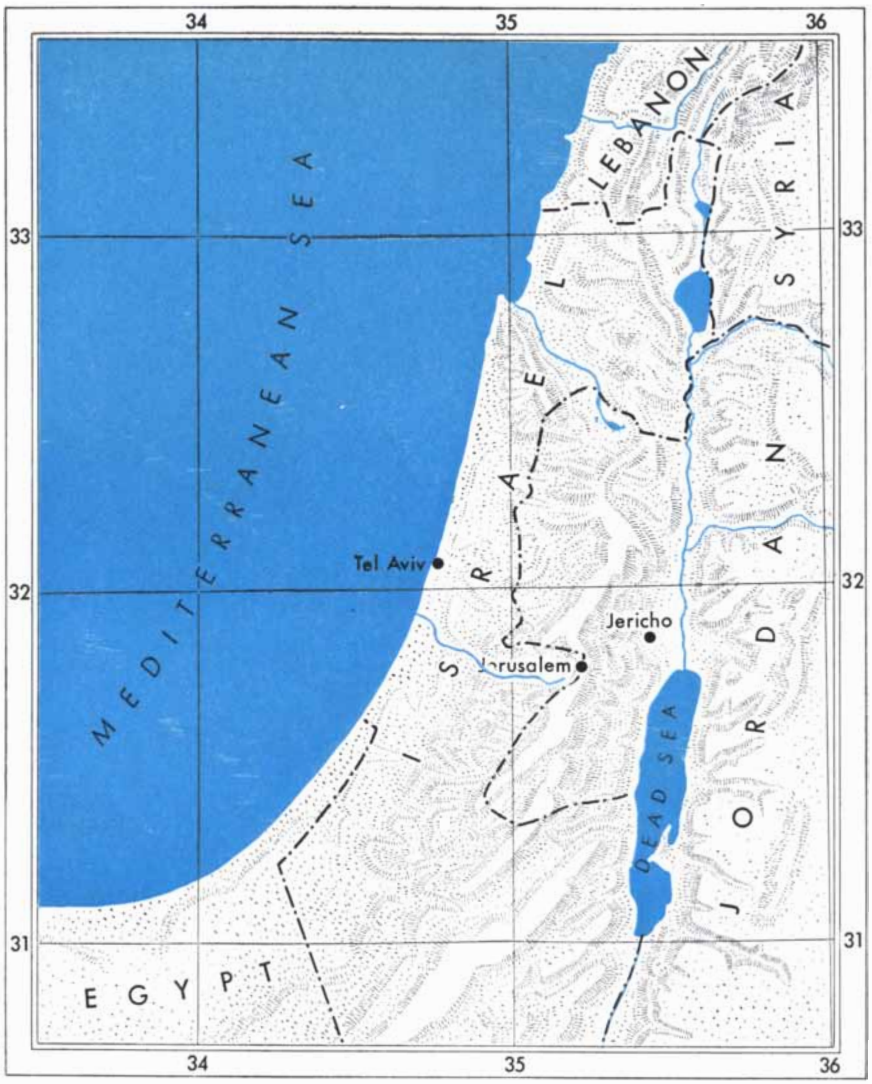
After the long interruption of World War II and the postwar political troubles in Palestine, archaeologists were keen to resume digging as soon as it became feasible. The British School of Archaeology in Jerusalem sent me to Jordan in 1951 to investigate the possibilities. I found that the Jordan Department of Antiquities was ready to welcome archaeologists and that the American School of Oriental Research in Jerusalem, with which our school had collaborated closely in the past, also wished to undertake excavations again. We had no difficulty in choosing a site: Jericho offered an ideal opportunity. So in January, 1952, a joint Anglo-American expedition of some 20 workers, with myself as director and A. Douglas Tushingham of the American School as assistant director, camped at the Jericho tell and went to work.

The ancient mound is a mile from the modern town of Jericho on the left bank of the River Jordan. It lies in a flat plain 840 feet below sea level. What



LATER NEOLITHIC houses had straight walls. Both walls and floors were covered with polished plaster. However, the people who lived in the houses had not invented pottery.

MIDDLE BRONZE AGE defenses are marked by the two farther men. The nearest man stands atop a later Bronze Age wall. In the foreground is a still later Iron Age structure.



JERICHO IS LOCATED in Jordan near the Dead Sea. It is in the midst of a desert, but has been made habitable for 7,000 years by the copious waters of Elisha's Fountain.

has made it habitable through all these thousands of years is a never-failing supply of fresh water gushing from Elisha's Fountain. We began systematically to uncover the ancient Jerichos, layer by layer. Modern archaeological research is built upon foundations laid by the great 19th-century archaeologist Sir Flinders Petrie, a pioneer far ahead of his time. The dating of ancient cultures must depend, when inscriptions are lacking, upon the evolution of artifacts, especially pottery. Petrie showed that each stage of human history in the East had a distinctive pottery, and that one could establish a pottery sequence, some stages of which could be linked with inscriptions of known date in Egypt or Mesopotamia. On the foundations created by Petrie this sequence has now been built up, period by period, so that it is now possible for an archaeologist to date finds with considerable accuracy as far back as the beginning of the Early Bronze Age, about 3000 B.C.

The basic method of stratigraphy, as Petrie enunciated it in 1890, is to establish a fixed reference point and record the level of each find (in number of feet) above that point. This technique has its limitations, because an archaeological layer may slope instead of being horizontal or may have been cut into by later occupants. Since Petrie's time the method has been considerably refined. Each layer of soil is now traced through and treated as an entity; the finds discovered in that structure (*e.g.*, a floor level) are then dated by it.

Obviously such work requires close supervision by experts, for the workmen doing the digging cannot be expected to identify or understand the significance of the layers. Each small gang works under the direct supervision of a field assistant, who records the layers in a notebook and labels the finds. Drawings are made, so that we have a permanent record of the structures excavated.

The process of excavation is a process of dissection. The archaeologist breaks down the history of the site by peeling off the layers one by one; he traces the history backward from the top down. At Jericho we have found that the surviving deposits go down in some places to depths of about 70 feet. Excavations are still in progress, and only in a very few places have we reached the earliest layers, but we have enough to tell something of a consecutive story of the site.

Garstang had discovered the Neolithic levels at the northwest end of the tell. The depth of deposit is so great there that he sounded the lowest levels only with a relatively narrow shaft. The present expedition is continuing the clearance of the levels he sounded. One of our first surprises was the discovery of Neolithic artifacts at a place on the west side of the tell some distance from where Garstang had found his. The Stone Age remains here were only about four feet below the surface, presumably because later levels in this place have been eroded or quarried away. What was remarkable about this discovery was that it showed that even in Neolithic times the settlement already covered a considerable area and had grown beyond the dimensions of a mere village.

In this area on the west side of the tell excavation has reached bedrock in some places. Just above the rock we have found rude huts which may be the Jericho settlers' earliest experiments in architecture. They are mud-brick structures with curved walls, and they look like a translation of the round tents and temporary structures of nomadic hunters into a more permanent material. This phase appears to have been short. The next stage (represented by a type of house discovered by Garstang at the north end) was a very big advance. These houses were rectangular, with solidly built walls, wide doorways and rooms grouped around courtyards. Most striking of all is the fact that the walls and floors were finished with highly burnished coats of fine plaster, giving a most sophisticated appearance. These houses belonged to a firmly established community, and moreover a well-organized one, for at this stage the settlement apparently was surrounded by a massive town wall.

These Stone Age people still had no pottery—a fact which underlines how close we are here to the beginnings of

NEOLITHIC PORTRAIT HEADS were made by covering skulls with plaster. The head at the top is shown as it was found. The one at lower left has eyes of cowrie shells. The one at lower right has bands of paint across the top and eyes with vertical slits.

MIDDLE BRONZE AGE TOMB was occupied by a skeleton and remarkably well-preserved grave goods. The skeleton is shown at the top. In the middle is a basket containing toilet articles. At the bottom is a dish containing the remains of a large slab of meat.

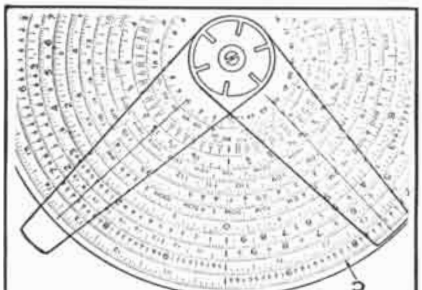
settled life, for pots and pans, a primary necessity, are one of the first technical inventions of settled man. No doubt the reason men settled here lies in the natural advantages of the site. The copious stream that emerges from the rock beside the settlement made the soil of the Jordan Valley, with its tropical climate, exceedingly fertile; the modern Jericho is still a brilliant green oasis in this arid land. The inhabitants of Jericho could be assured of success in their first experiments in agriculture, and the settlement could become truly permanent.

The progress of those early settlers was not in material things alone. In the Neolithic levels we unearthed a room which in all probability was a small shrine. At one end of the room we found a niche with a rough stone pedestal, and nearby lay a carefully worked bit of volcanic stone which must have been a cult object and probably stood on the pedestal. Figurines of animals modeled in clay suggest that the religion of these early agriculturists was a fertility cult.

Our expedition's most remarkable find so far is a group of seven portrait heads. On actual human skulls the artist had modeled features in plaster. The heads have an astonishingly lifelike appearance. There can be little doubt that they are portraits, probably of venerated ancestors. Thus we are looking at the faces of individuals who died 7,000 years or more ago. These portraits are among the earliest examples of human art.

We do not yet know the exact date of this early settlement, but we guess it to be about 5000 B.C., and hope soon to have our guess tested by radiocarbon analysis of the charcoal from its layers. Its life was certainly a long one, for its successive layers of houses make a mound many feet high. Above this pre-pottery Neolithic stage we find the ruins of a second Neolithic stage in which pottery appears. This stage again lasted a considerable time, and added further height to the mound. By the time Jericho approaches the dawn of the historic period, after 3000 B.C., its walls crown a mound already some 60 feet high.

In the Early Bronze Age, a period of great urban development in Palestine, Jericho became an important walled city. It guarded a gateway through which nomads from the desert to the east were continually trying to force their way into the more fertile lands of Palestine. The Jericho city walls were breached and rebuilt no fewer than 17 times; time and again they were damaged or destroyed by enemies or by natural agencies such as earthquakes. About 2100 B.C. they



were totally destroyed by the nomadic Amorites who overran much of Palestine. The city was burned to the ground.

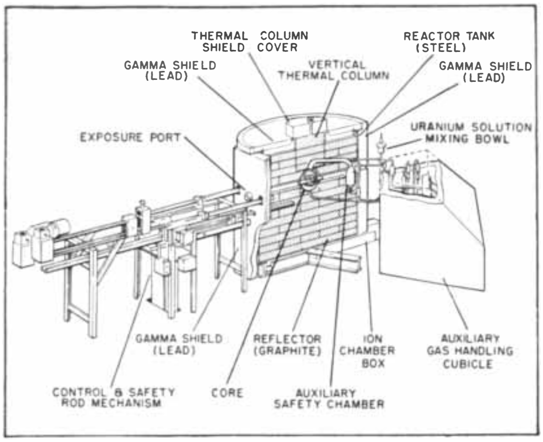
There followed some 200 years of cultural sterility. The newcomers were not town dwellers. Their houses and equipment were simple and primitive. But about 1900 B.C. well-built houses and city walls again begin to appear at Jericho. They were built by a new people, probably from the north, who brought with them the advanced culture of the Middle Bronze Age. Under them Jericho grew to the greatest size it has ever attained. Its walls were rebuilt on a new system with the base defended by a sloping ramp, presumably against the approach of chariots.

Our best evidence for the culture of these people comes from a number of tombs which we have been fortunate enough to find intact. The hot climate of the Jordan Valley has preserved their contents—wood, textiles, basketwork, even food. Everywhere else in Palestine such objects have perished; hence the Jericho remains are the first material evidences of the culture of Palestine in the period around the 17th century B.C.

Each tomb is rich in provisions of food, drink and household equipment that were left with the dead for the afterlife. The furniture was simple: wooden tables, stools and beds, all made with considerable skill. Wooden or pottery bowls held the food, and great four-handled jars, each provided with a small dipper, contained the drink. There were rush mats, toilet accessories in wooden boxes or in alabaster flasks, many wooden combs and other small objects in baskets. We have even recovered fragments of clothing, which when they are analyzed should tell us how they were woven and of what materials.

The Middle Bronze Age came to an end with another sack of the city, probably at the hands of the Egyptians about 1560 B.C. There, unfortunately, most of the archaeological history of Jericho comes to an end. Garstang found a few remnants of structures going down to about 1350 B.C. But over most of the rest of the mound erosion and human depredations have removed all traces of the Jericho after the 16th century B.C. No sign of the walls attacked by Joshua has been found. Nevertheless, though we have been disappointed in our search for the city of the Biblical story, this disappointment has been more than compensated by the uncovering of its remarkable earlier history. It is hoped that our further excavations will continue to be as richly rewarded.

Water boiler reactor designed and built by North American



put this **experience** to work for you in nuclear reactor development

Since 1948 North American Aviation has been a prime contractor to the Atomic Energy Commission.

Research Reactors have been designed and built by North American for AEC contractors.

A complete program of engineering development including design, evaluation and experimentation has been conducted for production and power reactors.

An integrated program for investigations in nuclear science, reactor materials, radiochemistry and other allied fields is currently underway.

Experimental Nuclear Reactor designed and built by North American

North American Aviation invites your inquiry regarding reactor development or any other project in which atomic energy can be put to productive use. As in the case of proposals now in process, North American will provide all engineering services necessary for reactor development and operation—insuring the widest possible range of reactor application.

Each phase of the North American reactor development program is supported by a highly integrated, skilled organization working with the most advanced equipment available . . . providing extensive atomic energy research and production facilities.

All reactor development is undertaken in accordance with the provisions of the Atomic Energy Act and subject to approval of the Atomic Energy Commission. Please address your inquiry to: NORTH AMERICAN AVIATION, INC., Atomic Energy Research Department, Downey, California.

organization, facilities and experience keep **North American Aviation** *years ahead*

in aircraft . . . atomic energy . . . electronics . . . guided missiles . . . research and development

GEOMETRY AND INTUITION

A classic description of how "common sense," once accepted as the basis of physics but now rejected, is also inadequate as a foundation for mathematics

We have grown so accustomed to the revolutionary nature of modern science that any theory which affronts common sense is apt to be regarded today as half proved by that very fact. In the language of science and philosophy the word for common sense is intuition—it relates to that which is directly sensed or apprehended. Twentieth-century discoveries have dealt harshly with our intuitive beliefs about the physical world. The one area that is commonly supposed to remain a stronghold of intuition is mathematics. The Pythagorean theorem is still in pretty good shape; the self-evident truths of mathematics are in the main still true. Yet the fact is that even in mathematics intuition has been taking a beating. Cornered by paradoxes—logical contradictions—arising from old intuitive concepts, modern mathematicians have been forced to reform their thinking and to step out on the uncertain footing of radically new premises.

Some years ago the brilliant Austrian mathematician Hans Hahn surveyed the situation in a Vienna Circle lecture which he titled "The Crisis in Intuition." His analysis is still fresh and timely, and it is published here, in part, for the first time in English. Hahn began with Immanuel Kant, the foremost exponent of the importance of intuition, and showed how the foundations of Kant's ideas about knowledge "have been shaken" by modern science. The intuitive conceptions of space and time were jolted by Einstein's theory of relativity and by advances in physics which proved that the location of an event in space and time cannot be determined with unlimited precision. Hahn went on to consider the demolition of Kant's ideas about mathematics, and he illustrated his theme with the case of geometry, where "intuition was gradually brought into disrepute and finally was completely banished." This section of his lecture, somewhat condensed, follows.

by Hans Hahn

One of the outstanding events in [the banishment of intuition from geometry] was the discovery that, in apparent contradiction to what had previously been accepted as intuitively certain, there are curves that possess no tangent at any point, or—what amounts to the same thing—that it is possible to imagine a point moving in such a manner that at no instant does it have a definite velocity. The questions involved here directly affect the foundations of the differential calculus as developed by Newton and Leibnitz.

Newton calculated the velocity of a moving point at the instant t as the limiting value approached by the average velocity between t and an instant close to it, t', as t' approaches t without limit. Leibnitz similarly declared that the slope of a curve at a point p is the limiting value approached by the average slope between p and a nearby point p' as p' approaches p without limit.

Now one asks: Is this true for every curve? It is indeed for all the old familiar ones—circles, ellipses, hyperbolas, parabolas, cycloids, etc. But it is not true, for example, of a wave curve such as is shown here [*Figure 1*]. In the neighborhood of the point p the curve has infinitely many waves. The wavelength and the amplitude of the waves decrease without limit as they approach p. If we take successive points closer and closer to p, the average slope between p and p' (the moving point) drops from plus 1 through 0 to minus 1 and then rises from minus 1 to plus 1. That is, as p' approaches p without limit through infinitely many waves, the average slope between p and p' keeps oscillating between the values 1 and -1. Thus there can be no question of a limit or of a definite slope of the curve at the point p. In other words, the curve we are considering has no tangent at p.

This relatively simple illustration demonstrates that a curve does not have to have a tangent at every point. Nevertheless it used to be thought, intuitively, that such a deficiency could occur only at exceptional points of a curve. It was therefore a great surprise when the great Berlin mathematician Karl Weierstrass announced in 1861 a curve that lacked a precise slope or tangent at *any* point. Weierstrass invented the curve by an intricate and arduous calculation, which I shall not attempt to reproduce. But his result can today be achieved in a much simpler way, and this I shall attempt to explain, at least in outline.

We start with a simple figure which consists of an ascending and a descending line [*Figure 2*]. We then replace the ascending line with a broken line in six parts, first rising to half the height of the

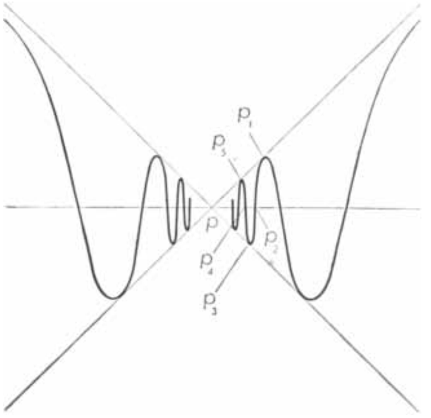


Figure 1

original line, then dropping all the way down, then again rising to half the height, continuing to full height, dropping back again to half height and finally rising once more to full height [*Figure* 3]. We replace the descending line also with a broken line of six similar parts. From this figure of 12 line segments we evolve, again by replacing each segment with a broken line of six parts, a figure of 72 line segments [*Figure 4*]. It is easy to see that repetition of this procedure will lead to more and more complicated figures. It can be demonstrated that the geometric objects constructed according to this rule approach without limit a definite curve possessing the desired property; namely, at no point will it have a precise slope, and hence at no point a tangent. The character of this curve of course entirely eludes intuition; indeed, after a few repetitions of the segmenting process the evolving figure has grown so intricate that intuition can scarcely follow. The fact is that only logical analysis can pursue this strange object to its final form.

Lest it be supposed that intuition fails only in the more complex branches of mathematics, I propose now to examine a failure in the elementary branches. At the very threshold of geometry lies the concept of the curve; everyone believes that he has an intuitively clear notion of what a curve is. Since ancient times it has been held that this idea could be expressed by the following definition: Curves are geometric figures generated by the motion of a point. But attend! In the year 1890 the Italian mathematician Giuseppe Peano (who is also renowned for his investigations in logic) proved that the geometric figures that can be generated by a moving point also include *entire plane surfaces*. For instance, it is possible to imagine a point moving in such a way that in a finite time it will pass through all the points of a square—and yet no one would consider the entire area of a square as simply a curve. With the aid of a few diagrams I shall attempt to give at least a general idea of how this space-filling motion is generated.

Divide a square into four small squares of equal size and join the center points of these squares by a continuous curve composed of straight-line segments [*Figure 5*]. Now imagine a point moving at uniform velocity so that it will traverse the continuous curve made of these line segments in a certain unit of time. Next divide each of the four squares again into four equal squares so that there are 16 squares, and connect their center points [*Figure 6*]. Imagine the point moving so that in the same time as before it will traverse this second curve at uniform velocity. Repeat the procedure, each time imagining the point to move so that in the same unit of time it will traverse the new system of lines at a uniform velocity. Figure 7 shows one of the later stages, when the original square has been divided into 4,096 small squares. It is now possible to give a rigorous proof that the successive motions considered here approach without limit a curve that takes the moving point through all the points of the large square in the given time. This motion cannot possibly be grasped by intuition; it can only be understood by logical analysis.

While a geometric object such as a square, which no one regards as a curve, can be generated by the motion of a point, other objects which one would not hesitate to classify as curves cannot be so generated. Observe, for instance, the wave curve shown here [*Figure 8*]. In the neighborhood of the line segment *ab* the curve consists of infinitely many waves whose lengths decrease without limit but whose amplitudes do not decrease. It is not difficult to prove that this figure, in spite of its linear character, cannot be generated by the motion of a point, for no motion of a point is conceivable that would carry it through all the points of this wave curve in a finite time.

Two important questions now suggest themselves. (1) Since the time-honored definition of a curve fails to cover the fundamental concept, what serviceable definition can be substituted for it? (2) Since the class of geometric objects that can be produced by the motion of a point does not coincide with the class of all curves, how shall the former class be defined? Today both questions are satisfactorily answered; I shall defer for a moment the answer to the first question and speak briefly about the second. This was solved with the aid of a new geometric concept—"connectivity in the small." Consider a line, a circle or a square. In each of these cases, we can move from one point on the figure to another very close to it along a path which does not leave the confines of the figure, and we remain always in close proximity to both points. This is the property called "connectivity in the small." Now the wave curve we have just considered does not have this property. Take for example the neighboring points p and q [*Figure* 9]. In order to move from p to q without leaving the curve it is necessary to traverse the infinitely many waves lying between them. The points on this path are not all in close proximity to p and q, for the waves all have the same amplitude.

It is important to realize that "connectivity in the small" is the basic characteristic of figures that can be generated by the motion of a point. A line, a circle and a square can be generated by the motion of a point because they are connected in the small; the wave figure shown cannot be generated by the mo-

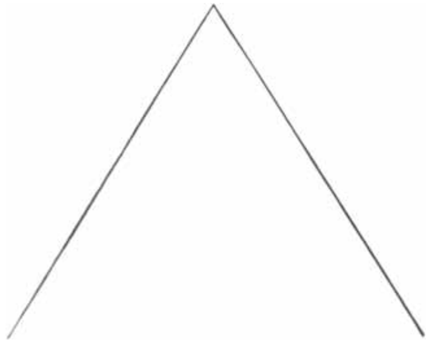


Figure 2

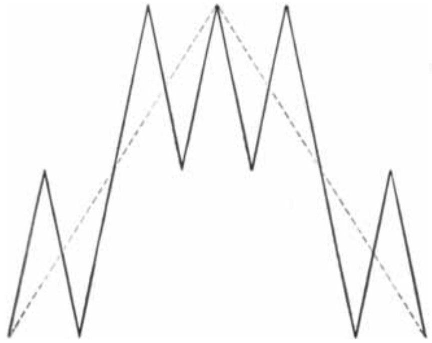


Figure 3

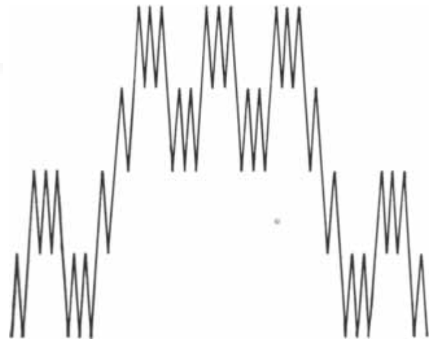


Figure 4

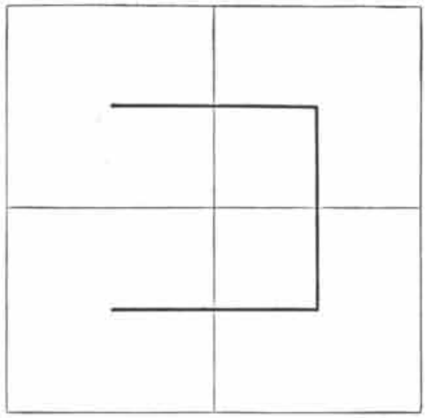


Figure 5

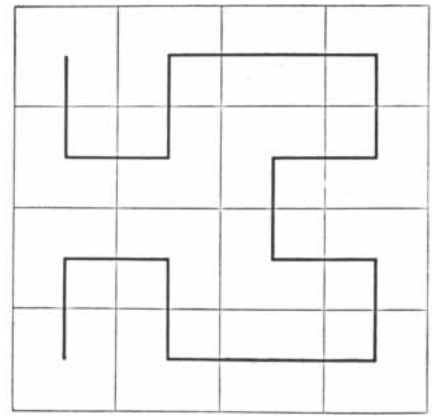


Figure 6

tion of a point because it is not connected in the small.

We can convince ourselves of the undependability of intuition, even as regards such elementary geometrical questions, with a second example. Think of a map of three adjoining countries [*Figure* 9]. There are certain points at which all three countries come together—so-called "three-country corners" (points *a* and *b*). Intuition seems to indicate that such corners can occur only at isolated points, and that at the great majority of boundary points on the map only two countries will be in contact. Yet the Dutch mathematician L. E. J. Brouwer showed in 1910 how a map can be divided into three countries in such a way that all three countries will touch one another at every boundary point!

Start with a map of three countries—one hatched (A), one dotted (B) and one solid (C)—and an adjoining unoccupied area [*Figure 10*]. Country A, seeking to bring this land into its sphere of influence, decides to push out a corridor which approaches within one mile of every point of the unoccupied territory but—to avoid trouble—does not impinge upon either of the two other countries

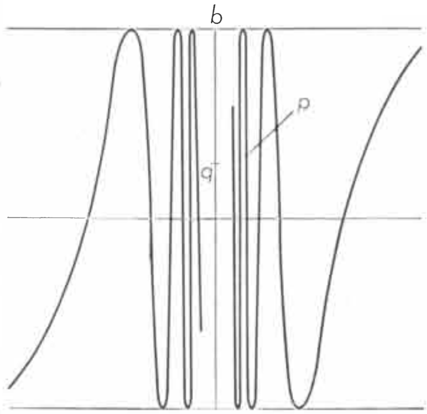


Figure 8

[*Figure 11*]. After this has been done, country B decides that it must do the same and proceeds to drive into the remaining unoccupied territory a corridor that comes within one-half mile of all the unoccupied points but does not touch either of the other two countries [*Figure 12*]. Thereupon country C decides that it cannot lag behind, and it also extends a corridor into the territory as yet unoccupied, which comes to within a third of a mile of every point of this territory but does not touch the other countries [*Figure 13*]. Country A now proceeds to push a second corridor into the remaining unoccupied territory, which comes within a quarter of a mile of all points of this territory but does not touch the other two countries. The process continues: Country B extends a corridor that comes within a fifth of a mile of every unoccupied point; country C, one that comes within a sixth of a mile of every unoccupied point; country A starts over again, and so on and on. And since we are giving imagination free rein, let us assume further that country A required a year for the construction of its first corridor, country B, the following half-year for its first corridor, country C, the next quarter year for its first corridor; country A, the next eighth of a year for its second, and so on, each succeeding extension being completed in half the time of its predecessor. It can be seen that after two years none of the originally unoccupied territory will remain unclaimed; moreover the entire area will then be divided among the three countries in such a fashion that all three countries will meet at every boundary point. Intuition cannot comprehend this pattern, but logical analysis requires us to accept it.

Because intuition turned out to be deceptive in so many instances, and because propositions that had been ac-

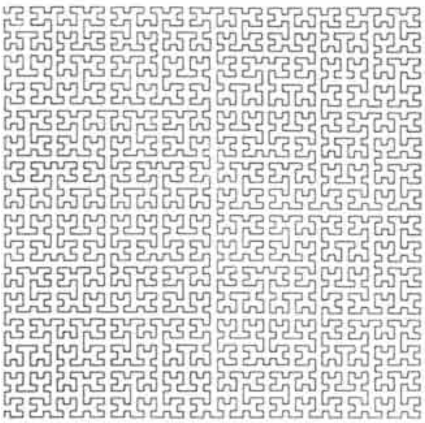


Figure 7

counted true by intuition were repeatedly proved false by logic, mathematicians became more and more skeptical of the validity of intuition. The conviction grew that it was unsafe to accept any mathematical proposition, much less to base any mathematical discipline on intuitive convictions. Thus a demand arose for the expulsion of intuition from mathematical reasoning and for the complete formalization of mathematics. That is to say, every new mathematical concept was to be introduced through a purely logical definition; every mathematical proof was to be carried through by strictly logical means. The pioneers of this program (to mention only the most famous) were Augustin Cauchy (1789-1857), Bernhard Bolzano (1781-1848), Karl Weierstrass (1815-1897), Georg Cantor (1845-1918) and Julius Wilhelm Richard Dedekind (1831-1916).

The task of completely formalizing or logicizing mathematics was arduous and difficult; it meant nothing less than a root-and-branch reform. Propositions that had been accepted as intuitively evident had to be painstakingly proved. As the prototype of an *a priori* synthetic judgment based on pure intuition Kant expressly cited the proposition that space is three-dimensional. But by present-day

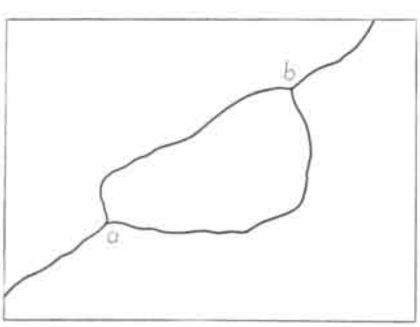


Figure 9

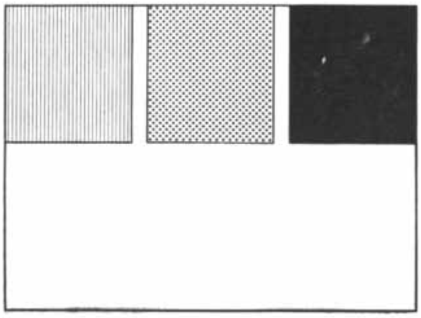


Figure 10

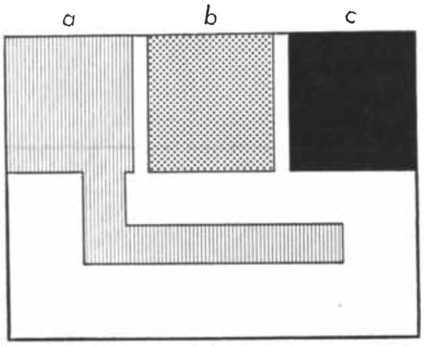


Figure 11

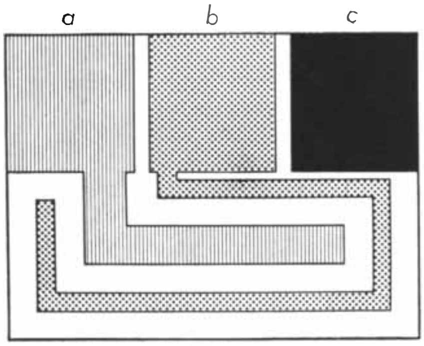


Figure 12

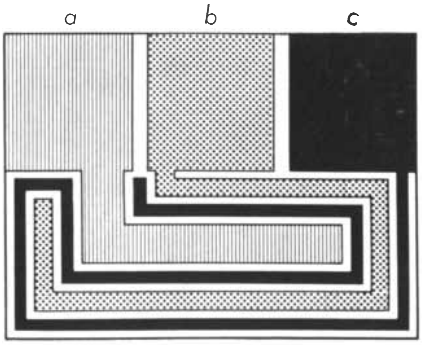


Figure 13

standards even this statement calls for searching logical analysis. First it is necessary to define purely logically what is meant by the "dimensionality" of a geometric figure, and then it must be proved logically that the space of ordinary geometry—which is also the space of Newtonian physics—as embraced in this definition is in fact three-dimensional. This proof was not achieved until 1922, and then simultaneously by the Vienna mathematician K. Menger and the Russian mathematician Pavel Uryson (who later succumbed to a tragic accident at the height of his creative powers). I wish to explain briefly how the dimensionality of a figure is defined.

A geometric figure is called a "point set." It is said to be null-dimensional if for each of its points there exists an arbitrarily small neighborhood whose boundary contains no point of the set. For example, every set consisting of a finite number of points is null-dimensional, but there are also many complicated null-dimensional points which consist of infinitely many points [*Figure 14*]. A point set that is not null-dimensional is called one-dimensional if for each of its points there is an arbitrarily small neighborhood whose boundary has only a null-dimensional set in common with the point set [*Figure 15*]. Every straight line, every figure composed of a finite number of straight lines, every circle, every ellipse—in short, all geometrical constructs that we ordinarily designate as curves—are one-dimensional in this sense. A point set that is neither null-dimensional nor one-dimensional is called two-dimensional if for each of its points there is an arbitrarily small neighborhood whose boundary has at the most a one-dimensional set in common with the point set. Every plane, every polygonic or circular area, every spherical surface—in short, every geometric construct ordinarily classified as a surface—is two-dimensional in this sense. A point set that is neither null-dimensional, one-dimensional nor two-dimensional is called three-dimensional if for each of its points there is an arbitrarily small neighborhood whose boundary has at most a two-dimensional set in common with the point set. It can be proved—not at all simply, however—that the space of ordinary geometry is a three-dimensional point set.

This theory provides what we have been seeking—a fully satisfactory definition of the concept of a curve. The essential characteristic of a curve turns out to be its one-dimensionality. But beyond that the theory also makes possible an unusually precise and subtle analysis of the structure of curves, about which I should like to comment briefly.

A point on a curve is called an end point if there are arbitrarily small neighborhoods surrounding it, each of whose boundaries has only a single point in common with the curve [*points* a *and* b *in Figure 16*]. A point on the curve that is not an end point is called an ordinary point if it has arbitrarily small neighborhoods each of whose boundaries has exactly two points in common with the curve [*point* c *in Figure 16*]. A point on a curve is called a branch point if the boundary of any of its arbitrarily small neighborhoods has more than two points in common with the curve [*point* d *in Figure 16*]. Intuition seems to indicate that it is impossible for a curve to be made up of nothing but end points or branch points. As far as end points are concerned, this intuitive conviction has been confirmed by logical analysis, but as regards branch points it has been refuted. The Polish mathematician W. Sierpinski proved in 1915 that there are curves *all of whose points are branch points*. Let us attempt to visualize how this comes about.

Suppose that an equilateral triangle has been inscribed within another equilateral triangle and the interior of the inscribed triangle erased [*Figure 17*]. In each of the three remaining triangles [*the unhatched areas*] inscribe an equilateral triangle and again erase its interior; there are now nine equilateral triangles together with their sides [*Figure 18*]. Imagine this process continued indefinitely. (Figure 19 shows the fifth step, where 243 triangles remain.) The points of the original equilateral triangle that survive the infinitely numerous erasures can be shown to form a curve all of whose points, with the exception of the vertex points *a*, *b* and *c* of the original triangle, are branch points. From this it is easy to obtain a curve with all its points branch points; for instance, by distorting the entire figure so that the three vertices of the original triangle are brought together in a single point.

But enough of examples—let us now summarize what has been said. Repeatedly we have found that in geometric questions, even in very simple and elementary ones, intuition is a wholly unreliable guide. And it is of course impossible to adopt this discredited aid as the basis of a mathematical discipline. The way is then open for other logical constructs in the form

ENGINEERS

the best careers are made here, too!

Westinghouse
AIR ARM DIVISION

Westinghouse Air Arm—world leader in the field of aviation-electronics—also leads in engineering career opportunities. Continued growth of operations has created a need for engineers who would like to establish themselves in positions with a solid future. In addition to high income and outstanding benefits, current openings offer—

- Job stability
- Extensive facilities
- Opportunities for advanced study
- Association with competent technical leaders

Flight Test Engineers responsible for laboratory and flight evaluation of radar directed fire control, autopilot, and navigation systems. Flight test these systems in many of nation's newest jet intercepters and attack bombers. Gain knowledge of complete airborne electronics systems.

Radar Advisory Engineer Technical consultation on problems pertaining to coherent and non-coherent radar systems. Long range planning on target detection systems. Analysis of radar system and determination of component parameters.

Materials and Standards Engineer Consulting and laboratory investigation of insulating materials in potting and encapsulating of electronic subassemblies. Development of subminiaturization techniques.

Operations Analysts Analysis of aircraft tactical problems. Evaluation of detection, acquisition, and destruction probabilities of aircraft armament systems. Study of weapons systems stability and accuracy requirements.

Computer Design Engineers Analysis and design of analog and digital computers for airborne fire control systems.

Hydraulics Engineers Analysis and design of hydraulic valves, pistons, actuators and servomechanisms for autopilot and fire control systems.

Electronic Components Engineers Design of fire control system components.

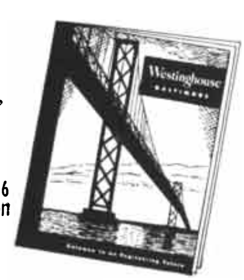
accelerometers	magnetic amplifiers	indicators
rate gyros	transformers	antennas
vertical gyros	modulators	receivers

If employed at your highest skill in a defense industry do not apply.

YOU CAN BE **SURE**...IF IT'S
Westinghouse
AIR ARM DIVISION
BALTIMORE, MARYLAND

SEND TODAY

For your copy of "Gateway to an Engineering Future."



ADDRESS:
R. M. Swisher, Jr.
Employment Supervisor, Dept. A-6
Westinghouse Electric Corporation
109 W. Lombard Street
Baltimore 1, Maryland

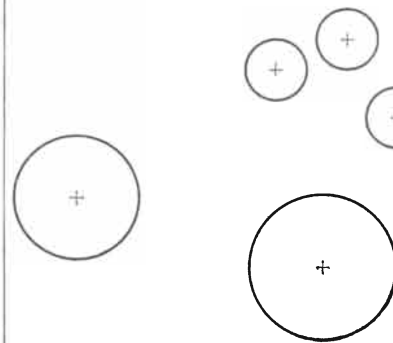


Figure 14

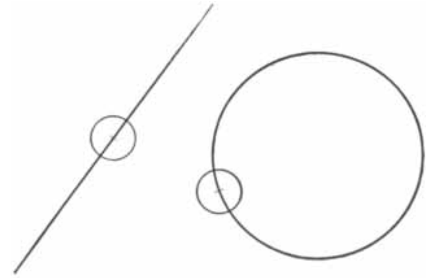


Figure 15

of spaces differing from the space of ordinary geometry; spaces, for instance, in which the so-called Euclidean parallel postulate is replaced by a contrary postulate (non-Euclidean spaces), spaces whose dimensionality is greater than three, non-Archimedean spaces (in which there are lengths that are greater than any multiple of a given length).

What, then, are we to say to the often-heard objection that the multidimensional, non-Euclidean, non-Archimedean geometries, though consistent as logical constructs, are useless in arranging our experience because they do not satisfy intuition? My first comment is that ordinary geometry itself is by no means a supreme example of the intuitive process. The fact is that *every* geometry —three-dimensional as well as multidimensional, Euclidean as well as non-Euclidean, Archimedean as well as non-Archimedean—is a logical construct. For several centuries, almost up to the present day, ordinary geometry admirably served the purpose of ordering our experience; thus we grew used to operating with it. This explains why we regard it as intuitive, and every departure from it contrary to intuition—intuitively impossible. But as we have seen, such "intuitional impossibilities" occur even in ordinary geometry. They appear as soon as we reflect upon objects that we had not thought about before.

Modern physics now makes it appear appropriate to avail ourselves of the logical constructs of multidimensional and non-Euclidean geometries for the ordering of our experience. (Although we have as yet no indication that the inclusion of non-Archimedean geometry might prove useful, this possibility is by no means excluded.) But, because these advances in physics are very recent, we are not yet accustomed to the manipulation of these logical constructs; hence they are still considered an affront to intuition.

The same reaction occurred when the theory that the earth is a sphere was advanced. The hypothesis was widely rejected on the grounds that the existence of the antipodes was contrary to intuition; however, we have got used to the conception and today it no longer occurs to anyone to pronounce it impossible because it conflicts with intuition.

Physical concepts are also logical constructs, and here too we can see clearly how concepts whose application is familiar to us acquire an intuitive status which is denied to those whose application is unfamiliar. The concept "weight"

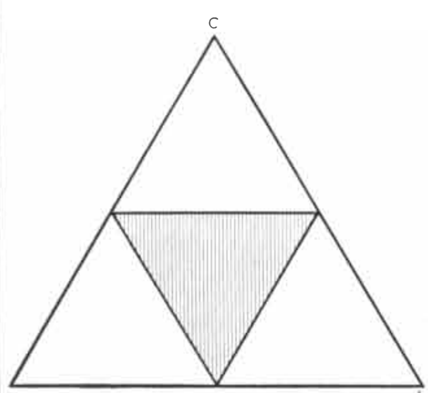


Figure 17

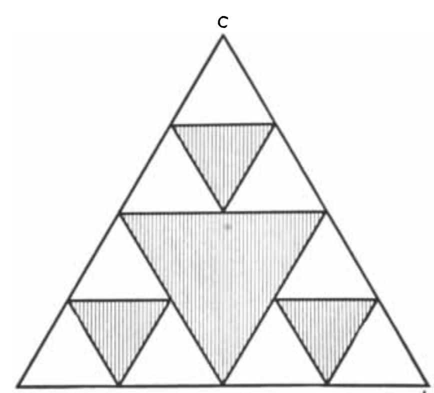


Figure 18

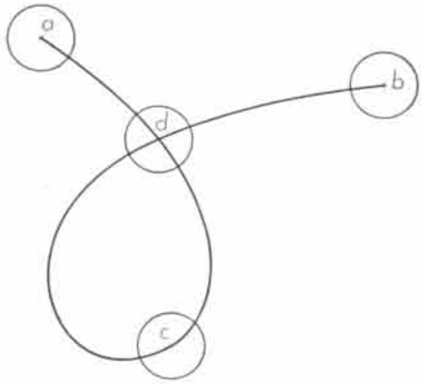


Figure 16

is so much a part of common experience that almost everyone regards it as intuitive. The concept "moment of inertia," however, does not enter into most people's activities and is therefore not regarded by them as intuitive; yet among many experimental physicists and engineers, who constantly work with it, moment of inertia possesses an intuitive status equal to that generally accorded the concept of weight. Similarly the concept "potential difference" is intuitive for the electrical technician, but not for most people.

If the use of multidimensional and non-Euclidean geometries for the ordering of our experience continues to prove itself so that we become more and more accustomed to dealing with these logical constructs; if they penetrate into the curriculum of the schools; if we, so to speak, learn them at our mother's knee as we now learn three-dimensional Euclidean geometry—then it will no longer occur to anyone to say that these geometries are contrary to intuition. They will be considered as deserving of intuitive status as three-dimensional Euclidean geometry is today. For it is not true, as Kant urged, that intuition is a pure *a priori* means of knowledge. Rather it is force of habit rooted in psychological inertia.

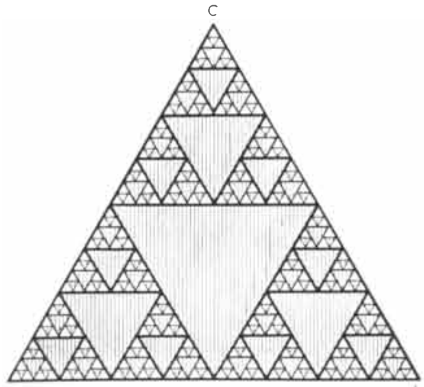
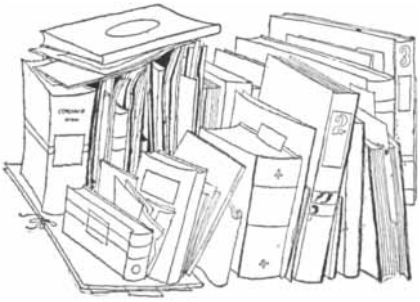


Figure 19



BOOKS

The pitfalls of applying the principles of genetics to the problems of society

by A. E. Mirsky

THE FACTS OF LIFE, by C. D. Darlington. George Allen & Unwin, Ltd. (35 shillings).

This book deals with genetics in its widest aspects. The author, a noted cytologist (who recently became a professor at Oxford), finds that "human studies in history, medicine, psychology and the social sciences have failed to keep in touch with the changing knowledge of the facts of life." They have, he says, repudiated genetics, and thereby have been led into errors. Darlington explains his aim as follows: "Some of this book may be read for light entertainment. Some of it too may be of technical interest. But my serious purpose is to show the immense possibilities which await the application of the elementary principles of heredity . . . to the great problems of society." In the process he ranges over problems raised by such assorted worthies as Aristotle, Plato, Lucretius, Moses, Freud, Jung, Toynbee, Lysenko and Kinsey.

He begins with a learned and lively survey of the historical development of genetics—the speculations and observations that have led to our present knowledge of cells and chromosomes. There can no longer be any doubt that materials in chromosomes determine many of the inherited traits of living creatures. Knowledge of chromosomes reveals the biological basis of individuality and leads to a solidly established theory of the origin of species by natural selection. Surely an inspiring story! Yet as it is presented here the account makes a reader uneasy and suspicious. Impressive as genetics is, much of this story is too slick and pat. Our knowledge of biology is not nearly as complete or certain as Darlington makes it out to be. In a book he published several years ago, *The Elements of Genetics*, he argued that in describing nature a scientist should "fill in the empty spaces [in the map of knowledge] according to the more likely assumptions." To have filled in the empty spaces of genetics, as Mendeleyev did for the periodic system of elements, would have been a great contribution. But Darlington's book was badly marred by his failure to distinguish between the "mapped area" and the "empty spaces."

The present book suffers from the same defect; it lies between science and science fiction. There is, for example, a rather pretty picture of how cells differentiate, based on the reasoning that "the differences between different tissues in the same animal . . . cannot be due to changes in the nucleus, for the chromosomes are visibly the same. . . . The differences must, therefore, be due to changes in the cytoplasm." But *are* the chromosomes visibly the same; and even if they are the same visibly, are they the same in chemical constitution? These questions blur the pretty picture. Never mind. Darlington's picture *is* amusing to the general reader; to the student and the investigator it is a vision of what might be and they will know what is wrong with it.

Besides providing "light entertainment," however, Darlington seeks to apply "the methods and notions of science for our social well-being." When his fact-and-fancy pictures concern the well-being of the general reader, they cease to be entertaining and are frequently pernicious. His discussion of cancer, for example, has a semifictional character. He assures readers that a generally effective early treatment for tumors is here, for "we possess a means of picking out the disobedient cells from the good cells . . . with what are called 'ionizing radiations.'" He ignores the fact that radiations have been found ineffective against the great majority of growths.

Also pernicious are his comments on racial crosses among human beings, inserted in the midst of a discussion of the crossing of breeds of dogs. Disharmonies observed among crossbred dogs, he says, "closely resemble the disharmonies arising in later generations of human race crosses where one race does not predominate in numbers to give general back-crossing of the F_1 and a consequent restoration of balance." He cites as one of the "worst" examples of such disharmonies the situation on Pitcairn Island, where the mutineers of H.M.S. *Bounty* interbred with Polynesians. Now it happens that J. C. Trevor of the Galton Laboratory at University College in London has just published a monograph on *Race Crossing in Man* in which he reports the results of several modern studies, including one of the progeny on Pitcairn Island. Trevor's results show that Darlington's statement is contrary to what has been observed. As the British geneticist L. S. Penrose observes in a prefatory note to Trevor's work: "He has been able further to demonstrate that many earlier speculations about the supposedly peculiar effects of racial mixture are quite unfounded."

Darlington writes about genetics with great enthusiasm. This is easy to understand; genetics is a wonderful science. It must, however, be said that in this book the claims for genetics are swollen. Where Darlington deals with man and society, his exaggerated claims for genetics will be obvious to any reader. To a biologist the exaggeration is apparent in many other parts of the book. His sweeping assertion that heredity is "the most enduring and fundamental problem of life," for example, is a gross overstatement, particularly in view of the fact that his book almost completely disregards the important parts played by physiology and nutrition in determining the development of living things.

Darlington would perhaps consider these criticisms irrelevant, for his purpose is to show how genetic determination can be applied to the problems of society. Hovering over this approach to social problems is the great figure of Francis Galton, undeniably one of the most creative and original investigators of the 19th century [see "Francis Galton," by James R. Newman; SCIENTIFIC AMERICAN, January]. For Darlington, Galton has heroic stature. Galton has powerfully impressed other scientists. Charles Darwin greatly admired him. Galton invented some of the mathematical tools for investigations of heredity; his highly perceptive observations on the incidence of color blindness among the Quakers, a "mating group," was a pioneer contribution to human genetics; he was the first to use twins for investigations on man, and a fine example of his wonderful acuity was his recognition of the distinction between one-egg and two-egg twins.

Yet it is important to recognize some of Galton's less admirable qualities, for they too have been of influence. He had much to say about race and class. In *Hereditary Genius*, published in 1869, he wrote: "If the Negro race in America had been affected by no social disabilities, a comparison of their achievements with those of the whites in their several branches of intellectual effort, having regard to the total number of their respective populations, would give the necessary information." And then he proceeded to give his reasons for regarding Negroes as inferior. Two of them (surely very "rough") he stated as follows: "It is seldom that we hear of a white traveler meeting with a black chief whom he feels to be the better man. . . . The number among the Negroes of those whom we should call half-witted is very large. Every book alluding to Negro servants in America is full of instances. I was myself much impressed by this fact during my travels in Africa. The mistakes the Negroes made in their own matters were so childish, stupid and simpleton-like as frequently to make me ashamed of my own species." Galton returned to this matter in a later book, saying that the Chinese as colonists "may, as I trust, extrude hereafter the coarse and lazy Negro from at least the metalliferous regions of tropical Africa."

In his enthusiasm for the determinism of heredity Galton made much of his studies of one-egg twins—their close resemblance in physical characteristics, their tendency to suffer from the same ailments, and so on. Although he had little significant data on the effects of environment and education on their mental characteristics, he nonetheless had firm opinions on that subject too. He acknowledged that parental teaching played a part in the mental development of a child, but in support of his theory of the paramount importance of heredity he asserted that parents and children are "able to understand the ways of one another more intimately than is possible to persons not of the same blood," and that in contrast to teaching by parents, "the marks left on the memory by the instruction of a foster mother are soon sponged clean away. Consider the history of the cuckoo, which is reared exclusively by foster mothers." (Darlington too is impressed by the cuckoo; in *The Facts of Life* he says: "The cuckoo is uniquely instructive in its relations with the environment.")

Now so-called identical twins have been studied closely by modern investigators. Horatio Newman of the University of Chicago made a classical investigation of identical twins who had been separated in early childhood and brought up apart, some of them with very different educational opportunities. The effect of heredity on their physical and mental characteristics was striking. It was clearly established, however, that education had a marked effect on their mental abilities. This conclusion is in line with what Sir Charles Sherrington, the great neurophysiologist, said about the human brain—"a new thing" that emerged only 80,000 years ago. "Before it, truly, there were educable systems in the animal world, but this is so educable as to be practically a new thing in the world." Indeed, man is not a cuckoo.

But with Galton as his prophet and genetics as his tool Darlington proceeds to apply his formula of genetic determination to a vast array of social problems: crime, individuality, sleep, speech, race, class, disease resistance, environment, sex, love, marriage, divorce, homosexuality, celibacy, population, food supply, instinct, psychoanalysis, immortality, free will, history, culture.

Darlington asserts, for example, that the technically backward classes and societies are in that condition "largely for genetic reasons." He says: "A few men may by scientific discovery greatly advance the possibilities of exploiting the growth of plants and animals on the soil of the earth. But these possibilities can be realized only by men with a certain genetically limited technical capacity; a capacity lower than that of the inventors but higher than that of the agricultural populations of the world today in almost every part of every country. The main requirement at the present moment is therefore not agricultural research, not soil, plant and animal research, but human research. The important means of increasing food production in Europe and in Asia is to breed better farmers and to put them in possession of the land. In England, for example, it is not lack of research which limits food production but the genetic unfitness of a large part of the tenant farmers, the legally secured occupiers who are organized to keep better men off the land."

Concerning class, race and culture Darlington makes comments like these:

"The difference that distinguishes social classes is genetic. . . . If persistent classes are not formed the culture deteriorates and the empire decays. . . . The materials of heredity contained in the chromosomes are the solid stuff which ultimately determines the course of history. . . . Not only the development but the absorption and exploitation of culture is entirely different among different races and is genetically determined. The capacity to make use of European culture is entirely different in West Africa and in India, in Japan and in the Philippines, in Java and in New Guinea. In some races that capacity depends on the occurrence of hybridization, in others on its absence. . . . A whole community working for generations is needed to make the culture, which only then reacts with an individual of the same community, with one of its own genotypes, to give the harmonious working which is represented amongst other things by what we may be permitted to call 'love of one's country.' "

All this will please racists. It will, however, appear arbitrary to many biologists, including geneticists, as well as to social scientists. To them reading this book will be tedious, because it is obvious that the main point has been missed: Man's brain, as Sherrington said, "is so educable as to be practically a new thing in the world." This makes possible in human societies the transmission of characteristics acquired by education. In plants and animals heredity is transmitted by means of chromosomes in sperm and egg cells, and acquired characters are not inherited. In human societies what has been acquired by learning can to some extent be transmitted to other individuals, just because transmission can be accomplished otherwise than by means of the chromosomes of sex cells. Such transmission is seen only in most rudimentary forms in other animals. To apply biology to human societies without recognition of this is somewhat like attempting to apply the principles of physics and chemistry to living organisms without being aware that such properties as physiological integration and self-propagation are important in the animate world.

There is no known limit to applications of physics and chemistry in the investigation of organisms; nor is there any limit to the application of biology to the study of man and society. In particular, it is desirable that our knowledge of biology, in all its forms, be used in inquiries concerning the physical and mental characteristics of classes, mating groups and races.

Despite the confident assertions of Darlington, little, if anything, is yet known about the genetic aspects of variable educability in classes and races. What is known is that barbaric populations have been sufficiently educable to acquire by transmission (which usually involves some mingling of chromosomes) precious elements in the acquired heritages of other peoples. For us the most important example of such transmission was the way the barbaric inhabitants of northwest Europe acquired from the civilized populations of the eastern Mediterranean region the underlying concepts and material appliances used in agriculture, the metallurgy of copper, bronze and iron, most of the main species of manual tools employed in handicraft or husbandry today and, not least, the alphabet. It would be folly indeed to suppose that other technically backward peoples cannot learn from us. It is important to remember that some of the geographical barriers to transmission were broken down only after the middle of the 19th century. This view of history and culture is far removed from that given by Darlington's so-called *Facts of Life*.

Short Reviews

BRITANNICA WORLD LANGUAGE DICTIONARY, compiled under the direction of the editorial staff of *Encyclopaedia Britannica*. Funk & Wagnalls Company ($35.00). This work offers for the first time a handy dictionary of not one or two but seven languages—English, French, German, Italian, Spanish, Swedish and Yiddish. Within the covers of one volume are given, in all seven languages, the equivalents of some 5,000 of the most commonly used English words. They are listed in parallel columns on the same page and then in alphabetically indexed translations from each language into English, together with pronunciations, some grammar principles and translations of a few common phrases in each language. Arising out of the enforced and growing interest of Americans in the rest of the world, the dictionary is intended for use in the home, in schools and in business and the professions. The work is published as a section of Funk & Wagnalls' two-volume *New Practical Standard Dictionary*.

THE CONQUEST OF EVEREST, by Sir John Hunt. E. P. Dutton & Company, Inc. ($6.00). At 11:30 a.m. on May 28, 1953, the 33-year-old New Zealand beekeeper Edmund Hillary and his 39-year-old companion, the renowned Sherpa mountain guide Tenzing Norkay hoisted themselves wearily to the top of Mount Everest. Their achievement was the culmination of more than 30 years of effort to climb to the highest point on the earth's surface. Eleven major organized attempts had been made since 1921; on three occasions climbers had got to within 1,000 feet of the peak. The story of the final triumph is told quietly in this book by Hunt, the expedition leader, with a chapter by Hillary on the last stage of the assault. It is a tremendously exciting record of the planning and preparations, of the men who made the camps, built and maintained the fragile lines of communications, carried thousands of pounds of supplies on their backs up the Khumbu Icefall and past the Lhotse Face to the South Col, established the "high-level ferry," cooked, gave medical care, repaired, improvised, set flag-markers and guide ropes, took pictures, recorded scientific data, reported progress to the press of the outside world, and stamped and hacked out every step of the snow and ice path to the summit. Almost as interesting as the chronicle of adventure are the details about diet, oxygen equipment, boots, clothing, tents, cookers, bridging equipment and physiological effects of high altitude. The cloth used for overgarments and tents, a cotton warp and nylon weft, was completely windproof in winds of 100 miles per hour and kept the men reasonably warm and moderately dry. The specially designed climbing boots lined with opossum fur between two layers of leather, with a woolen felt innersole and a thin rubber sole, leaked and froze during the night so that they had to be toasted over an open flame to make them wearable. Nevertheless they were light and comfortable, and there were no cases of frozen feet. An aluminum-alloy builders' ladder turned out to be invaluable for crossing crevasses. The food included not only compact, balanced rations but also "luxury boxes" with personal preferences in food (this expedition favored jam, apricots and sardines). Hillary and Tenzing in the final push drank enormous quantities of lemon juice and sugar to prevent dehydration and ate sardines on biscuits. Hunt's book lacks a relief map of the central mountain group or a clear chart of the ascent route. But these are forgivable blemishes in an unforgettable narrative of human endurance, skill and courage—an epic of men joined in common purpose.

PHILOSOPHICAL INVESTIGATIONS, by Ludwig Wittgenstein. The Macmillan Company ($6.00). Wittgenstein, who died in 1951, was one of the strangest and most remarkable of modern philosophers. He published only one book, the *Tractatus Logico-Philosophicus*, and read one brief paper to the Aristotelian Society. As professor of philosophy at Cambridge University, he permitted only a few selected students to attend his lectures. Nevertheless it is doubtful that any other philosopher of our age has so profoundly shaken up its thought. The *Tractatus,* published in 1921, formed the basis of the philosophy of logical positivism. The posthumous book now published is a much larger work than the *Tractatus*. It is in the same style: a series of numbered observations, both in German and English, in more or less aphoristic form. Its topics include the concepts of meaning, of understanding, of a proposition, of logic, the foundations of mathematics, states of consciousness. A less technical, more human "album" than the *Tractatus,* it continues to emphasize the theme that the only meaningful function of philosophy is the study of language. Metaphysics is nonsense. "Philosophy is a battle against the bewitchment of our understanding by means of language. . . . When we do philosophy we are like savages, primitive people, who hear the expressions of civilized men, put a false interpretation on them, and then draw the queerest conclusions from it." Bertrand Russell has said he was uncertain, on first meeting Wittgenstein, whether he was a "genius or a crank." The initial doubt is understandable; but on reading this brilliant, memorable book, you will conclude, as did Lord Russell, with the more favorable opinion.

THE GREAT IRON SHIP, by James Dugan. Harper & Brothers ($3.50). Isambard Kingdom Brunel was a tiny Englishman who wore a high beaver hat stuffed with memoranda written to himself and carried a leather pocket case "holding 50 Trincomalee cigars." Known as "the Little Giant," a nickname later appropriated for Stephen A. Douglas, Brunel was the foremost civil engineer of the middle 19th century. He designed and built railroads, bridges, tunnels, dry docks and steamships. His most ambitious creation was the *Great Eastern*, the largest steamship of its time, with a length of 692 feet, a beam of 120 feet and a passenger capacity larger than that of the *Queen Mary*. The *Great Eastern* was a great bundle of woe. It took three months in the winter of 1857 to push her into the water; she bankrupted her owners, drove Brunel to death from exhaustion, drowned her first captain, tore a gigantic hole in her bottom in Flushing Bay, sank four ships, killed 35 men, entertained four mutinies and was reduced in the end to the dismal role of an anchored showboat in the River Clyde. Her single spectacular triumph was the laying of the Atlantic Cable—a feat regarded as impossible and therefore perfectly suited for an impossible ship. The poor marine creature was of course as much too big as her builder was too small; not the least of her defects was that she was badly underpowered. She carried a cast-iron screw weighing 36 tons and 24 feet in diameter—the largest ever fitted on a ship—but her boiler pressure was only 25 pounds per square inch, contrasted with 620 in a moderate-sized modern vessel. Dugan tells his rattling yarn with verve.

NORTH: THE NATURE AND DRAMA OF THE POLAR WORLD, by Kaare Rodahl. Harper & Brothers ($3.50). One of the most remarkable phenomena of the North Polar Basin is the group of great floating ice islands that drift in a clockwise direction around the Pole. Ranging up to 300 square miles or more in area and 200 feet thick, they circulate majestically year in and year out, until they are caught in the East Greenland Current and carried to destruction in the Atlantic. These huge bergs, fragments born of the shelf-ice on the north coast of Ellesmere Island, reminded one explorer of "stretches of prairie." That they are islands of floating ice and not land was verified for the first time in 1946. A U. S. Air Force reconnaissance plane caught an "enormous heart-shaped object" on its radar scope 300 miles north of Point Barrow. The object was immediately classified "secret" and designated as "Target X." On subsequent sightings Target X had moved (the islands move at the rate of only a mile a day) and it became obvious that it was neither a land island nor some strange naval vessel. Rodahl's book describes an expedition to one of the bergs (4½ by 9 miles). A C-47 performed the difficult and hazardous feat of landing on the island, leaving Rodahl and two other men to explore it and prepare the way for larger parties to follow. Today the island, known as T-3, is a floating scientific laboratory, manned and equipped to collect information in meteorology, oceanography, geophysics, glaciology and biology. It will remain in business as a base for a generation or more, as long as it eludes the Greenland Current. Rodahl, an expert on arctic medicine and nutrition, has written a fine account of an extraordinary achievement and of the Arctic in general. His book is the most

informative and readable work about the North that has been published in many years.

THEORETICAL ANTHROPOLOGY, by David Bidney. Columbia University Press ($8.50). The author of this book, a professor at Indiana University, undertakes a survey of the "postulates and assumptions underlying the development of modern cultural anthropology." He points out that the major emphasis of most anthropological research has been on field work and the gathering of ethnographic data: the systematic study of concepts and hypotheses has been neglected. Bidney attempts to compare and evaluate the numerous anthropological theories, including those of A. L. Kroeber, Ernst Cassirer, Auguste Comte, Robert H. Lowie, E. B. Tylor, Leslie A. White, Herbert Spencer, Pitirim A. Sorokin, Franz Boas, Emile Durkheim, Melville J. Herskovits, Bronislaw Malinowski and E. E. Evans-Pritchard. Though Bidney is knowledgeable and holds strong opinions, he is not a very stimulating writer: his ideas struggle vainly to escape from under a leafy blanket of words. Nevertheless it is safe to say that this survey, the first of its kind, will repay the diligent attention of students of anthropology, sociology and philosophy.

THE VIENNA CIRCLE, by Victor Kraft. Philosophical Library ($3.75). In this volume are presented a history of the Vienna Circle and a discussion of its philosophical achievements—the "rebirth and reformation of positivism and empiricism." In the early 1920s a group of persons interested in philosophy formed around Moritz Schlick, professor of philosophy at the University of Vienna. The Circle drew adherents from a variety of professions and disciplines. Among them were the mathematicians Friedrich Waismann, Hans Hahn, Karl Menger and Kurt Gödel and the philosophers Otto Neurath and Rudolf Carnap. Ludwig Wittgenstein's book *Tractatus Logico-Philosophicus* (*see page 96*) played a major part during the early years of shaping the thought of the Circle, though he never attended the meetings. By 1930 the doctrines of the Circle had spread to England, the Scandinavian countries and the U. S. They provided a constant source of ferment in philosophical activity. The German annexation of Austria forced the group to disband and its members (those who were able to escape) to emigrate to other parts of the world. The positivist movement is still very much alive, though ladies often faint on hearing its tenets and even strong men cover their ears. Victor Kraft, Schlick's successor at the University of Vienna, has written a sympathetic and informative, if somewhat abbreviated, account of the work of the Circle.

AFRICA: A STUDY IN TROPICAL DEVELOPMENT, by L. Dudley Stamp. John Wiley & Sons, Inc. ($8.50). A noted social geographer presents a comprehensive survey of the features and resources of the African continent, which administrators, economists and others concerned with the problems of tropical development will find extremely useful. Among the topics considered in the text and in a rich assortment of maps, charts, diagrams, plates and statistical summaries are climate, water problems, soils, forest, grassland, desert, African peoples and ways of life, pests and diseases, transportation.

HISTORICAL ASPECTS OF ORGANIC EVOLUTION, by Philip G. Fothergill. Philosophical Library ($6.00). This is a carefully documented history of the idea of evolution from the earliest times, written by a Catholic who says his aim is "to show that any person holding any form of religious belief is quite able to write and expound a scientific theory on a purely phenomenal and evidential level." In this aim he has certainly succeeded. His book is useful and disinterested—except in an epilogue in which he deliberately allows his "personal feelings about evolution" to come to the surface. It is a considerable feat to give a clear summary of the growth of this many-sided, controversial concept.

MEDICINE, edited by Hugh G. Garland and William Phillips. St. Martin's Press Inc. ($25.00). In these two large volumes, totaling more than 2,100 pages, 42 British specialists present a survey of modern medical knowledge. Besides the usual run of topics found in a comprehensive medical textbook, the work contains articles on the evolution of modern medicine, the assessment and promotion of physical and mental health, social aspects of the causes of disease, the genetic factors in disease, tropical diseases, diseases principally encountered in industry, aviation medicine. There are 167 pages of plates (of which a few are in color), numerous half-tone and line illustrations, brief bibliographical references accompanying each article, and a satisfactory index.

THE AMATEUR SCIENTIST

On a well-made refracting telescope and testing airplanes in the bathtub

Conducted by Albert G. Ingalls

Thousands of airplane crashes take place in the U. S. every pleasant week end without getting into the newspapers. Nobody gets hurt in these accidents. But they do cost the fliers a pretty penny—a total somewhere in five figures. The perilous sport to which these statistics refer of course is the building and flying of model airplanes.

In the U. S. there are now some 100,000 enthusiasts who build and fly miniature aircraft. The group includes commercial airline pilots as well as cub scouts. Needless to say, these hobbyists wish they could find some way to test their designs scientifically and inexpensively beforehand to cut down the high accident rate when they submit their craft to the hazard of flight.

Discussing the techniques of aerodynamic research, a famous airplane designer once said: "If we could only see the splash, our troubles would end!" George Davis, an aeronautical engineer of Teaneck, N. J., recently made a related comment: "If someone hit on the secret of keeping models within arm's reach during test flights, I would pay him a million dollars for exclusive rights to the idea!"

David Raspet, a 13-year-old amateur of State College, Miss., thinks he has the answer—and would like Davis' address. His method? Fly the models in a water model of the air! By using water he compresses the scale: miles per hour become inches per second, and the geometry of the flying field shrinks to the proportions of the family bathtub. It may be argued that data derived from hydrodynamics do not necessarily hold for aerodynamics. Within limits the argument has substance. Still, our knowledge of the laws of streamline flow obeyed by aircraft is based in part on the hydraulic studies of the 18th-century Swiss mathematician Daniel Bernoulli. Lessons learned in the bathtub actually can be applied to the design of a model plane.

David permitted his father, August Raspet, of the Aerophysics Department at Mississippi State College, to assist in working out the details of his experimental procedures. They make the following joint report:

"During a reluctant session in the bathtub one wintry Saturday evening the senior author of this account (the son) happened to find a small plastic airplane model beside the tub. It seemed more interesting than the brush and soap, and he occupied himself with certain experiments. While attempting to sail the plane under water, he noticed that it stalled from a normal glide. To improve its balance he trimmed the model with a few tacks stuck with soap into the nose. The result was a surprisingly good slow-speed glide.

"Interestingly enough, this kind of underwater experiment provides a good study of slow-speed motions of airplanes. After many such fascinating experiments, the senior author and his father (the junior author) decided to write this article and thereby communicate the pleasure to their fellow enthusiasts of aviation.

"The nice thing about the technique that will be described is the ease with which it may be carried out. The very elegantly molded plastic models, usually only something to look at, can actually be made to fly without a motor—under water. These flights are reasonably similar to real flights in the air in that they show stalls, spins, pitching on the nose and whip stalls. All this can be observed in slow motion without expensive high-speed motion picture photography. Measurements of glide angle and flying speed can easily be made. In addition it is possible to study the nature of the boundary layer (the thin layer of air that surrounds the surface of the whole plane) and of the wing-tip vortex, and to investigate the influence of stall on the tip vortex and the nature of wing-root interference. In other words, here is an entertaining and instructive technique which requires only a simple plastic model and a bathtub. If you don't have a bathtub, go to your local swimming pool or to a pond and conduct your underwater aerodynamics there.

"You can buy a cheap plastic model for 10 cents at most dime stores. We have used the Spitfire and P-40 of this type. The wing span of the models is four inches. Next in size and price come such models as Olin's Howard Pete or Mooney Mite, which has a span of 6½ inches and sells for 25 cents. In the more realistic class are the F-51 made by Hawk, a model of 9½-inch span, and the Grumman F9F and the 10-inch F-90, both made by Aurora. All of these models cost less than a dollar.

"For those fortunate enough to have war-surplus recognition models, we suggest the Gotha 242 glider as an ideal performer. It has a 13¼-inch span and is a little big for the average bathtub, but it would be a fine size for a swimming pool. These recognition models sold for several dollars. In the field of exact-scale plastic models the Allyn models are excellent. Their prices run from $1.79 to $2.79.

"The 10-cent models require only a little weight added to the nose to achieve stable flight. We used one or two small tacks stuck into soft soap molded into the open bottom of the nose to get balance on these models.

"Most of the more expensive plastic jobs have hollow fuselages which must be filled with water. You must make sure that there are no air bubbles inside the model for bubbles will move back and forth as the model pitches, thereby changing the center of gravity and affecting the stability as badly as shifting ballast will in a large airplane. Quite a few test pilots have met with accidents due to shifting ballast.

"When the model is completely free of bubbles, it can be 'flown' in the tub and its trim can be checked. Usually a little lead or a nail is needed in the nose or spinner to get longitudinal balance. The model will behave exactly as models in the air except that the flight will be very slow. If the model pitches its nose up and stalls, more weight is needed in the nose. When correct balance is obtained, a smooth, straight flight results.

"On jet-type models the jet intakes need not be closed, for when the model is filled with water the water merely flows through the jets at slow speed.

"On the recognition models it may be necessary to drill two holes (at the top and bottom of the fuselage) to be sure of filling the fuselage with water. You can make tests at different wing loadings: for a low wing loading fill the fuselage with wax; for a heavier loading, with a heavy liquid.

"When a model which is slightly tail-heavy is launched in a normal glide, it will pull up to a stall. If the model is perfectly symmetrical, it will recover by nosing down in a normal manner, but if it is slightly asymmetrical, it will fall off into a slow-motion spin. This is really a fascinating maneuver to observe.

"A research-minded modeler may well find that he wants to go beyond experiments with planes of conventional construction. We suggest that you cut off the horizontal tail and then try to trim the model for stable flight. On swept-back models such as the F-90 it is quite easy to achieve stable flight without the horizontal tail.

"The function of a vertical tail can easily be seen when a model with and without the vertical tail is flown in a tub. Without the vertical tail stable flight is impossible: if you stall the model it cannot recover, and it spins to the bottom.

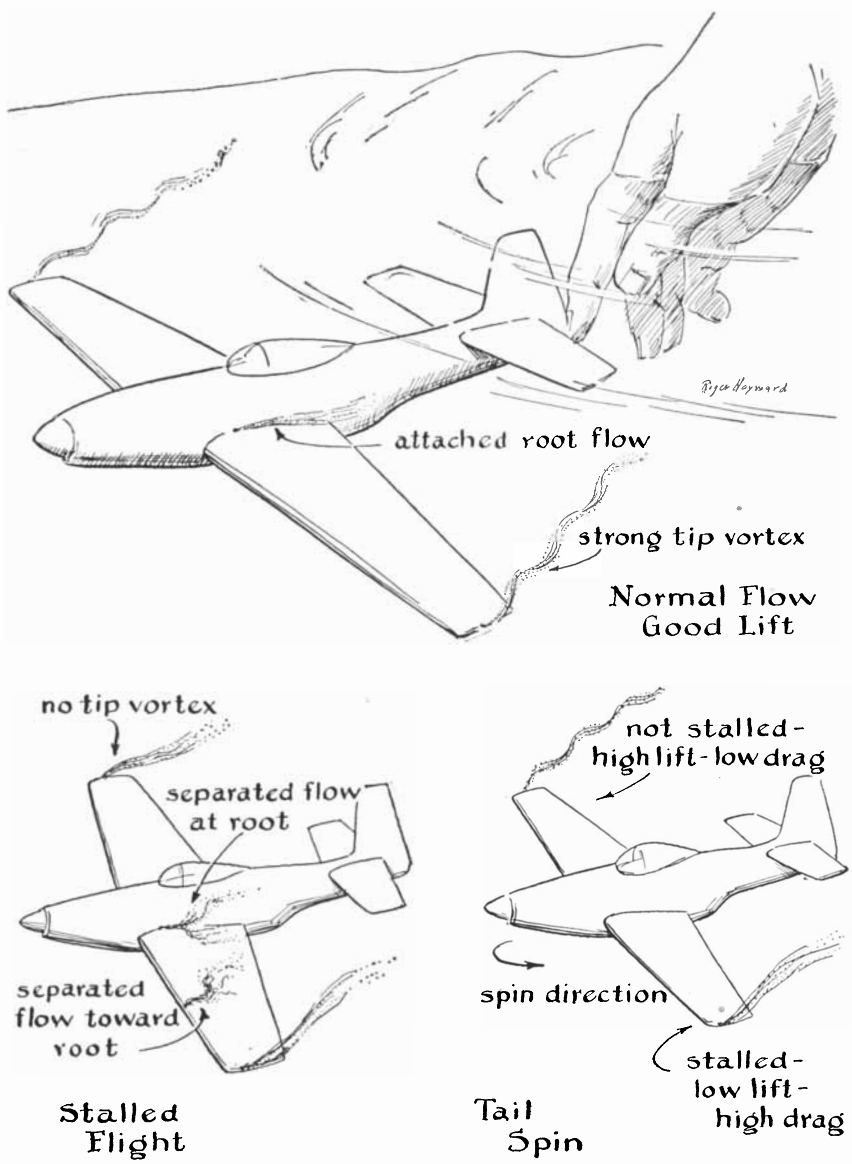
"When a model properly trimmed for straight flight is launched in a sideslip, the model usually recovers in a very short distance. But if it is slightly tail-heavy, it will emerge from the slip in a spiral dive.

"These are only a few of the stability tests that can be made. You can test the model's response to gusts of wind by agitating the water with your hand just as it flies by. You can even reproduce a rising thermal by letting the tub faucet run; a column of water moves up around the falling stream. When a model hits this gust of water it will react exactly as it would in the air. Just as a sailplane, bird or model soars on an atmospheric thermal, a small model will gain a few inches of altitude as it flies into the tub 'thermal.'

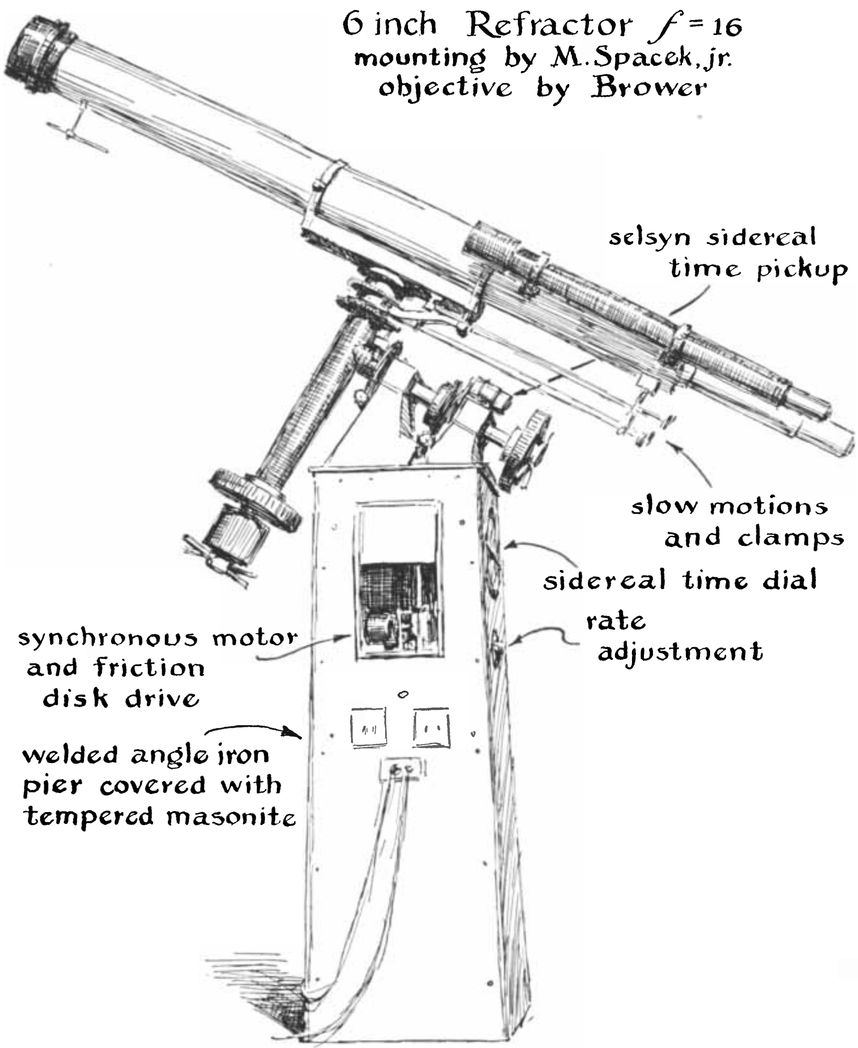
"One of the really nice features of underwater testing of models is that the water ordinarily is quiet and free of turbulence. For this reason glides made underwater are truly a measure of the performance of the model. The method of making measurements is quite simple. Make two marks about 36 inches apart on the bottom of the tub, either with a wax pencil or some adhesive tape. Then release the model from a point in the water above the first mark so that it glides to the bottom at the second mark. The glide ratio is easy to calculate: it is 36 divided by the altitude in inches at which the model is released. Quite consistent results can be obtained if you take a little care to launch at the correct glide and with the model's normal flight speed. Enterprising modelers may wish to time the flight speed with a stop watch. From this speed and the wing loading, engineers are able to compute the lift coefficient. Using the lift coefficient and the glide ratio, it is possible to compute the drag coefficient.

"You can even hold flight competitions in the bathtub. The authors had such a competition, using 10-cent models of a P-40 and a Spitfire. The object was to see who could get the better glide angle out of his model by cleaning it up. The hollow fuselages were filled with wax, the props filed off, the spinners smoothed with sandpaper, the landing gear removed, all sharp corners rounded and rough edges filed down. The canopy was filled flush with wax and the under camber of the wing also filled with wax (modeling clay may be used instead). When all this was done, the glide ratio was improved from two to one to three to one—a 50 per cent gain. The Spitfire won the competition with a glide ratio of 3¼ to 1.

"The same process of drag reduction can be applied to the larger plastic models. Propeller-driven models should have the propeller blades removed and



The aerodynamics of a model airplane are investigated under water



The maker of this telescope had special advantages

the spinner filed smooth. All joints should be smooth and the leading edges nicely rounded. Embossed insignia should be filed off or sanded smooth.

"Another really fascinating and instructive experiment is to make the flow of water around the model visible. In a wind tunnel this is done by injecting smoke into the tunnel. In the bathtub you merely attach a small crystal of potassium permanganate to the model with soft soap. As the model flies, the permanganate dissolves, leaving a clearly visible trail of purple. If you place the crystal of permanganate on the very end of the wing tip you will see the trail curl up into the tip vortex [*see drawing at the top of illustration on preceding page*]. If you launch the model so that it will stall, you will note the first indication of loss of lift in the weakening of the tip vortex. When the model recovers from the stall, the tip vortex again rotates strongly. The lift is directly proportional to the strength of the tip vortex.

"Place a crystal of permanganate in the wing root on the top side at the leading edge. Now fly it under water, preferably with the water a little warm in order to get a more dense purple color in the flow line. You will notice that as the model approaches a stall the flow line separates from the surface of the model [*drawing at lower left in illustration on preceding page*]. The lift in a region which has a separated flow is very much weaker than when the flow is attached. On large models in wind tunnels or in full-scale flight tests, the regions of separated flow are commonly indicated by tufts of wool attached in the right places.

"You can see what happens when a plane approaches a stall by placing a crystal in the middle of the wing on the upper side. In the stall the flow there is inward toward the fuselage. This shows that the pressures on a stalled wing are lower on the root than toward the tip.

"You can also observe the effect of surface disturbances on the flow around a wing. If you place a wire on the upper surface of the wing, lying spanwise near the 25 per cent point of the chord, you will see an early separation. If you put the wire on only one wing, you will force the model into a spin, for the wing with the wire will lose lift earlier than the other. The wire acts as a lift spoiler. A wire placed ahead of the wing will make the flow over the wing turbulent. The flow line will spread like a diffuse jet. But you will notice that the flow does not separate as early as it does on a plain wing. A turbulent boundary layer does not separate as soon as a laminar one does.

"In these days of high technology even in modeling, one must know something about the regime in which his flight tests are taking place. One thing you want to know is the Reynolds number, which is a measure of the boundary-layer flow around the plane at a given speed. At a Reynolds number of about 60,000 (in the air) most model airplanes perform poorly because of the increase in drag. If your model flies slightly below this number, you can improve its performance by adding a wire or by roughening the leading edge to increase turbulence.

"In the air the Reynolds number is the speed in miles per hour times the chord in feet times 10,000. In water the Reynolds number is found by multiplying the speed in miles per hour by the chord in feet by 150,000; that is, the number is 15 times higher in water than in air. But of course the models fly much more slowly under water than in the air.

"You can easily compute the Mach number of their underwater flight. The Mach number is simply the ratio of the speed of the flight to the speed of sound in the medium. In water the speed of sound is 5,000 feet per second. Thus when your model flies at one foot per second (*e.g.*, the Grumann F9F), the Mach number is 1/5000. You do not have to worry about the sound barrier or shock effects!

"Although motorless flight is fascinating enough, you will want before long to try some propulsion on your water model. You can easily equip the plastic P-51 with a suitable motor: Install a small thrust bearing on the spinner, drill the prop spinner for a prop hook of piano wire, thread a double strand of ⅛-inch rubber through the fuselage and hook it to the rear with a wire clip. Now wind up your motor and release the model—preferably from the bottom of a swimming pool. You will get a nice flight, in some cases even reaching the 'ceiling' (pool surface) from a depth of six feet. Don't be surprised if the model pops to the surface, but if by any chance the model should take off into the air, let us know!

"For jet propulsion of a jet model, place a few pieces of dry ice inside the jet, seal the jet intakes with scotch tape, fill the fuselage with water and then launch the model. The carbon dioxide gas evaporated from the dry ice emerges under pressure from the jet exhaust and thus gives propulsion.

"The authors wish you many pleasant and interesting evenings with bathtub aerodynamics. Archimedes long ago made a famous discovery in a bathtub. You may not make any great discoveries, but you will learn some aerodynamic fundamentals and find a lot of entertainment—which has proved challenging enough to interest a number of scientists, professional and amateur. Perhaps you will even invent some new variations on these fascinating experiments."

Among the thousands of amateur telescope makers, some are mechanics by vocation as well as by avocation. Michael Spacek, Jr., of Royersford, Pa., whose telescope is illustrated in the drawing on the opposite page, is a toolmaker. He enjoys the great advantage of access to shop equipment which is not available to the average amateur.

Spacek's telescope rests on a pier made of heavy angle iron welded into a rigid unit and covered with tempered Masonite. The polar axis is sloped parallel to the earth's axis in the latitude of Tampa, Fla., where the telescope is used by Malcolm Maner. It is made of solid shafting 1¾ inches thick, and turns on roller bearings of the needle type. The declination axis has the same diameter and bearings, plus a thrust bearing. It turns in a cast-iron housing 3¼ inches in diameter. The housing was line-bored on a large lathe to obtain alignment.

The drive is basically the same as the friction-disk drive described in *Amateur Telescope Making—Advanced*, page 317. A roller on the shaft of a 1/60-horsepower Bodine synchronous motor drives a leather-faced disk by friction. A "rate adjustment" knob on the side of the pier adjusts the motor shaft axially to select the correct ratio for the change from the standard time of the synchronous motor to the desired sidereal time, or to the rate for the moon or a planet, or for guiding the telescope. This type of drive avoids the use of gears.

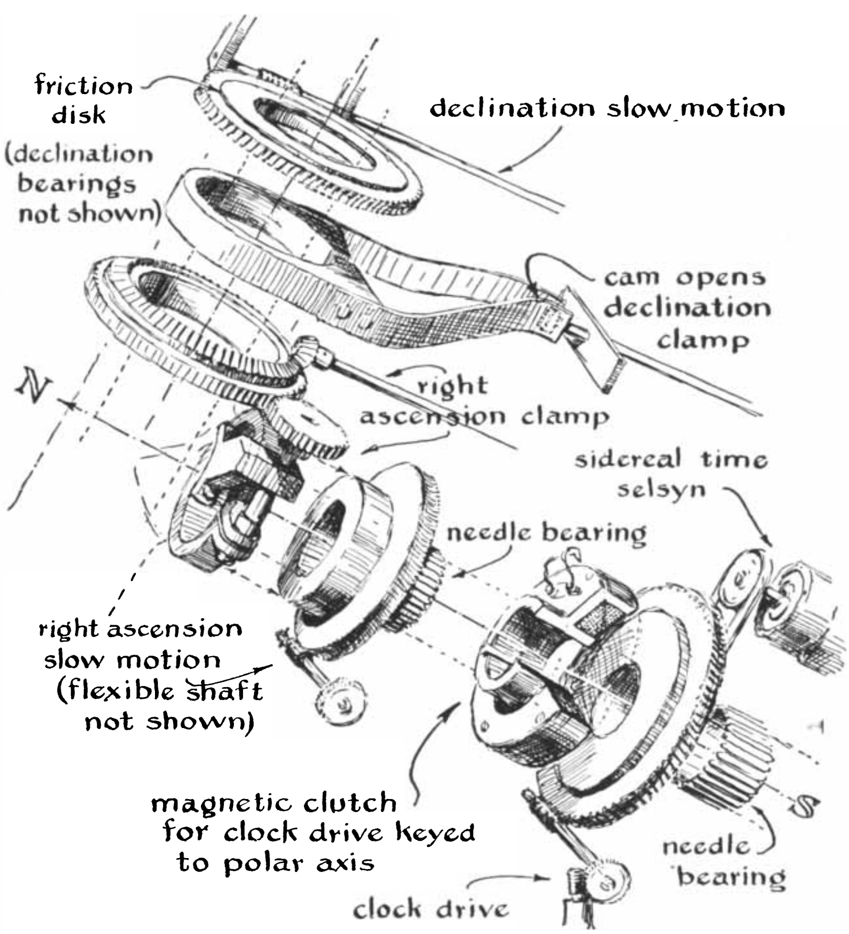
The time-indicating device is a separate electrical unit consisting of two selsyn motors on a single circuit. The first, shown in the illustration on the next page, is driven from the polar axis by a rubber belt and two accurately matched V pulleys. The second, or slave, selsyn is inside the pier and has on its shaft a dial pointer which extends through the pier wall to the sidereal time dial. This is calibrated by hours —1 to 24. Whenever the master motor is moved, the slave motor precisely imitates its movements, whether large or small, quick or gradual.

A third electrical unit, separate from the others, is the magnetic clutch, which is keyed to the polar axis shaft by a spline and can move only endwise. This may be clamped to the steel disk on the worm gear by closing or opening a switch. It is powered by direct current of four amperes at six to eight volts from a selenium rectifier battery charger. The magnet has several hundred turns of No. 22 insulated wire. The energy of a single flashlight cell magnetizes it so powerfully that it cannot be pulled away from the disk. The clock drive in the pier rotates the worm gear on the polar axis by a vertical shaft. When the observer closes the control switch energizing the magnet, the drive rotates the polar axis shaft also, and the telescope starts tracking.

The telescope tube is made of seamless aluminum tubing with an inside diameter of 6¼ inches and a ⅛-inch wall. The objective was made by Stanley Brower of the Laboratory Optical Co., Plainfield, N. J. Spacek says it performs excellently. He found, however, that the leather-covered friction disk on the drive did not work well. Whenever the telescope lay idle for several days, this disk became indented by the drive pulley and the drive bumped badly. Means had to be provided to relieve the pressure from the leather during such periods.

Spacek made all the patterns and did all the machining. He has also built a coating equipment. He is building a new telescope which will have a 10-inch Zeiss objective on the mounting just described.

After studying the telescope for his illustrations, Roger Hayward commented: "The Spacek telescope is noteworthy. The clamps are ingenious, the selsyn timepiece is plushy. But the right-ascension slow motion, independent of the drive, might be bothersome. Having set the instrument on an object, you have to unclamp the slow motion and then clamp the drive, unless you let the clock push it through the slip ring." Spacek replied: "By adjusting the current fed into the



Details of the Spacek telescope mounting

magnetic clutch the tube can be moved, and slow motion in right ascension may be operated, without unclamping it and without gear damage. However, Hayward's idea is better."

Hayward and others have urged the use on telescopes of needle bearings, made by the Torrington Manufacturing Company in Connecticut. Spacek's were manufactured by the Roller Bearing Company of America, Trenton, N. J. He says: "I chose needle bearings because they are compact, rugged and will carry a heavy load. With them you can use a heavier shaft in the same or a smaller telescope axis housing."

In the December issue of the *Journal of the Optical Society of America* P. R. Yoder, Jr., F. B. Patrick and A. E. Gee of the Frankford Arsenal made public the results of an investigation of the new Dall-Kirkham spherical secondary Cassegrainian telescope. This instrument has almost wholly supplanted the classical form of Cassegrainian among amateurs who build compound telescopes (chiefly because of their high magnification) for planetary observation. By trigonometric ray tracing, the most exact method, the investigators found that the off-axis images in the new telescope are appreciably poorer than those given by the classical Cassegrainian. For example, an $f/11$ true Cassegrainian of 130-inch effective focal length gives excellent images over a field of about 1.7 degrees, while a telescope of the modified type with the same optical dimensions has less than one fourth as wide a field.

Amateur astronomers are anxiously inquiring whether this news spells the doom of the Dall-Kirkham form, which is much easier to make than the old form. The question was submitted to the investigator Gee, who is a professional optical worker but retains the amateur's point of view. He replied:

"The increased coma in the Dall-Kirkham form of the Cassegrainian telescope has little significance for the average amateur. Unless the telescope is to be used for direct photography of star fields at the secondary focal point (a rare case for the amateur), the coma is usually within acceptable limits. R. T. Jones of Palo Alto, Calif., reports in a paper not yet published that the increase in coma in the Dall-Kirkham form is dependent (among other things) upon the magnification of the secondary mirror. The coma worsens in proportion to the increase in secondary magnification.

"To illustrate, the $f/11$ telescope of 130-inch effective focal length used as an example in the paper by Yoder, Patrick and myself had a secondary magnification of approximately three times. Its coma was approximately four times as bad as would have been the case for a classical Cassegrainian, although still within acceptable limits. Had the secondary magnification been four times, while still retaining the 130-inch effective focal length at $f/11$, the coma would have been six times as bad as in the classical form. This merely indicates that trouble from coma may be expected in severe forms of the Dall-Kirkham Cassegrainian; that is, those with very fast primaries, high-magnification secondaries and fast over-all systems.

"Coma varies inversely as the square of f ratio in either form of the Cassegrainian. Consequently the slower the over-all system, the less the coma. For example, if our 11.8-inch telescope had a secondary giving 177-inch effective focal length ($f/15$) instead of 130-inch ($f/11$), its coma in the classical form would be reduced by a factor of approximately two. In this case (assuming the same f ratio primary), the secondary would magnify approximately four times. As pointed out above, this would mean that the Dall-Kirkham form would have approximately six times the coma of the classical form, rather than the four times it had at $f/11$. However, the coma in the classical form was improved by a factor of two, while increasing the magnification due to the secondary only worsened the proportional coma by 6/4, or 1½. Thus our $f/15$ Dall-Kirkham telescope of practically the same physical dimensions as the $f/11$ has about 30 per cent improvement in coma.

"To sum up, an amateur need not worry about increased coma in the Dall-Kirkham Cassegrainian if he designs telescopes of conventional dimensions. (A secondary magnification of three to four times and an effective f ratio of $f/10$ or less are considered conventional.) Secondary magnifications can be increased if the f ratio of the system is made slower. Stick to primary mirrors of $f/4$ or slower and I promise you won't be bothered by the coma."

A new 93-page illustrated book titled *Astrophotographe D'Amateur*, by Jean Texereau of the Paris Observatory and Gérard de Vaucouleurs of the Astrophysical Institute, covers compactly the testing of camera lenses and the building, mounting and use of short-, medium- and long-focus lenses. It is available for 800 francs (approximately $2.32) from *La Revue D'Optique Théorique et Instrumentale*, 165 rue de Sèvres, Paris 15, France.

INDEX OF ADVERTISERS

APRIL, 1954

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful.

THE CONTROL OF FERTILITY

A MEDICAL HISTORY OF CONTRACEPTION. Norman Edwin Himes. Williams & Wilkins Co., 1936.

PHYSIOLOGIC CONTROL OF FERTILITY. Paul S. Henshaw in *Science*, Vol. 117, No. 3048, pages 572-582; May 29, 1953.

BIOLOGICAL CLOCKS AND THE FIDDLER CRAB

DIURNAL VARIATIONS OF RESPONSE TO LIGHT IN THE FIDDLER CRAB, UCA. H. Marguerite Webb in *Physiological Zoology*, Vol. 23, pages 316-337; October, 1950.

STUDIES OF THE DAILY RHYTHMICITY OF THE FIDDLER CRAB, UCA. MODIFICATIONS BY LIGHT. F. A. Brown, Jr., in *Physiological Zoology*, Vol. 22, pages 136-148; April, 1949.

TEMPERATURE RELATIONS OF AN ENDOGENOUS DAILY RHYTHMICITY IN THE FIDDLER CRAB, UCA. F. A. Brown, Jr., and H. M. Webb in *Physiological Zoology*, Vol. 21, pages 371-381; October, 1948.

TRITIUM IN NATURE

THE POTENTIAL USEFULNESS OF NATURAL TRITIUM. W. F. Libby in *Proceedings of the National Academy of Sciences*, Vol. 39, No. 4, pages 245-247; April, 1953.

TRITIUM IN NATURE. A. V. Grosse, W. M. Johnston, R. L. Wolfgang and W. F. Libby in *Science*, Vol. 113, No. 2923, pages 1-2; January 5, 1951.

THE FORM OF CITIES

CIVIC ART, AN ARCHITECT'S HANDBOOK: THE AMERICAN VITRUVIUS. Werner Hegemann and Elbert Peets. Architectural Book Publishing Co., 1922.

THE CULTURE OF CITIES. Lewis Mumford. Harcourt Brace and Company, 1938.

A THEORY OF CITY FORM. Hans Blumenfeld in *Society of Architectural Historians Journal*; July, 1949.

TOWNS AND BUILDINGS. S. E. Rasmussen. Harvard University Press, 1952.

THE URBAN PATTERN. Arthur B. Gallion and Simon Eisner. D. Van Nostrand Company, Inc., 1950.

THE LATE EDWIN H. ARMSTRONG

COMMUNICATION THROUGH THE AGES. Alfred Still. Murray Hill Books, Inc., 1946.

RADIO'S SECOND CHANCE. Charles Siepmann. Little, Brown and Company, 1946.

THE SPIRIT OF DISCOVERY: AN APPRECIATION OF THE WORK OF MARCONI. Edwin H. Armstrong in *Electrical Engineering*; August, 1953.

A STUDY OF THE OPERATING CHARACTERISTICS OF THE RATIO DETECTOR AND ITS PLACE IN RADIO HISTORY. Edwin H. Armstrong in *Proceedings of the Radio Club of America, Inc.*, Vol. 25, No. 3; 1948.

HEAT DEATH

HEAT DEATH, HEAT INJURY, AND TOXIC FACTOR. L. V. Heilbrunn, D. L. Harris, P. G. Le Fevre, W. L. Wilson and A. A. Woodward in *Physiological Zoology*, Vol. 19, No. 4, pages 404-429; October, 1946.

ANCIENT JERICHO

JERICHO GIVES UP ITS SECRETS. Kathleen M. Kenyon and A. Douglas Tushingham in *The National Geographic Magazine*, Vol. CIV, No. 6, pages 853-870; December, 1953.

GEOMETRY AND INTUITION

INTRODUCTION TO MATHEMATICAL THINKING. Friedrich Waismann. Frederick Ungar Publishing Co., 1951.

PARADOXES OF THE INFINITE. Bernard Bolzano. Yale University Press, 1950.

THE AMATEUR SCIENTIST

AERODYNAMICS FOR MODEL AIRCRAFT. Avrum Zier. Dodd, Mead and Company, 1942.

EXPERIMENTS WITH AIRPLANE INSTRUMENTS. Nelson F. Beeler and Franklyn M. Branley. Thomas Y. Crowell Co., 1953.

AMATEUR TELESCOPE MAKING. Edited by Albert G. Ingalls. Scientific American, Inc., 1952.

AMATEUR TELESCOPE MAKING — ADVANCED. Edited by Albert G. Ingalls. Scientific American, Inc., 1952.

AMATEUR TELESCOPE MAKING — BOOK THREE. Edited by Albert G. Ingalls. Scientific American, Inc., 1953.

Another new development using

B. F. Goodrich Chemical *raw materials*

B. F. Goodrich Chemical Co. does not manufacture these cotton picking bags. We supply the Geon paste resin only.

Cotton picking bag has wonderful drag

COTTON picking bags have a short life as you will see why. When full they hold 65 pounds of cotton, and as the picker drags it over stone and earth the wear is extreme—and costly.

The bag manufacturer came up with an idea that gives this cotton picking bag 3 times the wear of the ordinary bag. He coats the outside with a plastisol based on Geon paste resin, which covers the bag with flexible armor that resists dragging action. Furthermore, it is not affected by the 100° heat common to cotton country—this plastic coating won't peel or chip.

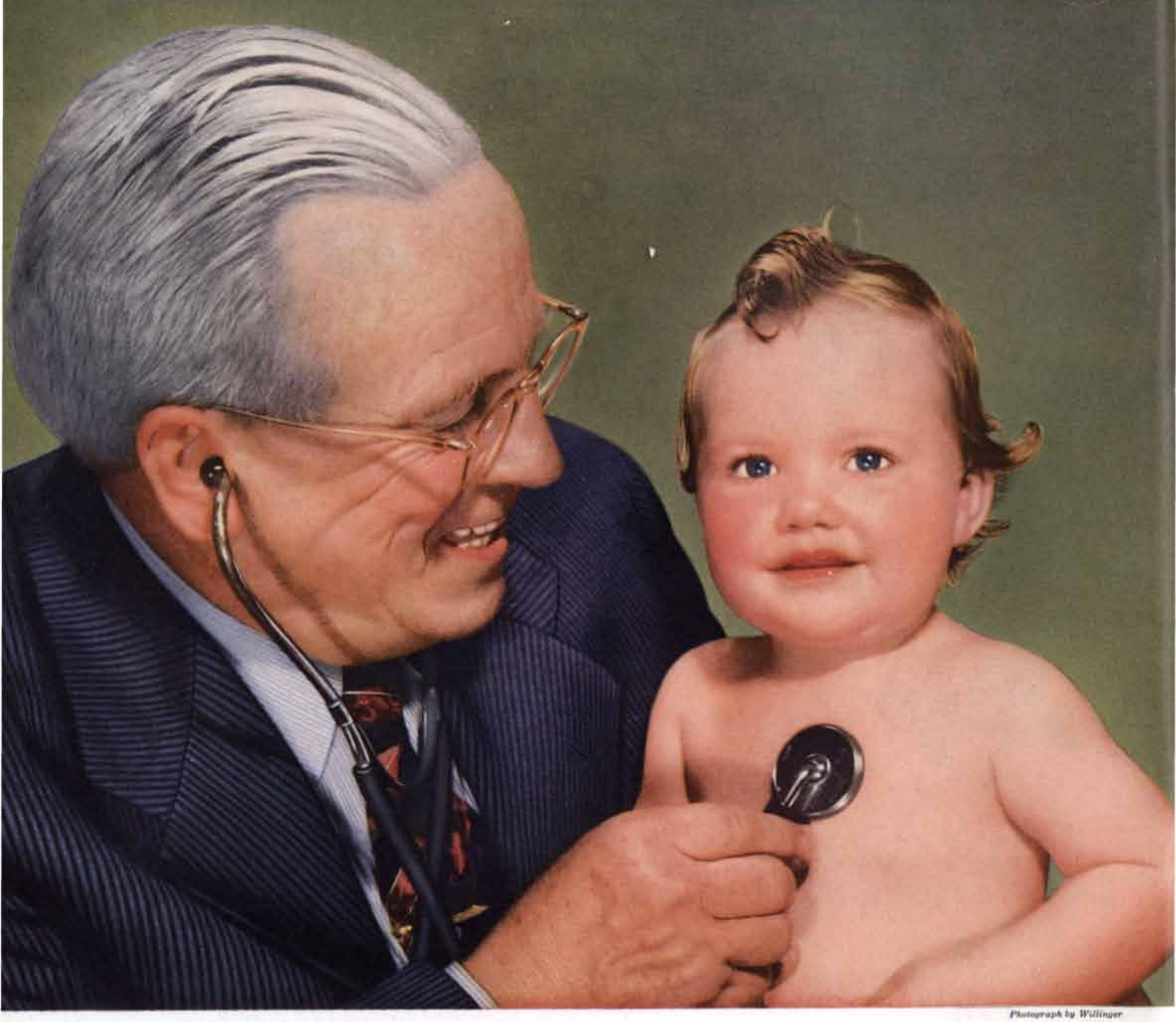
You may find an idea in this success story that can help you improve or develop more saleable products. For Geon-based plastisols and other Geon materials have helped build sales for many necessities—such as wire insulation, durable flooring, colorful upholstery, rigid paneling and tubing and many more.

Check with us; we'll help you select the Geon material best suited to your product's requirements. For technical information, please write Dept. D-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Geon Polyvinyl Materials

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable.

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors



Photograph by Willinger

The Good Listener

Nobody listens more attentively than your doctor listens, and nobody hears such vital sounds. Among the sounds that have special meaning for him are the first cry of a baby . . . your heartbeat, your respiration and other barely audible sounds that may murmur of illness or tell of good health.

Yet because your doctor is dedicated to the fight against illness, few sounds give him more pleasure than the news of some proved medical discovery that will help him better to protect the health of you and your family. From wherever in the world it may come, you may be sure he will hear of it and will bring you its benefits if needed.

The making of just such news has long been the aim of medical research at the Lederle Laboratories Division of American Cyanamid Company. Indeed, it was from Lederle that the news came of the development of Aureomycin* Chlortetracycline, Achromycin® Tetracycline, and also certain types of sulfa drugs. And it is the purpose of Cyanamid's continuing research to go on making news that will mean good listening for your doctor, good health for you.

*Trade-mark

AMERICAN *Cyanamid* COMPANY

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.