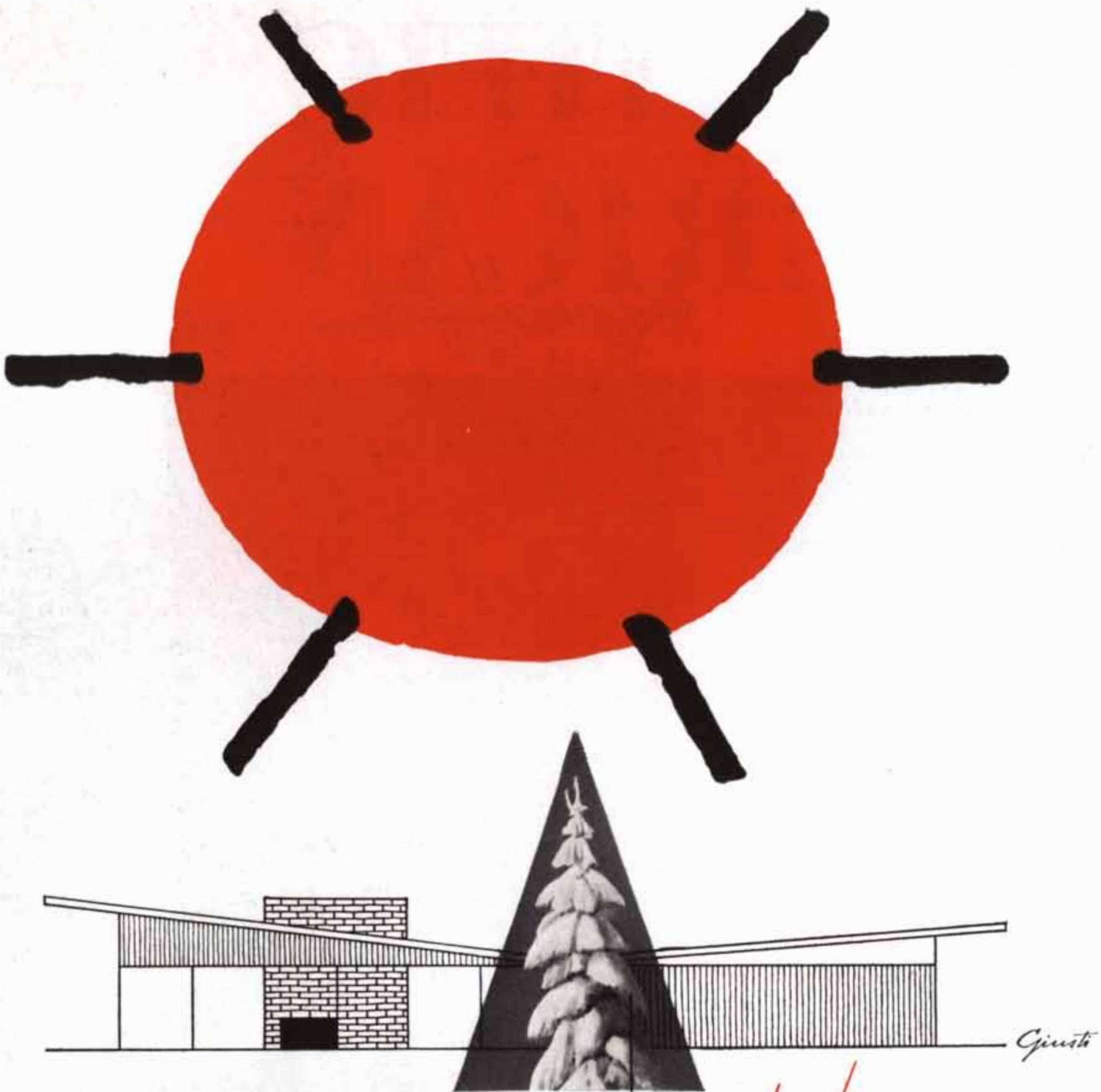
SCIENTIFIC AMERICAN

DESERT FLOWERS

FIFTY CENTS

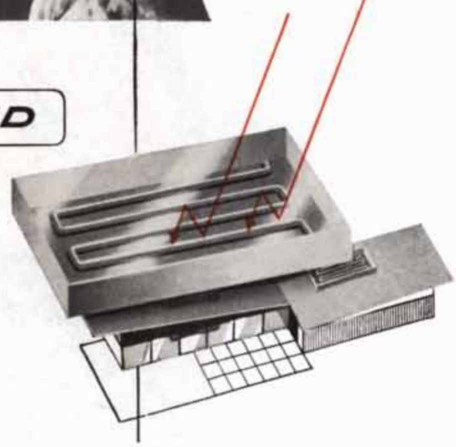
April 1955



Western ROLL-BOND

TRADE-MARK

solar heating units make the sun serve... all winter long



Full scale working models of solar heating units utilize the superb heat transfer characteristics of Western roll-bonded metal for the production of hot water. The heat-producing sun's rays are trapped by solar glass and expend their energy on roll-bonded sheets through which water flows. The steaming water is then used as needed.

Today, cheap, easy hot water heating from the sun's rays is only one of the countless uses for the new Western roll-bonding process that may eventually be used to heat an entire house. The future of roll-bonding is limitless, bounded only by imagination. As an example of another practical present-day use of roll-bonding, one leading refrigerator manufacturer has built over 350,000 refrigerators using this magical metal method that produces tubes *inside* single homogeneous sheets. Thus tubing and heat wasting welds are eliminated forever. Designs can be produced in weeks, changed in days. If you have an idea or problem that requires tubes or internal systems, call or write today. We can help you to a fast, simple solution.

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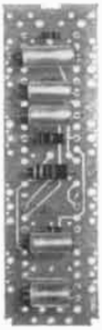

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Autofab's first assignment is defense work. It's helping IBM build huge air defense computers for the Air Force faster and at less cost. But other units will soon be available for assembling printed circuits used in radios, television sets and other electronic products.

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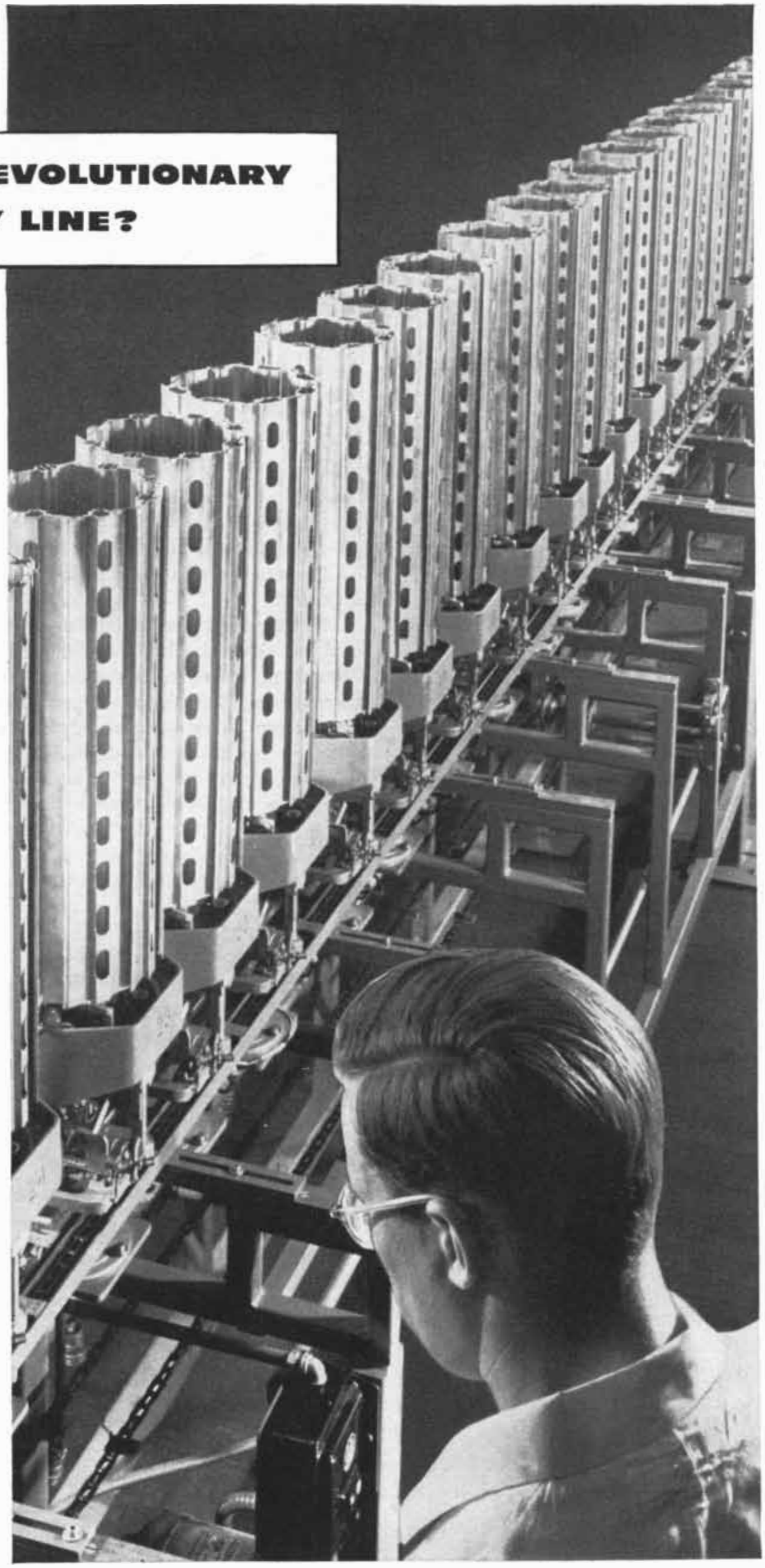

MECHANICAL DIVISION OF General Mills, Inc.

LETTERS

Sirs:

The article by Bernard and Judith Mausner in your February issue, entitled "A Study of the Anti-Scientific Attitude," interests us here in Boulder, Col., for our experience with water fluoridation has been similar to that in Northampton, Mass. A recommendation for fluoridation was made by our Health Department last spring to the city council, which voted 7 to 2 in favor of it. Opponents of fluoridation then circulated a referendum petition, and in October we had a special city election in which fluoridation was one of three issues on the ballot. It lost by 2,395 to 3,127 votes. Less than half the electorate voted.

The campaign was a short one. Our local newspaper, the Boulder *Daily Camera*, published correspondence and advertisements for two weeks preceding the election, being scrupulously fair to both sides but taking no editorial stand. A forum was held by our radio station and a few talks were given to P.-T.A. groups. Unfortunately the local dentists had to carry the ball almost alone, financially and otherwise, until near the end of the campaign, when many letters favoring fluoridation came in too late to be published by the newspaper.

From talking to people afterwards I believe that a big reason why fluoridation failed to win acceptance was the hasty and somewhat authoritarian way in which it had been introduced. The precinct-by-precinct vote strongly suggested that those who voted against fluoridation also voted for another measure: a change in the constitution of the city council, which had incurred dissatisfaction for reasons quite other than fluoridation.

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Boulder is a university city and the new home of two laboratories of the National Bureau of Standards. The precincts having the most university and Bureau personnel favored fluoridation heavily, suggesting the same correlation between educational level and attitude on fluoridation that was found in Northampton. And I fear that, while publicly unspoken, anti-intellectualism and suspicion of "eggheads" may have been a factor here in Boulder.

The same arguments against fluoridation were used here as in Northampton. Of these one of the hardest to answer for the nonscientist, to whom the concept of a "threshold value" is a strange one, is the "poison" label on bottles of sodium fluoride. I drank two 200-milligram doses of sodium fluoride in 400 milliliters of water on successive days with no ill effects, and published my findings in the newspaper, but I doubt if anybody noticed. Another idea which nonscientists accept easily is that there must be a difference between "raw sodium fluoride, artificially added" and the fluoride present in natural waters, such as those of nearby Colorado Springs.

We had plenty of scare propaganda, ranging from honest misunderstandings to deliberate and malicious lies. We know that certain prominent agitators are behind the anti-fluoridation campaign nationally; it is hard to understand their motives, short of a general grudge against the human race. By contrast, I am glad to note that the chairman of the Boulder anti-fluoridation committee acted like a gentleman.

I have enough faith in my fellow men to think that if they are fairly presented with the facts and given time to think them over, and above all are not insulted by being "talked down to," they will come to a sensible decision in due course. It is up to us as scientists to see that they get the facts, and, even more, the attitude of objective fairness that we like to call "scientific." In this connection I am sorry to note one of the findings of Lewis M. Terman [SCIENTIFIC AMERICAN, January], that scientists as a group take little interest in local elections.

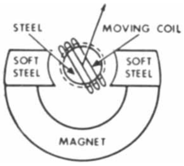
Meanwhile on my kitchen shelf is a dropping bottle containing a 1 per cent

Carboloy Trends and Developments for Design Engineers...

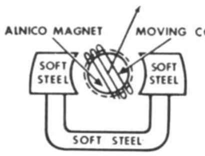
How to select the right permanent magnet
How to improve products by vacuum melting

Simplified permanent magnet makes meter more efficient

There was nothing *wrong* with this meter assembly:



But Carboloy magnet engineers brought a large meter manufacturer substantial savings by helping to design a *better* one:



This new meter assembly uses a Carboloy® Alnico 5 permanent magnet, only one quarter the volume of the previous steel magnet. Yet it provides the same air-gap field intensity — preserving the meter sensitivity.

Today, more and more designers call upon Carboloy magnet engineers to solve the complex problems involved in selecting the proper magnets for their products.

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required field strength
magnetic-material characteristics
magnet size and configuration

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cost per pound
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to attain optimum performance at minimum cost.

Carboloy assistance to designers is not limited to selection and design of magnets. Carboloy engineers can also help solve many of the problems associated with the use of permanent magnets: magnetizing, demagnetizing, testing, and stabilizing. Why not write, today, for more information.

Vacuum melting produces new engineering materials

Melting metals and alloys in a vacuum — instead of in air —eliminates undesirable impurities, dissolved gases, and inclusions. But even more important to the designer, this "cleansing" operation brings spectacular improvements in physical properties and fabrication characteristics.

These improvements add up to increased performance and longer life.

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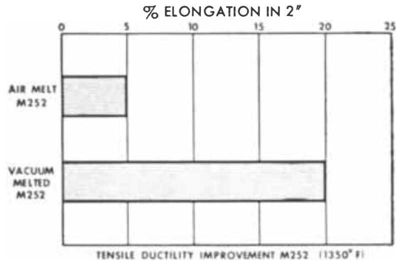
Improved electrical properties. Through greater cleanliness and purity, vacuum processing improves both electrical conductivity and magnetic properties.



Vacuum-melted metals yield more pieces per pound, and any rejects have greater salvage value.

Experienced Carboloy engineers are now ready to help you utilize the tremendous potential of vacuum melting . . . through the improvement of existing metals and alloys, or the development of new alloys.

And Carboloy engineers can also assist you with improving your products through the use of other Carboloy Created - Metals: *Cemented carbides* for combatting wear; *Hevimet* for high-density and radioactive shielding applications; *Thermistors* for detection, measurement, and control of minute temperature changes.

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CARBOLOY CREATED-METALS FOR INDUSTRIAL PROGRESS solution of sodium fluoride. One half-milliliter goes into every quart of milk and fruit juice we drink (when I don't forget), for our three children are still young enough to benefit. To a chemist "kitchen-sink fluoridation" is only a minor nuisance, well worth the little trouble and infinitesimal cost, but the average housewife and househusband may find it less easy. At least it is worth considering as an alternative to which nobody can object—except, of course, the adults of tomorrow whose parents didn't do it today!

HAROLD F. WALTON

Department of Chemistry
University of Colorado
Boulder, Col.

Sirs:

The article on the anti-scientific attitude by Bernard and Judith Mausner [SCIENTIFIC AMERICAN, February] is a case study in its own subject. It even follows the usual pattern of misrepresenting and distorting science while posing as science in its own right.

Not one of the questions used by the authors in their survey has any possible bearing on "pro-" or "anti-" scientific attitudes; and the correlations they offer between the answers and such factors as age, parenthood and education are statistically meaningless pseudo science. Far from being "A Study of the Anti-Scientific Attitude," the article is a thinly veiled propaganda piece for a political program of compulsory mass-medication.

Such professions as medicine, engineering and architecture are not in any true sense "scientific." Their function is to adapt knowledge, both scientific and empirical, to human purposes. Purposes lie wholly outside the ken of science and even the methods of adaption are matters of judgment which also lie outside the scope of science.

That the purpose of fluoridation is political rather than medical is attested by the fact that it makes no possible sense medically. It is uncontested that the effects of fluoride, both good and bad, are determined by the amounts consumed and only indirectly by concentration. When any such drug is administered in the water supply, no control of dosage is possible. Dose is then tied to water-consumption, which is highly variable and wholly unrelated to need for the drug. If any person gets the "right amount," others are bound to get far too much or far too little.

The only possible reason for putting fluoride in the water, instead of giving it in controlled and individualized dosage, is the desire to make its use compulsory and have it serve as precedent for compulsory medication in noncommunicable disease. It is in the public record that such is the purpose of those behind the drive to fluoridate.

It is also in the record that the so-called proofs of safety and effectiveness of artificial fluoridation are falsified. For example, the authors tell us that "enormous amounts of fluoride, more than is ever normally stored at a water-treatment station, would be required to produce a concentration high enough even to mottle the teeth." The fact is that the promoters of fluoridation *expect* it to mottle teeth, and that the so-called "optimum concentration" which they recommend has been selected as the amount that will cause mottling in not more than 20 per cent of the population. Damage up to 20 per cent is considered "unobjectionable."

The purpose of the article, however, goes far beyond propagandizing for fluoridation. It is an open attack on science. It may be considered that science was born when Galileo dropped two balls from the Leaning Tower of Pisa and established that facts are to be determined by observation and investigation, and *not by authority*. When the authors say: "The question concerning the acceptance or rejection of scientific authority is what especially interests us here," they are attempting to re-establish the supremacy of authority over science, and to carry us back to the Dark Ages or "forward" into totalitarianism.

F. B. EXNER, M.D., F.A.C.R.

Seattle, Wash.

Sirs:

It is distressing to find a respectable, supposedly unbiased journal risking its future by printing such clever propaganda as "A Study of the Anti-Scientific Attitude," by Bernard and Judith Mausner.

It is hard to believe that you would knowingly lend your prestige to the promotion of the boldest scientific hoax of all time, but it is even more incredible that with all the facilities at your disposal you have made no effort to investigate fluoridation yourself. If the former is true, this letter will not be printed, but it will then be evidence of your position.

You have assisted in branding as ig-

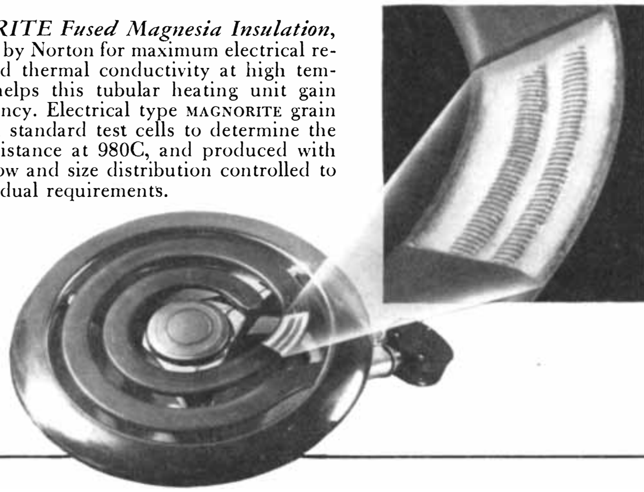
What Can High-Purity Fused Magnesia Do For You?

MANY magnesium oxide products are earth-like, lack strength, and contain impurities that cause them to soften well below the melting point of MgO. Here the difference between such products and MAGNORITE* fused magnesia is readily apparent.

As produced in Norton arc furnaces, MAGNORITE fused magnesia is periclase of carefully controlled purity and crystallization in its densest form. It bears up under loads and does not soften prematurely under high heat — thus permitting maximum utilization of the very high melting point of its basic material.

Although many types of MAGNORITE fused magnesia can be refined in the Norton furnace plant, the bulk of production consists of two major types: refractory type, for refractory and metallurgical uses; and electrical type, processed by a special Norton technique for controlling electrical resistivity, thus increasing its usefulness as an insulator for handling electrical components at high temperature.

MAGNORITE Fused Magnesia Insulation, engineered by Norton for maximum electrical resistance and thermal conductivity at high temperature, helps this tubular heating unit gain peak efficiency. Electrical type MAGNORITE grain is tested in standard test cells to determine the specific resistance at 980C, and produced with packing, flow and size distribution controlled to meet individual requirements.



Refractory Type

Among other characteristics, MAGNORITE magnesia of the standard refractory type has a melting point of 4,750F, true specific gravity of 3.58, and a bulk density of 125 lbs. per cu. ft. A typical chemical analysis shows:

MgO	96.39%
CaO	1.91
SiO_2	1.21
Fe_2O_3	0.23
Al_2O_3	0.26

Unlike most magnesium oxide materials, MAGNORITE fused magnesia grain offers high resistance to moisture attack. It does not require additives that decrease purity and refractoriness. Its density — close to theoretical — prevents coalescence of the grains and subsequent shrinkage problems in high temperature operations. Being chemically basic, it can be used to contain or control corrosive caustic materials. And it is suitable for use with many ferrous and non-ferrous metals and alloys.

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Electrical Type

MAGNORITE magnesia for electrical applications is produced in three sub-types, produced to similar standards and closely resembling the refractory type in general characteristics. These sub-types are E155, E214 and E231. In composition, these differ chiefly in the varying small amounts of aluminum oxide, as shown in the following chemical analyses:

	E155	*E214*	*E231*
MgO	93.76%	94.85%	96.63%
SiO_2	3.45	3.50	2.48
Al_2O_3	1.28	0.12	0.09
Fe_2O_3	0.08	0.08	0.05
CaO	1.43	1.45	0.75

These types of MAGNORITE magnesia are widely used in the production of electric range units and other electrical heating equipment. E214 is the standard material and E231 is designed for particularly severe service, such as high wattage units. In E155 the added Al_2O_3 forms a spinel, after proper heat treatment — a patented feature which acts as a blotter to absorb metallic vapors.

Other Norton Electric Furnace Products

include ALUNDUM* fused alumina, CRYSTOLON* silicon carbide, NORBIDE* boron carbide, Fused Stabilized Zirconia and many others, including a number still undergoing research and development.

These high-melting materials which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory ℞'s — refractories *engineered and prescribed* for the widest range of uses.

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Norton Company not only supplies these materials in their crude form, but has extensive facilities for processing and fabricating — and is ready to work with you in engineering materials to your particular requirements. A new booklet "Norton Refractory Grain — Electrochemically Refined" contains detailed information on these interesting materials. NORTON COMPANY, 543 New Bond St., Worcester 6, Massachusetts.

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Other Moraine products include:
Moraine-400 bearings, toughest automotive engine bearings ever made—M-100 engine bearings and Moraine conventional bi-metal engine bearings—self-lubricating bearings—Moraine friction materials—Moraine porous metal parts—Moraine rolled bronze and bi-metal bushings—Moraine power brakes—Delco hydraulic brake fluids, Delco brake assemblies, master cylinders, wheel cylinders and parts.

norant, backward and anti-scientific, such sound and sensible opponents of fluoridation as:

Dr. Fred Exner of Seattle, who proved to a Congressional committee that the pseudo scientists promoting fluoridation have perjured themselves and are deliberately using fraudulent "scientific" data (Congressional hearings published in H.R. 2341).

Dr. Leo Spira of Vienna, London and New York, who has had more than 30 years of clinical experience with fluorine in low concentrations, besides his animal experimentation, and has definitely proved its lethal effects ("The Drama of Fluorine," by Spira, and H.R. 2341).

Others who oppose it because it promotes cancer (H.R. 2341, Van de Vere; Delaney hearings, Dr. Taylor; Dr. Richardson's paper to W. R. Cox). If you will read page 377 of H.R. 2341 you will see at once that our infiltrated U. S. Public Health Service has admitted concealing cancer deaths in Grand Rapids, Mich., and hiding them in other classifications. This is in the record—is it scientific to ignore it? Shall we believe facts—or cleverly engineered "endorsements"?

Is it "anti-scientfic" to oppose a measure that is obviously a deadly conspiracy, promoted by a government agency with a large number of Russian-born doctors on its rolls (Congressional Record, June 1, 1954), using falsified pseudoscientific data and fraudulent assumptions? All of the true scientific facts prove that fluoridation will destroy our military manpower. . . .

GEORGE INDEST, D.D.S.

New Orleans, La.

Sirs:

The letter-writing tendencies of opponents of fluoridation have again been demonstrated by the unusual volume of mail called forth by our article on the fluoridation controversy. A content analysis of 27 unfavorable letters did not reveal any new anti-fluoridation arguments. The three major themes mentioned in the article occur with the following frequency: (1) lack of proof for the success of the procedure is mentioned four times, (2) the "rat-poison theme" (the supposed dangers in the use of fluorides) occurs 16 times, (3) a fear that fluoridation is an invasion of individual rights, a conspiracy on the part of scientists and chemical industry, occurs 16 times.

Since the case for fluoridation has been frequently and ably presented, we shall not attempt to evaluate these arguments again. (Our article was not intended as a piece of special pleading for fluoridation, but as a study of the movement in opposition to it.) May we point out to those who accuse us of presenting only one side of the issue that the anti-fluoridation arguments were stated in our article, and that one of the suggested references was the report on the Weir bill hearings in which all opponents of the procedure had a full opportunity to speak?

One point raised in many of the letters does merit further discussion. We are accused of attempting to suppress controversy. The idea that controversy is the lifeblood of science is a dangerous half-truth. Controversy leads to the growth of science only when the opponents have an agreed method for testing hypotheses. Otherwise the result of controversy is sterile polemic. When artificial fluoridation was first proposed there *was* a proper basis for question as to its effectiveness and its possible dangers. Controlled epidemiological studies of populations which have been drinking naturally fluoridated water for generations, and of those which have had artificially fluoridated water, have indicated that fluoridation is not dangerous; it does work. At this point the only basis for controversy would be the presentation of new data.

Does it follow then that anti-fluoridation sentiment is necessarily evidence of an anti-intellectual attitude? Undoubtedly many sincerely oppose fluoridation through caution or lack of all available information about it. And certainly the public is entitled to be cautious about new procedures and to receive the fullest possible information about them. Our article urged that scientists avoid the error of assuming that their prestige alone would be sufficient to assure public support for procedures such as fluoridation.

However, the crusaders who form the core of the anti-fluoridation campaign appear to be motivated in part by a generally anti-intellectual attitude. The evidence for this is their rejection of the consensus of relevant scientific opinion. In reply to Dr. Exner, we do not urge that *scientists* rely on authority in their own areas of competence. However, the fact remains that in deciding on many of the complex issues posed by modern science the *lay* public must often depend on the testimony of authorities.

BERNARD AND JUDITH S. MAUSNER

Pittsburgh, Pa.

One of a series telling
how the producing companies of
General Precision Equipment Corporation
are contributing to America's progress.

precision technology

GPE Coordinated Precision Technology is the basic GPE operating policy which inter-relates the research, development and manufacturing facilities, techniques and capabilities of the producing companies of General Precision Equipment Corporation. Thus each company's specialization in its particular areas of competence is supplemented by the application of the resources of the other companies, wherever relevant. A diversified line of advanced precision equipment of superior design and performance has resulted from this application of the newest and most advanced techniques possessed among the companies in every technical capacity.

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Ten of the GPE Producing Companies work in this important field. These companies were "born in electronics" and pioneered in its development before the word was coined. Their work covers every phase of electronics and GPE coordination relates each new electronic problem to the specialized knowledge and experience which is most valuable. This secures the optimum solution for the customer with minimum expenditure of time and money.

GPE Producing Companies have been responsible for the research, development and manufacture of a wide range of electronic precision components, equipment and systems, including Theatre Sound Systems, Sonar Equipments, Flight Simulators, Industrial Control Systems, Analogue Computers, Digital Computers and Components, Industrial and Studio Television, Navigation Systems—both airborne and marine. GPE systems, in most instances, are advanced concepts, often employing components specifically developed for the purpose by one of the GPE companies. Of the great number, two are shown.

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50 AND 100 YEARS AGO

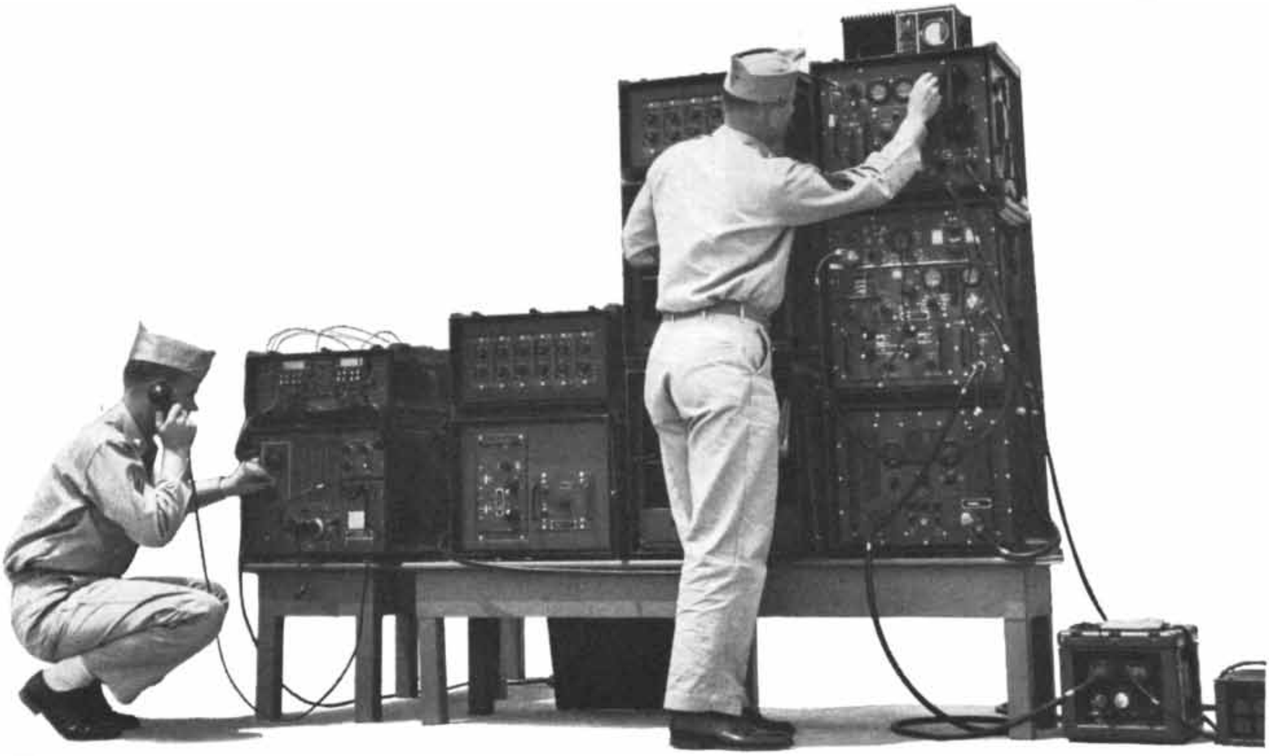
SCIENTIFIC AMERICAN

APRIL, 1905: "Particulars of a new and painless anaesthetic are published by the *Petit Journal*. This drug, which is obtained from a plant found in Japan, has been named 'scopolamine.' It is administered by hypodermic injection, and has the effect of inducing deep sleep for eight or nine hours. Scopolamine, it is claimed, is far superior as an anaesthetic to any of the drugs at present in use for the purpose of operation, and has absolutely no after effects."

"Sir William Ramsay gave an account at the Royal Society of the quantities of neon and helium in atmospheric air. After a series of delicate investigations, which he described, he arrived at the conclusion that there are in gaseous air 86 parts of neon by weight in a thousand million, and 123 parts in the same by volume, while of helium there are 56 parts by weight in ten thousand million and 400 by volume in the same. Such minute amounts seem almost incalculably small, but corroborative tests had been applied, which indicated that the estimates could not be far from accurate."

"It is stated that Emile Wenz, of Reims, France, has recently applied kite-photography with success to geological pictures, and it is predicted that the field geologist of the future will find a kite and its camera essential to his outfit. M. Wenz succeeded in taking good photographs from a height of over 650 feet, and found them very valuable in the production of maps."

"In a recent paper presented before the International Electrical Congress Prof. C. T. R. Wilson alluded to an apparatus he developed which is called a cloud chamber, and which permits of suddenly rarefying, in adjustable ratio, a known volume of moisture-laden air, for the purpose of studying the cloud thereby produced. From the amount of the expansion the extent of the sudden chill is known, and knowing the temperature and vapor pressure of the water in the



Tuning in for radio transmission. Each item of equipment is not much bigger than a suitcase.

A leapfrog telephone system for the Armed Forces!

A new communications system, which takes to the air when water or rough terrain prevents the stringing of wires, has been developed for the U.S. Signal Corps by Bell Telephone Laboratories.

The system uses cable and radio relay interchangeably over a 1000-mile range. It is easily portable, unaffected by climate, and rugged enough for global use. Twelve voices travel at once over a pair of wires or radio waves—as clearly and naturally as over the regular telephone system.

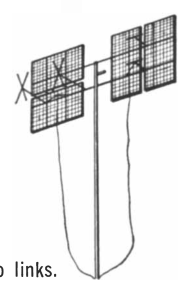
This is the first time a completely integrated wire and radio system of this large a channel capacity has been available for tactical use by the Armed Forces. It is already in production at Western Electric, manufacturing and supply unit of the Bell System.

The new system is a joint achievement of the Signal Corps, Bell Laboratories and Western Electric . . . one of the many results of long and fruitful co-operation. It shows again how techniques which the Laboratories develop contribute to our national strength.

Bell Telephone Laboratories

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

Amplifiers like this are used every 5¾ miles in the cable portions of the system. They are weatherproof, can be used on a pole or the ground, and will even work under water. The system uses a spiral wound cable developed by the Signal Corps.



Easily raised antennas send or receive for the radio links.

chamber before the chill takes place, the degree of supersaturation at which the miniature cloud forms is readily determinable."

"An interesting pamphlet on the use of the rural telephone has just been issued by the North Electric Company of Cleveland. Telephone tea parties are now in vogue on farm lines. There are telephone evening musicales. The accomplished contribute the programme, while others, scattered over an area of many miles, form the audience. The result is more satisfactory than the phonograph. A news service is one of the innovations of rural telephones. At seven o'clock in the evening a general call is rung. When each subscriber is at his instrument, the exact time is given; for instance: 'It is now one minute and a half past seven.' Then the weather conditions; then the late afternoon national and international news. McKinley's death was known to farmers ten miles from market towns as soon as in the cities. It is not too much to say that the telephone is working a revolution in rural life which in time will form an important chapter in sociology."

"Some interesting demonstrations were recently given by Prof. Dewar at the Royal London Institution of his remarkable discoveries concerning the peculiar absorptive properties of charcoal under the influence of liquid air. His investigations show that, as the temperature of charcoal is reduced, its absorptive power is increased. When submitted to the intense cold produced by liquid air and liquid hydrogen, the charcoal consumes all the air or gases surrounding it, and, if enclosed, will produce a very high vacuum. This discovery is of inestimable value to scientists, since now the maintenance of high vacua, which hitherto has been a problem of great difficulty, will be resolved into the simple question of the utilization of charcoal and liquid air. Furthermore, by varying the temperatures the charcoal can be made to separate any given gas from a complicated combination of gases."

SCIENTIFIC AMERICAN

APRIL, 1855: "Since our old lighthouse system was revolutionized a few years ago, a great improvement in the character of the lights and their manage-

ment has been the result. This has been chiefly through the adoption and erection of the French lights of the celebrated Fresnel, one of whose lights was sold for old iron under the old Lighthouse Board, so badly was it managed. The same light, since then, has been erected on Cape Hatteras, we understand, and is one of the best in our country. The lights still in general use in this country are formed on the plan of reflecting, by means of mirrors of different descriptions, the light of a large number of oil lamps. This plan has been found very expensive, and far from perfect. The principle of refraction is that applied to lights of the French Lighthouse Board, under the system perfected by Mr. Fresnel. To such perfection has this plan been brought, that lamps are now in course of construction which will render the light of four one-inch burners equal to 6,600 burners, which can be seen at the distance of fifty miles!"

"That remarkable phenomenon in natural science, the coal mountain in Pennsylvania which has been on fire since 1837, will soon be extinguished, as the fire is approaching a point which can be submerged in water. A mass of coal has been consumed three eighths of a mile long, 60 feet wide, 300 deep, and equal to 1,420,000 tuns."

"A statement has been made to us (for the truth of which we do not vouch) that a large number of springs have been discovered in Western Pennsylvania, which, by a process of evaporation and distillation, yield an oil equal in purity to the best sperm oil. The oil is represented as furnishing a brilliant light, and as not being affected by the cold with the thermometer 14 degrees below zero. It is said 1,000 gallons have already been produced. Is there any truth in the report?"

"Major Wayne has been appointed by the government to proceed to Persia, and purchase fifty camels, and bring them to the United States, for the purpose of army transportation in the great Western Wilderness. It is believed by many that these animals can be acclimated and made exceedingly useful in our country. We do not see why this may not be accomplished. The horse is not a native of our continent, yet he has prospered wonderfully, both in a wild and cultivated state, since he was first introduced by the Spaniard. The camel is a native of the same country—Arabia—where the horse is found in his most perfect condition."

THE CHALLENGE OF CYANOETHYLATION

ACRYLONITRILE has thrown laboratory doors wide open to unexplored frontiers. Scores of new compounds are waiting to be born.

By reacting with virtually any material containing a labile hydrogen atom, acrylonitrile presents an exciting challenge to chemists everywhere.

When cotton is reacted with acrylonitrile to replace all or part of the original hydroxyl hydrogen with the group $-CH_2CH_2CN$, a cyanoethylated cotton is produced that is resistant to rot, mildew and heat degradation, and that has improved dyability.

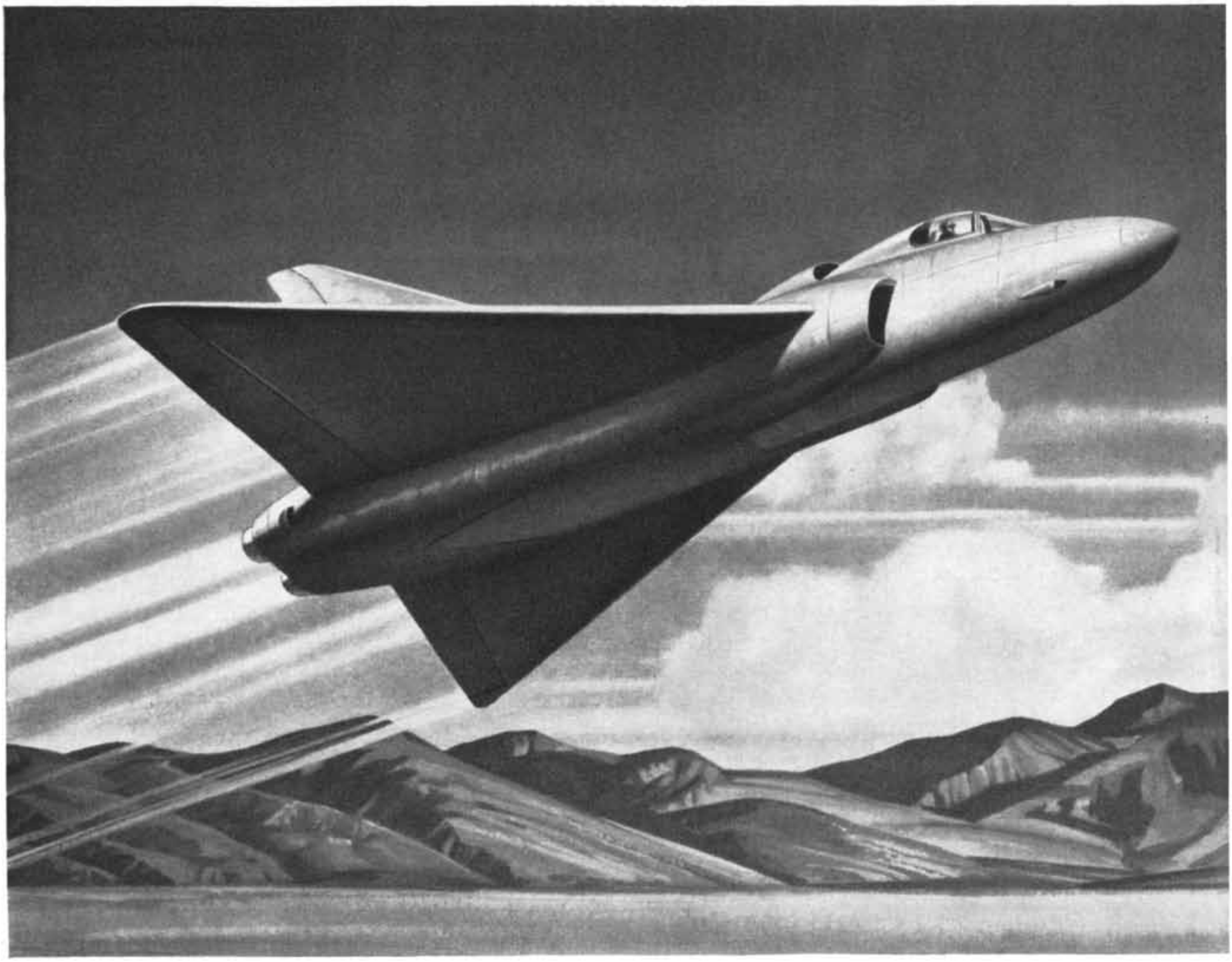
What effects will cyanoethylation produce on other forms of cellulose? Sawdust? Sisal? Paper? Jute? Hemp?

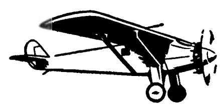
The answers to these questions are still to be written.

Laboratory-size Samples: *If your company would like to experiment with acrylonitrile, you are invited to write Monsanto, the Monomer Headquarters of America for laboratory-size samples. Address your request to Monsanto Chemical Company, Plastics Division, Dept. SA4, Springfield 2, Massachusetts.*

MONSANTO

SERVING INDUSTRY...WHICH SERVES MANKIND



FROM THE "SPIRIT OF ST. LOUIS"  TO JETS

Bendix Has Helped American Aviation Solutions to Fuel Metering and Engine

WHEN anything moves as fast as aviation has since Lindbergh's famous flight, a special brand of creative engineering is required to successfully anticipate the industry's needs.

You can't just design a fine carburetor and rest on your oars, because somebody will come up with a different or more powerful engine that needs a new carburetion approach.

You can't even confine your thinking to carburetors, because DC-7s, Super Constellations and B-36 bombers require something entirely different. And unless your ingenuity has produced an answer like the Bendix* direct fuel injection system, you are out of the ball game.

And then, of course, they're liable to throw away the script and heave you the jet-engine curve you can't touch with either carburetors or direct injection.

The jet is absolutely no kin to the piston-type engine. It's a super-powerful, sensitive creation that gave pilots many, many problems until Bendix brought out a completely automatic system of fuel metering and engine control. It has been so successful that Bendix fuel metering and engine control systems are standard equipment on a great majority of modern jet engines. And going further, Bendix fuel metering controls do an excellent job on guided missiles.

A quick review shows how Bendix ingenuity and leadership in this field pays off—Bendix carburetors are on DC-3s, DC-4s, DC-6s, Convairs and Martins; direct injection systems are on DC-7s, Super Constel-

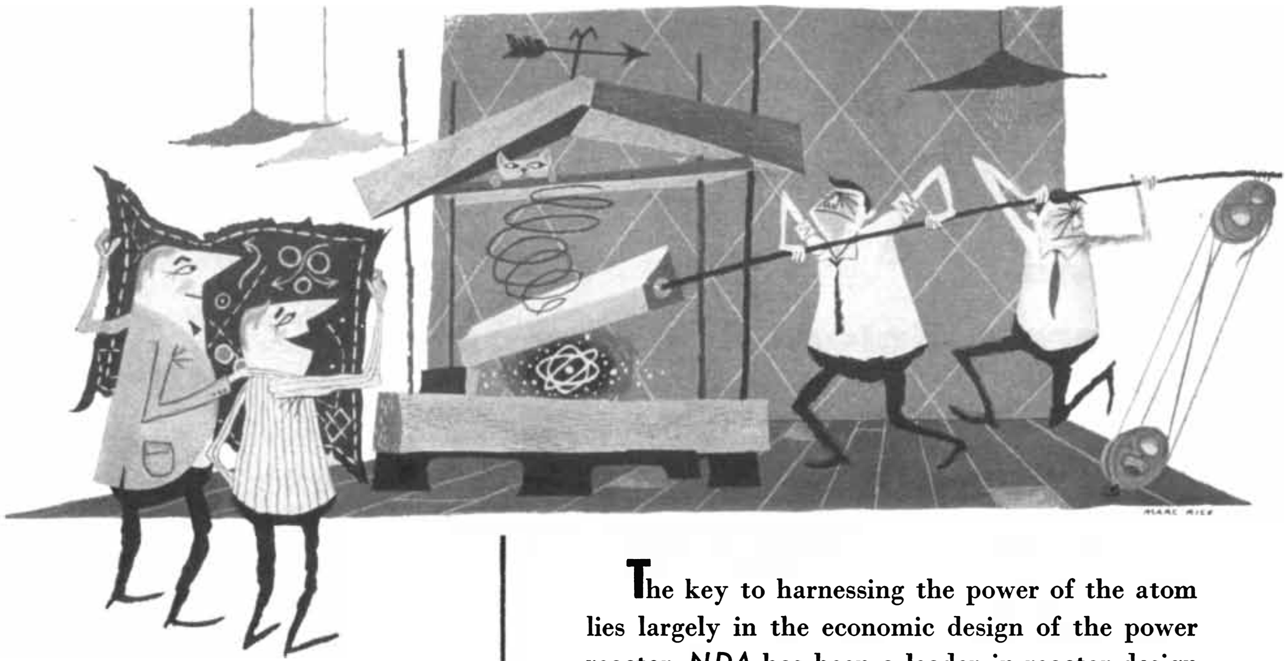
THE AUTHORS

DONALD J. HUGHES ("International Cooperation in Nuclear Power") is senior physicist in charge of a group doing reactor and neutron research at the Brookhaven National Laboratory on Long Island. A note about him appeared in the August, 1953, issue of this magazine with his article on "The Nuclear Reactor as a Research Instrument."

VERNON C. APPLEGATE AND JAMES W. MOFFETT ("The Sea Lamprey") are zoologists with the U. S. Fish and Wildlife Service in the Great Lakes. Applegate, a New Yorker who did his undergraduate and graduate work at the University of Michigan, began studying the lamprey problem in the Great Lakes for the Michigan Conservation Department in 1945. Moffett was born in American Fork, Utah, and in his youth worked on ranches and in mines and sawmills. He, too, took a Ph.D. in zoology at the University of Michigan. Applegate is director of the Fish and Wildlife research laboratory in the Great Lakes and Moffett is chief of investigations.

JONAS E. SALK ("Vaccines for Poliomyelitis") is the Pittsburgh virologist whose polio vaccines are currently being tested on large numbers of school children. Born and educated in New York City, he got through high school without taking a single course in science. As a freshman at the College of the City of New York he took a few science courses "out of curiosity." He decided to go to the New York University Medical School, and in his fourth year began working with viruses under the epidemiologist Thomas Francis, Jr. Later, after internship at the Mt. Sinai Hospital, he joined Francis at the University of Michigan School of Public Health, working on the influenza virus. In 1947 he went to the University of Pittsburgh School of Medicine and began his studies of the polio virus. He now directs the School's Virus Research Laboratory. For Salk the current field trials of the polio vaccine are the culmination of a long research. He is managing to keep calm. "The worrying," he says, "is done ahead of time while calculating all of the possible risks. Then the die is cast and there is nothing to do but wait."

JOHN G. KEMENY ("Man Viewed as a Machine") is, at the age of 28, a



HOW TO SQUEEZE JUICE FROM AN ATOM

The key to harnessing the power of the atom lies largely in the economic design of the power reactor. *NDA* has been a leader in reactor design and engineering since 1948—longer than any other independent private enterprise. For example, the large-scale atomic power plant being planned by the Detroit Edison Company and its associated companies will employ an advanced reactor for which much of the nuclear engineering and physics has been evolved in the engineering offices and laboratories of *NDA*. Many other reactor designs, ranging from small units for research to large-scale power reactors capable of producing 200,000 kilowatts of electricity, have been conceived and designed by *NDA*.

Technological contributions such as these have been made possible by the coordinated efforts of *NDA*'s highly trained team of scientists, engineers and technicians. Their capabilities in the fields of research, design, development and engineering have been demonstrated repeatedly by their past achievements. Before your company initiates any project requiring advanced nuclear technology, consult *NDA* for expert counsel.

For more information about *NDA*'s services write for brochure SJ7.

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professor of mathematics at Dartmouth College. Born in Budapest, Hungary, he came to the U. S. at the age of 13 and attended George Washington High School in New York City, graduating first in his class. He then entered Princeton University, but was interrupted by the U. S. Army, which put him to work on calculating machines at Los Alamos. He returned to Princeton, graduated first in his class and went on to take a Ph.D. in mathematics. He spent his last year of graduate study as Albert Einstein's assistant at the Institute for Advanced Study. Most of his own research has been in symbolic logic.

FRITS W. WENT ("The Ecology of Desert Plants") is a Dutch-born professor of plant physiology at the California Institute of Technology. His father was professor of botany at the University of Utrecht. Went writes that "in spite of his concern that he would push me into his own field I became a plant physiologist. It was my high school teacher in biology, who had no inhibitions in acquainting me with the endless problems of nature, who made me a biologist." For his Ph.D., which he took in 1927, Went investigated the plant growth hormone, for which he developed a quantitative assay. He worked at the Botanical Gardens in Java for five years. His article on "The Plants of Krakatoa" [SCIENTIFIC AMERICAN, September, 1949] was based on his own observations on that volcanic island. Went has been at Cal Tech since 1933.

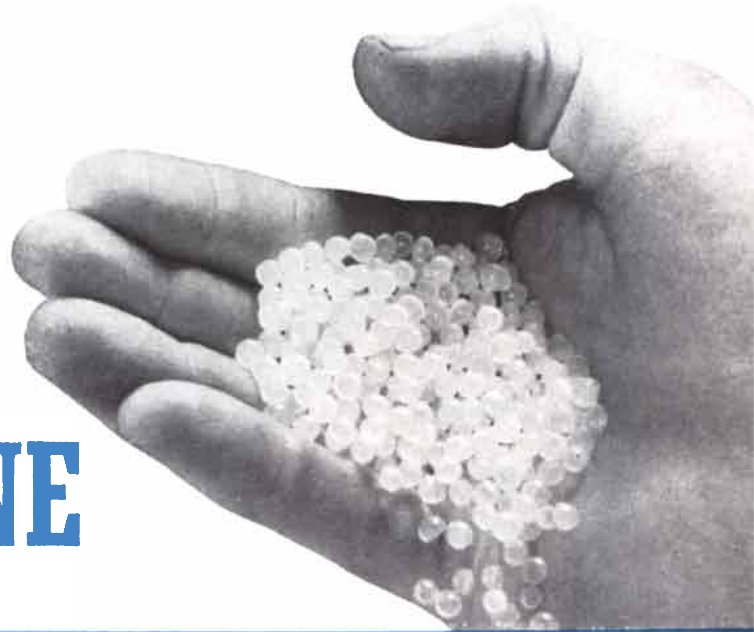
O. FRANK TUTTLE ("The Origin of Granite") is professor of geochemistry and head of the department of earth sciences at the Pennsylvania State University. As a youth he worked in the Pennsylvania oil fields. He went to Penn State, studied optical mineralogy with A. P. Honess ("an inspiring teacher") and decided on a career in geology. During the 1940s he worked on crystal synthesis for the Office of Scientific Research and Development and took a Ph.D. in petrology at the Massachusetts Institute of Technology. For several years he was a petrologist at the Geophysical Laboratory of the Carnegie Institution of Washington. His field studies of rocks have taken him from Finland to Wyoming. In 1951 he received the Mineralogical Society award, the first year it was granted, for having found a way of using optical changes in quartz as a geological thermometer.

EDWARD T. HALL, JR. ("The Anthropology of Manners"), formerly pro-

The big news

in plastics is

TENITE POLYETHYLENE



In November 1954 the first shipment of Tenite Polyethylene left the new Texas Eastman plant at Longview, Texas. This made Eastman the first new supplier of polyethylene in over ten years.

Along with this new primary source comes a new form of polyethylene . . . *spherical* pellets.

Spherical pellets offer many advantages. They flow freely through molding machine hoppers without bridging-over. The new pellets are easier to keep clean during storage and use. Their smooth surfaces do not readily catch dust and foreign particles. Spherical pellets also mean fewer fines, making it easier to clean the hopper when changing colors.

This new form has a 10% lower bulk factor. You can store or ship 1,000 pounds of Tenite Polyethylene pellets in the space that would hold only 900 pounds of ordinary pellets.

Tenite Polyethylene is available for injection molding, blowing or continuous extrusion (including wire covering). It can be furnished in a wide variety of colors and color concentrates.

For more information on Tenite Polyethylene, write EASTMAN CHEMICAL PRODUCTS, INC., Subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

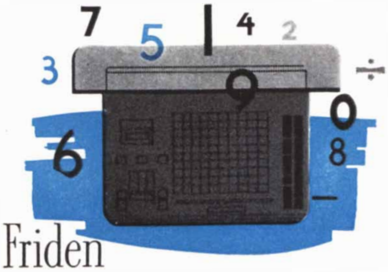
TENITE
POLYETHYLENE
an Eastman plastic

Information regarding Tenite also can be obtained from local representatives listed under "Plastics—Tenite" in the classified telephone directories of the following cities: Chicago, Cleveland, Dayton, Detroit, Houston, Leominster (Mass.), Los Angeles, New York City, Portland (Ore.), Rochester (N. Y.), St. Louis, San Francisco, Seattle, and Toronto —elsewhere throughout the world, from Eastman Kodak Company affiliates and distributors.

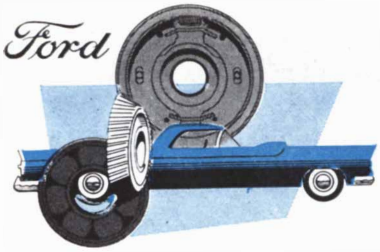
fessor of anthropology at the Foreign Service Institute of the Department of State, has just joined American University. He dates his first cross-cultural experiences from the age of four, when his family lived for a year in New Mexico, a meeting place of Spanish, Indian and North European cultures. Hall has degrees in anthropology from three universities: Arizona, Denver and Columbia. Taking linguistic analysis as a model, he and his associate George L. Trager have been trying to pick out the building blocks in other phases of culture, keeping their eyes open for simple units of behavior equivalent to what phonemes are in language. During the war Hall served as an officer in a Negro engineers' regiment in Europe and the Southwest Pacific. Later he worked as an anthropologist for the U. S. Commercial Company in the Truk Islands in Micronesia and taught anthropology at the University of Denver and at Bennington College, where he collaborated with the psychiatrist Erich Fromm.

SALVADOR E. LURIA ("The T2 Mystery") has been professor of bacteriology at the University of Illinois since 1950. He was born in Turin, Italy, where he received an M.D. in 1935. While camping in the Alps as a medical officer in the Italian Army, he began to study mathematics. This, together with his friendship with several young physicists, led him to study physics in Rome. There he began to use viruses and bacteria as material for radiobiology. He went to the Radium Institute of Paris in 1938 and to Columbia University in 1940. He discovered with some surprise that he had become a bacteriologist when he was asked to teach bacteriology at Indiana University in 1943. His work on mutations of viruses and bacteria has provided the basis for the modern genetics of these groups. Luria has dabbled in oil painting and gardening, but considers working in the lab his real hobby.

DONALD A. BLOCH, the writer of the chief book review (*The Mental Hospital*) in this issue, is a psychiatrist in private practice in Washington, D.C. He was once a resident psychiatrist in a mental hospital himself, at the Chestnut Lodge Sanitarium in Maryland. He became interested in psychiatry through reading Karen Horney while studying for his M.D. at the New York University–Bellevue Medical Center. He was until recently chief of the Children's Service at the research hospital of the National Institutes of Health in Bethesda, Md.



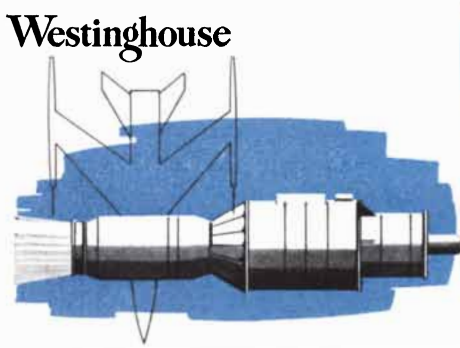
Friden Calculating Machine Co., Inc. has many production as well as research uses for *-hp-* counters. These include matching relay closing times, checking electrical stability, determining electrical requirements of experimental circuits and testing pilot and production models.



Ford's Engineering Research Laboratory at Dearborn finds *-hp-* counters a new, fast way to study automatic transmission performance, time braking action, measure engine cylinder volume and study valve train dynamics.

Douglas uses *-hp-* Counters for time interval work, (measuring time segments as small as 1/100th second) as well as for frequency measurement on AC inverters and generators and determining frequency characteristics of transformers.

IBM quality control relies on *-hp-* Counters to check split-second operating times in electric typewriters and similar mechanisms. Counters help insure uniform type impressions.



At Westinghouse, the same versatile *-hp-* counters that measure turbo-jet rpm's also check adjustment of precision circuitry in new color television receivers and perform many other useful measuring jobs daily.

General Electric uses *-hp-* Counters in both development and production measurements. Typical uses include checking watthour-meter performance and checking crystal frequencies for keying G-E color and monochrome TV receivers.

CHRYSLER

Chrysler products must prove themselves before an impressive array of test devices. *-hp-* Counters measure revolutions and evaluate performance of moving parts with extreme accuracy—even timing actions occurring over intervals as small as 1/100,000 second.

Electronic Counters are one of many electronic test instruments ready to give you better engineering and manufacturing—*today!*

These Counters are not delicate, expensive prima donnas requiring a staff of PhD's to operate and maintain. About the size of a large table radio, they're rugged, dependable, job-proven, versatile, manufactured in quantity and priced from about $900. Anyone who can count can use them—they require no charts or complex calculation. Yet their performance is perfection itself—direct-reading, instantaneous, automatic; accurate within 1 part per 1,000,000.

Industry uses Electronic Counters to measure rpm and rps, weight, pressure, temperature, velocity, speed, acceleration, slippage, elapsed time or time intervals, frequency rates, production quantities. And, they have many other functions; Electronic Counters are only at the threshold of their usefulness to industry.

Electronic Counters

new way to better engineering

ESSO LABORATORIES

Standard Oil Development Company's Esso Research Center uses *-hp-* counters to reveal gasoline performance by quickly, easily measuring engine speed vs. torque, time lapse between "spark" and explosion, time required for maximum thrust after firing.

Hewlett-Packard is a world leader in Electronic Counters, as well as other major electronic measuring instruments. The *-hp-* line includes over 250 different equipments—providing almost complete coverage of measurements that can be made electronically.

Over 100 *-hp-* field engineers serve manufacturers throughout the United States and overseas. Their first job is to give you the right answers about applicability of electronic instruments to your operation. Their second is to recommend and help apply the correct equipment. If you'd like to explore this idea in more detail, please write us. The *-hp-* engineer in your city will reply promptly.

World Leader in Electronic Measuring Equipment

HEWLETT-PACKARD COMPANY

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THE COVER

The painting on the cover shows a group of tiny flowers that grow in the deserts of California (*see page 68*). Small as they are, the flowers are much larger than the plants of which they are a part. Facetiously called "belly plants" (because that is where an observer must lie to see them), they develop in profusion after winter rains. Now in April they flower simultaneously in response to the increasing length of the day. The largest of the flowers is the yellow *Oenothera dentata*. It is about the size of a nickel, one of which is shown at the lower right for direct comparison. The smaller lavender flowers are *Gilia parryae*. The still smaller red ones are *Nama demissum*. The tiny brown flowers are the species *Filago californica*.

THE ILLUSTRATIONS

Cover painting by Rudolf Freund

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32	British Information Services
33	Joint Establishment for Nuclear Energy Research
34	Naamloze Vennootschap tot Keuring van Electrotechnische Materialen
35	Lennart Nilsson (*top*), Commissariat à L'Energie Atomique (*bottom*)
36	Eric Mose
37	U. S. Fish and Wildlife Service
38-39	Eric Mose
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77	Pennsylvania State University
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85-88	Saul Steinberg
93-98	John Langley Howard
111-116	Roger Hayward

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 11

COMBATING CORROSION

ALUMINUM is widely recognized as a light weight material of construction having good mechanical properties and excellent resistance to corrosion. With industry placing increased emphasis on longer equipment life, and therefore on less rapid corrosion deterioration, there has been a strong trend toward replacing less corrosion resistant metals with aluminum alloys. To obtain the fullest benefits from these changes in materials of construction, each installation should be properly designed from the corrosion standpoint so that maximum service life can be obtained.

Why Aluminum Is Corrosion Resistant

Corrosion is essentially the reversion of a metal to its ore under the influence of natural weathering and other accelerating factors. Aluminum owes its comparative immunity to corrosion to the formation of a thin invisible coating of oxide which forms very rapidly over its surface. This oxide is kept in constant repair by the atmosphere, and it usually affords a very high degree of protection to the metal in all except the most corrosive of environments. However, in extremely corrosive environments the protection given by the oxide film may not be quite enough to prevent corrosion completely, and small white deposits of hydrated aluminum oxide may form at weaker places in the surface film. Even here, however, the attack on the metal rapidly comes to a virtual halt due to the additional protection afforded by the corrosion products themselves. Table 1 shows the small decreases in mechanical properties of aluminum alloys exposed to rural, industrial and marine atmospheres for a ten year period.

TABLE 1

RESISTANCE OF WROUGHT ALUMINUM ALLOYS TO CORROSION BY NATURAL ENVIRONMENTS

% Change in Tensile Strength Resulting from Ten Year Tests

Alloy	ATMOSPHERE		
	Rural	Industrial	Marine
1100-H14	−3	−6	−3
3003-H14	−1	−5	−1
2024-T3	−3	−7	−7
Alclad 2024-T3	+2*	+1	+2

**Increase in mechanical properties is due to ambient temperature age hardening*

Data based on information published in ASTM Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals published February 27, 1946.

How to Design for Maximum Corrosion Resistance

The test results shown in Table 1 clearly reflect the excellent corrosion resistance of flat panels of aluminum alloys. However, any highly resistant material of construction will never give the maximum service in a poorly designed structure. Some methods of insuring good design from the corrosion standpoint are outlined below:

Avoiding Crevice Corrosion and Liquid Entrapment Inaccessible places such as sharp re-entrant angles are ideal places for the accumulation of solids and for liquid entrapment. Under such conditions it is difficult for oxygen to circulate freely and repair any damage to a protective oxide film. These places are, therefore, potential trouble spots with even the most highly corrosion resistant metals. Sharp corners must be avoided wherever possible (Fig. 1).

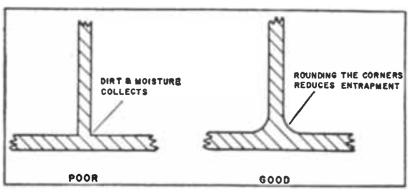

Fig. 1. Reducing entrapment by rounding sharp corners greatly improved corrosion behavior.

In equipment involving the use of liquid solutions, adequate facilities must be provided to insure complete drainage (Fig. 2).

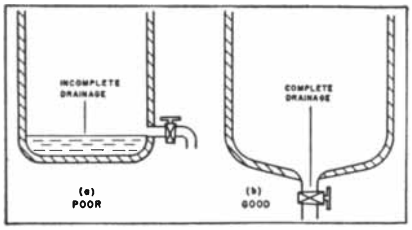

Fig. 2. Design to improve drainage and enhance corrosion resistance.

Welded connections should be used instead of bolting or riveting, and butt welds are definitely preferable to lap welds (Fig. 3).

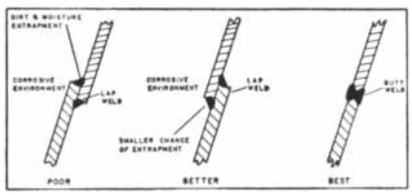

Fig. 3. Design of welded joints from the corrosion standpoint.

Where a bolted connection is mandatory, the crevices should be sealed wherever possible by a mastic compound or by weld metal.

Heat exchangers should be designed to give smooth, non-turbulent flow with a minimum of air entrainment and should be provided with suitably located strainers in the cooling lines to prevent the build-up of deposits at unavoidable local obstructions.

PLEASE TURN TO NEXT PAGE

Every effort should be made to prevent the accumulation of dirt and insoluble matter on aluminum structures. Such deposits and poultice-like material will frequently be the sites of unnecessary corrosion. Low pitch aluminum roofs should be avoided in areas of low rainfall where the washing action of the rains is insufficient to remove wind-blown deposits. Under these conditions a regular hosing down of the structure will greatly extend its service life.

Avoiding Galvanic Corrosion Galvanic corrosion of aluminum in contact with some dissimilar metals can be a serious hazard in a corrosive environment. In most cases, aluminum will suffer accelerated corrosion while partially or completely protecting the other metal.

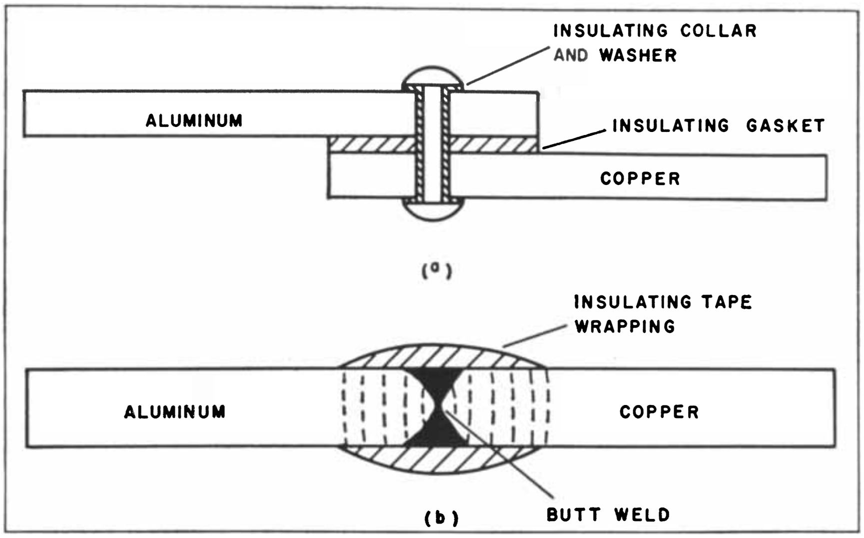

Fig. 4. Methods of insulating dissimilar metals to prevent galvanic corrosion.

Clearly, the best way to design around this problem is to make the equipment entirely of aluminum alloys. Where this is impossible, consideration must be given to using dissimilar metals, such as galvanized iron and stainless steel, which show only very limited galvanic activity with aluminum. In most environments contact with these two products is not harmful to aluminum.

However, direct contact with copper, brasses, bronzes and steel can stimulate the corrosion of aluminum to an undesirable level, particularly in marine environments. This type of corrosion can be reduced or eliminated by the following design measures:

1) Keep the area of copper small and that of the aluminum as large as possible. This reduces the overall corrosion and reduces its intensity by spreading it out.

2) Paint or protect both the aluminum and the copper or the copper alone. Under no circumstances protect the aluminum alone, because the intensity of corrosion at any discontinuity in the protective coating will be very high.

3) Wherever possible, insulate the copper from the aluminum by insulating gaskets or by wrapping with tape as shown in Figure 4.

Avoiding Stress Corrosion and Corrosion Fatigue Since most aluminum alloys have high resistances to stress corrosion and to corrosion fatigue, proper design practices in operating equipment can further reduce these corrosion hazards to an almost non-existent level. Proper design to prevent both types of corrosion consists of minimizing the stress levels in the equipment. This may be achieved by avoiding stress raisers such as sharp radius bends, small radius fillets, crevices and notches. Residual stresses should be reduced wherever possible by insuring accurate fitting of assemblies, while members carrying the highest design loads can be made extra thick. In this way stresses may be kept to a minimum and the maximum service life can be attained.

The design practices outlined above represent those most commonly applied to obtain the highest degree of corrosion resistance from aluminum equipment. More detailed assistance with design and alloy selection may be obtained through the Kaiser Aluminum sales office listed in your telephone directory, or through one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office:* Palmolive Bldg., Chicago 11, Ill.; *Executive Office:* Kaiser Bldg., Oakland 12, California.

SCIENTIFIC AMERICAN

Established 1845

CONTENTS FOR APRIL, 1955 VOL. 192, NO. 4

ARTICLES

DEPARTMENTS

Assembly-line adhesive speeds bonding of honeycomb panels

To meet today's increasing demand for honeycomb panels, a fast yet positive method of bonding this versatile core material is essential.

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International Cooperation in Nuclear Power

The progress of European nations in developing atomic power for peaceful purposes, President Eisenhower's "atomic pool" proposal and other recent events presage a new period in the Atomic Age

by Donald J. Hughes

January 17, 1955, was a historic day in the Atomic Age. On that morning the submarine *Nautilus* glided into Long Island Sound under nuclear power, launching the world's first use of atomic power for transport. On that same Monday morning scientists of seven countries met at the United Nations to lay plans for the world's first international conference on development of atomic energy for peaceful purposes. And the same morning the U.S.S.R. announced a program for nuclear power collaboration among nations within the Communist orbit.

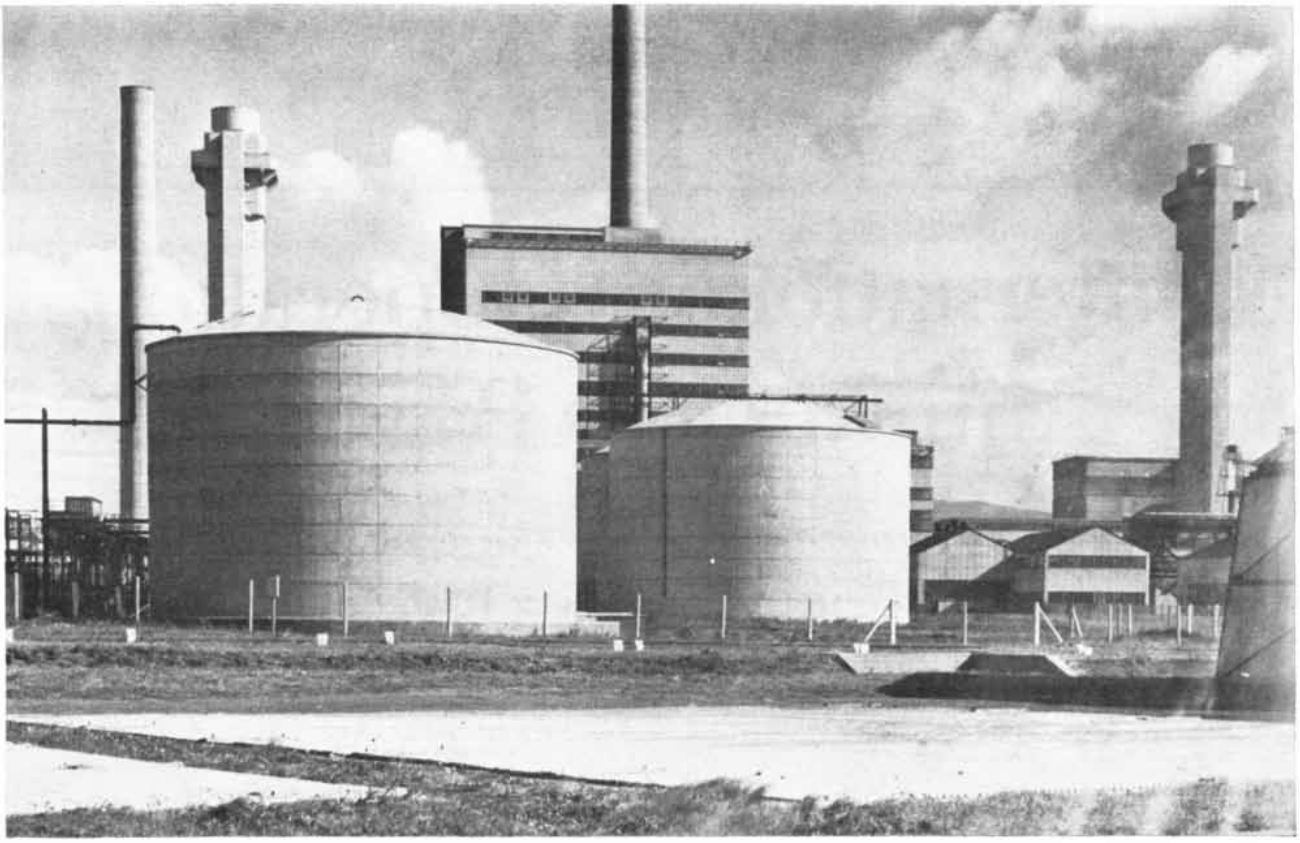
These three events within a single day demonstrated how rapidly things are moving in the atomic power field, politically as well as technologically. Twelve years after the first successful chain reaction in Chicago, giving birth to the nuclear era, the large-scale gains to man so eagerly prophesied at the time are beginning to emerge. The first nuclear power furnaces are already functioning. Almost every important nation in the world is engaged, in greater or lesser degree, in exploring nuclear power. And now that President Eisenhower's "atomic pool" proposal has broken the ice for international cooperation, the pace should accelerate. Soon a number of nations will be sharing information on nuclear power, and probably fissionable material also. It may well be that between the West and the East there will be competition rather than cooperation in the race to make nuclear power economically feasible, but the ultimate effect of such a competition is likely to be all to the good.

The international conference under the auspices of the UN will open in Geneva on August 8. At least 80 nations will be represented. The scientists and technicians who will gather there will consider not only reactor technology but also such matters as the availability of uranium, its cost relative to coal and so on. Let no one suppose that this conference will be a one-way affair, with the U. S. merely passing on its know-how to have-not nations. Some of the European nations will have a great deal to contribute to us, for they have been exploring and developing ideas of their own.

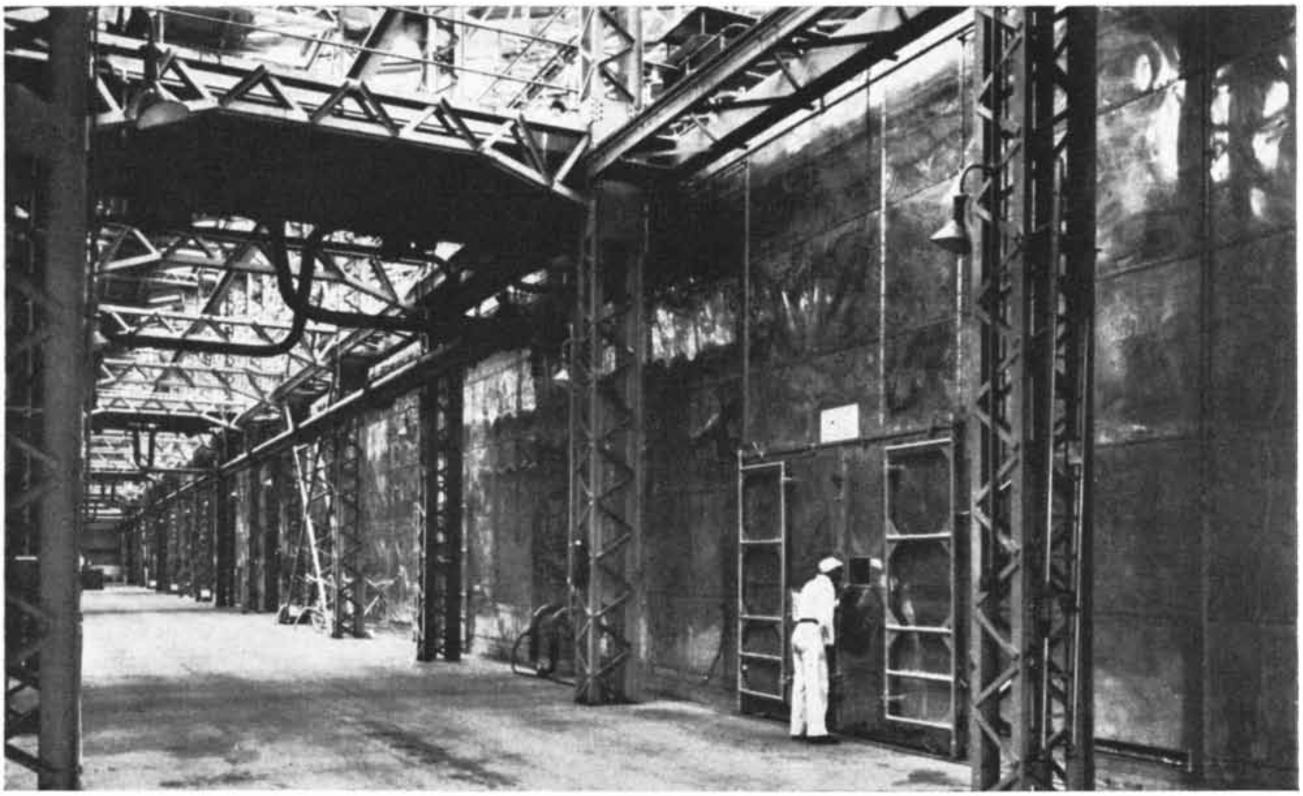
As a Fulbright professor and State Department specialist in Europe last year, I had an opportunity to survey the work in atomic power in England and on the Continent. Measured in dollars, the programs of all the nations of Western Europe together do not begin to approach our own. But they are working vigorously and pushing ahead rapidly to practical application, in some respects much more rapidly than we are. In Europe most of the nuclear work is open and was shown to me freely.

The British were the first, as far as is known, to produce useful heat from a reactor. For four years now the large graphite pile at Harwell has been heating buildings at the laboratory. It is not cheap heat, but it represents nuclear power which would otherwise be thrown away, as is now done with hundreds of thousands of kilowatts at our Hanford plants. And Great Britain has made such rapid strides on the road to nuclear power that she was able to announce last month a spectacular program, contemplating the construction of 12 nuclear power plants in the next 10 years.

Britain has been pushed to this effort by her coal emergency; her mines are so depleted that she has begun to import coal from the U. S. At the same time her electric power needs are rising swiftly; they have doubled in the past 10 years and will double again in the next 10. The nuclear power program is an answer to this crisis. The British will spend some $840 million to build the 12 plants. They will yield 1.5 million kilowatts or more of electricity, burning some 500 or 600 tons of nuclear fuel a



BRITISH PLUTONIUM PLANT at Windscale on the Cumberland coast has special stacks (*right and second from left*) to filter waste gases. Now under construction at Windscale is a large reactor that will produce 40,000 kilowatts of electricity in about a year. This reactor will be of the natural-uranium, graphite-moderated type. It will use high-pressure carbon dioxide for the generation of steam.



BRITISH GASEOUS-DIFFUSION PLANT is located at Capenhurst. Its function is to enrich natural uranium whose uranium 235 has been depleted in plutonium reactors. This photograph of the plant shows a corridor between two rows of diffusion cells.

year instead of five or six million tons of coal. The cost of the electricity is expected to be about seven mills per kilowatt-hour—comparable to the cost at coal-burning stations. Looking ahead 20 years, the British believe that by 1975 nuclear plants may supply 15 million kilowatts, a fourth of the nation's total electric power. Replying to a member of the House of Lords who objected last year to spending six million pounds on a "grandiose scheme" for a 20,000-kilowatt nuclear power plant, Lord Salisbury, head of the atomic program, said that was just a beginning: by the year 2000 most of Britain's electricity would be generated by nuclear fuel.

Two preliminary reactors are already under construction. At Calder Hall on the Cumberland coast the British Atomic Energy Authority is building a 40,000-kilowatt power plant costing some $50 million. Using natural uranium and graphite as the moderator, it is conventional in all respects except that the coolant will be carbon dioxide under high pressure. This plant will go into operation soon. The other experimental plant, in Scotland, will be a fast-neutron breeder, producing electricity and plutonium fuel.

The 12 large new plants will be built on a staggered schedule starting in 1957. They will include gas-cooled and liquid-cooled types, perhaps even a homogeneous reactor. Some of the plants may produce as much as 200,000 kilowatts. The British estimate that the fabricated uranium fuel for a large plant of the Calder Hall type will cost about $14 million and will have to be renewed every three to five years.

France's atomic energy effort, though on a much smaller scale than the British, is being pursued with equal seriousness. Year by year France has to import more coal, and her engineers have investigated all possible power possibilities, even the harnessing of the tides. The French will soon build a 40,000-kilowatt reactor to produce plutonium as capital for fueling breeder reactors. They now have two research reactors of the heavy-water type. One is an extremely good research instrument; its neutron flux is twice as intense as that of the reactor at our Brookhaven National Laboratory.

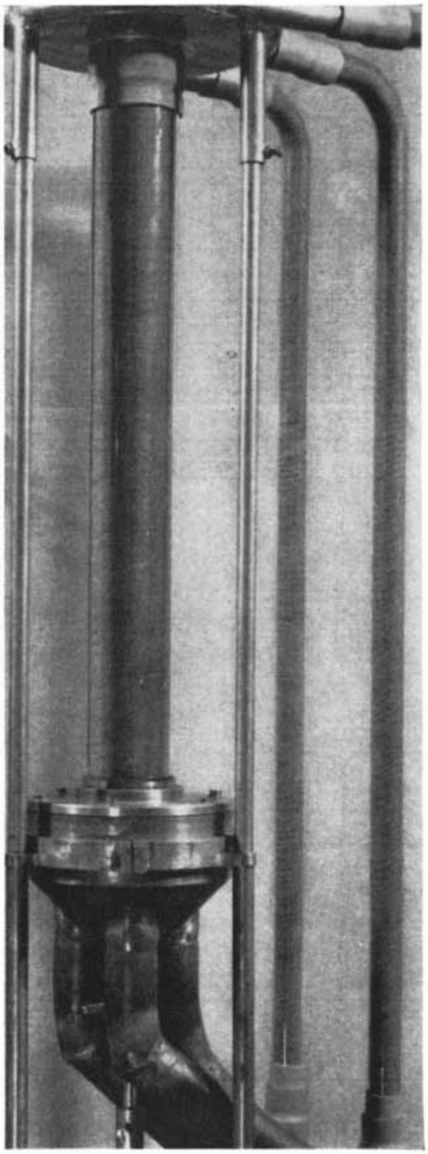
Norway got an early start in the nuclear power field, primarily because she possessed one of the first plants for making heavy water. The Norwegians made a cooperative arrangement with the Dutch to obtain uranium and built a 300-kilowatt research pile in Oslo four years ago. I found an international group working at this pile, including scientists from the Netherlands, France, Yugoslavia and India. Norway is now going ahead with plans for a mobile reactor for ship propulsion.

In Sweden a low-power research reactor went into operation several months ago. It is located in a large room blasted out of rock under a park in Stockholm. This reactor is being used primarily to gain experience in neutron physics. The second Swedish reactor will be a power producer.

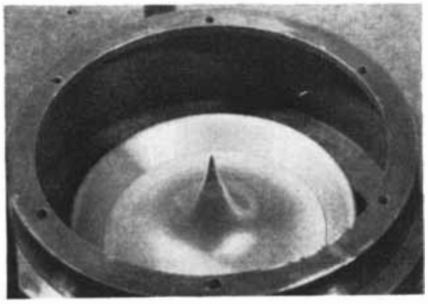
In the Netherlands a group of scientists and engineers, having gained knowledge from the cooperative construction of the Norwegian pile, are pushing ahead on plans for a power-producing reactor. A visit to their research center at Arnhem convinced me that they are considering designs much more advanced than any discussed in the U. S. Drawing on their considerable experience in handling slurries and powders, the Dutch propose to use uranium fuel in the form of fluidized powder. If the idea is successful, they will avoid all the complicated problems of protective coatings and removal of fuel elements that apply to the usual solid-fuel reactors.

In other European countries, reactor projects were not quite so far along. Nevertheless in every country I found groups enthusiastically at work. From each I got a strong feeling that atomic energy is looked on as indispensable to the country's industrial future. The projects are tiny compared to those of the U. S., but because of that very fact the investigators feel freer to try new ideas. For example, a small group working

DUTCH-NORWEGIAN RESEARCH ESTABLISHMENT is located at Kjeller in Norway. The reactor building is off to the left. In the foreground are bicycles used by the staff.



DUTCH APPARATUS for the use of fluidized uranium-oxide powder as a reactor fuel is depicted in these two photographs. The large tube at the left in the photograph above simulates one of 200 that will pass through a heavy-water moderated reactor. The dry uranium-oxide powder flows downward through the tube. Its velocity is adjusted by a vibrating valve shown in the photograph below. The hot uranium-oxide particles will be recycled through a heat exchanger (*smaller tubes at the right above*).



under Werner Heisenberg in Germany is making extraordinarily dense graphite on an experimental scale. The German scientists also feel that they can develop more economical methods for making heavy water; one gets the impression that their chances of success are very good. The Italians and French are working on the same problem.

What I saw in western Europe is but a sample of the world-wide interest and activity in peacetime nuclear power. India, for example, has just arranged to buy 10 tons of heavy water from the U. S. Atomic Energy Commission for a research reactor to be built near Bombay. Australia, New Zealand, the Philippines, Formosa, Pakistan, Iran, Turkey, Greece and Spain are among the other countries starting work in atomic energy.

If Europe's scientists are making such rapid progress, why are they so enthusiastic about the international atomic pool and help from the U. S.? What have we to give them? The answer is: mainly detailed technical knowledge. We have a great wealth of information on reactor building and operation (*e.g.*, the behavior of materials at high temperature and under intense radiation) which can save the other nations years of expensive research and testing. Communication of the results of our research can solve many of their problems with very little effort on our part.

Our atomic energy program has been so vast, and so hedged with secrecy, that the Europeans tend to suppose that we have explored all avenues to nuclear power and that ideas we are not pursuing have been proved unworkable. The truth is that our program, preoccupied with production of fissionables, has necessarily been conservative. We have not investigated all avenues. The Europeans are in an excellent position to try novel approaches which will repay us for the engineering help we give them.

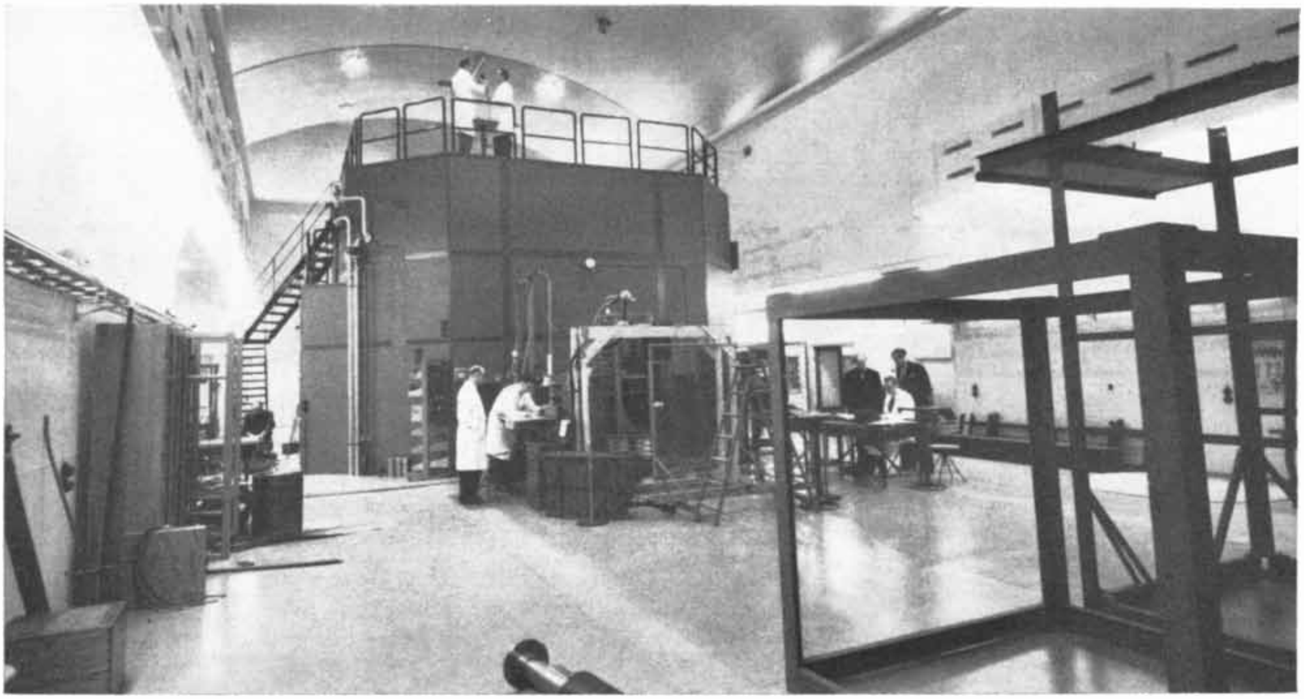
Of course most of these nations also need fissionable material. Nuclear fuel is the capital one must have to start in the atomic energy business. To obtain this capital each nation would have to build, at enormous cost, large plants for separating uranium 235 or making plutonium. But with a gift or loan of fuel from us, other countries could pay back the original outlay of fissionables within a few years.

Coupled with the great enthusiasm for the U. S. pool plan, I found in every country a certain amount of skepticism. In the months following President Eisenhower's proposal, months in which apparently nothing happened, the Europeans came to look upon it as mere propaganda. However, when it became known that private negotiations with the U.S.S.R. had been going on during this period, the European scientists became much more impressed by the serious intent of the U. S. Now that steps toward international cooperation have at last begun, their optimism and spirit have revived.

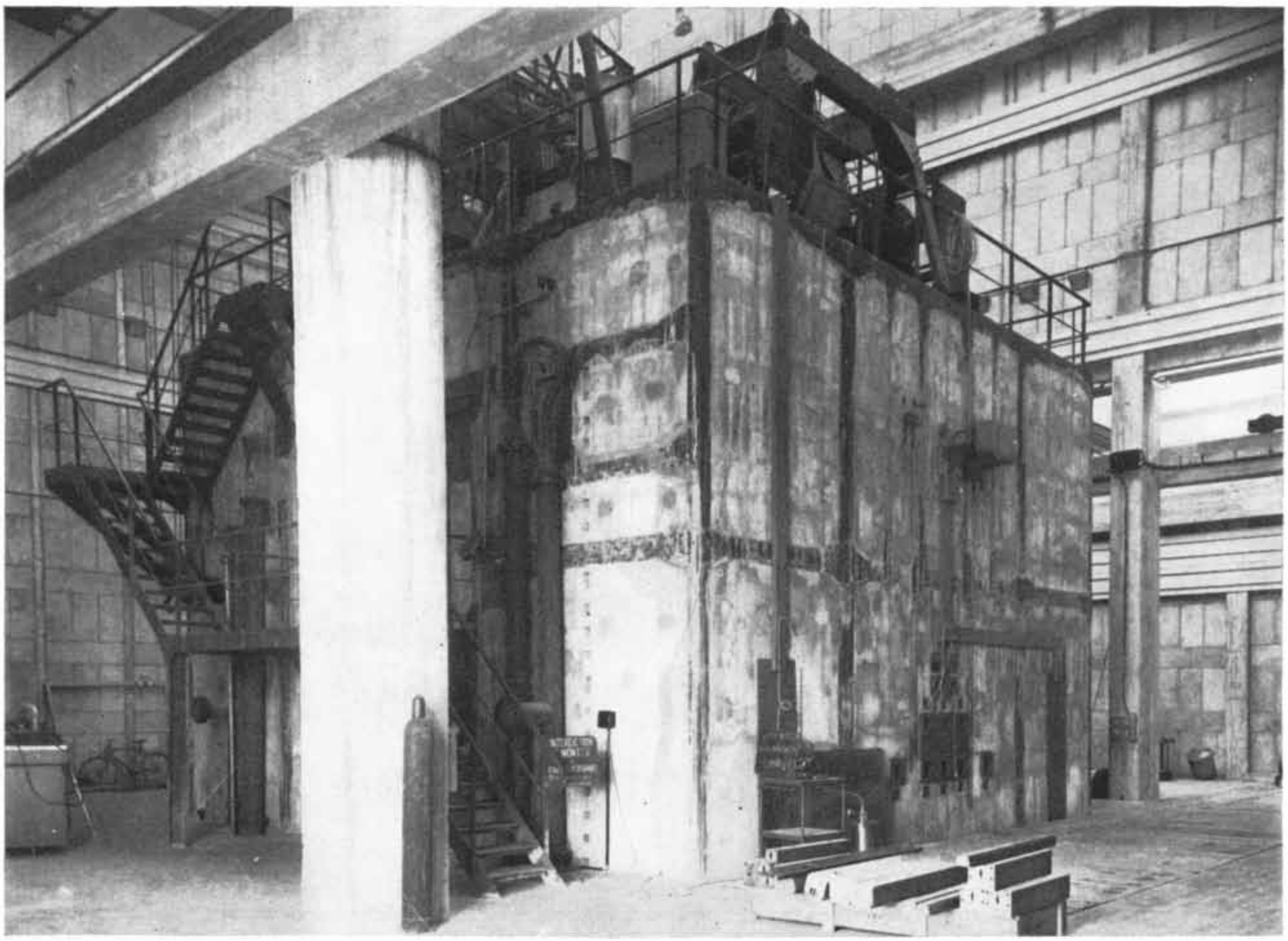
What the U. S. has to gain from the proposed international agency will not be obvious at first but should become more apparent as time goes on. The European scientists are extremely good; they are moving ahead boldly and rapidly in spite of tremendous material handicaps. The rapidity with which they are mastering the atomic energy field and the thoroughgoing nature of their investigations is proof of their ability. In many laboratories I found them investigating fundamentals of neutron physics which we have never had time to study in detail. I became convinced that under the present conditions they will do much more careful work on these fundamentals of reactor physics than we shall do. With our help, in very short order they will be producing results of great value to us—results that will be doubly valuable because they are done with a fresh approach. Already the European work on such things as international neutron-source calibrations and standardizations of certain basic neutron cross sections has helped our own standardization tremendously.

In the nuclear field we shall be engaging in "trade, not aid." The trade will be an exchange of extremely valuable fundamental scientific concepts on which all the economic progress will depend. European scientists will also begin to offer competition with us in atomic energy which will have a salutary effect.

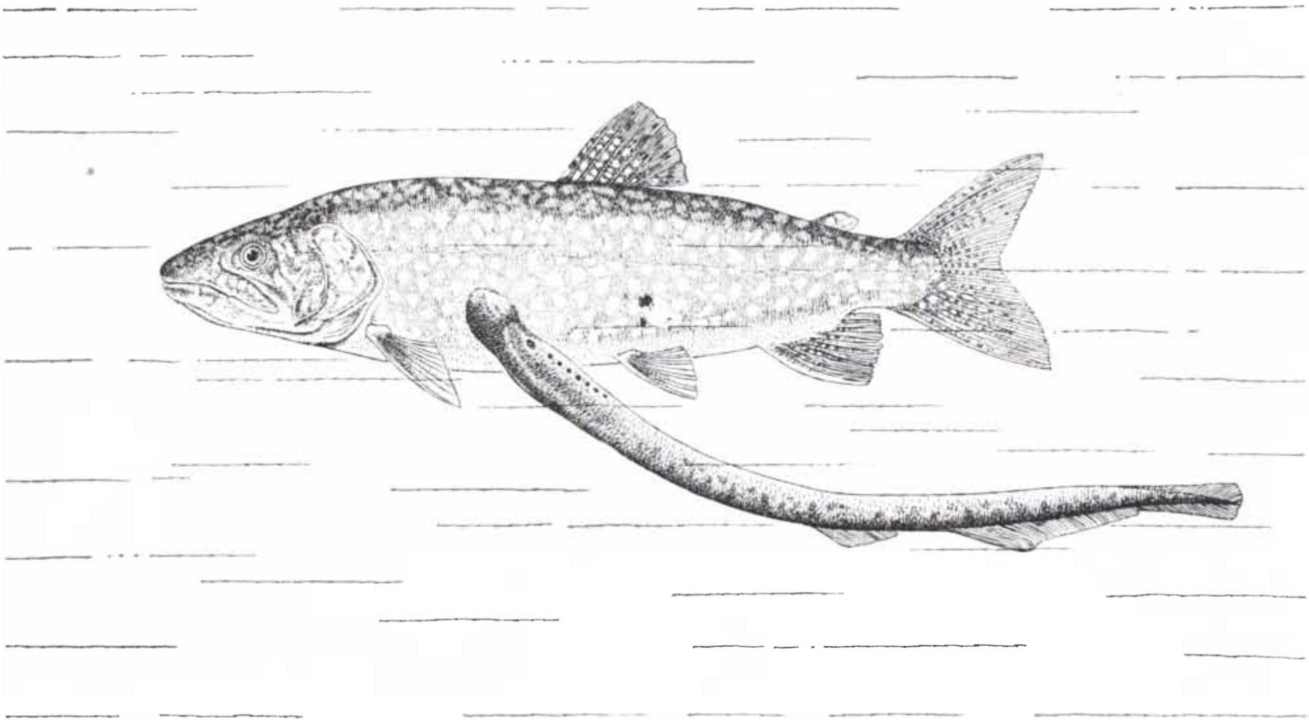
All this is independent of the part to be played by the U.S.S.R. Even if the Russians do not participate in the program, their competition will stimulate the West. If they do come in, something important may happen in international relations. During the years from 1942 to 1945, when only a few men knew of the tremendous new force that had been unleashed from the atom, they often talked of the possibility that it might become a force for peace in the postwar world. Perhaps the atom may still serve as an instrument for demonstrating that international cooperation can work.



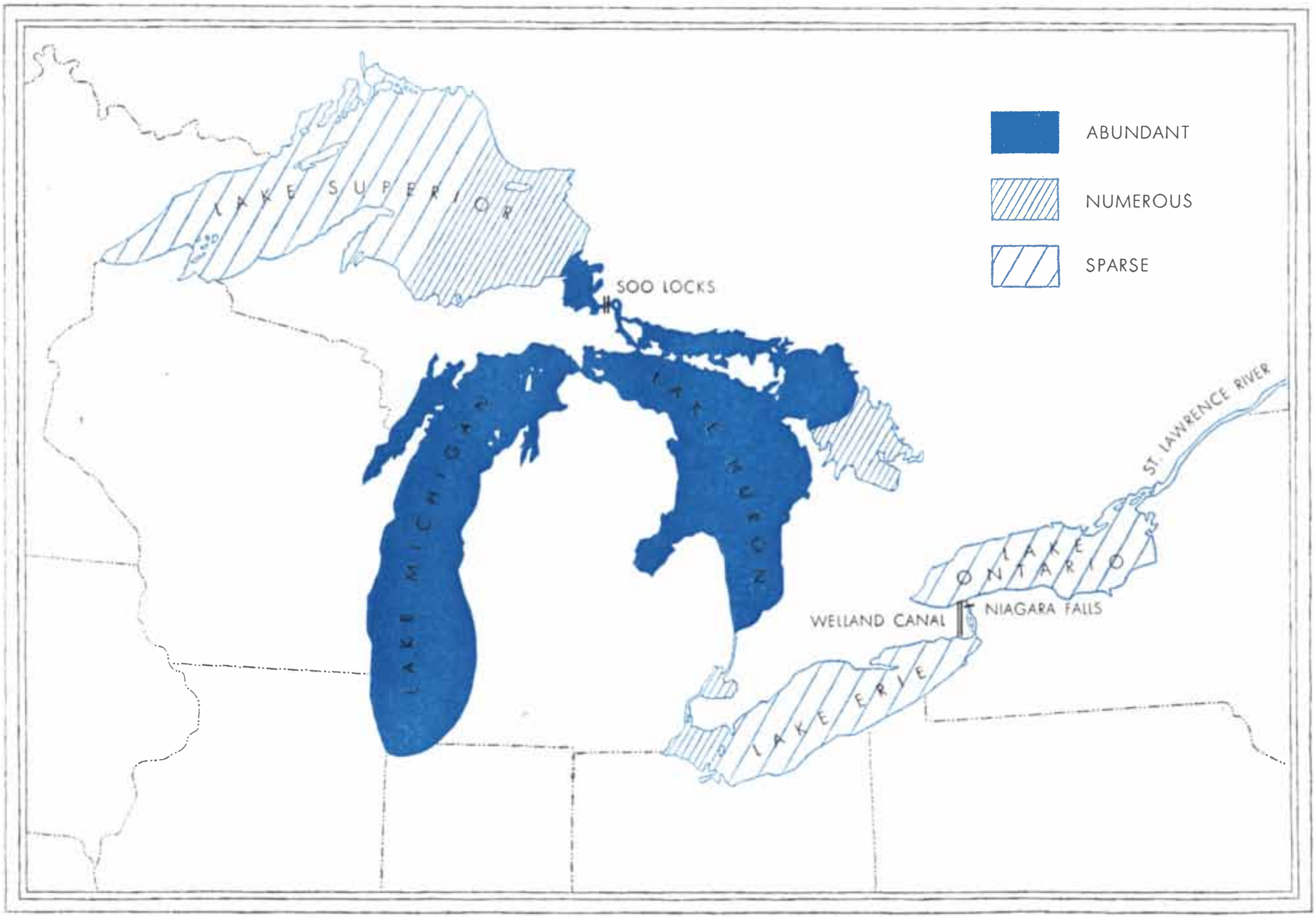
SWEDISH REACTOR, located in a cavern blasted in the rock under a Stockholm park, went into operation a few months ago. Moderated by heavy water, it is used primarily for research in neutron physics. The Swedes are planning to build a power reactor.



FRENCH REACTOR is one of two heavy-water types in that country. This is the larger, called P2. The smaller is called "Zoe." P2, which is used for research purposes, has a neutron intensity twice that of the research reactor at Brookhaven National Laboratory.



SEA LAMPREY FEEDS on a lake trout. The lamprey may remain attached to a fish for weeks. Some fish, however, die in as little as four hours. The adult lamprey ranges from 12 to 24 inches in length. Its back is dark blue and its belly silvery white.



SEA LAMPREY INVADED Lake Erie in the 1920s by way of the Welland Canal. In this lake, however, the lamprey did not flourish. By the 1930s the lamprey had reached Lake Huron and Lake Michigan. It is now becoming established in Lake Superior.

The Sea Lamprey

This eel-like creature fastens itself to fish and sucks their blood. Within the past 25 years it has invaded Lake Huron and Lake Michigan and destroyed their teeming population of trout

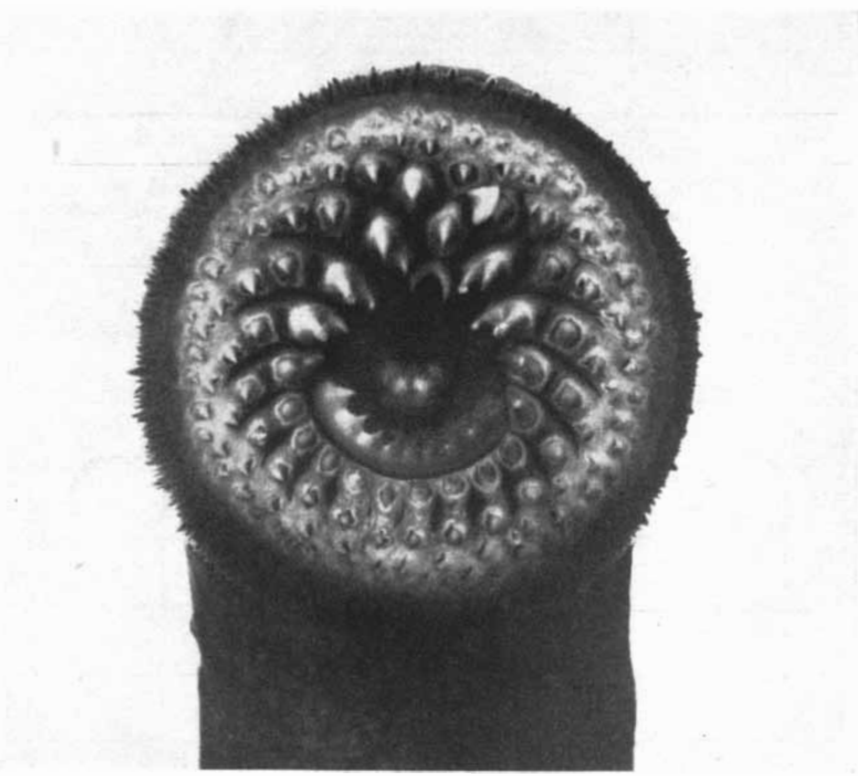
by Vernon C. Applegate and James W. Moffett

For more than 80 years fishing in the Great Lakes has been a sizable industry and a popular recreation for fishermen of the U. S. and Canada. Each year it yields a commercial catch of more than 100 million pounds of choice food, to say nothing of the millions of pounds caught by sportsmen. The most prized fish, and the backbone of the fishing industry, has been the lake trout. In good years the trout catch amounted to more than 15 million pounds, worth nearly $8 million. But in the past 15 years the Great Lakes trout has suffered a disaster. The U. S., preoccupied with more spectacular troubles on a global scale, has not paid a great deal of attention to this calamity in its own backyard, though it threatens to destroy an important industry and relaxation.

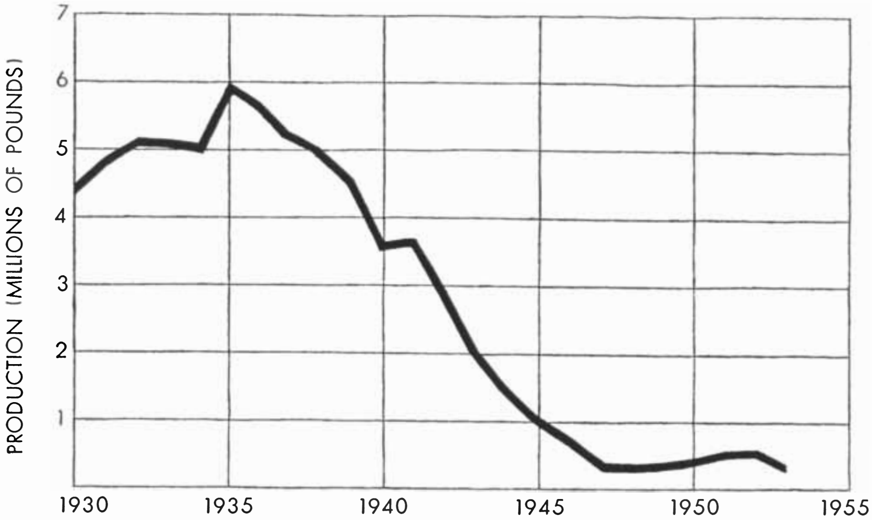
The trout catastrophe began in Lake Huron in 1939. The fish suddenly began to decline in numbers, and within 14 years it had all but disappeared from that lake; the catch dropped from more than five million pounds a year to 344,000 pounds in 1953. The same fate began to overtake Lake Michigan's trout in 1946, and the catch there fell from more than five and a half million pounds to a mere 402 pounds in 1953. Now the slaughter has started in Lake Superior and has begun to cut sharply into its annual trout catch of four and a half million pounds.

Neither overfishing nor weather nor disease is responsible for the annihilation of the trout. The culprit is an eel-like fish known as the sea lamprey. It is a murderous animal efficiently equipped with tools for destroying fish much larger than itself. The lamprey has a sucker-like mouth, sharp teeth and a tongue as rough as a file. Attaching itself to its victim with its mouth, it rasps a hole in the fish's body and sucks the blood and body juices; it is assisted in this by a substance in its saliva, called lamphredin, which prevents coagulation of the blood and dissolves the torn flesh. The victim thrashes about violently but cannot shake off its parasite. The lamprey, a swift swimmer with excellent vision, makes easy prey of fishes, because they are not alarmed by it and tend to ignore it until it strikes. Once it has gained a hold, the lamprey hangs on until it is satiated or the victim dies. A full-grown lamprey may kill a delicate fish such as the trout in as little as four hours. When the victim is more hardy, or the lamprey small, the parasite may cling and feed on the fish for days or even weeks. In the laboratory large lampreys stick to their victims for an average of about 40 hours if the fish survive that long.

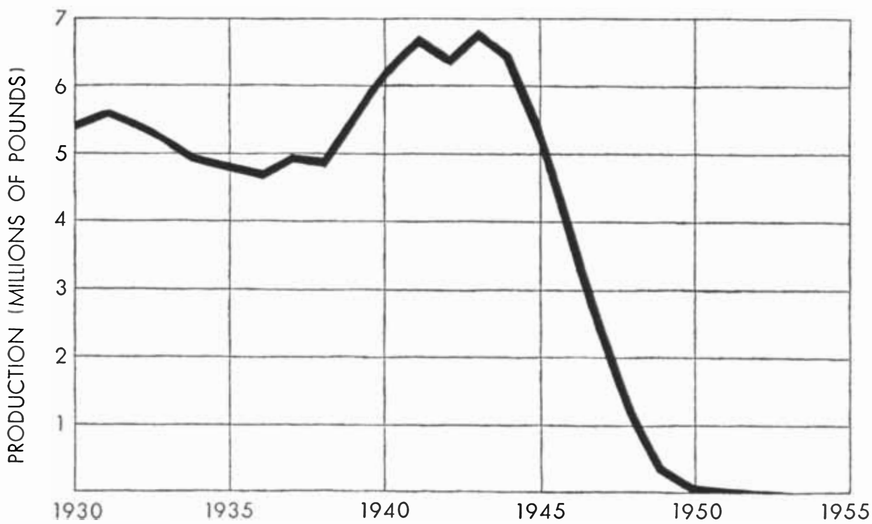
The sea lamprey is a newcomer to the upper Great Lakes. It is a marine species which, like certain salmon, hatches in a fresh-water stream, migrates to the ocean to spend its adult life, and then comes back to fresh water to spawn. In some places it has adjusted



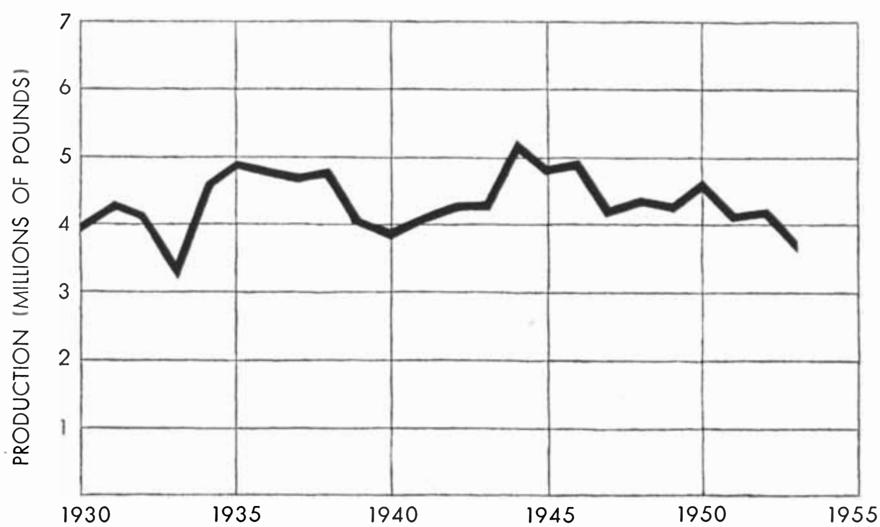
MOUTH of the sea lamprey is photographed through a flat piece of glass to which it is attached. The mouth is lined with horny teeth. In the center of the mouth is the rasped tongue.



LAKE HURON produced 5,998,000 pounds of lake trout in 1935 and 344,000 in 1953. At 1950 dockside prices the 1935 catch was worth $2,999,000; the 1953 catch, $172,000.



LAKE MICHIGAN produced 6,860,000 pounds of lake trout in 1943 and 3,000 pounds in 1952. At 1950 dockside prices the 1943 catch was worth $3,430,000; the 1952 catch, $1,500.



LAKE SUPERIOR does not yet show a catastrophic decline in trout production. However, production fell off from a high of 5,293,000 pounds in 1944 to 3,784,000 pounds in 1953.

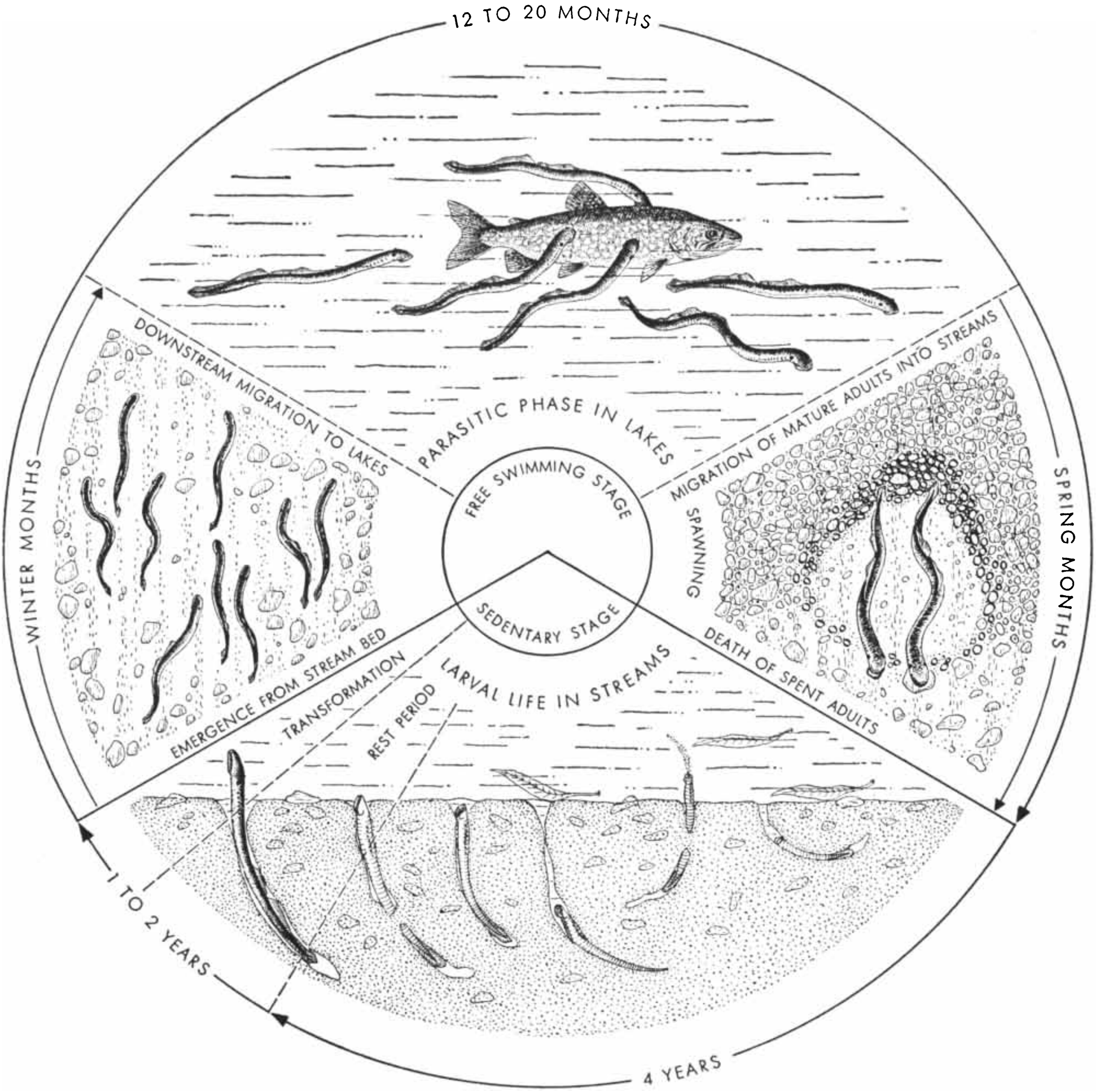
itself to spend its entire life cycle in fresh water, passing its adulthood in lakes instead of in the ocean. It is an old inhabitant, for example, of the St. Lawrence River and Lake Ontario. Until 1829 the Niagara Falls blocked it from migrating into the other Great Lakes. Then the building of the Welland Ship Canal provided a passage around the Falls to Lake Erie, but the lamprey seems to have been slow to take advantage of the route. No lamprey was seen in Lake Erie until 1921.

In Lake Erie the lamprey did not flourish; the waters were too warm and the spawning conditions poor. But by the late 1930s the destroyer had penetrated into the next of the Great Lakes, Lake Huron. Fishermen's nets began to bring up trout and other fish with ugly wounds on their bodies. Sometimes the fish had lampreys still clinging to them. Lake Huron was a particularly favorable environment for the lampreys; they multiplied rapidly and made great inroads into the fish of that lake. Meanwhile they also spread through the Straits of Mackinac into Lake Michigan and increased meteorically there. Apparently further migration into Lake Superior was slowed by the locks and dams at the head of Saint Marys River, but the lampreys finally cleared that hurdle and are now well established in Superior.

The kill of trout by the lampreys was prodigious. Experiments in laboratory aquaria have shown that during its period of active feeding a lamprey kills a minimum of 20 pounds of fish. As many as 25,000 spawning lampreys have been trapped in a single northern Lake Huron stream in a year; simple arithmetic shows that this one group must have destroyed 500,000 pounds of fish.

Commercial fishing for trout in Lakes Huron and Michigan came to an end several years ago. As the trout gave out, the lampreys turned more and more to other fish—whitefish, suckers, walleyes and so forth. Today much of the fishing industry in the Great Lakes is in serious economic difficulty. If the Lake Superior trout go, the industry there probably will collapse. To try to save the trout and other fish, the U. S. Fish and Wildlife Service, the Great Lakes states and Canada have been carrying on research and testing measures against the lampreys. A treaty for joint action by the U. S. and Canada was signed on September 10, 1954, and awaits ratification.

As in any pest-control problem, we must find the vulnerable points in the life cycle of the animal to attack it effectively. The life cycle of the sea lam-



LIFE CYCLE of the lamprey is depicted in this chart. The lamprey lives 6½ to 7½ years. The size of the segments in the chart do not correspond to the length of time the lamprey spends in each stage. The lamprey spends most of its life as a larva.

prey begins in the shallow riffles of a stream. Here it passes the major portion of its life as a blind, harmless larva. Of its approximately seven-year life span, a lamprey spends only the last 18 months in the lakes as a parasite. At the end of that time it goes back to the stream to spawn and die. Let us follow the cycle in some detail from the spawning stage.

The old sea lampreys begin their migration up the tributaries of the Great Lakes to spawn in early spring, the time of migration in each lake depending on the water temperature. They congregate in bays and in the estuaries of rivers during late winter, and when the stream temperature rises above 40 degrees Fahrenheit they start moving upstream. They seek out streams with a gravel or sand bottom and a moderately strong current.

Normally the male starts building the nest; then he is joined by a female who helps in the construction. They clear a small area, picking up stones with their sucker-like mouths and piling them in a crescent-shaped mound on the downstream side of the nest. When the nest is finished and the temperature of the stream is warm enough (over 50 degrees F.), the spawning begins. The female extrudes a small number of eggs; the male at once fertilizes them, and the eggs are carried by the current to the gravel rim of the nest, where they lodge in the spaces among the stones. Then the female lays another batch of eggs and the process is repeated. The eggs accumulating in the nest rim are covered with sand and additional stones. The pair go on producing fertile eggs until they are spent—after anywhere from one to three days. Then both partners die within a matter of hours.

The female has deposited from 24,000

to 107,000 eggs; the average is about 61,500. Fortunately less than 1 per cent of these eggs will hatch out into larvae.

Hatching takes 10 to 12 days. The hatched larvae remain buried in the sand and gravel until about the 20th day. Then the tiny creatures, only about a quarter of an inch long and hardly thicker than a fine needle, emerge from the nest and drift downstream until they reach quiet waters. Here they dive for the bottom and each digs an individual burrow. This will be its home for about five years, unless erosion washes it away. Throughout its larval life the young lamprey is blind and harmless. It sucks food, mainly microscopic organisms, from the water passing the mouth of its burrow. A filtering apparatus in its throat keeps out debris and passes food organisms to its digestive tract.

After four years the larva undergoes a striking metamorphosis. It develops large, prominent eyes, a round mouth lined with horny teeth, a filelike tongue and enlarged fins. Its slim body becomes dark blue above and silvery white beneath. The new young lamprey, some four to seven inches long, may emerge from its mud flat when late fall rains raise the river level, but usually it waits until the spring breakup and flood. It drifts downstream to the big lake and begins its parasitic existence, living on the blood of fish. Feeding upon a succession of hosts, it grows very rapidly, attaining a final length of 12 to 24 inches.

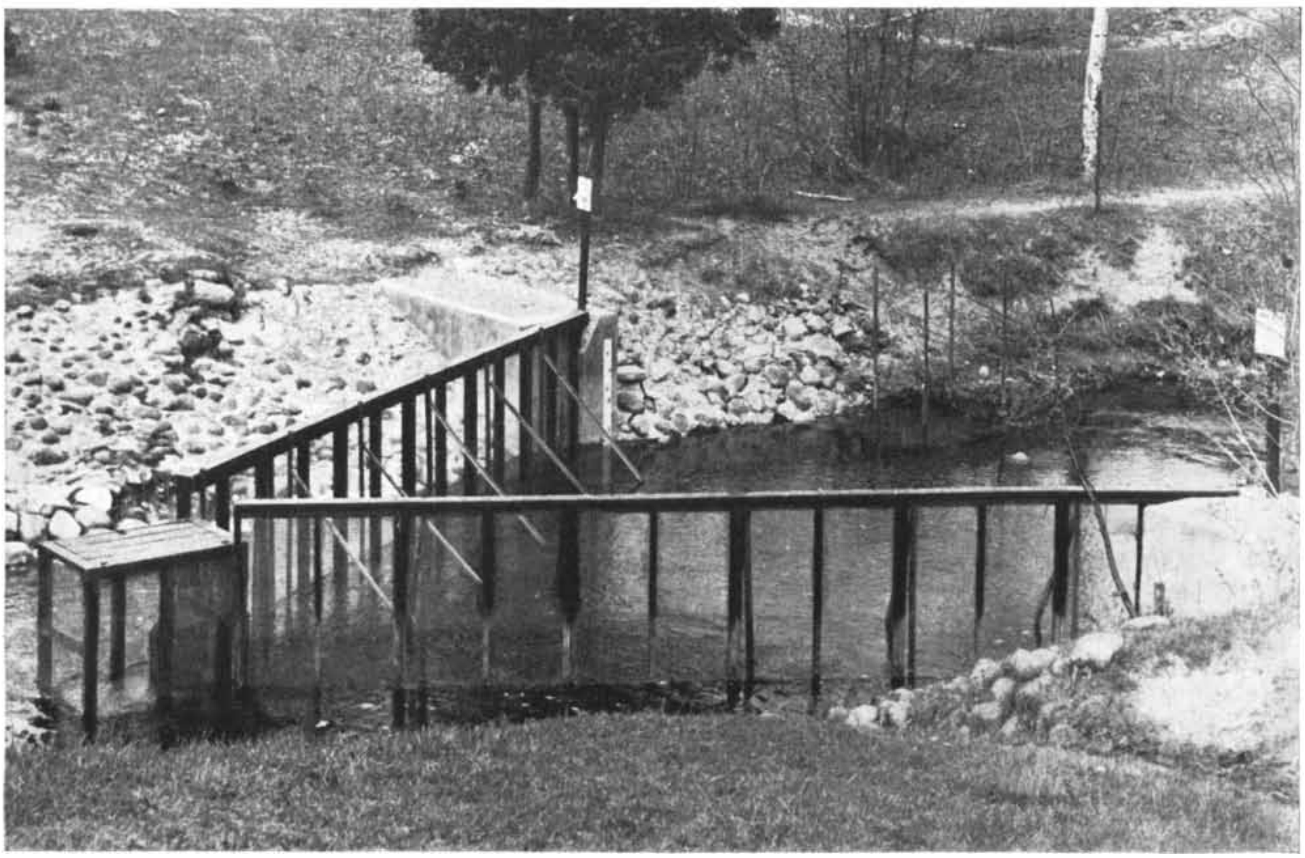
The adult lamprey apparently has a great range of movement. Marked lampreys, released in the autumn at the northern tip of Lake Huron, were recovered throughout the length and breadth of the lake by the following spring. Several individuals had traveled nearly the entire length of the lake, a distance of over 200 miles. But details of the lampreys' movements in the lakes are scanty. There is some evidence that they migrate first to deep water, where they attack lake trout, chubs and other deep-water species. As the lampreys grow larger, they move shoreward and in the fall are found in relatively shallow water. It is at this time that attacks on whitefish, suckers and other shallow-water fish reach their maximum.

Toward the end of winter sexually maturing lampreys begin to assemble off the mouths of streams. During this waiting period tremendous internal changes occur. The sex glands expand enormously, while the digestive tract shrinks and the lamprey becomes incapable of feeding. From now on it will live only on its own tissues. Even its muscles, skin and eyes deteriorate. If the lamprey is delayed in reaching its spawning grounds, death may overtake it before it can spawn.

Plainly the most vulnerable times in the lamprey's life are its periods in the stream—as a larva or young migrant and later when it goes back to spawn. The vulnerability is enhanced by the fact that only about 200 streams tributary to Lakes Huron, Michigan and Superior are suitable for spawning.

One attack on the lampreys has been to build mechanical weirs and traps and barrier dams to block their spawning runs. Although effective, these devices have numerous drawbacks. They are generally expensive to install and maintain; the weirs and traps must be cleared regularly. They may break down under flood conditions. The reproductive potential of the sea lamprey is so great that even a few escaping individuals can "seed" a stream sufficiently to maintain the population.

When the shortcomings of the me-



MECHANICAL WEIR crosses Carp Creek, a Michigan tributary of Lake Huron. It is designed to trap spawning lampreys as they go upstream. This kind of weir has been supplanted by electromechanical weirs such as the one depicted on the opposite page.

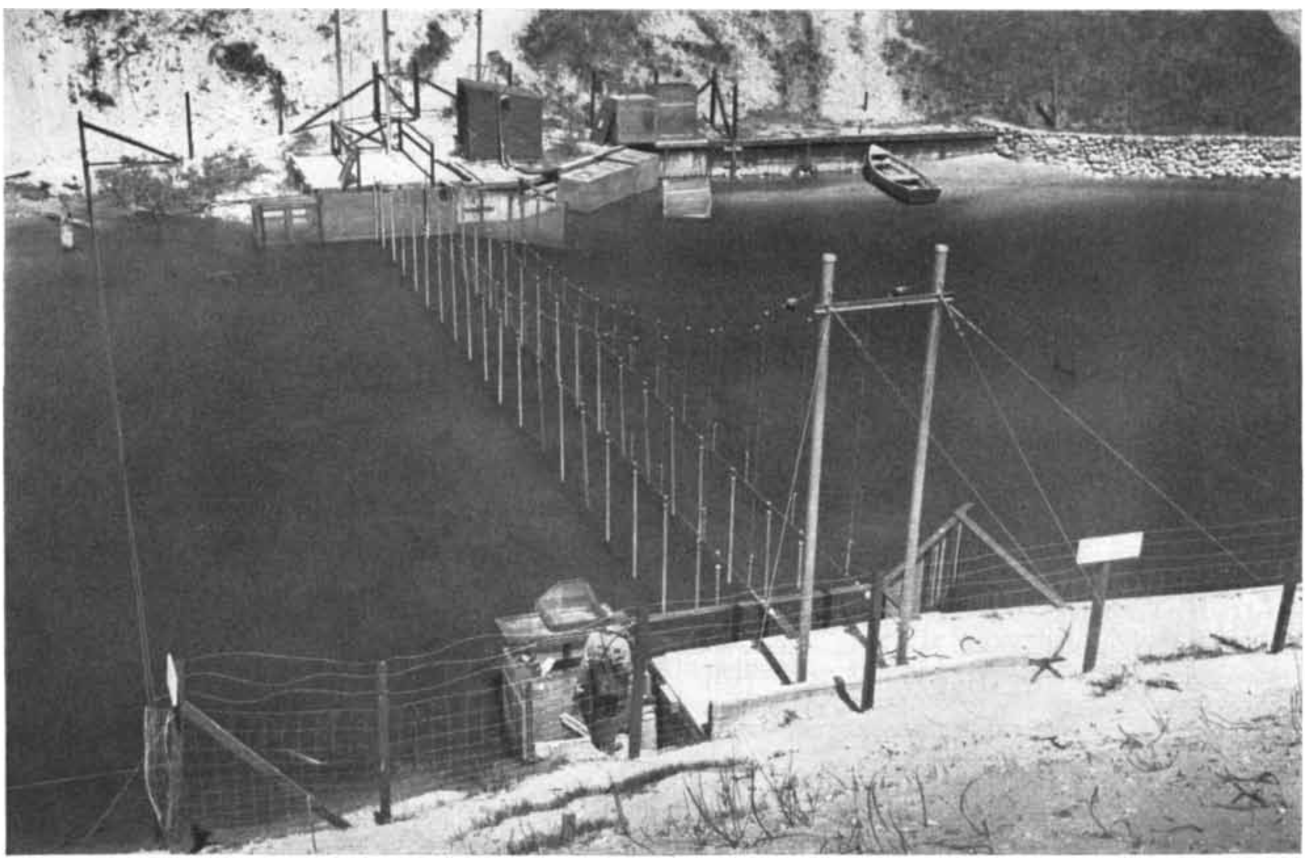
chanical barriers became evident, we turned to electricity. Linear arrays of electrodes were set up in the water to create electrical fields just strong enough to stop the movement of lampreys upstream to their spawning grounds. Using regular 110-volt alternating current, the electrical devices are more economical to construct and operate than purely mechanical structures. Unfortunately, however, the prevention of spawning, even if completely successful, will not show results for at least seven years. It will not kill off the generations of larvae already in the streams.

If we could destroy the larvae or the young downstream migrants, we might reduce the population substantially in less than two years. But so far no practicable means of achieving either objective has been found. Traps for capturing the downstream migrants do not work during the flood stages, when most migration occurs. A dam with an inclined-screen trap is effective, but it is expensive to build and requires continual attention. Furthermore, in many streams the topography precludes the use of this type of structure. Attempts were made to electrocute the young migrants with a simple system of electrodes in the stream, but these experiments were discontinued when it was discovered that young lampreys are extraordinarily resistant to electrical currents and the power required would be prohibitively costly. As for destroying the larvae, the problems become even more difficult. It was found that young American eels, a notably voracious species, would destroy lamprey larvae, but they kill desirable fish as well. So do most poisons. Recent investigations have, however, encouraged the hope that we may find chemicals which are toxic to lampreys and relatively harmless to other fish. Thousands of chemicals are being tested in an effort to discover a specific larvicide.

Notwithstanding the defects of the available control methods, the urgency of the Great Lakes fishing industry's plight has prompted us to apply some of them while better methods are being sought. Electromechanical barriers have been installed in 44 tributaries of Lake Superior on the U. S. side and 24 more are under construction in Canada. Practically all the spawning streams in the U. S. part of the Lake Superior basin have been blocked. In Lakes Michigan and Huron of course it is too late to save the trout. But if the trout can be protected in Lake Superior, they will provide a supply of eggs for restocking Michigan and Huron when the sea lamprey has been brought under control.

Fortunately no other fish has usurped the environmental niche of the trout in the Great Lakes. The small fishes on which trout feed have increased to the point of overcrowding, and there will be an abundance of food for trout when they can return. Another encouraging factor is that lampreys apparently do not single out trout if there are larger fish around. Thus when effective control of lamprey spawning comes into sight, we can begin to plant lake trout with the hope that the lamprey can be exterminated before the young trout grow large enough to be attacked. This may reduce the time required to develop a breeding population of trout from 11 years to seven.

Complete eradication of sea lampreys from the Great Lakes above Niagara Falls is our objective. It may prove to be a long operation, as difficult as the campaign sometimes necessary to stamp out an agricultural or forest pest, but we are confident that we shall ultimately succeed.



ELECTROMECHANICAL WEIR crosses the Ocqueoc River, also a Michigan tributary of Lake Huron. In the spring of 1954 10,183 lampreys on their way upstream to spawn were killed or captured at this site. No lampreys were found on the upstream side.

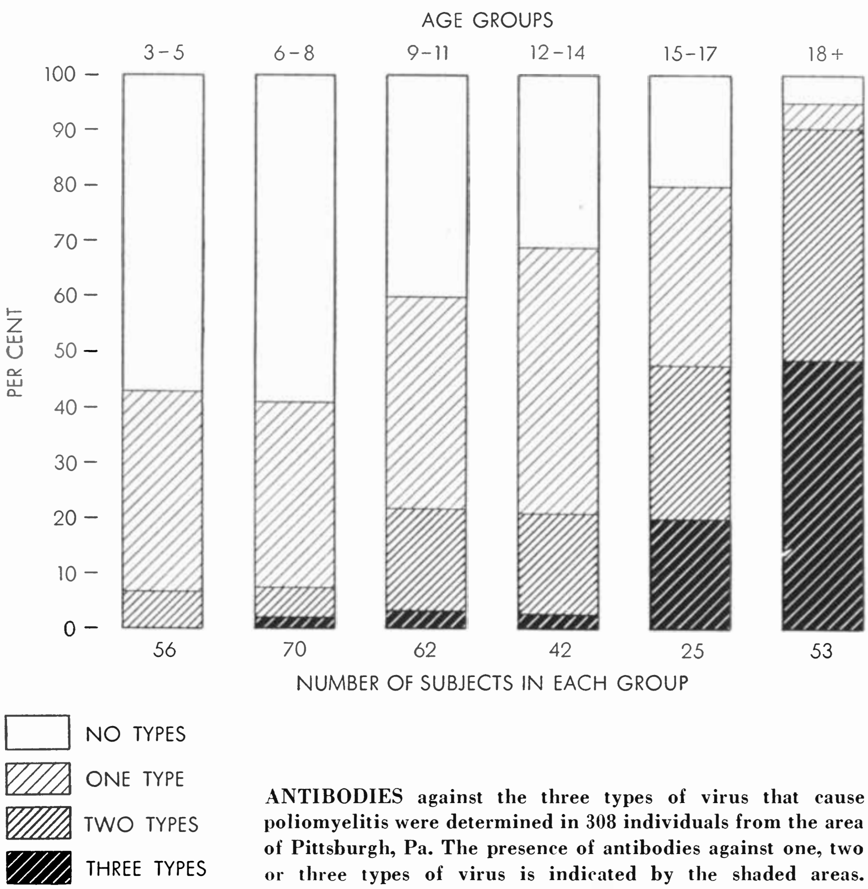
VACCINES FOR POLIOMYELITIS

There has been some discussion as to whether one made of "killed" viruses can be as effective as one made of live viruses. A brief account of the matter by an investigator of killed-virus vaccine

by Jonas E. Salk

We shall soon learn the results of last year's extensive field test of the vaccine against poliomyelitis. Whatever the analysis of that test shows, the type of vaccine that is being tested will continue to be an issue among virologists, because an immunological principle is under test as well as a vaccine. The vaccine in question is made of a "killed" virus, that is, a virus rendered noninfectious by treatment with formaldehyde. Many virologists believe such a vaccine can never be as effective as one containing live virus, and that the best hope of conquering poliomyelitis is to develop a safe live-virus vaccine. The question has been discussed at a number of recent meetings. I share the view that a killed-virus vaccine not only avoids the hazards of live virus but, if properly prepared and used, may be just as effective in producing immunity. This article will present some findings that bear on the questions involved.

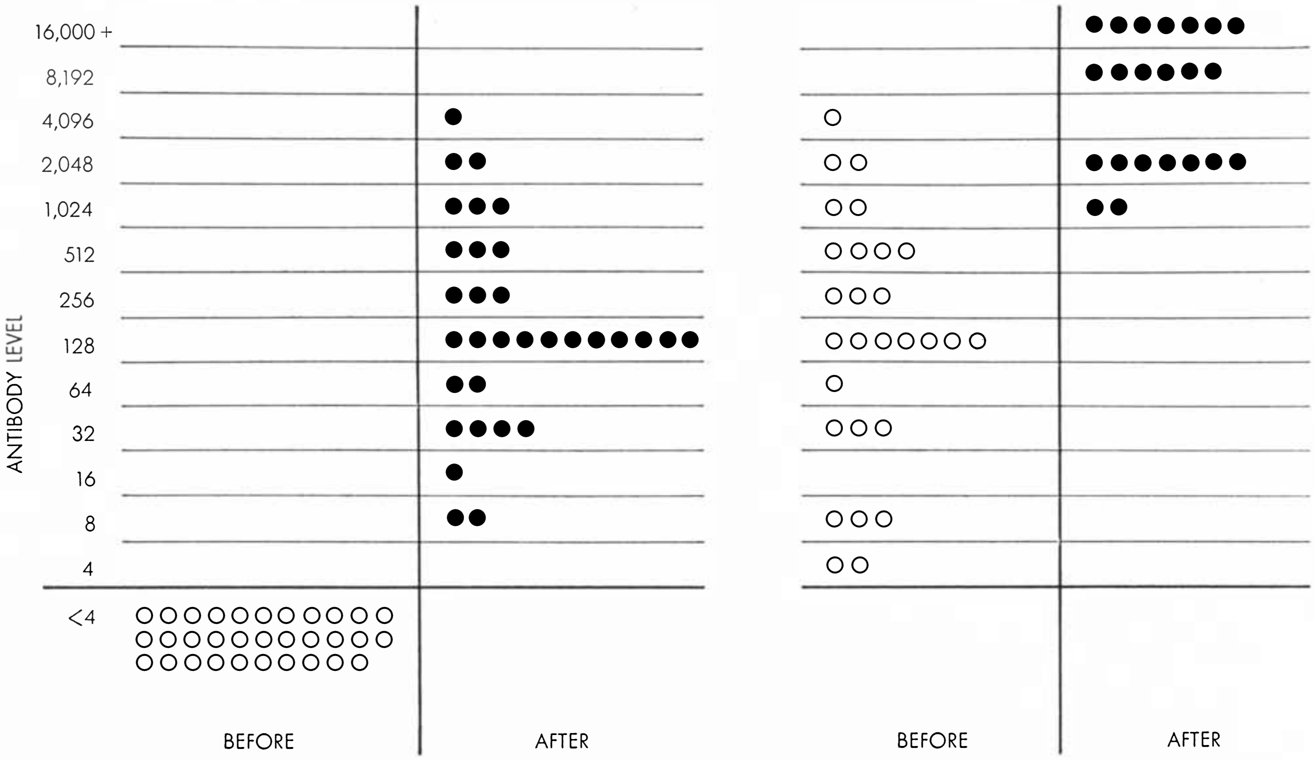
Many authorities have long held the view that "there is no immunity like convalescent immunity," meaning the immunity a person acquires after recovery from infection. Poliomyelitis is considered a particularly good illustration of this principle, because infection with the virus seems to give lifelong immunity to those who recover. Pursuing this reasoning further, proponents of the live-microbe approach point to the success of the live-virus vaccines against smallpox and yellow fever, and observe that no human virus disease has yet been brought under control by a killed-virus vaccine.



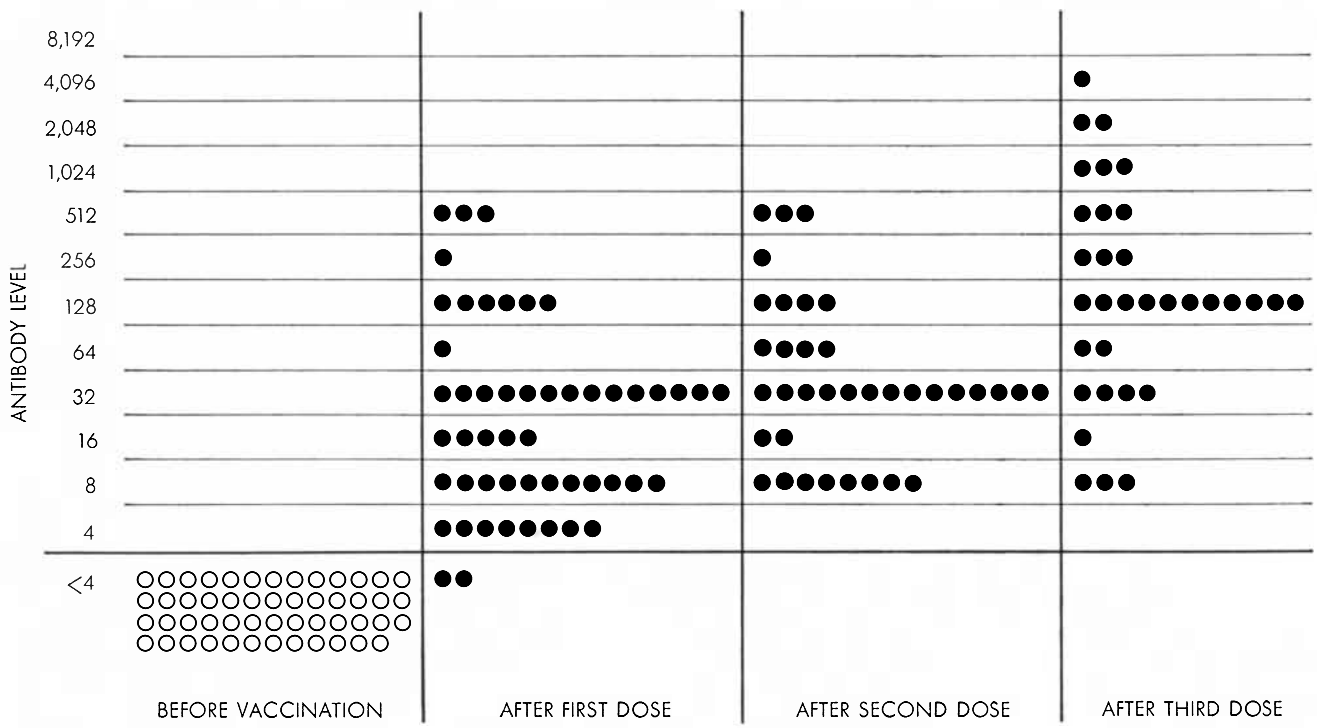
ANTIBODIES against the three types of virus that cause poliomyelitis were determined in 308 individuals from the area of Pittsburgh, Pa. The presence of antibodies against one, two or three types of virus is indicated by the shaded areas.

In reply it is possible to point out that convalescent immunity is not always permanent or absolute. The smallpox vaccine, made of a modified virus, usually does not confer lifelong immunity, one indication of which is that travelers abroad must be revaccinated if they have not been vaccinated within three years. And there is no lasting immunity after infection by a virus of influenza or the common cold. In the case of poliomyelitis we have strong reasons to seek a solution which will avoid the risk of putting the live virus in human beings. On the basis of studies of both poliomyelitis and influenza, there is every reason to believe that a killed-virus vaccine can work, and that the failures of such vaccines hitherto have been due not to inherent limitations but to the way they were prepared or used.

The theory of the killed-virus vaccine rests on the well-established fact that an inactivated virus, though it has lost the power to infect or multiply, may still act as an antigen stimulating the body to produce antibodies against the specific virus. That the present vaccine can evoke these antibodies has been proved abundantly. The chief question



PRIMARY AND BOOSTER EFFECTS of vaccine containing killed poliomyelitis viruses is demonstrated in these two charts. The vaccine contained viruses of all three types. The antibody level is measured in titers. The open circles at the left side of the first chart represent 32 measurements of antibody against any one of the viruses; they indicate that the individuals had less than four units of the antibody measured. The same individuals were then given three doses of the vaccine, the second dose two weeks after the first and the third dose five weeks after the first. Two weeks after the third dose the same antibodies were measured. The primary effect is shown at the right side of the first chart. The open circles at the left side of the second chart represent 28 antibody measurements in another group; they indicate that these individuals had naturally acquired antibodies. The same individuals were then given the same three doses of vaccine. The booster effect is shown at the right side of the second chart.



NO BOOSTER EFFECT was observed when doses of vaccine were given at short intervals to individuals with less than four units of antibody. The open circles represent 51 antibody measurements. Here again the second dose was given two weeks after the first and the third dose five weeks after the first. For the full effect the booster dose should be given about seven months after the first.

is how long immunity will last. The vaccine under test has not been in use long enough to give an answer. But we have some clues.

A monkey that has been vaccinated with the killed-virus vaccine at a certain strength will resist a paralyzing dose of poliomyelitis virus injected into its blood. When the vaccine is diluted to one part in four, it still prevents paralysis in every case. Indeed, six out of 10 monkeys suffer no paralysis, as one experiment showed, even when the vaccine is diluted to one part in 256. A vaccine dilution that produces a barely detectable level of antibody in the bloodstream is sufficient to prevent the virus from invading the central nervous system from the blood. The vaccine will prevent paralysis in monkeys even if the virus is introduced into the nervous system, but in that case a somewhat higher level of antibody is required.

Now let us see what happens to the antibody level in human beings when they are vaccinated. As is now well known, there are three poliomyelitis viruses—three different types with more or less independent powers of infection. In a typical U. S. population a majority of the children are not exposed to the virus during their early years, but as they grow older most of them are attacked by the virus (usually to only a mild, unnoticed degree) and gradually acquire antibodies to one or more of the virus types [*see chart on page 42*]. Suppose we inject the killed-virus vaccine into two groups, one consisting of persons who have no detectable antibody and the other of persons who have some antibody from an infection at some time in the past. The results of such an experiment are shown in the two upper charts on the preceding page. What these charts emphasize is that the vaccination has a strong booster effect in the persons who already have some antibody, increasing the amount of antibody against the three virus types to a high level.

We can get the same booster effect by vaccinating previously uninfected persons two or three times at suitably spaced intervals. How long should these intervals be? As the lower chart on the preceding page shows, doses given two and five weeks after the first dose add comparatively little to the antibody level. For the full booster effect, we deduce from studies still not completed, a secondary dose should be given between four and seven months after the primary set of inoculations.

How long will the immunizing effect last? That depends on the capacity of the antigen (the killed poliomyelitis virus) not only to incite antibody formation but also to leave a lasting impression upon the "conditioned" body cells that form the antibody. Some strains of the virus seem to call forth antibody more easily than others. In fact, this accounts for the potency of very small doses of the vaccine. By experimenting with the various strains we have been able to develop vaccines more potent than those with which we started.

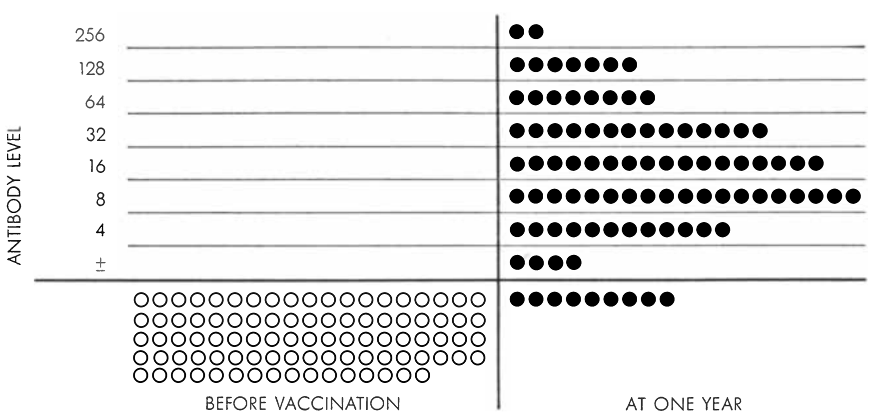
We have learned recently that one virus type may have antigenic components like those in another, so that one may call forth antibodies which are also active against the other. For instance, an infection with the type 2 virus seems to reduce the chances that a later infection by type 1 will produce paralysis. This is highly significant, because the type 1 virus appears to be more dangerous than type 2 or 3: among hundreds of paralyzed poliomyelitis patients examined, infection by type 1 was eight times as frequent as by type 2 or 3.

Now a number of tests show that antibody persists for an appreciable time after vaccination with the killed-virus vaccine. Even after a single dose of the relatively weak preparations used when this vaccine was first made, most of the persons vaccinated had detectable levels of antibody a year after the inoculation [*see chart below*]. But even more interesting is the fact that when an individual is given a booster injection of the killed vaccine some months after the first, the antibody jumps to a high level—often higher than that after natural infection. This jump occurs even when the second injection is given as long as two years after the first.

Evidently the first exposure to the antigen, whether it is the killed virus or live virus in a natural infection, heightens the reactivity of the body to the antigen. In this hyperreactive state the body responds with rapid formation of antibody to a second invasion, either by live or by killed virus. We do not yet know whether immunity depends on this hyperreactivity or on the actual level of antibody present in the blood. Whichever is the case, the killed vaccine seems to meet both requirements: it produces the hyperreactive state and it maintains antibody in the blood, especially when a booster dose is given some months after the initial vaccination.

Our recent studies suggest that hyperreactivity may be sufficient. Apparently infection with the type 2 virus makes some persons hyperreactive to the type 1 virus, and such individuals seem to be able to resist type 1 paralysis even though there is no measurable antibody against that specific virus in their blood at the time of exposure. This must mean that the new exposure to type 1 causes the sensitized individual to produce type 1 antibody rapidly enough to block the invading virus before it can reach the central nervous system, or perhaps even before it gets into the blood.

This concept of the dynamics of the immunizing process suggests a new outlook toward infectious diseases that behave like poliomyelitis. If the concept is correct, we should test immunity by testing for hyperreactivity. Tests for the degree of hyperreactivity, based on the response to a booster injection, are now being devised. The booster injection would thus serve a double function against poliomyelitis—a test for immunity and a stimulus for the production of more protective antibody.



PERSISTENCE OF ANTIBODIES a year after vaccination is illustrated by this chart. The open circles represent 92 measurements of antibody against any one of the viruses. With a stronger vaccine and a booster dose at the proper interval, the level of antibody sustained after vaccination would be higher. Plus and minus signs indicate traces of antibody.

Kodak reports to laboratories on:

reviewing flames, fractures, and explosions . . . making candy dandy longer . . . our rare-element glasses

Slicing time

If you would like to live over and over again a certain ⅜ second sliced into 2,000 1.2-μsec slices, we have just the ticket for you.

The *Kodak High Speed Camera*, we admit with no shame at all, is not highbrow instrumentation.* It is a 16mm movie camera designed for and widely used by practical men with practical manufacturing problems to solve and impatient production chiefs to keep happy. Its controls are relatively few and unimpressive. Aside from a few photoflood lamps and maybe a stand, there is little auxiliary equipment for the assistant photographic engineer to tote.

With such an unsophisticated approach, you get an exposure time for each frame that is always ⅕ the repetition rate. Since the camera speed range is 1000 to 3200 frames per second, this means that the time available for smearing out the image is 63 to 200 μsec. The distance moved by a machine part in this time, divided by the image-to-object size ratio, is rarely large enough for blurring.

Flames, fractures, and explosions are another matter. Here we do use extra equipment to illuminate the subject by repetitive flashes from a discharge lamp with enough output even for schlieren photography with the camera. A reluctance pickup gives a synchronizing pulse at the instant when each frame is in position. And that's how we get 1.2-μsec shavings from big, fat 63 to 200-μsec slices.

The distinguished high speed photographic pioneers, Edgerton, Germeshausen & Grier, Inc., 160 Brookline Avenue, Boston 15, Mass., make this stroboscopic auxiliary equipment for the Kodak High Speed Camera. *It is to them we suggest inquiries on this matter be directed. For a booklet on the camera itself, write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.*

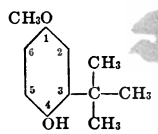
Nuts

Nuts are about 60% oil or fat. Some varieties of pecans run as high as 76% fat.

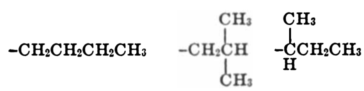
After a while the fat goes bad, as oxygen from the air attacks some of the fatty acid chains that contain double bonds. Wiser heads than ours continue to debate the details of this phenomenon, that one might suppose to be well understood by now. We, rather, regard ourselves as experts on what to do about it and maintain the only laboratory we know of devoted wholly to food antioxidants.

These antioxidants act by breaking a vicious circle. Atmospheric oxygen, according to the most widely held view, attaches itself at or near a double bond and in so doing becomes more active than free O_2. First chance it gets, it takes off to attack another double-bonded molecule, leaving the preceding one to fall apart in foul-tasting ruins. As long, however, as there is antioxidant left on the scene to absorb the brunt of the activated oxygen onslaught, exponential build-up of deterioration is stayed.

Right now we are wooing the nut business (direct and in candy) with talk of wrapping materials, roasting oils, and treated salt all containing small quantities of antioxidants of the form



This is butylated hydroxyanisole. That position 3 for the butyl group is more active than position 2. The three alternative arrangements of the butyl group



are much less effective than the tertiary arrangement. But if one replaces the CH_3O with a CH_3 and puts a second tertiary butyl group at the adjacent position on the ring on the other side of the hydroxyl, one has butylated hydroxytoluene, another excellent food antioxidant. In some cases a combination of both BHA and BHT provides the greatest protection against rancidity. The reasons behind these observations might make challenging exercises in several disciplines.

"Nuts," say the nut men and the candy men (who care little about steric hindrance), "that can keep that crunchy, fresh-from-the-roaster goodness in chocolate bars after 120 days in the warehouse, the trucks, and the coin machines are a better proposition than nuts that go bad in 45 days."

So they write to Eastman Chemical Products, Inc., Kingsport, Tenn., and ask for a list of packaging and food fat houses that supply Tenox-*treated goods. Or, if they want to get into it a little deeper, they ask which* Tenox *antioxidant best fits their cooking temperatures, ingredients, storage, etc.* "Tenox"—*that's our trade-mark for various formulations of BHA, BHT, the synergistic antioxidant propyl gallate, and cation-sequestering citric acid—wholesome substances all.*

Our glass is different

We make some freak glasses. We use boron in the role that glassmakers have assigned to silicon through all of recorded history; fluorine in place of oxygen; lanthanum, tantalum, thorium, and tungsten in place of calcium, lead, and barium. These substitutions in various combinations and proportions result in strange indices of refraction and relationships between index and wavelength.

Our own lens designers, naturally, tramped first over these untrodden parameters and brought in trophies, usually inscribed with the words "Kodak Ektar." So patents issue, professors lecture and write, and soon in the conversation of optical men sitting up late in hotel rooms, the freakish becomes classical. At this point, the only thing to do is to publish a glass catalog like the others.

Ours is a modest three-page typewritten affair. It gives all the standard index and dispersion values and a little more about those Kodak rare-element glasses on which our production is high enough to be worth mentioning outside the walls.

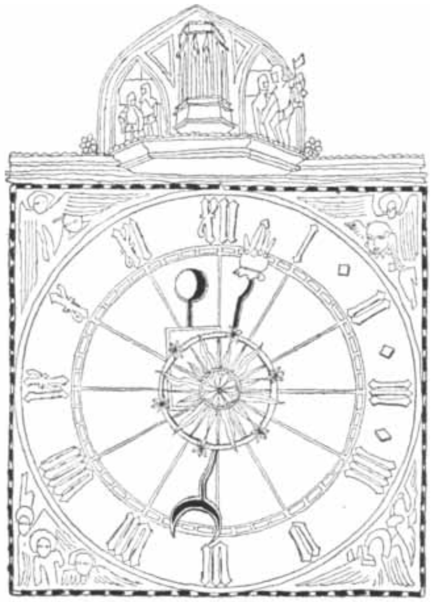
We post one warning: the data are of no earthly use to anyone who has not devoted a few years of his life to the theory and practice of optical design. With this in mind, you may write to Eastman Kodak Company, Special Products Sales Division, Rochester 4, N. Y.

*Nevertheless, we venerate highbrows, particularly for what they do with our film.

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



Fall-Out

The only "defense" against the hydrogen bomb, authorities agree, is not to be where it explodes. Last month the Atomic Energy Commission finally released information showing how difficult it will be to run far enough away. Radioactive fall-out from the March 1, 1954, test in the Pacific contaminated an area 220 miles downwind from the explosion and 40 miles wide. Within the first 120 miles, all persons who failed to take shelter would probably have been killed. The report said: "About 7,000 square miles of territory downwind from the point of burst was so contaminated that survival might have depended upon prompt evacuation of the area or upon taking shelter and other protective measures."

Partial shelter would be afforded by any building far enough away from the blast to remain standing. The radiation level on the first floor of an ordinary frame house would be about half that outdoors, the Commission said. In the basement the level would be cut to a tenth, and in an "old-fashioned cyclone cellar with a covering of earth about three feet thick" it would be reduced to one 5,000th. "Designs of shelters of simple yet effective construction have been prepared by the Civil Defense Administration and are available to the public," the Commission declared.

Regarding the possibility that test explosions threaten the genetic heritage of all the earth's peoples, the report admitted that no conclusive data were available. However, the average dose of radiation received by U. S. residents from all nuclear weapons tests to date was said to be no more than that received in one chest X-ray. The Commission reiterated its belief that controlled tests give no "basis for serious concern." A similar opinion had been expressed a few weeks earlier by the University of California geneticist Curt Stern.

The AEC disclosures on fall-out were accurately anticipated by Ralph Lapp in an article in the *Bulletin of the Atomic Scientists*. The author said that persons caught in a fall-out area would have to spend two or three days underground, in cellars or even foxholes. Then they might venture out and begin to decontaminate their homes, for example by washing down the roof and plowing under the lawn. Lapp recommended that the Government undertake a $2 billion program for building a ring of concrete shelters around the outskirts of all large cities.

Last month Great Britain became the third nation to announce that it knew how to make hydrogen bombs. It is proceeding with "development and production." Not all Englishmen found much cheer in the news. C. F. Powell, a Nobel prize winner in physics, pointed out that 10 or 20 hydrogen bombs dropped on Great Britain would make "ordinary organized life impossible. . . . It would be a poor consolation to the pathetic remnant of our country that we had been able to reduce other lands to a similar condition of ruin." Powell estimated that the U. S. has 4,000 fission bombs and the U.S.S.R. 1,000. Each is a potential H-bomb.

Private Atomic Power

The first wholly private plan to make and sell nuclear energy on a commercial scale was announced last month by the Consolidated Edison Company of New York. The company told the Joint Congressional Committee on Atomic Energy that it intends to buy, with its own funds, a reactor producing between 100,000 and 200,000 kilowatts of electricity. The plant is expected to cost $30 to $40 million.

Consolidated Edison believes the nuclear plant will be "reasonably competitive" with conventional plants in the New York area, where coal costs are relatively high. Construction is expected to start in about a year and to require at least three years. The utility will order the reactor "as a finished product from one of our usual suppliers, if possible at a fixed price." The plant is to be located on the Hudson River five miles south of Peekskill.

Polio Vaccine

The Salk vaccine for poliomyelitis (*see page 42*) will be available to some 18 million U. S. children this spring. The National Foundation for Infantile Paralysis has bought enough to vaccinate nine million children. It will offer immunization free of charge to pupils in the first and second grades of elementary school and to all children who participated as controls in last year's tests and did not receive the vaccine. Doses for another nine million are expected to be available to physicians.

A report on the effectiveness of the vaccine is expected during the first two weeks in April from the Poliomyelitis Vaccine Evaluation Center at the University of Michigan.

Synthetic Diamonds

Nature's hardest material can now be duplicated in the laboratory. The General Electric Company announced last month that a group of its scientists have synthesized diamonds up to 1/16 of an inch long. The artificial stones have the unmistakable X-ray pattern of diamonds and are so hard that they scratch even natural diamonds. The company believes it may soon produce small stones for industrial use economically, but it does not expect to make gems.

The diamonds were synthesized by subjecting a "carbonaceous compound" (still a trade secret) to a pressure of 800,000 pounds per square inch and a temperature of 5,000 degrees Fahrenheit. The 1,000-ton press in which this is done is the first such device to combine high temperature with high pressure. It can exert a pressure of more than 1.5 million pounds per square inch.

Working on the development were Francis P. Bundy, H. Tracy Hall, Herbert M. Strong and Robert Wentorf.

Pipeline for Words

A pipe that may revolutionize long-distance telephone, radio and television transmission has been developed by Bell Telephone Laboratories. It is a new type of wave guide, the first to conduct electromagnetic energy around corners without substantial losses. A single tube about two inches in diameter will be able to carry tens of thousands of telephone conversations and hundreds of television programs at the same time. A coaxial cable can handle only 600 phone calls and two TV shows.

The wave guide, an efficient carrier at high frequencies (where more bands can be accommodated at once), has not been used for long-distance transmission hitherto because waves are absorbed at bends in the pipe. The Bell Laboratories overcame the difficulty by inventing a helical wire wave guide to replace the solid pipe. The wire is insulated, and the tightly wound helix is held in a flexible outer wrapping. The electrical characteristics of a helix enable electromagnetic waves to negotiate curves without appreciable energy loss.

Bell engineers expect the new equipment to operate in the range from 35,000 to 75,000 megacycles, *i.e.*, at wavelengths from one centimeter to four millimeters. This would give the enormous band width of 40 billion cycles.

Help for Science Teaching

The American Association for the Advancement of Science has begun to put into effect a four-part program for alleviating the shortage of high-school science teachers. It is working with state and local school authorities to uncover additional teachers in each community (the best source appears to be married former teachers). It is asking universities to relax their prerequisites for graduate study in science. It plans to offer a number of annual cash awards for outstanding teachers in science. And it is arranging with a few school systems to try using expert teachers as roving consultants. It believes that a single experienced and talented teacher might be more widely effective as a "circuit rider," advising younger colleagues, than by staying in one classroom.

The plan was developed by a standing AAAS committee on mathematics and science teaching, whose members come from a large number of professional and educational organizations.

Mistakes in the Air

Almost half of all airline accidents, and more than half of the fatalities, are attributable to pilot error, according to an analysis by C. R. Spealman of the Civil Aeronautics Administration pub-

Overall view of Stokes continuous vacuum metallizing dolly system for aluminizing TV tubes at RCA's Marion, Indiana, plant. Operator is required only to load and unload tubes from the carts.

lished recently in *The Journal of Aviation Medicine.*

In a sample of 109 pilot errors occurring in the past few years, 62 were committed under routine flying conditions, and 39 of them were deliberate violations of regulations or departures from established safe practices.

Spealman found that most of the engine and equipment failures, and accidents due to pilots' mistakes in handling controls, could be blamed on poor engineering design.

Unhappy Technologists

Engineers and physical scientists employed in industry are near the bottom of the happiness scale, two University of Chicago sociologists have found. They are only a little happier in their jobs than factory laborers and are much less contented than skilled workers, foremen, salesmen or management, say David G. Moore and Richard Renck of the University's Industrial Relations Center. Moore and Renck recently surveyed 587 engineers, physicists and chemists in a number of companies. The results of the study were summarized in *The Journal of Business*, published by the School of Business of the University of Chicago.

The employees' attitudes were tested by their agreement or disagreement with a list of 78 statements covering most aspects of work. The engineers and the scientists differed in their feelings about individual aspects of their jobs. The scientists were reasonably enthusiastic about the demands of their work and their working conditions; the engineers, less so. The latter, on the other hand, were much more comfortable with their fellow employees and felt more secure in their jobs. Both groups had little confidence in management, in the technical competence of their supervisors or in the effectiveness of the administration. The engineers felt a stronger identification with their companies than did scientists, but both were below average.

Management on its side, the sociologists found, tends to regard professional employees as a "sour" bunch, always complaining, dragging their feet, difficult to motivate. The two groups have little sympathy with each other's point of view. To management, who must cut through details in reaching its decisions, the professionals seem unnecessarily bent on complicating things: "You ask them a simple question and you get back a 40-page tome." The scientists and engineers feel their opinions and advice are disregarded and that businessmen

IBM news FOR ENGINEERS

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APRIL'S BIG CAREER OPPORTUNITIES

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Digital computer component development—design of components and functional units of accounting and data processing machines—transistors and transistorized units—special electron tubes—counters—magnetic core, drum, tape, and ferro-electric storage devices. ALSO fine openings in digital computer circuit design, electro-mechanical development and systems planning and analysis.

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says Wallace D. Bolton, Development Engineer at the Endicott Laboratories

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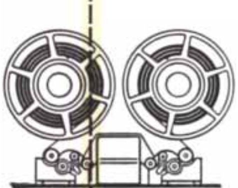
IBM MAGNETIC TAPE DEVELOPED BY ADVANCED ENGINEERING



The great data processing machines produced by IBM employ the latest advances in processing and data storage. Among these is oxide-coated acetate tape used to record information in the form of magnetized spots. Tape units for either reading or writing operate at a rate of 15,000 characters per second.

The density of recording is 200 characters per inch, permitting permanent files of data to be compressed onto a 10½-inch diameter reel holding 2,400 feet of tape. A single reel can contain over 50,000 grouped records of 100 characters each.

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****Required**: major or graduate degree in Mathematics, Physics, or Engineering with Applied Mathematics equivalent. Desirable, but not required, experience in teaching Applied Mathematics and use of automatic computing equipment.

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have a habit of making decisions on the basis of flimsy evidence which "borders on charlatanism."

How Many Chinese?

Following the first complete census ever to be taken in China, the People's Republic of China has announced the mainland population totals 582,603,417. It said there are 7,592,298 more Chinese on Formosa and 11,743,320 in other countries.

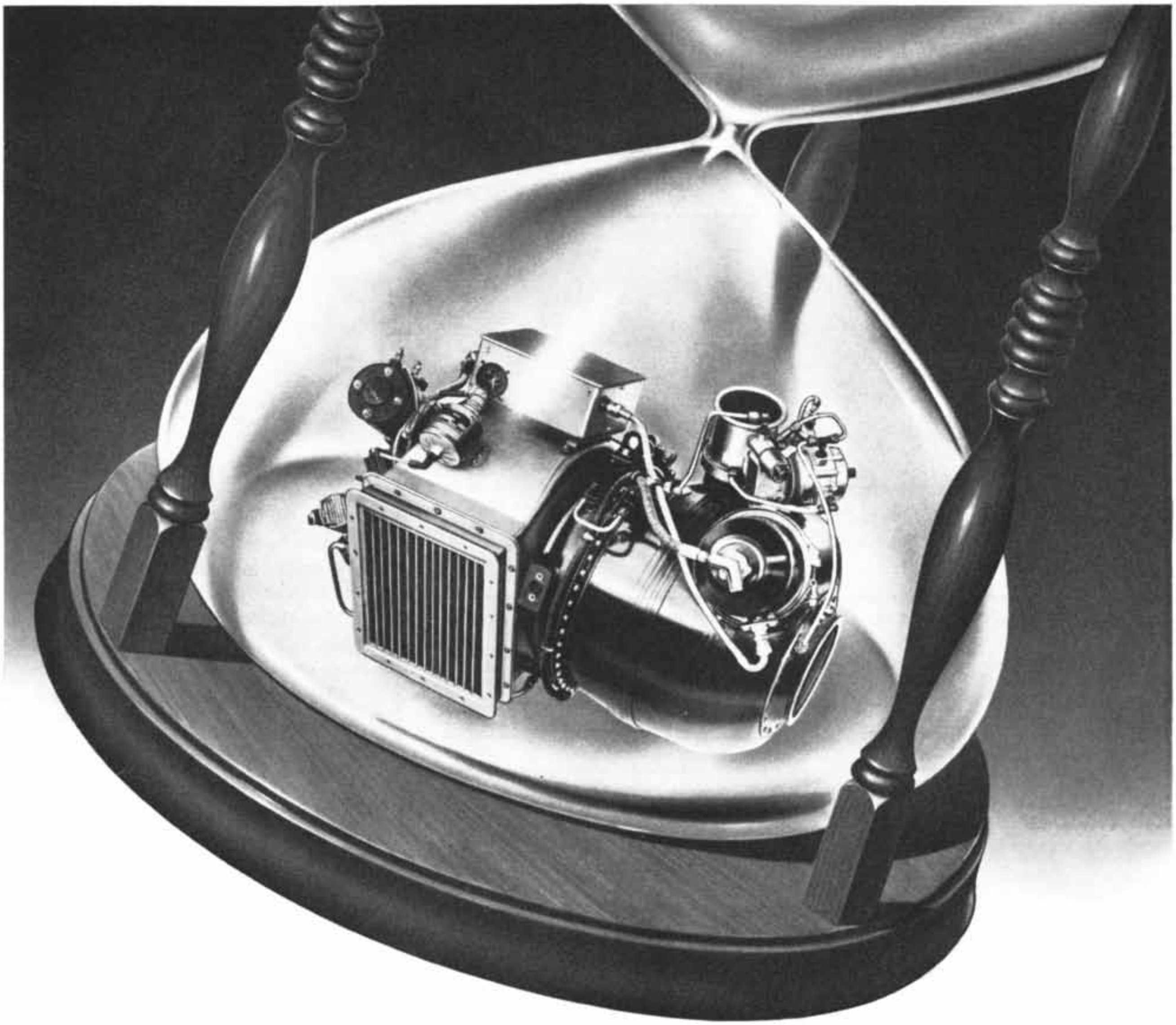
Chinese Communist officials recently indicated that the Government thinks the population may be high enough. The New York *Times* reported that Shao Li-tze, a deputy of the National People's Congress, told a meeting of the Congress last fall: "It's a good thing to have a large population, but in an environment beset with difficulties it appears that there should be a limit set."

Research on Ice

The scientists who were with the U.S.S. *Atka* on her recent voyage to the Antarctic got a frigid foretaste of what they will be up against two years hence during the International Geophysical Year. The naval icebreaker was sent to probe the inhospitable coastline of the Antarctic continent in search of locations where bases can be established for the big research project. A vivid account of the expedition by Walter Sullivan, the only correspondent with the ship, appeared in the New York *Times.*

On the way to Little America, its first Antarctic port of call, the *Atka* saw very little of the drifting ice pack that surrounds the continent. It passed through a few "bergy bits" and pieces of "slob ice"—melting remnants of the pack. The ship made its call but Little America was gone. Much of it had broken off and drifted away. This region of the coast is a floating extension of the polar icecap known as the Ross Shelf Ice. Every now and again the shelf "calves." One such break carried away the harbor of Little America, the Bay of Whales, and all of the camp left by the last U. S. Antarctic expedition, led by Admiral Byrd in 1947. Now the coastline is a sheer, 100-foot cliff of ice.

To the east of Little America the *Atka* explored a small indentation known as Kainan Bay, and found it a possible, though not ideal, site for a base. Kainan Bay may have to do, however, because after leaving it the *Atka* was never again able to reach the Antarctica coast on the Pacific side. The ship battered futilely at enormous fields of drift ice for the



next two weeks, then gave up and sailed under Cape Horn to the Atlantic side of the continent. Here it discovered a promising base site in a harbor named Admiral Byrd Bay.

The expedition was marred by one casualty. Lieutenant John P. Moore, a Navy pilot, was killed when his helicopter crashed during a "white-out." This condition, one of the chief hazards of Antarctic travel, occurs when sunlight diffuses through a solid overcast. The effect is that of being in a cloud. No boundaries can be seen. Men on the ground may walk into crevasses and airplane pilots may crash because they cannot tell where the surface is.

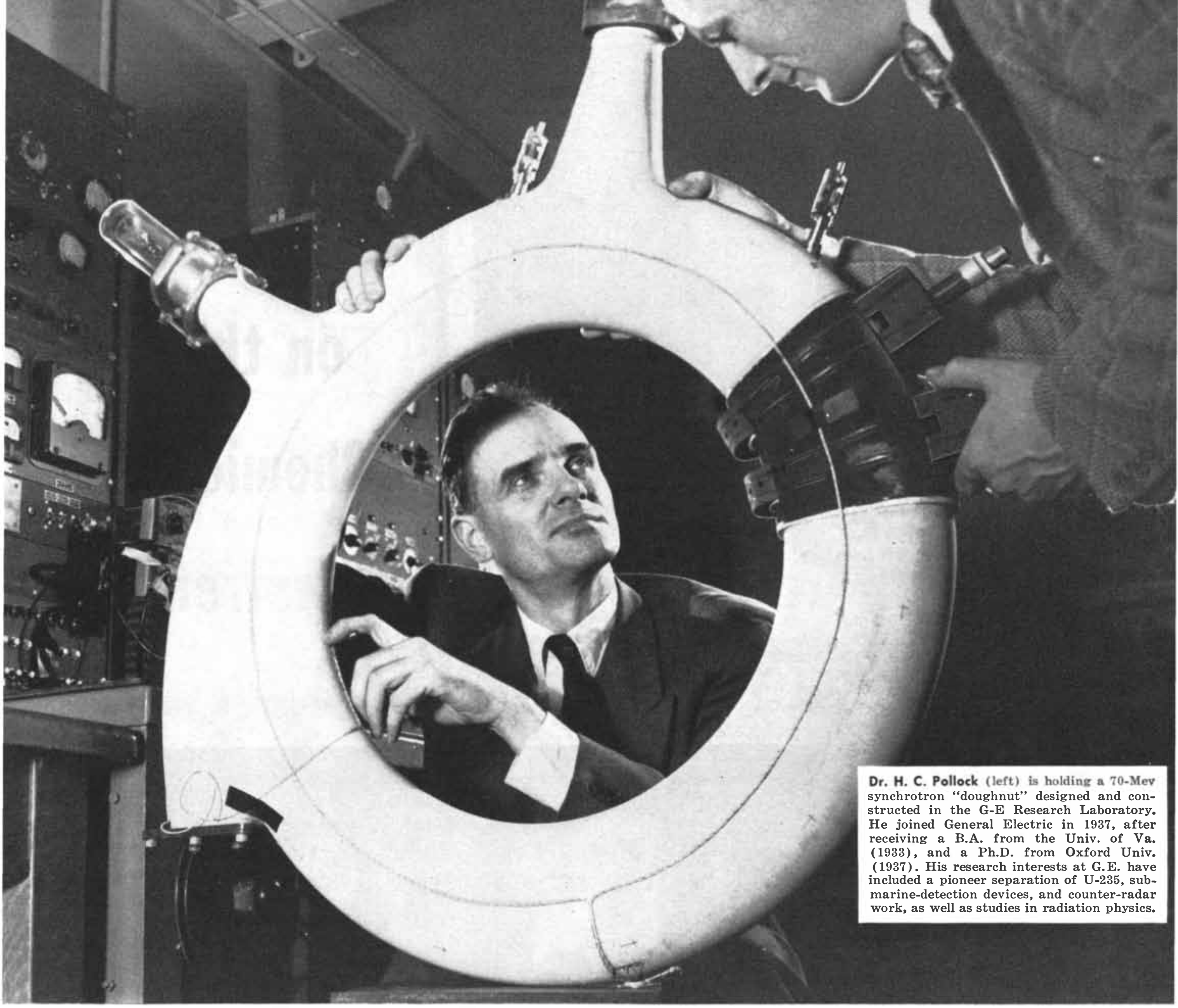
The Electron and the Bee

In the transistorized age now dawning, even beekeeping may be electrified. The British journal *Communications and Electronics* describes a new device called an "apidictor," with which an apiculturist will be able to divine the innermost secrets of his bees.

One of the most vexing problems facing a bee farmer is swarming. When a hive becomes too full of bees and honey, most of the inmates "swarm"—*i.e.*, leave in a body—and set up housekeeping in less crowded quarters. This undesirable dispersion can be headed off by adding a new section to the hive at just the right moment. At present the only way to tell when the moment has arrived is to open the hive and look for "queen cells"—structures the deserting bees build for a new queen to replace the one departing.

E. F. Woods, a British Broadcasting Corporation engineer, learned that bees tip off their intentions by the sounds they make. A happy hive with no thoughts of swarming buzzes along at a contented 180 cycles per second. When the brood section gets so crowded that nurse bees cannot feed the larvae in their care, the frustrated guardians add a soft 250-cycle warble to the hive noise. Woods designed a microphone that can be placed in the hive entrance and a selective, battery-powered transistor amplifier which analyzes the bees' sound output. Their warble is detected and gives the warning.

The apidictor tells other things. A colony with a healthy, functioning queen signals that fact by responding to any sudden stimulus, such as a jar, with a short hiss at around 3,500 cycles per second. A colony being robbed by foreign bees rings an alarm by unusually large variations in the loudness of its basic 180-cycle note.



Dr. H. C. Pollock (left) is holding a 70-Mev synchrotron "doughnut" designed and constructed in the G-E Research Laboratory. He joined General Electric in 1937, after receiving a B.A. from the Univ. of Va. (1933), and a Ph.D. from Oxford Univ. (1937). His research interests at G.E. have included a pioneer separation of U-235, submarine-detection devices, and counter-radar work, as well as studies in radiation physics.

More power to electrons

General Electric's Dr. Pollock combined the principles of two accelerators to produce high-energy electrons

The tools used by physicists to accelerate electrons up to the high energies needed for nuclear research are usually very large and heavy. Some years ago, Dr. Herbert C. Pollock of the General Electric Research Laboratory showed that by combining the actions of betatron and synchrotron, a smaller machine could be made to accelerate electrons. A successful 70-million electron volt synchrotron of this new type — using a magnet weighing 8 tons compared to 135 tons in a 100-Mev betatron — was designed and built by Dr. Pollock and other G-E scientists in 1947.

This was an important link in the chain of increasingly more powerful electron-accelerating machines which are now helping to extend the frontiers of nuclear physics and medicine. Synchrotrons which accelerate electrons up to 300 Mev and more have been constructed recently at Schenectady and elsewhere. Today, physicists are looking ahead to electron energies in excess of a billion electron volts.

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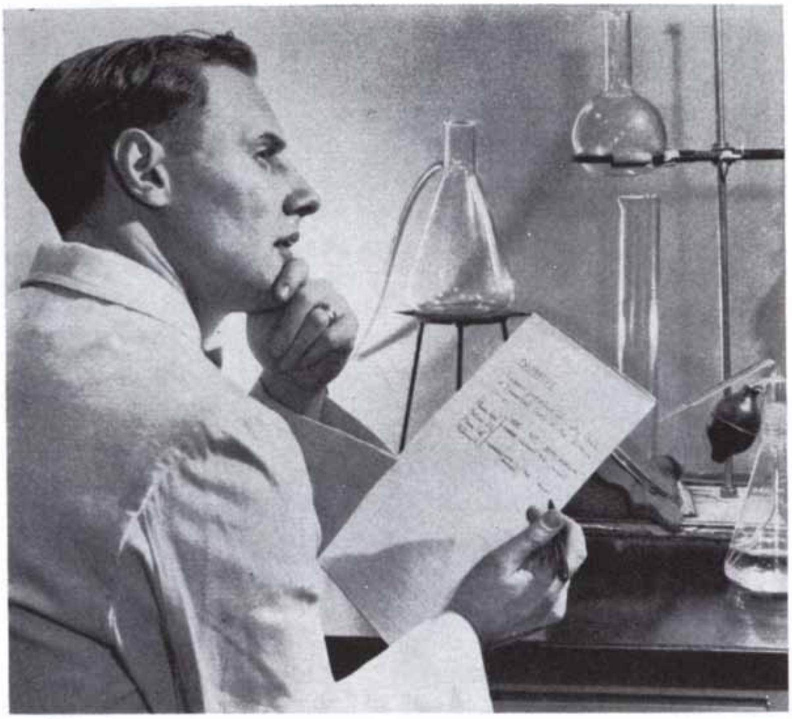

Life on the Chemical Newsfront

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NOW VINYL FILM IS "BREATHABLE." Tiny holes by the millions won't affect appearance or strength but they will give new comfort to users of vinyl upholstery materials. Improvements like this have stimulated vinyl production from 40,000 yards in 1940 to more than 450,000,000 yards today. Another such stimulant to vinyl popularity is the durability and long-lasting flexibility imparted by plasticizers made with AERO* Phthalic Anhydride, esterified with various monohydric alcohols. A new Technical Bulletin describing properties and many uses of AERO Phthalic Anhydride is now available. (No. 2)

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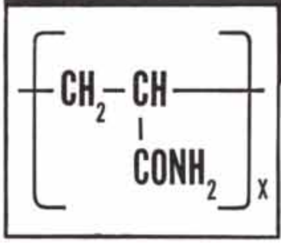

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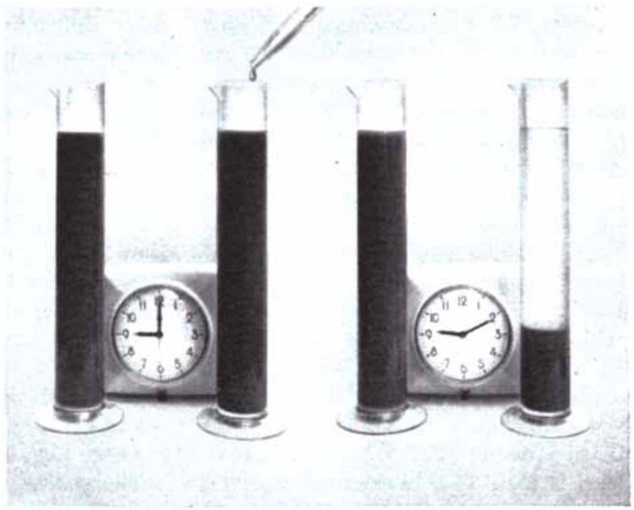

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SEND more information on the following items mentioned in the April, 1955 issue of LIFE on the Chemical Newsfront:

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Man Viewed as a Machine

"Muscle" and "brain" machines do much of his daily work. Now he conceives a machine that will reproduce itself. This once again brings up the question of whether man himself is only a machine

by John G. Kemeny

Is man no more than a machine? The question is often debated these days, usually with more vigor than precision. More than most arguments, this one tends to bog down in definition troubles. What is a machine? And what do we mean by "no more than"? If we define "machine" broadly enough, everything is a machine; and if by "more than" we mean that we are human, then machines are clearly less than we are.

In this article we shall frame the question more modestly. Let us ask: What could a machine do as well or better than a man, now or in the future? We shall not concern ourselves with whether a machine could write sonnets or fall in love. Nor shall we waste time laboring the obvious fact that when it comes to muscle, machines are far superior to men. What concerns us here is man as a brain-machine. John von Neumann, the mathematician and designer of computers, not long ago made a detailed comparison of human and mechanical brains in a series of lectures at Princeton University. Much of what follows is based on that discussion.

We are often presented with Utopias in which all the hard work is done by machines and we merely push buttons. This may sound like a lazy dream of heaven, but actually man is even lazier than that. He is no sooner presented with this Utopia than he asks: "Couldn't I build a machine to push the buttons for me?" And indeed he began to invent such machines as early as the 18th century. The flyball governor on a steam engine and the thermostat are elementary brain-machines. They control muscle machines, while spending only negligible amounts of energy themselves. Norbert Wiener has compared them to the human nervous system.

Consider the progress of the door. Its earliest form must have been a rock rolled in front of a cave entrance. This may have provided excellent protection, but it must also have made the operation of going in and out of the cave quite difficult. Slowly, as man found better means of defending himself, he made lighter and more manageable doors, until today it is literally child's play to open a door. But even this does not satisfy us. To the delight of millions of railroad passengers, the Pennsylvania Railroad installed electric eyes in its New York terminal. Man need only break the invisible signal connecting the two photoelectric "eyes," and immediately the little brain-machine commands the door to open. This control device needs only a negligible amount of energy, is highly efficient and is vastly faster than any doorman.

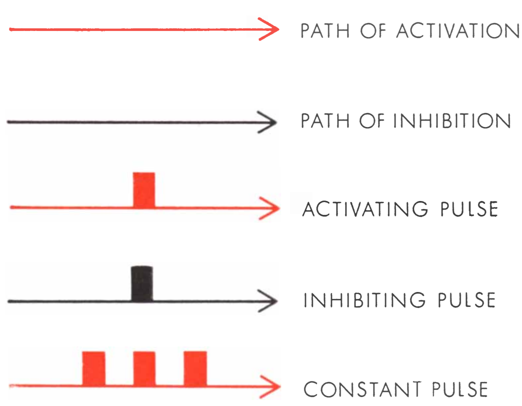
The central switchboard in an office is another brain-machine, especially if the office has installed the dial system. Messages are carried swiftly and efficiently to hundreds of terminals, at the expense of only a small quantity of electricity. This is one of those brain-machines without which modern life is supposed to be not worth living.

And, finally, there is the example most of us are likely to think of when brain-machines are mentioned: namely, the high-speed computer. Electric eyes and telephone exchanges only relieve us of physical labor, but the calculators can take the place of several human brains.

The Slow Brain

In economy of energy the human brain certainly is still far ahead of all its mechanical rivals. The entire brain with its many billions of cells functions on less than 100 watts. Even with the most efficient present substitute for a brain cell—the transistor—a machine containing as many cells as the brain would need about 100 million watts. We are ahead by a factor of at least a million. But von Neumann has calculated that in theory cells could be 10 billion times more efficient in the use of energy than the brain cells actually are. Thus there seems to be no technical reason why mechanical brains should not become more efficient energy-users than their human cousins. After all, just recently by inventing the transistor, which requires only about a hundredth of a watt, we have improved the efficiency of our machines by a factor of 100; in view of this the factor of a million should not frighten us.

While we are still ahead in the use of energy, we are certainly far behind in speed. Whereas a nerve cannot be used more than 100 times a second, a vacuum tube can easily be turned on and off a million times a second. It could be made to work even faster, but this would not contribute much to speeding



SIMPLE CIRCUITS for a brain machine are depicted on the next five pages. The activating and inhibiting pulses are identical but follow different paths.

up the mechanical brain at the moment. No machine is faster than its slowest part, so we must evaluate various components of the machine.

In a calculating machine four different problems confront the designer: the actual computations, the "logical control," the memory and the feeding of information to the machine and getting answers out. Speed of computation, a bottleneck in mechanical computers such as the desk calculator, has been taken care of by the vacuum tube. The next bottleneck was the logical control—the system for telling the machine what to do next after each step. The early IBM punch-card machine took this function out of the hands of a human operator by using a wiring setup on a central board which commanded the sequence of operations. This is perfectly all right as long as the machine has to perform only one type of operation. But if the sequence has to be changed frequently, the wiring of the board becomes very clumsy indeed. To improve speed the machine must be given an internal logical control. Perhaps the greatest step forward on this problem has been accomplished by MANIAC, built at the Institute for Advanced Study in Princeton. This machine can change instructions as quickly as it completes calculations, so that it can operate as fast as its vacuum tubes will allow.

That still leaves the problems of speeding up the memory and the input and output of information. The two problems are closely related. The larger the memory, the less often the operator has to feed the machine information. But the very fact that the machine performs large numbers of computations between instructions clogs its memory and slows it down. This is because an accumulation of rounding errors makes it necessary to carry out all figures in a calculation to a great number of digits. In each computation the machine necessarily rounds off the last digit; in succeeding operations the digit becomes less and less precise. If the computations are continued, the next-to-last digit begins to be affected, and so on. It can be shown that after 100 computations the last digit is worthless; after 10,000 the last two digits; after 1,000,000, the last three. In the large new computers an answer might easily contain four worthless figures. Hence to insure accuracy the machine must carry more digits than are actually significant; it is not uncommon to carry from eight to 12 digits for each number throughout the calculation. When the machine operates on the binary system of numbers, instead of the decimal system, the situation is even worse, for it takes about three times as many digits to express a number in the binary scale.

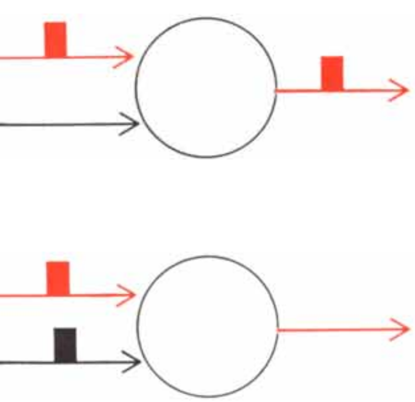
MANIAC uses up to 40 binary digits to express a number. Due to the necessity for carrying this large number of digits, even MANIAC's celebrated memory can hold no more than about 1,000 numbers. It has an "external memory," in the form of a magnetic tape and magnetic drums, in which it can store more information, but reading from the tape or drums is a much slower operation than doing electrical computations.

In spite of the present limitations, the machines already are ahead of the human brain in speed by a factor of at least 10,000—usually a great deal more than 10,000. They are most impressive on tasks such as arise in astronomy or ballistics. It would be child's play for MANIAC to figure out the position of the planets for the next million years.

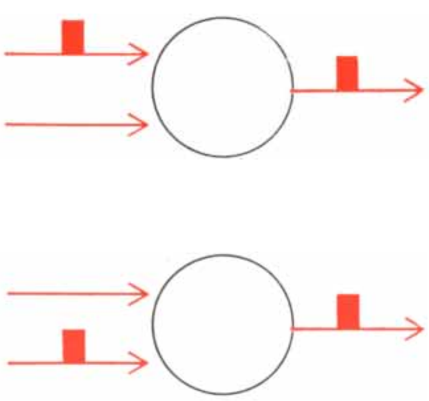
Still we are left with the feeling that there are many things we can do that a machine cannot do. The brain has more than 10 billion cells, while a computer has only a few tens of thousands of parts. Even with transistors, which overcome the cost and space problems, the difficulty of construction will hardly allow more than a million parts to a machine. So we can safely say that the human brain for a long time to come will be about 10,000 times more complex than the most complicated machine. And it is well known that an increase of parts by a factor of 10 can bring about differences in kind. For example, if we have a unit that can do addition and multiplication, by combining a few such units with a logical control mechanism we can do subtraction, division, raising to powers, interpolation and many other operations qualitatively different from the original.

The Complex Memory

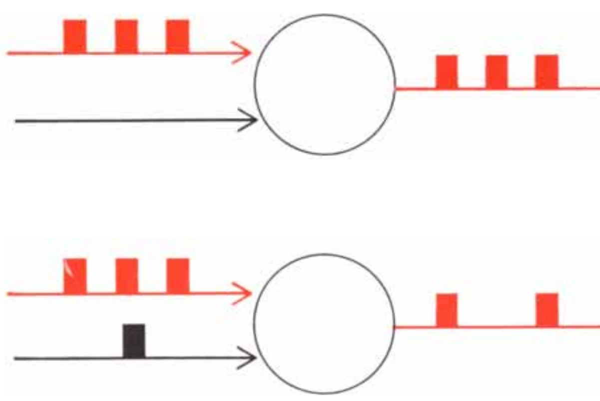
Part of man's superior complexity is his remarkable memory. How does MANIAC's memory compare with it? For simplicity's sake let us measure the information a memory may hold in "bits" (for binary digits). A vacuum tube can hold one digit of a binary number (the digit is 1 if the tube is on, 0 if it is off). In vacuum-tube language it takes 1,500 bits to express the multiplication table. Now MANIAC's memory holds about 40,000 bits, not in 40,000 separate tubes but as spots on 40 special picture tubes, each of which can hold about 1,000 spots (light or dark). Estimates as to how much the human memory holds vary widely, but we certainly can say conservatively that the brain can remember at least 1,000 items as complex



BASIC CELL (*circle*) will fire when it is activated (*top*). It will not fire, however, if it is inhibited at the same time (*bottom*).



"OR" CIRCUIT requires two paths of activation. The cell fires if a pulse arrives on one path (*top*) "or" the other (*bottom*).



"NOT" CIRCUIT incorporates constant activating pulses. The cell can thus fire constantly (*top*). It signals "not" when it is briefly inhibited (*bottom*).

as the multiplication table (1.5 million bits), and a reasonable guess is that its capacity is closer to 100 million bits—which amounts to acquiring one bit per 20 seconds throughout life. So our memory exceeds that of MANIAC by a factor of 1,000 at least.

Is the difference just a matter of complexity? No, the fact is that machines have not yet imitated the human brain's method of storing and recovering information. For instance, if we tried to increase MANIAC's memory by any considerable amount, we would soon find it almost impossible to extract information. We would have to use a complex system of coding to enable the machine to hunt up a given item of information, and this coding would load down the memory further and make the logical control more complex. Only when we acquire a better understanding of the brain's amazing ability to call forth information will we be able to give a machine anything more than a limited memory.

The Logical Machine

Let us now consider the inevitable question: Can a machine "think"? We start with a simple model of the nervous system such as has been constructed by Walter Pitts and Warren S. McCulloch of the Massachusetts Institute of Technology. Its basic unit is the neuron—a cell that can be made to emit pulses of energy. The firing of one neuron may activate the next or it may inhibit it. The neurons are assumed to work in cycles. This corresponds to our knowledge that after firing a neuron must be inactive for a period. To simplify the model it is assumed that the various neurons' cycles are synchronized, *i.e.*, all the neurons active during a given period fire at the same time. For a given neuron to fire in a given cycle two conditions must be satisfied: in the previous cycle it must have been (1) activated and (2) not inhibited. If, for example, a neuron has two others terminating in it of which one activates and one inhibits, and if the former fires in a given cycle and the latter does not, then the neuron will fire in the following cycle. Otherwise it will be inactive for a cycle.

Out of this basic pattern we can build the most complex logical machine. We can have a combination that will fire if a connected neuron did not fire (representing "not") or one that will fire if at least one of two incoming neurons fired (representing "or") or one that will fire only if both incoming neurons fired (representing "and"). Combining these, we can imitate many logical operations of the brain. The simple arrangement diagrammed on pages 62 and 63 will count up to four, and it is easy to see how to generalize this technique.

We can also construct a very primitive memory: *e.g.*, a system that will "remember" that it has been activated until it is instructed to "forget" it. But if it is to remember anything at all complex, it must have an unthinkably large number of neurons—another illustration of the fact that human memory acts on different principles from a machine.

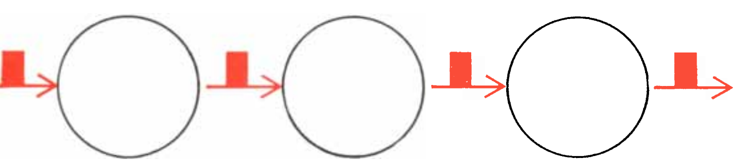
The Turing Machine

If we were to stop here, we might conclude that practical limitations of memory and complexity must forever restrict the cleverness or versatility of any machine. But we have not yet plumbed the full possibilities. The late A. M. Turing of England showed, by a brilliant analysis, that by combining a certain few simple operations in sufficient number a machine could perform feats of amazing complexity. Turing's machines may be clumsy and slow, but they present the clearest picture of what a machine can do.

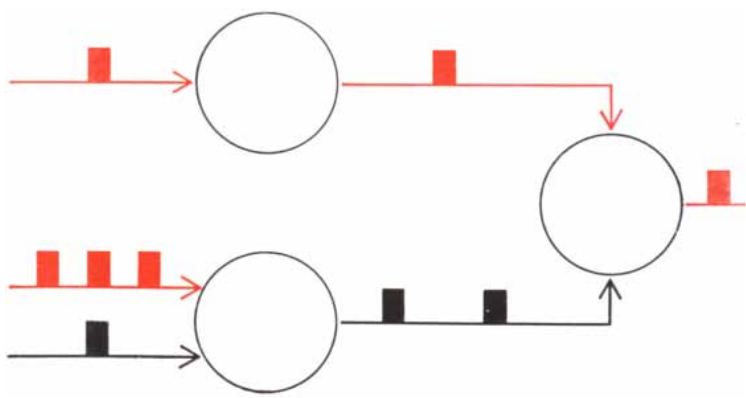
A Turing machine can be thought of as a mechanical calculator which literally works with pencil and paper. The paper it uses is a long tape divided into successive squares, and it operates on one square at a time. As it confronts a particular square it can do one of six things: (1) write down the letter X; (2) write down the digit 1; (3) erase either of these marks if it is already in the square; (4) move the tape one square to the left; (5) move the tape one square to the right; (6) stop.

Essentially this machine is a number writer. It writes its numbers in the simplest possible form, as a string of units. This is even simpler than the binary system. In the binary system the number 35, for example, is written 100011. In a Turing machine it is a string of 1's in 35 successive squares. The X's are merely punctuation marks to show where each number starts and ends.

The machine has the following parts: a device that writes or erases, a scanner, a motor to move the tape, a numbered dial with a pointer, and a logical control consisting of neuron-like elements, say vacuum tubes. The logical control operates from a prepared table of commands which specifies what the machine is to do in each given state. The



DELAY CIRCUIT is based on the fact that the basic cell receives a pulse in one "cycle" and fires it in the next. In this arrangement of three basic cells the pulse would be delayed three cycles.



"AND" CIRCUIT utilizes three cells. The first (*upper left*) has only an acti vating input. The second (*lower left*) has a constant activating input and a inhibiting input. The third (*right*) is the conventional basic cell. In the firs state consists of two elements: what the scanner "sees" in the square before it, and where the pointer is on the dial. For example, the table of instructions may say that whenever the square has an X and the pointer is at the number 1 on the dial, the machine is to erase the X, and move the pointer to the number 2 on the dial. As the machine proceeds from step to step, the logical control gives it such commands, the command in each case depending both on the position of the dial and on what the scanner sees in the square confronting it. Observe that the dial functions as a primitive "memory," in the sense that its position at any stage is a consequence of what the scanner saw and where the pointer stood at the step immediately preceding. It carries over the machine's experience from step to step.

Turing's machine thus consists of a tape with X's and 1's in some of its squares, a dial-memory with a certain number of positions, and a logical control which instructs the machine what to do, according to what it sees and what its memory says. The diagram on pages 64 and 65 shows a very simple version of the machine, with a dial having only six positions. Since the scanner may see one of three things in a square—blank, 1 or X—the machine has 18 possible states, and the logical control has a command for each case [*see table at right of illustration*]. This machine is designed to perform a single task: it can add two numbers—any two numbers. Suppose it is to add 2 and 3. The numbers are written as strings of 1's with X's at the ends. Say we start with the dial at position 1 and the scanner looking at the second digit of the number 3 [*see diagram*]. The instructions in the table say that when it is in this state the machine is to move the tape one square to the right and keep the dial at position 1. This operation brings the square to the left, containing another digit 1, under the scanner. Again the instructions are the same: "Move the tape one square to the right and keep the dial at position 1." Now the scanner sees an X. The instructions, with the dial at position 1, are: "Erase (the X) and move the dial to position 2." The machine now confronts a blank square. The command becomes: "Move the tape one square to the right and keep the dial at position 2." In this manner the machine will eventually write two digit 1's next to the three at the right and end with the answer 5—a row of five digits enclosed by X's. When it finishes, an exclamation point signifies that it is to stop. The reader is advised to try adding two other numbers in the same fashion.

This surely is a cumbersome method of adding. However, the machine becomes more impressive when it is expanded so that it can solve a problem such as the following: "Multiply the number you are looking at by two and take the cube root of the answer if the fifth number to the left is less than 150." By adding positions to the dial and enlarging the table of instructions we can endow such a machine with the ability to carry out the most complex tasks, though each operational step is very simple. The Turing machine in fact resembles a model of the human nervous system, which can be thought of as having a dial with very many positions and combining many simple acts to accomplish the enormous number of tasks a human being is capable of.

Turing gave his machines an infinite memory. Of course the dial can have only a finite number of positions, but he allowed the machine a tape infinite in length, endless in both directions. Actually the tape does not have to be infinite—just long enough for the task. We may provide for all emergencies by allowing the machine to ask for more tape if it needs it. The human memory is infinite in the same sense: we can always make more paper to make notes on.

The Universal Machine

If we allow the unlimited tape, the Turing idea astounds us further with a universal machine. Not only can we build a machine for each task, but we can design a single machine that is versatile enough to accomplish all these tasks! We must try to understand how this is done, because it will give us the key to our whole problem.

The secret of the universal machine is that it can imitate. Suppose we build a highly complex machine for a difficult task. If we then supply the universal machine with a description of the task and of our special machine, it will figure out how to perform the task. It proceeds very simply, deducing from what it knows about our machine just what it would do at each step. Of course this slows the universal machine down considerably. Between any two steps it must carry out a long argument to analyze what our machine would do. But we care only about its ability to succeed, not its speed. There is no doubt about it: anything any logical machine can do can be done by this single mechanism.

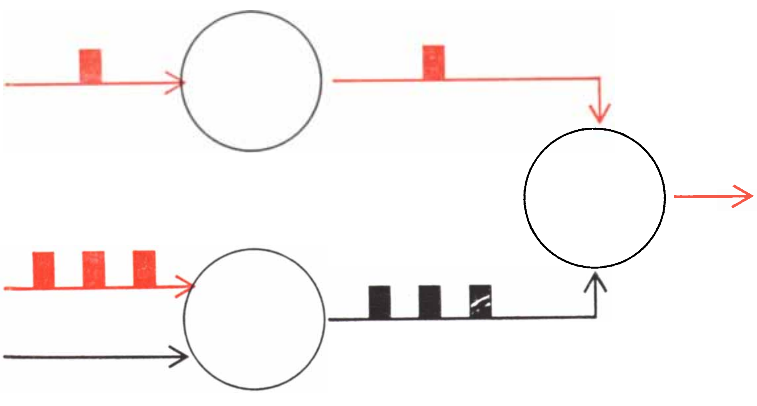
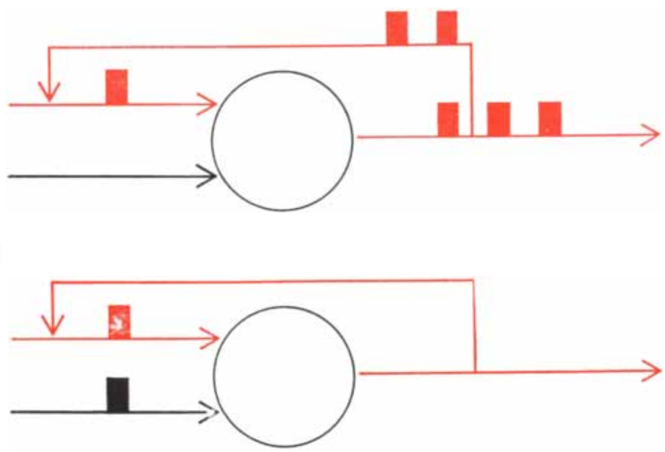
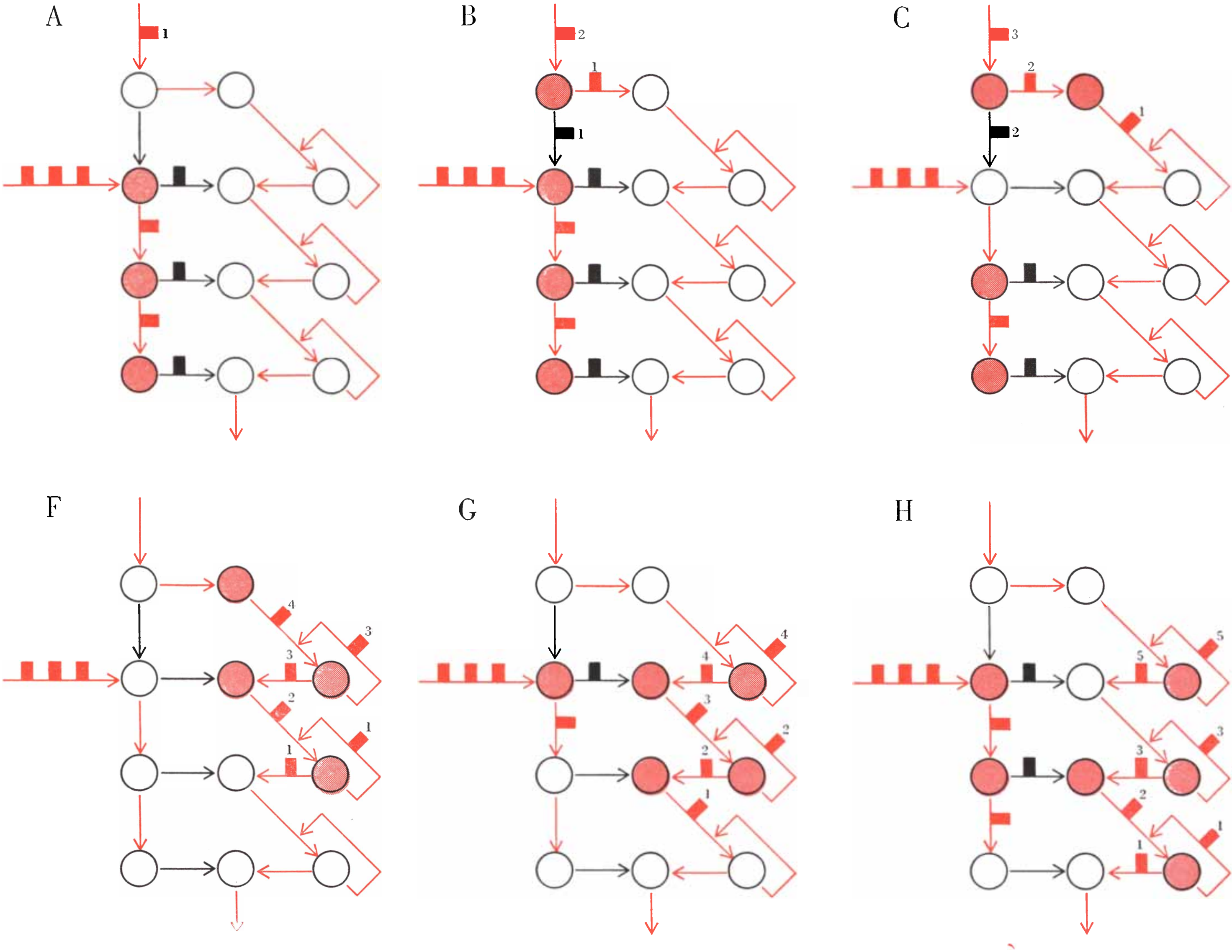


diagram the pulse received by the first cell is not fired by the third. The third cell will fire the pulse only if the activating pulse of the first cell "and" the inhibiting pulse of the second are fired on the same cycle (*second diagram*).



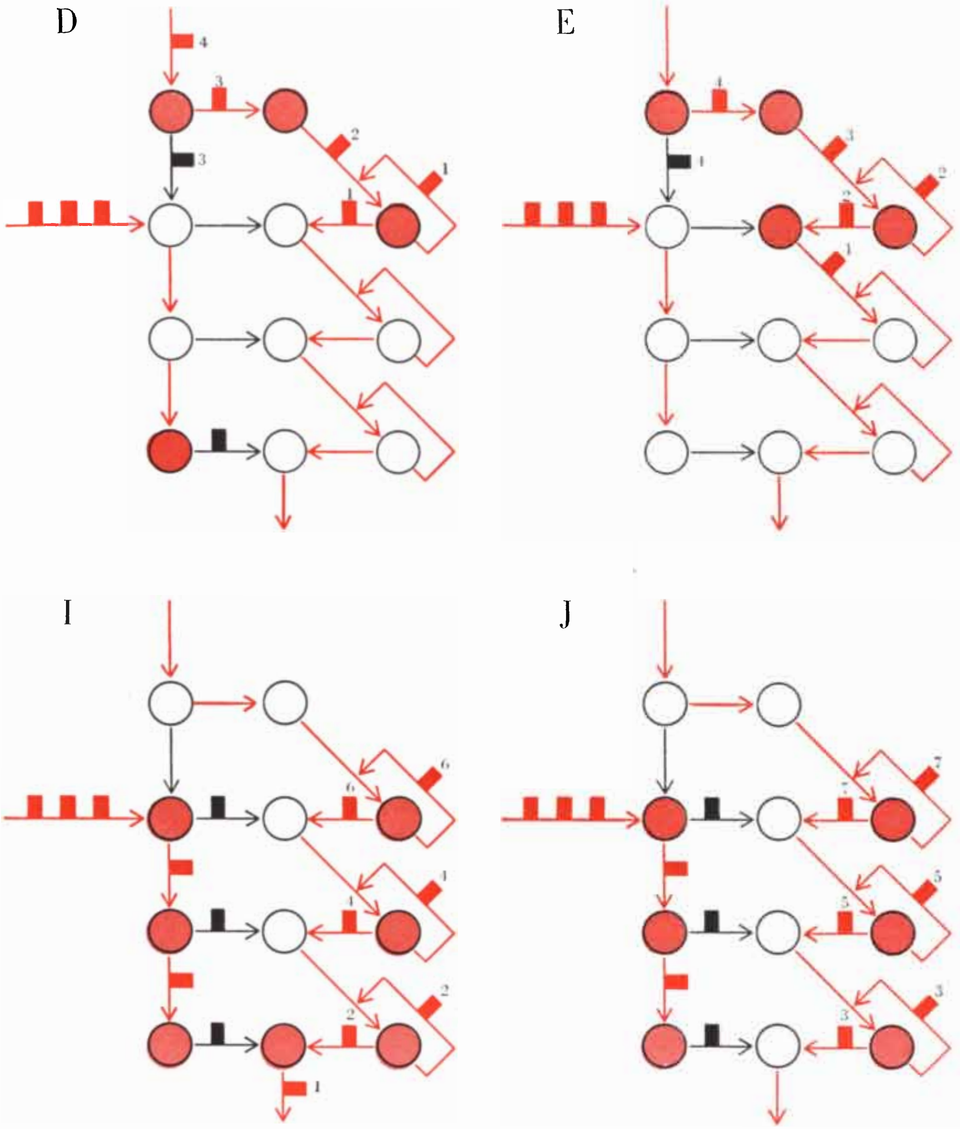
MEMORY CIRCUIT feeds the output of a cell back into its input. Thus if the cell is activated, it "remembers" by firing constantly (*top*). If it is inhibited at any time later, it stops firing (*bottom*).



COUNTING CIRCUIT "counts" to four and then fires. The conventions in this series of diagrams are the same as those in the illustrations on the four preceding pages, with two important exceptions. The first is that, where the diagrams on the preceding pages show each circuit during two or more cycles, each of these diagrams shows the circuit during a single cycle. The second exception is that, when a cell fires, it lights up (*red tone*). The input of this circuit is the activating pathway at the top. The output of the circuit is the activating pathway at the bottom. In addition one of the cells has a constant activating input (*left*). The three cells at the right are memory cells (*see diagram at the right on preceding page*). These cells can activate the three cells to the left of them.

The key question is: How do you describe a complex machine in terms that a relatively simple machine can understand? The answer is that you devise a simple code which can describe any machine (or at least any Turing machine), and that you design the universal machine so that it will be able to understand this code. To understand a Turing machine we need only know its table of commands, so it suffices to have a simple code for tables of commands. We will sketch one possible way of representing each conceivable table of commands by an integer. Of course there are infinitely many such tables, but there are also infinitely many integers—that is why they are so useful in mathematics.

A table of commands consists of *P* rows. Each row has three commands in it, corresponding to seeing a blank, an X or a 1. The first step is to get rid of the letters in the table [*refer again to page 65*]. This can be done by replacing *E*, *X*, *D*, *L*, *R* and *S* by 1 through 6 respectively. Thus the commands on the first line of the table of our sample machine become 3–6, 1–2, 5–1. Step two: Get rid of the question mark and the exclamation point, say by putting 1 and 2 for them respectively. (Since these occur only in conjunction with an S, there is no danger of confusing them with memory positions 1 and 2.) Thus the second row of our table becomes 5–2, 1–3, 6–1. Step three: Represent each row by a single integer. There is a famous simple way of doing this; namely by treating the numbers as exponents to primes and obtaining a product which completely specifies the series of numbers. As the final step, we represent the entire table with a single number obtained by the same trick. Our code number for this table will be $2^{2991509440920}$ times 3 raised to the number of the second row. It is an enormous number, but it does identify our table of commands uniquely. And it is a straightforward mechanical task to design the universal machine so that it can



These three cells can in turn be inhibited by the three cells to the left of them. Now in the first four cycles (A, B, C and D) four pulses are put into the circuit. The position of each pulse in succeeding cycles is indicated by small numbers. In the ninth cycle (I) the circuit, having "counted" the four pulses, fires once. In the 10th cycle (J) the circuit returns to its original state with the exception that pulses are still circulating through the memory cells. A practical counting circuit would be fitted with a device to wipe out these memories.

decode the large number and reproduce the table of commands. With the table of commands written down, the machine then knows what the machine it is copying would do in any given situation.

The universal machine is remarkably human. It starts with very limited abilities, and it learns more and more by imitation and by absorbing information from the outside. We feel that the potentialities of the human brain are inexhaustible. But would this be the case if we were unable to communicate with the world around us? A man robbed of his five senses is comparable to a Turing machine with a fixed tape, but a normal human being is like the universal machine. Given enough time, he can learn to do anything.

But some readers will feel we have given in too soon to Turing's persuasive argument. After all a human being must step in and give the universal machine the code number. If we allow that, why not give the machine the answer in the first place? Turing's reply would have been that the universal machine does not need a man to encode the table; it can be designed to do its own coding, just as it can be designed to decode.

So we grant this amazing machine its universal status. And although its table of logical control has only a few thousand entries, it seems to be able to do essentially all the problem-solving tasks that we can. Of course it might take a billion years to do something we can do in an hour. The "outside world" from which it can learn is much more restricted than ours, being limited to Turing machines. But may not all this be just a difference of degree? Are we, as rational beings, basically different from universal Turing machines?

The usual answer is that whatever else machines can do, it still takes a man to build the machine. Who would dare to say that a machine can reproduce itself and make other machines?

Von Neumann would. As a matter of fact, he has blue-printed just such a machine.

The Reproducing Machine

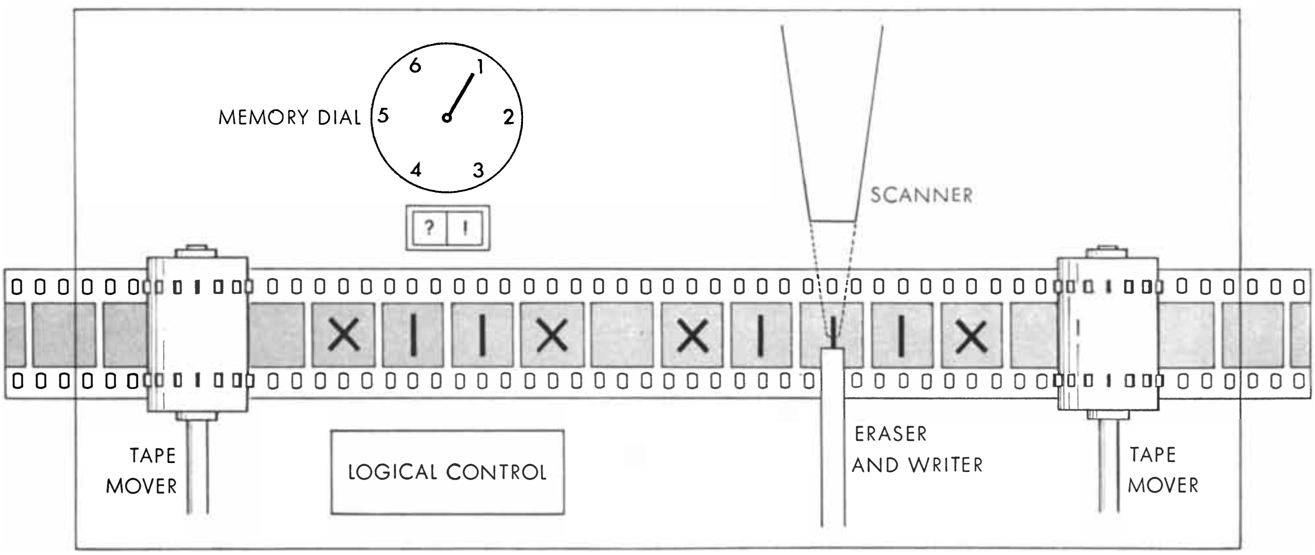
What do we mean by reproduction? If we mean the creation of an object like the original out of nothing, then no machine can reproduce, but neither can a human being. If reproduction is not to violate the conservation of energy principle, building materials must be available. The characteristic feature of the reproduction of life is that the living organism can create a new organism like itself out of inert matter surrounding it.

If we agree that machines are not alive, and if we insist that the creation of life is an essential feature of reproduction, then we have begged the question: A machine cannot reproduce. So we must reformulate the problem in a way that won't make machine reproduction logically impossible. We must omit the word "living." We shall ask that the machine create a new organism like itself out of simple parts contained in the environment.

Human beings find the raw material in the form of food; that is, quite highly organized chemicals. Thus we cannot even say that we produce order out of complete disorder, but rather we transform more simply organized matter into complex matter. We must accordingly assume that the machine is surrounded with pieces of matter, simpler than any part of the machine. The hypothetical parts list would be rolls of tape, pencils, erasers, vacuum tubes, dials, photoelectric cells, motors, shafts, wire, batteries and so on. We must endow the machine with the ability to transform pieces of matter into these parts and to organize them into a new machine.

Von Neumann simplified the problem by making a number of reasonable assumptions. First of all he realized that it is inessential for the machine to be able to move around. Rather, he has the mechanism sending out impulses which organize the surroundings by remote control. Secondly, he asssumed that space is divided into cubical cells, and that each part of the machine and each piece of raw material occupies just one cell. Thirdly, he assumed that the processes are quantized not only in space but in time; that is, we have cycles during which all action takes place. It is not even necessary to have three dimensions: a two-dimensional lattice will serve as well as the network of cubes.

Our space will be a very large (in principle infinite) sheet, divided into squares. A machine occupies a connected area consisting of a large number of squares. Since each square represents a part of the machine, the number of squares occupied is a measure of the complexity of the machine. The machine is surrounded by inert cells, which it has to organize. To make this possible the machine must be a combination of a brain and a brawn machine, since it not only organizes but also transforms matter. Accordingly the von Neumann machine has three kinds of parts. It has neurons similar to those discussed in the model of the nervous system. These provide the logical control. Then it has transmission cells, which carry messages



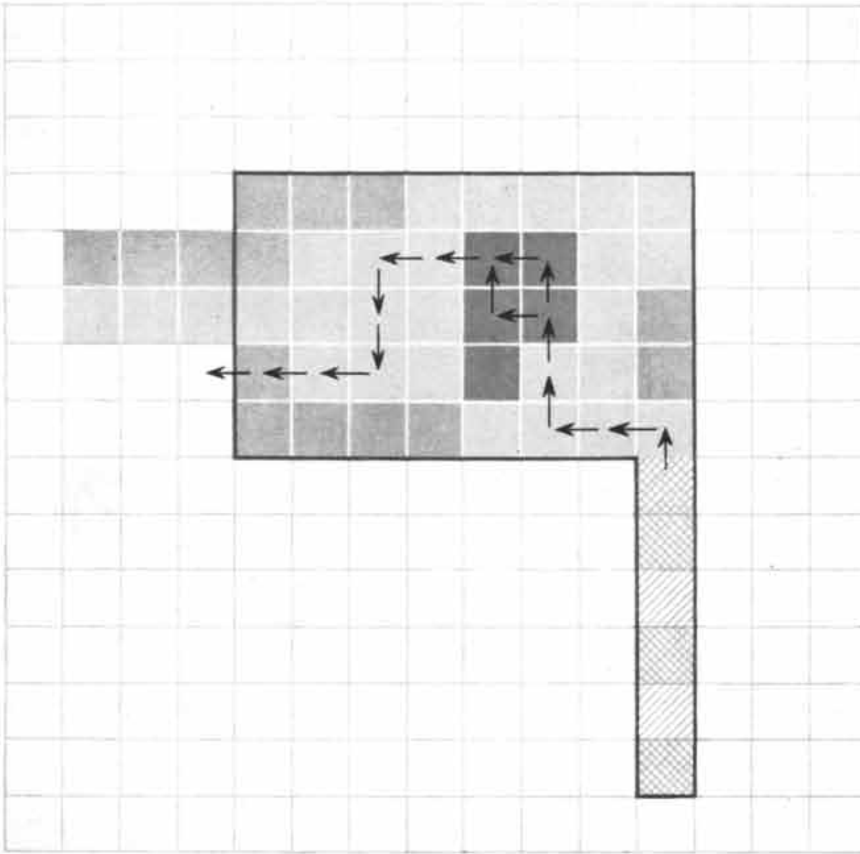
TURING MACHINE designed for simple addition is confronted with the numbers 2 and 3. The numbers are indicated on the tape; each digit is represented by a 1. X is a signal that a number is about to begin or has just ended. The logical control of the machine is depicted in the table on the opposite page. The horizontal rows of the table represent the position of the memory dial (*1, 2, 3, 4, 5 or 6*). The vertical columns represent the symbol on the tape (*blank, X or 1*). The symbols at the intersection of the rows and columns are commands to the machine. E means erase the symbol on the tape; X, write an X on the tape; D, write the digit 1 on the tape; R, move the tape one frame to the right; L, move the tape one frame to the left; S, stop; ?, something is wrong; !, the operation is completed; 1, 2, 3, 4, 5 or 6, turn the memory dial to that position. Thus at the upper left in the table the memory dial is in position 1 and the tape is blank; the command is D6, or write the digit 1 on the tape and turn the memory dial to position 6. Then in the beginning position shown above the machine begins to operate as follows. In the first step the memory dial is in position 1 and the tape shows a 1. The command is R1: move the tape one frame to the right and leave the memory dial in position 1. In the second

from the control centers. They have an opening through which they can receive impulses, and an output through which the impulse is passed on a cycle later. A string of transmission cells, properly adjoined, forms a channel through which messages can be sent. In addition the machine has muscles. These cells can change the surrounding cells, building them up from less highly organized to more complex cells or breaking them down. They bring about changes analogous to those produced by a combination of muscular and chemical action in the human body. Their primary use is, of course, the changing of an inert cell into a machine part.

As in the nervous system, the operation proceeds by steps: the state of every cell is determined by its state and the state of its neighbors a cycle earlier. The neurons and transmission cells are either quiescent or they can send out an impulse if properly stimulated. The muscle cells receive commands from the neurons through the transmission cells, and react either by "killing" some undesired part (*i.e.*, making it inert) or by transforming some inert cell in the environment to a machine part of a specified kind. So far the machine is similar in structure to a higher animal. Its neurons form the central nervous system;

	·	X	I
1	D6	E2	R1
2	R2	E3	?2
3	R3	E4	E5
4	L4	?4	R6
5	L5	?5	R1
6	X6	!6	R3

step the situation and the response are the same. In the third step the memory dial is in position 1 and the tape shows an X. The command is E2: erase the X and turn the memory dial to position 2. In this way the machine comes up with the answer 5 on its memory dial in 36 steps. On the 37th step the machine stops and signals with a ! that it is finished. If the reader is skeptical and hardy, he is invited to trace the whole process!



VON NEUMANN MACHINE is theoretically capable of reproducing itself. This is a highly simplified diagram of its conceptual units. The darkest squares are the "nerve cells" of the "brain." The next lightest squares are "muscle cells." The next lightest are transmission cells. The crosshatched squares are the "tail" which bears the instructions of the machine. The double hatching represents an "on" signal; the single hatching, an "off" signal. The empty squares are units of the environment which the machine manipulates. The arrows indicate that instructions are coming from the tail, on the basis of which the brain instructs a muscle cell to act on its surroundings. The machine has sent out a "feeler" to the left.

the transmission cells establish contact with various organs; the organs perform their designated tasks upon receiving a command.

The instructions may be very long. Hence they must in a sense be external. Von Neumann's machine has a tail containing the blueprint of what it is to build. This tail is a very long strip containing coded instructions. The basic box performs two types of functions: it follows instructions from its tail, and it is able to copy the tail. Suppose the tail contains a coded description of the basic box. Then the box will, following instructions, build another box like itself. When it is finished, it proceeds to copy its own tail, attaching it to the new box. And so it reproduces itself.

The secret of the machine is that it does not try to copy itself. Von Neumann designed a machine that can build any machine from a description of it, and hence can build one like itself. Then it is an easy matter to copy the large but simple tail containing the instructions and attach it to the offspring. Thereafter the new machine can go on producing more and more machines until all the raw material is used up or until the machines get into conflict with each other—imitating even in this their human designers.

It is amazing to see how few parts such a machine needs to have. Von Neumann's blueprints call for a basic box of 80 by 400 squares, plus a tail 150,000 squares long. The basic box has the three kinds of parts described—neurons, transmission cells and muscle cells. The three types of cells differ only as to their state of excitation and the way in which they are connected. The tail is even simpler: it has cells, which are either "on" or "off," holding a code. So we have about 200,000 cells, most of which are of the simplest possible kind, and of which only a negligible fraction is even as complex as the logical control neuron. No matter how we measure complexity, this is vastly simpler than a human being, and yet the machine is self-reproducing.

The Genetic Tail

Pressing the analogy between the machine and the human organism, we might compare the tail to the set of chromosomes. Our machine always copies its tail for the new machine, just as each daughter cell in the body copies the chromosomes of its parent. It is most significant that while the chromosomes take up a minute part of the body, the tail is larger than the entire basic box in the machine. This indicates that the coding of traits by chromosomes is amazingly efficient and compact. But in all fairness we must point out that the chromosomes serve a lesser role than the tail. The tail contains a complete description of the basic box, while the chromosome description is incomplete: the offspring only resembles the parent; it is not an exact duplicate. It would be most interesting to try to continue von Neumann's pioneer work by designing a machine that could take an incomplete description and build a reasonable likeness of itself.

Could such machines go through an evolutionary process? One might design the tails in such a way that in every cycle a small number of random changes occurred (*e.g.*, changing an "on" to an "off" in the code or *vice versa*). These would be like mutations; if the machine could still produce offspring, it would pass the changes on. One could further arrange to limit the supply of raw material, so that the machines would have to compete for *Lebensraum*, even to the extent of killing one another.

Of course none of the machines described in this article has actually been built, so far as I know, but they are all buildable. We have considered systematically what man can do, and how much of this a machine can duplicate. We have found that the brain's superiority rests on the greater complexity of the human nervous system and on the greater efficiency of the human memory. But is this an essential difference, or is it only a matter of degree that can be overcome with the progress of technology? This article attempted to show that there is no conclusive evidence for an essential gap between man and a machine. For every human activity we can conceive of a mechanical counterpart.

Naturally we still have not answered the question whether man is more than a machine. The reader will have to answer that question for himself.

THE ECOLOGY OF DESERT PLANTS

What selects the plants in an extreme environment? Is it a sort of war? The study of plants in the desert and in the laboratory indicates otherwise, which points a moral for the human species

by Frits W. Went

The laws of human behavior are very much in dispute, largely because there are no obvious experimental approaches to them. But animal and plant behavior can be studied both in nature and in the laboratory, and the science of their ecology should eventually be helpful in the understanding of human relationships, for the basic laws which govern the interrelations among organisms in general must also underlie human behavior. Ecology is an extremely complex study. For a relatively uncomplicated case, from which we may be able to extract some generalizations about behavior, I want to take you with me to the desert to survey its plant life.

The desert is an ideal area for research. It is usually unspoiled by the encroachment of civilization. Its plant life is sparse enough to be studied conveniently in detail, and it shows clearly and primitively the effects of the physical factors at play in the environment. Most important of all, the desert climate is violent: winds sweep over it unchecked, and its temperature and rainfall swing between wide extremes. Rainfall may vary fivefold from year to year. There are so few rainstorms that the effects of individual rains can be measured. The desert's sharply contrasting conditions can be reproduced in the laboratory for convenient experimental investigation of the germination and growth of plants. And the desert has an unending lure for the botanist; in the spring it is a delightful place.

The most extreme desert in the U. S. is Death Valley. Screened off from the nearest source of water vapor—the Pacific Ocean—by the tall Sierra Nevada, the valley bottom has an average annual rainfall of only 1.35 inches. It has almost no surface water—only a few springs bringing up the scanty runoff from the dry surrounding mountains. Since it is sunk below sea level, Death Valley has no drainage. As a basin which holds and collects all the material that may be washed into it from the mountain canyons, it has accumulated salts in its central part. Seen from above, this salt bed glistens like a lake, but a traveler on foot finds it a dry, rough surface, studded by sharp salt pinnacles which crackle and tinkle as they expand or contract in the heat of the day and the cold of the night.

In the salt plain no green plants can grow: there are only bare rocks, gravel and salt. But on the fringes of the plain plant life begins. Here and there are patches of a lush green shrub—the mesquite. With their tender green leaflets, which suggest plenty of water, the plants seem completely out of place. Actually they do have a considerable source of water, but it is well underground. The mesquite has roots from 30 to 100 feet long, with which it is able to reach and tap underground lenses of fresh water fed by rain percolating down from the mountains.

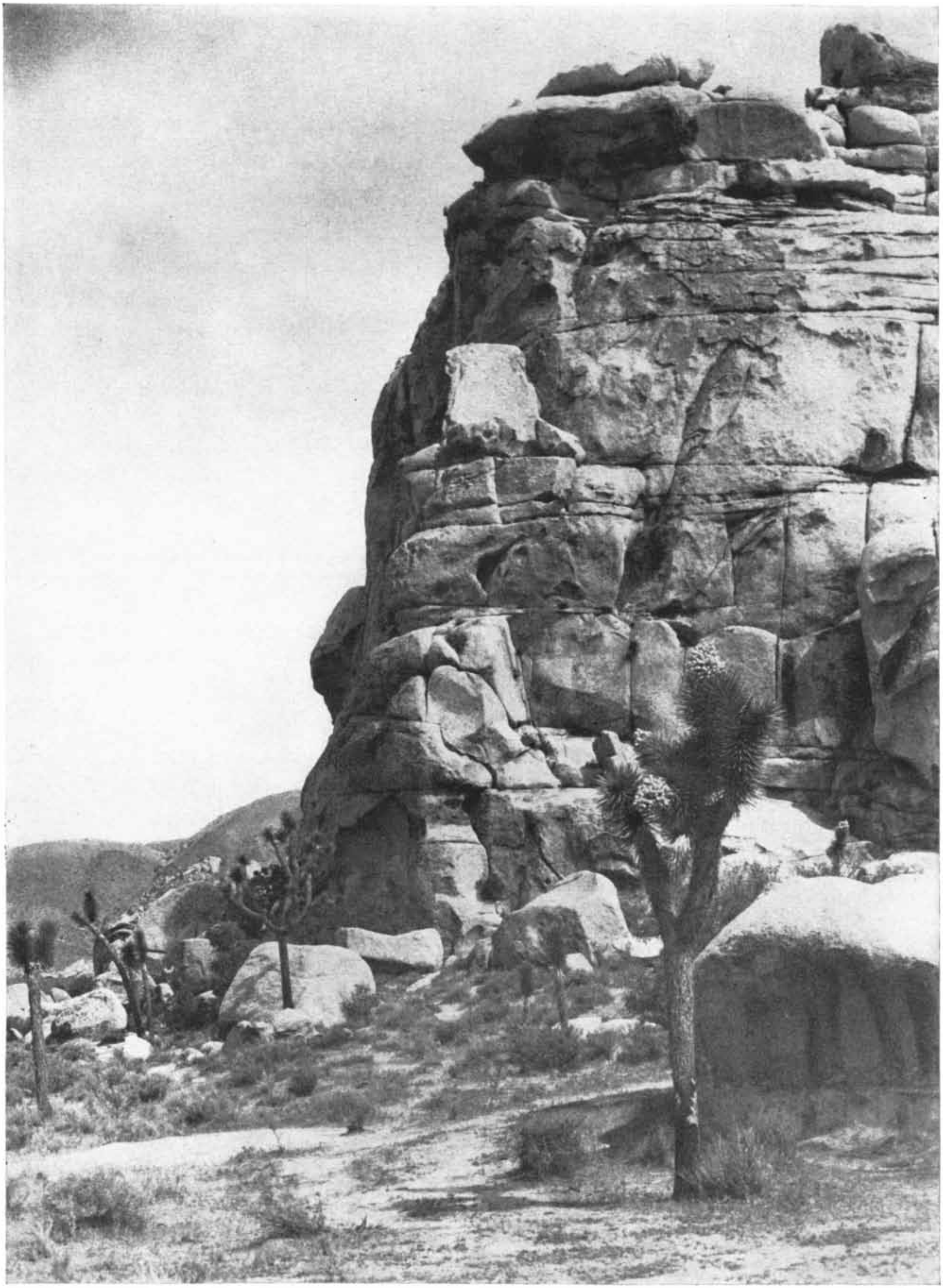
The mesquite is the only shrub that can reach the water table here with its roots. But a mesquite seedling must send its roots down 30 feet or more through dry sand before it reaches this water. How, then, does it get established? This is one of the unsolved mysteries of the desert. Most of the mesquite shrubs in Death Valley are probably hundreds of years old. Some are all but buried by dunes of sand, piled around them over the years by the winds that sometimes blow with great force through the valley. There are places where dozens or hundreds of stems protrude from a dune, all probably the offshoots of a single ancient shrub rooted beneath the dune.

Another Death Valley plant endowed with a remarkable root system is the evergreen creosote bush. It has wide-reaching roots which can extract water from a large volume of soil. The creosote bush is spread with amazingly even spacing over the desert; this is especially obvious from an airplane. The spacing apparently is due to the fact that the roots of the bush excrete toxic substances which kill any seedlings that start near it. The distance of spacing is correlated with rainfall: the less rainfall, the wider the spacing. This probably means that rain leaches the poisons from the soil so that they do not contaminate as wide an area. We commonly find young creosote bushes along roads in the desert, where the road builders have torn up the old bushes.

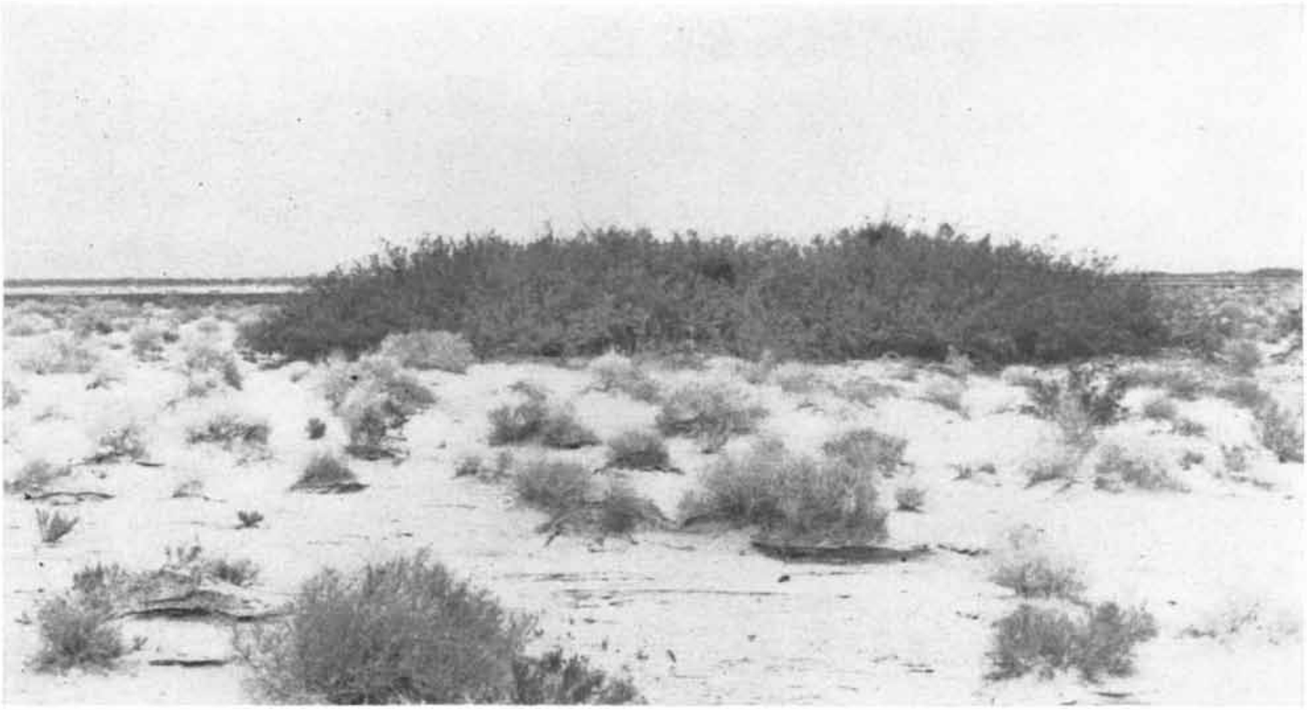
During prolonged periods of drought creosote bushes lose their olive-green leaves and retain only small brownish-green leaves. Eventually these also may drop off, and the bush then dies unless rain comes soon afterward. However, it takes a really long drought to kill off all the creosote bushes in an area. They have suffered severely in some areas of the southern California deserts during the drought of the past five years. Because a killing drought tends to remove them wholesale, there are usually only a few age classes of creosote bushes in an area; each group springs up after a drought or during a period of unusual rainfall.

There are other shrubs that master the harsh conditions of the desert, among them the lush green *Peucephyllum*, which seems to be able to live without water, and the white-leaved desert holly, which grows in fairly salty soil.

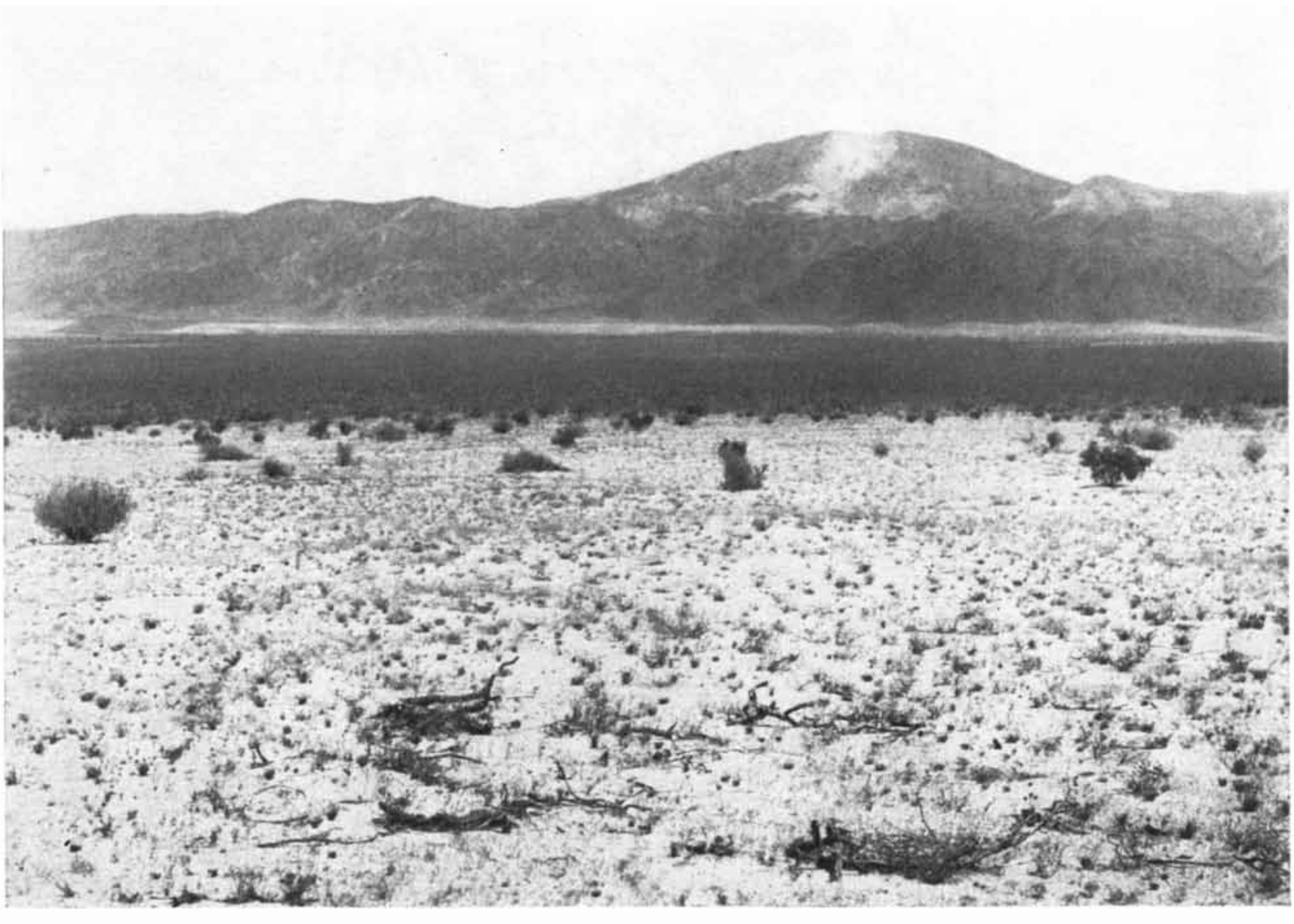
Two prime factors control the abundance and distribution of plants: the number of seeds that germinate, and



JOSHUA TREES (*Yucca brevifolia*) grow among the fantastic rock formations of the Joshua Tree National Monument in southern California east of Los Angeles. These plants are characteristic of high steppe-desert vegetation in the southwestern U. S.



MESQUITE (*Prosopis*) grows in a large clump, indicating a source of water not more than 30 feet down. In the foreground are salt-bushes, reflecting salty soil near the surface. The absence of annuals among the shrubs shows that there has been no rain for months.



CREOSOTE BUSHES (*Larrea*) dot the desert landscape in the middle distance. After a series of dry years the creosote bushes in this area died; their stems are visible in the foreground. Here the ground is covered with annual plants because of recent rains.

the growing conditions the seedlings encounter while they seek to establish themselves. In the case of the desert shrubs the main controlling factor is the growing conditions rather than germination, for though many seedlings may come forth in a rainy season, few survive long enough to become established. The story is entirely different for the annual plants in the desert.

There are years when the desert floor in Death Valley blooms with a magic carpet of color. In the spring of 1939 and again in 1947 the nonsalty portion of the valley was covered with millions of fragrant, golden-yellow desert sunflowers, spotted here and there with white evening primroses and pink desert five-spots. The bursts of flowering are not necessarily correlated with the year's rainfall. For instance, the wettest year in Death Valley was 1941, when 4.2 inches of rain fell, but there was no mass flowering that year or the following spring. If Death Valley is to bloom in the spring, the rain must come at a certain time—during the preceding November or December. There will be a mass display of spring flowers if November or December has a precipitation of well over one inch: in December of 1938 and in November of 1946 the rainfall was 1.4 inches. Rain of this magnitude in August, September, January or February seems ineffective.

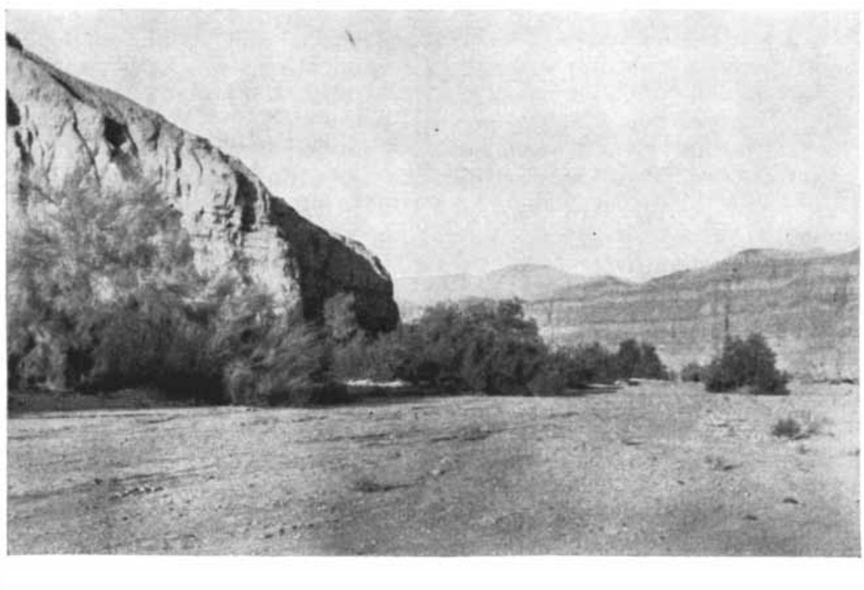
Let us consider these annual plants in greater detail. Probably their most remarkable feature is that they are perfectly normal plants, with no special adaptations to withstand drought. Yet they are not found outside the desert areas. The reason lies in the peculiar cautiousness of their seeds. In dry years the seeds lie dormant. This itself is not at all amazing; what is remarkable is that they refuse to germinate even after a rain unless the rainfall is at least half an inch, and preferably an inch or two. Since the upper inch of soil, where all the viable seeds lie, is as wet after a rain of a tenth of an inch as after one of two inches, their discrimination seems hard to explain. How can a completely dormant seed measure the rainfall? That it actually does so can easily be verified in the laboratory. If seed-containing desert soil is spread on pure sand and wet with a rain sprinkler, the seeds will not germinate until the equivalent of one inch of rain has fallen on them. Furthermore, the water must come from above; no germination takes place in a container where water only soaks up from below.

Of course this sounds highly implausible—how can the direction from which the water molecules approach make any difference to the seed? The answer seems to be that water leaching down through the soil dissolves seed inhibitors. Many seeds have water-soluble germination inhibitors in their covering. They cannot germinate until the inhibitors are removed. This can be done by leaching them in a slow stream of water percolating through the soil, which is what happens during a rainstorm. Water soaking up in the soil from below of course has no leaching action. Some seeds refuse to germinate when the soil contains any appreciable amount of salt. A heavy rain, leaching out the salts, permits them to sprout. Other seeds, including those of many grasses, delay germination for a few days after a rain and then sprout if the soil is still moist—which means that the rain probably was fairly heavy. Still other seeds have inhibitors that can be removed only by the action of bacteria, which requires prolonged moisture. Many seeds preserve their dormancy until they have been wet by a series of rains.

In the washes (dry rivers) of the desert we find a completely different vegetation with different germination requirements. The seeds of many shrubs that grow exclusively in washes (paloverde, ironwood, the smoke tree) have coats so hard that only a strong force can crack them. Seeds of the paloverde can be left in water for a year without a sign of germination; but the embryo grows out within a day if the seed coat is opened mechanically. In nature such seeds are opened by the grinding action of sand and gravel. A few days after a cloudburst has dragged mud and gravel over the bottom of a wash, the bottom is covered with seedlings. It is easy to show that this germination is due to the grinding action of the mudflow: for instance, seedlings of the smoke tree spring up not under the parent shrub itself but about 150 to 300 feet downstream. That seems to be the critical distance: seeds deposited closer to the shrub have not been ground enough to open, and those farther downstream have been pulverized. Smoke-tree seedlings form about three leaves, then stop their above-ground growth until their roots have penetrated deep enough to provide an adequate supply of moisture for the plant. Thereafter the roots grow about five times as fast as the shoots. Few of these seedlings die of drought, but a flood will destroy most of them; only the oldest and biggest shrubs resist the terrific onslaught of rocks, gravel, sand and mud streaming down the wash.

The ability of the smoke tree to make the most of the available moisture was demonstrated by the following experiment. Cracked smoke-tree seeds were sown on top of an eight-foot-high cylinder containing sand moistened with a nutrient solution. Rain water was then sprinkled on them for a short time. Six seeds germinated, and five of the plants survived and have grown for 18 months in a high temperature with only a single watering midway in that period. Indeed, they have grown better than seedlings which were watered daily!

We have studied the control of germination in great detail in our laboratory at the California Institute of Technology. We have learned, for instance, that two successive rains of three tenths of an inch will cause germination provided



DESERT WASH is traced by ironwood (*Olneya*) and paloverde (*Cercidium*) plants. The seeds of these species were made to germinate when they were abraded by a violent flow of mud.

they are given not longer than 48 hours apart. Rain in darkness has a different effect from rain during the day. Most amazing is the seeds' specific responses to temperature. When a mixture of rain-treated seeds of various annuals is kept in a warm greenhouse, only the summer-germinating plants sprout; the seeds of the winter annuals remain dormant. When the same seed mixture is kept in a cool place, only the winter annuals germinate. From this it is obvious that the annuals will not germinate unless they can survive the temperatures following their germination—and unless there has been enough rain to allow them to complete their life cycle. Since these desert plants cannot depend on "follow-up" rains in nature, they germinate only if they have enough rain beforehand to give them a reasonable chance for survival.

A very small percentage of seeds (less than 1 per cent) germinate after an insufficient rain. Such seedlings almost invariably perish before reaching the flowering stage. On the other hand, more than 50 per cent of all seedlings that have sprouted after a heavy rain survive, flower and set seed. And here we find a remarkable fact: even though the seedlings come up so thickly that there are several thousand per square yard, a majority of them grow to maturity. Though crowded and competing for water, nutrients and light, they do not kill one another off but merely fail to grow to normal size. In one case 3,000 mature plants were found where an estimated 5,000 seedlings had originally germinated. The 3,000 belonged to 10 different species. All had remained small, but each had at least one flower and produced at least one seed. This phenomenon is not peculiar to desert plants. In fields of wheat, rice and sugar cane, at spots where seeds happen to have been sown too thickly, all the seedlings grow up together; they may be spindly but they do not die. It is true that in gardens weeds often crowd out some of the desirable plants, but usually this happens only because these plants have been sown or planted out of season or in the wrong climate. Under those conditions they cannot compete with the plants fully adapted to the local growing conditions—plants which we usually call weeds.

We must conclude, then, that all we have read about the ruthless struggle for existence and the "survival of the fittest" in nature is not necessarily true. Among many plants, especially annuals, there is no struggle between individuals for precedence or survival. Once an annual has germinated, it matures and fulfills its destiny of forming new seed. In other words, after successful germination annual plants are less subject to the process of "natural selection." Very likely this accounts for the fact that so few of the desert annuals seem to show adaptations to the desert environment. This does not mean that the plants have avoided evolution, but the evolution has operated on their seeds and methods of germination rather than on the characteristics of the grown plants. Selection on the basis of germination has endowed the plants with a remarkable variety of mechanisms for germinating, and at the same time it has made them slow to germinate except under conditions insuring their later survival. The opposite is true of the cultivated plants that man has developed: his selection has favored the plants that germinate most easily and quickly. This has given us the wrong perspective on the significance of germination in plant survival.

We return now to our original theme: Can the ecology of plants in the desert teach us anything about human ecology or human relations? At least one moral stands out. In the desert, where want and hunger for water are the normal burden of all plants, we find no fierce competition for existence, with the strong crowding out the weak. On the contrary, the available possessions—space, light, water and food—are shared and shared alike by all. If there is not enough for all to grow tall and strong, then all remain smaller. This factual picture is very different from the time-honored notion that nature's way is cut-throat competition among individuals.

Actually competition or warfare as the human species has developed it is rare in nature. Seldom do we find war between groups of individuals of the same species. There are predators, but almost always they prey on a different species; they do not practice cannibalism. The strangler fig in the tropical jungle, which kills other trees to reach the light, is a rare type [see "Strangler Trees," by Theodosius Dobzhansky and João Murça-Pires; SCIENTIFIC AMERICAN, January, 1954]. Even in the dense forest there is little killing of the small and weak. The forest giants among the trees do not kill the small fry under them. They hold back their development, and they prevent further germination. In a mountain forest in Java it was observed that the small trees living in the shade of the forest giants had not grown after 40 years, but they were still alive.

Hundreds of different species of trees, large and small, grow in a tropical jungle. This diversity of vegetation is one of the jungle's most typical characteristics. Some trees grow faster, taller or wider than others, but these growing characteristics, which we have always considered as useful adaptations in the struggle for existence, do not really control the trees' survival. If they did, we would find very few species of trees in a jungle, and there would be an evolutionary tendency for these trees to become taller and taller. Actually the tallest trees are found not in jungles but in more open forests in temperate climates; remarkably enough, tropical jungles often have no particularly high or large trees. All this shows that selection does not work on the basis of growth potential. It works on the ability of plants to grow and survive with very little light.

In our minds the struggle for existence is usually associated with a ruthless extermination of the less well adapted by those better adapted—a sort of continuous cold war. There is no cold war or even aggression in the desert or jungle. Most plants are not equipped with mechanisms to combat others. All plants grow up together and share whatever light or water or nutrients are available. It is only when the supply of one of these factors becomes critical that competition starts. But it appears likely that in the jungle, as in the desert, survival is taken care of by the control of germination. Competition and selection occur during germination, and we can speak of germination control of the plant community—comparable to birth control in human society.

Apparently evolution has already eliminated most of the plant types that are unable to compete successfully. Fast-growing, slow-growing or tall plants all have the same chances once they have germinated. The struggle for existence is not waged among the well-established plant forms but tends to eliminate new types which germinate at inopportune times, have a decreased ability to photosynthesize or are less frost-resistant. This explains why so few plants die in the desert from drought or in the jungle from lack of light or in cold climates from frost.

As a general moral we conclude that war as man wages it finds no counterpart in nature, and it has no justification on the basis of evolution or natural selection. If we want to describe the process of control of the plant population in human terms, we should talk about birth control.

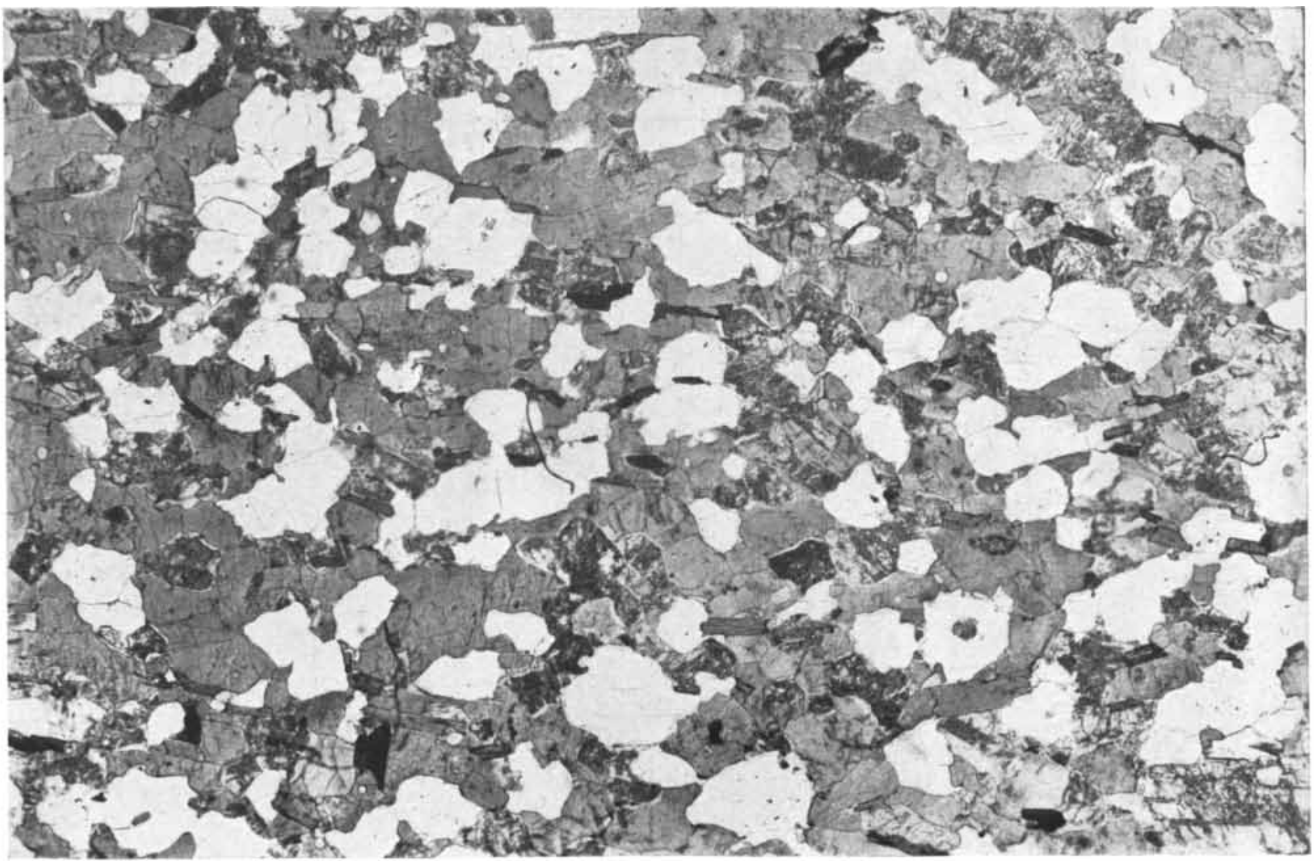
THE ORIGIN OF GRANITE

Geologists debate whether it was formed by (1) crystallization from a melt or (2) alteration of other rocks. An account of experiments on the problem which imitate conditions in the interior of the earth

by O. Frank Tuttle

In the continental areas of our planet the upper 10 miles of the earth crust consists largely of granite or granite-like rocks. This is true not only at the rockbound coast of Maine and in the Rocky Mountains, where the granite is plain to see, but also under the prairies of the Midwest, where the great granite basement is covered with a veneer of soil and sedimentary rock. Granite is a combination of minerals, undoubtedly formed originally from something else. Whence came all the granite? How was it formed? For decades this has been a hotly debated subject in geology, and the controversy has recently reached a high pitch [see "The Crust of the Earth," by Walter H. Bucher; SCIENTIFIC AMERICAN, May, 1950].

The argument has been based mainly on studies of rocks and formations in the field. We decided to investigate the matter in the laboratory; that is, to see whether we could synthesize granite under the conditions assumed by one of the theories of how it is formed in nature. There are three principal theories. Briefly they are: (1) that granites are formed by the metamorphism of other rocks, usually sedimentary, through the

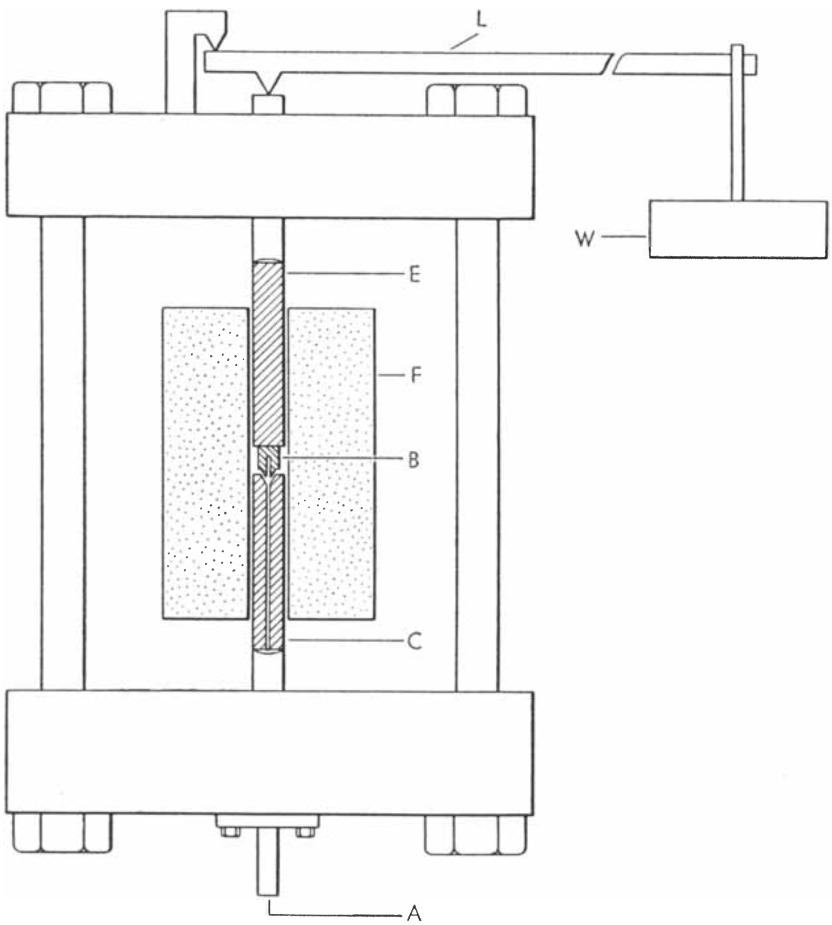


GRANITE consists mainly of three minerals: quartz, orthoclase and albite. In this photomicrograph of a polished section of granite from Westerly, R. I., the quartz is the lightest-colored grains; the orthoclase, the uniformly gray grains; the albite, the irregularly speckled dark grains with a light rim where they touch the grains of orthoclase. The picture enlarges the grains 100 diameters.

action of hot solutions which move up through the rocks and change them chemically; (2) that they are metamorphosed from the same pre-existing rocks not by solutions but by the exchange of ions among rock-forming crystals in the solid state; or (3) that they crystallize from molten magma deep in the earth's crust—the kind of material we know as volcanic lava. The third of these processes would require much higher temperatures than the other two. We undertook to test this hypothesis by investigating the melting and crystallization of granite and its component minerals at high temperatures and high pressures such as must exist far down in the earth's crust.

The first task was to build an apparatus that could produce these extreme conditions. It had to be inexpensive, as financial support for such nonatomic studies does not come freely or in adequate amounts. Fortunately the first try produced an apparatus which proved to be remarkably well suited to our needs [*see diagram below*]. Inside a cylindrical furnace there is a small pressure vessel (B) held between two plungers. The cone-shaped bottom of the vessel fits into a similarly shaped seat in the lower plunger so as to form a seal. The pressure is produced by pumping a liquid or gas (usually water vapor) into the vessel through a channel in the lower plunger. The samples of material to be investigated are placed in tiny platinum crucibles which stand on a pedestal in the pressure vessel.

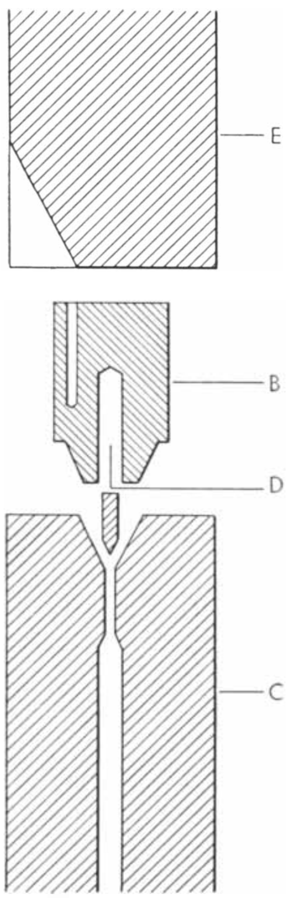
In this apparatus granite and its components have been subjected to temperatures up to 1,200 degrees centigrade and pressures up to 60,000 pounds per square inch. At 60,000 pounds of water-vapor pressure granite melts completely at 640 degrees C. At lower pressures the melting point is higher. Granite can be melted at atmospheric pressure, but then it will not crystallize on cooling; it becomes a glass like the volcanic glasses called obsidian. The high pressure is necessary to dissolve water in the molten



EXPERIMENTAL APPARATUS was used to study the behavior of granite and its constituents at high temperatures and pressures. At left is the entire apparatus; at right is an enlarged portion of it. A gas or liquid is pumped to the desired pressure and admitted to the apparatus at A. The gas or liquid is then conducted to the pressure vessel B through the rod C. The sample to be tested is placed within a small platinum crucible which fits into the granite and reduce its viscosity so that it will recrystallize when cooled.

Granite is made up of three principal minerals: quartz (SiO_2), albite feldspar ($NaAlSi_3O_8$) and orthoclase feldspar ($KAlSi_3O_8$). The average granite contains about equal amounts of these three minerals, together with certain other substances in small quantities.

The first investigations with the high-pressure apparatus were made in collaboration with N. L. Bowen at the Geophysical Laboratory of the Carnegie Institution, where the author was then a staff member. We began by studying mixtures of the principal minerals in granite two at a time. The two minerals were mixed in various proportions, melted and then cooled to see how they would crystallize. Let us see what happens when we heat a mixture of quartz and albite under a water-vapor pressure of, say, 30,000 pounds per square inch. At 740 degrees C. the mixture begins to melt. The molten material at this point will contain 62 per cent albite and 38

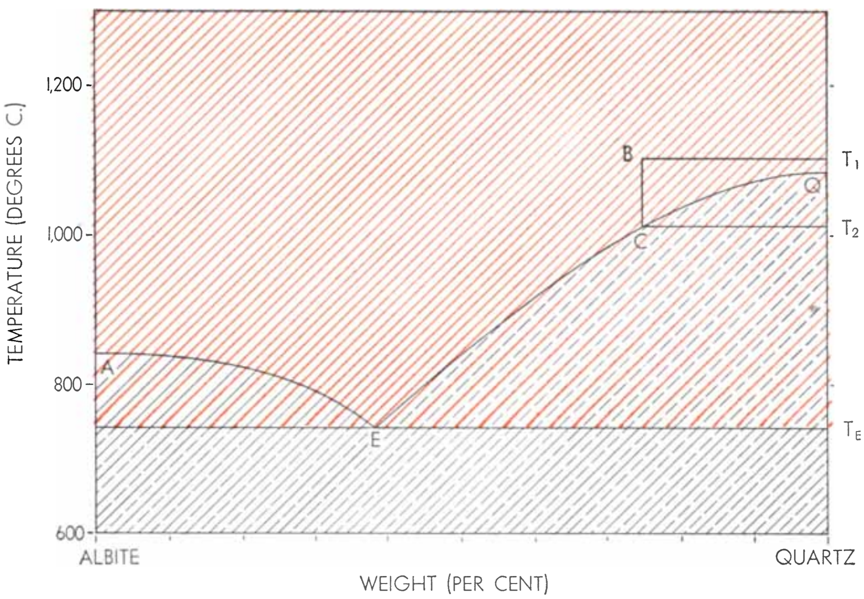


chamber D. The pressure within the chamber is maintained by the downward thrust of the rod E, which is linked to a lever (L) and a weight (W). The chamber is heated by the electric furnace F, which surrounds it.

per cent quartz. If the original solid mixture consists of the two minerals in these proportions, all of it will melt at 740 degrees. But if there is an excess of albite (more than 62 per cent) or an excess of quartz (more than 38 per cent), the excess does not melt at this temperature. Thus if the mixture before heating contained 75 per cent quartz and 25 per cent albite, at 740 degrees all of the albite and part of the quartz melts, but most of the quartz remains suspended in the liquid in solid form as crystals. As the temperature is raised above 740 degrees, more of the quartz dissolves in the liquid, until at 1,010 degrees the mixture is completely liquid.

On cooling, the reverse takes place. If the liquid is 75 per cent quartz and 25 per cent albite, only quartz crystallizes until the temperature drops to 740 degrees and the composition of the liquid is again 62 per cent albite and 38 per cent quartz; thereafter both crystallize together until the whole mixture solidifies. In short, at the joint crystallization point these two minerals will crystallize in certain specific proportions, called the "eutectic" [*see chart below*].

What does this have to do with the origin of granite? Simply this: It suggests a test for deciding whether granite or any similar rock was formed by crystallization of a liquid. If a rock composed of albite and quartz, for instance, was formed in that manner, we should expect to find the two minerals combined in something like the eutectic proportions. The reason is twofold. First, nature is a rather sloppy chemist, and as a liquid slowly crystallizes the precipitating crystals and the liquid are not likely to stay neatly packaged together; the early crystals may settle out by gravity or the liquid may flow away from them. Thus the liquid will tend toward the eutectic composition, where the minerals crystallize together, regardless of what the proportions of the minerals were originally. Second, when a large body of rock is heated to the melting point, the first liquid formed may flow away before melting is completed, and this separated liquid will have the eutectic composition.



RESULTS OF EXPERIMENTS with mixtures of two of the three constituents of granite are summarized in this diagram. The constituents were albite (*lower left*) and quartz (*lower right*). The proportion of each constituent in each mixture is indicated by the percentage scale (*bottom*). At point B, for example, the sample tested was 25 per cent albite and 75 per cent quartz. To the quartz and albite in each sample was added water. For all points plotted on the diagram the water vapor pressure is 30,000 pounds per square inch. When any of the mixtures was heated to a temperature above the curve AEQ, it became liquid (*area marked with red lines*). When it was allowed to cool to a temperature below this curve, it behaved in a characteristic way. For any mixture between A and E, only albite crystals formed at first (*area marked with red and solid black lines*). For any mixture between E and Q, only quartz crystals formed at first (*area marked with red and broken black lines*). Thus a mixture with the composition B will be completely liquid at temperature T_1. When it is allowed to cool to temperature T_2, quartz crystals begin to form. Thereafter, with quartz being removed from the liquid, its composition changes toward a higher proportion of albite along the curve CE. When the temperature falls to T_E, quartz and albite crystallize together in the proportion E—62 per cent albite and 38 per cent quartz.

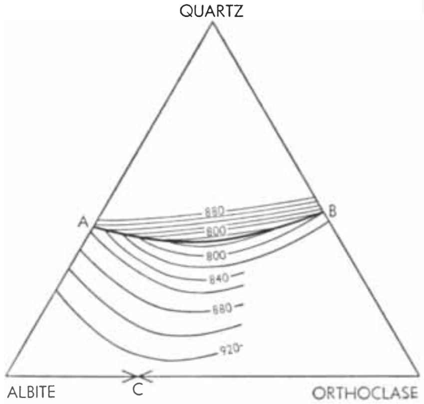
Mixtures of orthoclase and quartz behave essentially like albite and quartz; they, too, crystallize together in definite proportions. The behavior of mixtures of albite with orthoclase is somewhat more complex, because these two feldspars when heated can dissolve completely in each other in the crystalline state. However, the laboratory tests show that melting and crystallization tend to change the original composition: the final composition, if the early-formed crystals are removed, will approach 70 per cent albite and 30 per cent orthoclase.

The remarkable fact is that in nature most rocks composed mainly of albite and orthoclase turn out to have this composition or something close to it. The mixtures of the two feldspars arrived at by crystallization in the laboratory closely approach those of certain natural lava rocks which are known to have gone through a liquid stage.

We now come to mixtures of the three principal constituents of granite—albite, orthoclase and quartz. In order to represent the compositional variations in a liquid with the three components it is convenient to use an equilateral triangle [*see diagram on opposite page*]. A point within the triangle indicates the relative proportions of the three components: for example, the point at the center represents equal amounts of all three; a point inside the triangle near the point A on the left side of the diagram represents a composition consisting of nearly equal amounts of quartz and albite and a small percentage of orthoclase.

This diagram summarizes the results of melting various combinations of the three components under a pressure of 7,500 pounds per square inch and then cooling them. The curved lines with numbers show the temperature at which each composition begins to crystallize. The line A-B marks the boundary between two fields: in any composition above the line, quartz crystallizes first on cooling; in compositions below the line, feldspar crystallizes first. The boundary line itself represents compositions in which quartz and feldspar appear simultaneously on cooling. The most interesting feature of this diagram is the fact that the minimum temperature at which all three components melt simultaneously falls near the center of the triangle, where the composition consists of about equal parts of quartz, albite and orthoclase.

A detailed description of crystallization in this system is beyond the scope

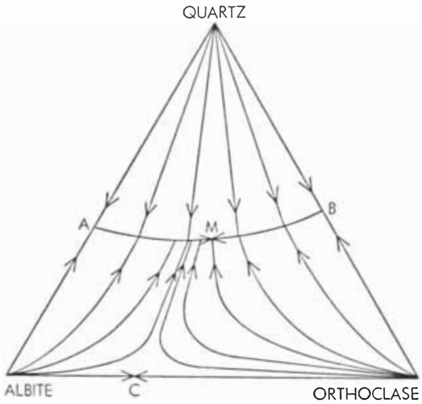


ALL THREE CONSTITUENTS of granite were mixed, heated and allowed to cool in the laboratory. In this diagram each corner of the triangle represents a pure constituent. Each side represents a mixture of two constituents. The interior represents a mixture of three constituents. The percentage of each constituent is measured by a parallel to the opposite side. At a water-vapor pressure of 7,500 pounds per square inch the triangle is divided into two areas: (1) the area quartz-A-B, in which quartz crystals first appear on cooling, and (2) the area albite-A-B-orthoclase, in which feldspar crystallizes first.

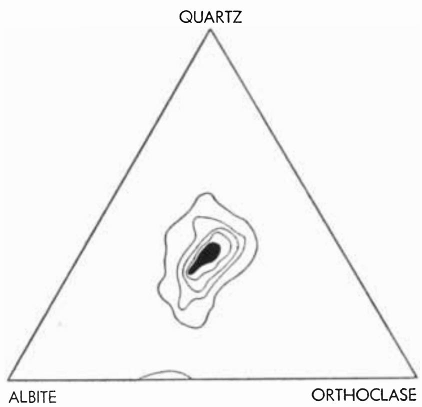
of this article. As only a brief discussion is necessary to understand the general relations, only one type of crystallization will be considered; namely, fractional crystallization where the crystals are assumed to be removed from the liquid during crystallization.

Under these circumstances the composition of the liquid changes during cooling according to the scheme shown in the diagram at the top of the next page. In the quartz field (where the liquid has a preponderance of quartz), only quartz crystallizes as the liquid cools, and this fact is indicated by a straight line going toward the boundary A-B. When the composition of the liquid arrives at that boundary, feldspar also begins to crystallize, and the compositional change moves along the boundary line toward M, where all the remaining liquid must crystallize. Similarly any liquid in the feldspar field (feldspar predominating over quartz) crystallizes only feldspar until it reaches the boundary. In the feldspar field the lines showing the change in composition are curved, because of complications introduced by the fact that albite and orthoclase are soluble in each other in the crystalline state. When the composition reaches the boundary at which quartz begins to crystallize, it again moves along the boundary toward M.

Thus all roads lead to M, and so it



PATHS OF CRYSTALLIZATION at a water-vapor pressure of 30,000 pounds per square inch are plotted on the same diagram as the one on the preceding page. As crystals form in each mixture they change the composition of the liquid in the direction indicated by the arrows on the various curves. This makes the liquids change composition during crystallization toward the point M.



SAMPLES OF GRANITE were analyzed on the same diagram for their content of each constituent. Out of 571 samples about a third fell within the dark contour and the one immediately outside it. Thus the composition of natural granite also tends to move toward M.

SAMPLES OF LAVA were also analyzed on the same diagram for their constituents. Here again the distribution of 361 natural lavas tended to cluster around the point M.

should be in the natural magmas. If granites owe their origin to crystallization from magma, their composition should be somewhere near that at the point M, as determined by the laboratory crystallization experiments. In nature, as in our laboratory manipulation, crystals probably are removed as the liquid cools. It is to be expected that the crystallization of large masses of molten rock, which may take thousands or millions of years, would offer many opportunities for the crystals and liquid to be separated, especially since the crystalline materials have a considerably higher density than the liquid from which they crystallize.

As we have noted, granites generally consist of about equal parts of albite, orthoclase and quartz. The actual compositions of a large number of samples of natural granitic rocks and rocks chemically related to granites are plotted in the two lower diagrams at the left. The contour scheme of the diagrams is the equivalent of a frequency curve, with the black (highest) portion of the plot showing the most frequent composition, and the other contours, descending frequency. By comparing these charts with the diagram at the top of the page one can see that the natural rocks cluster in composition around the point M, exactly as predicted by the experimental studies!

This striking agreement leaves little doubt that granites originate from hot magmas. Those who advocate any other theory of granite formation—*e.g.*, transformation of sedimentary rocks by hot solutions or ions migrating in a solid—will have to explain how their processes could control the composition of the granites to such a strong degree. There is another laboratory finding that argues against these other hypotheses. At low temperatures (below about 660 degrees C.) albite and orthoclase do not dissolve in each other completely. Yet many granites contain the two feldspars in 50-50 proportions and completely mixed together in a homogeneous crystalline phase. It is very difficult to see how the feldspars could be so thoroughly united by a low-temperature process such as transformation by solutions or ion-diffusion.

We must conclude that the laboratory studies strongly support the magma hypothesis. One corollary of this finding is that granitic liquids probably exist in some parts of the earth's crust at all times and that granites are being formed today by the slow crystallization of these liquids deep in the crust.

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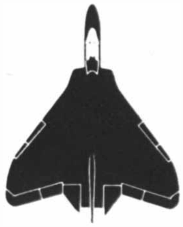

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The Anthropology of Manners

If an American addresses a Latin from a distance of 20 inches, is he impolite? If an Arab arrives for a 2:30 appointment at 2:45, is he late? All about the customs that unconsciously shape our relations

by Edward T. Hall, Jr.

The Goops they lick their fingers
and the Goops they lick their knives;
They spill their broth on the table cloth—
Oh, they lead disgusting lives.
The Goops they talk while eating,
and loud and fast they chew;
And that is why I'm glad that I
am not a Goop—are you?

In Gelett Burgess' classic on the Goops we have an example of what anthropologists call "an enculturating device"—a means of conditioning the young to life in our society. Having been taught the lesson of the goops from childhood (with or without the aid of Mr. Burgess) Americans are shocked when they go abroad and discover whole groups of people behaving like goops—eating with their fingers, making noises and talking while eating. When this happens, we may (1) remark on the barbarousness or quaintness of the "natives" (a term cordially disliked all over the world) or (2) try to discover the nature and meaning of the differences in behavior. One rather quickly discovers that what is good manners in one context may be bad in the next. It is to this point that I would like to address myself.

The subject of manners is complex; if it were not, there would not be so many injured feelings and so much misunderstanding in international circles everywhere. In any society the code of manners tends to sum up the culture—to be a frame of reference for all behavior. Emily Post goes so far as to say: "There is not a single thing that we do, or say, or choose, or use, or even think, that does not follow or break one of the exactions of taste, or tact, or ethics of good manners, or etiquette—call it what you will." Unfortunately many of the most important standards of acceptable behavior in different cultures are elusive: they are intangible, undefined and unwritten.

An Arab diplomat who recently arrived in the U. S. from the Middle East attended a banquet which lasted several hours. When it was over, he met a fellow countryman outside and suggested they go get something to eat, as he was starving. His friend, who had been in this country for some time, laughed and said: "But, Habib, didn't you know that if you say, 'No, thank you,' they think you really don't want any?" In an Arab country etiquette dictates that the person being served must refuse the proffered dish several times, while his host urges him repeatedly to partake. The other side of the coin is that Americans in the Middle East, until they learn better, stagger away from banquets having eaten more than they want or is good for them.

When a public-health movie of a baby being bathed in a bathinette was shown in India recently, the Indian women who saw it were visibly offended. They wondered how people could be so inhuman as to bathe a child in stagnant (not running) water. Americans in Iran soon learn not to indulge themselves in their penchant for chucking infants under the chin and remarking on the color of their eyes, for the mother has to pay to have the "evil eye" removed. We also learn that in the Middle East you don't hand people things with your left hand, because it is unclean. In India we learn not to touch another person, and in Southeast Asia we learn that the head is sacred.

In the interest of intercultural understanding various U. S. Government agencies have hired anthropologists from time to time as technical experts. The State Department especially has pioneered in the attempt to bring science to bear on this difficult and complex problem. It began by offering at the Foreign Service Institute an intensive four-week course for Point 4 technicians. Later these facilities were expanded to include other foreign service personnel.

The anthropologist's job here is not merely to call attention to obvious taboos or to coach people about types of thoughtless behavior that have very little to do with culture. One should not need an anthropologist to point out, for instance, that it is insulting to ask a foreigner: "How much is this in real money?" Where technical advice is most needed is in the interpretation of the unconscious aspects of a culture—the things people do automatically without being aware of the full implications of what they have done. For example, an ambassador who has been kept waiting for more than half an hour by a foreign visitor needs to understand that if his visitor "just mutters an apology" this is not necessarily an insult. The time system in the foreign country may be composed of different basic units, so that the visitor is not as late as he may appear to us. You must know the time system of the country to know at what point apologies are really due.

Twenty years of experience in working with Americans in foreign lands convinces me that the real problem in preparing them to work overseas is not with taboos, which they catch on to rather quickly, but rather with whole congeries of habits and attitudes which anthropologists have only recently begun to describe systematically.

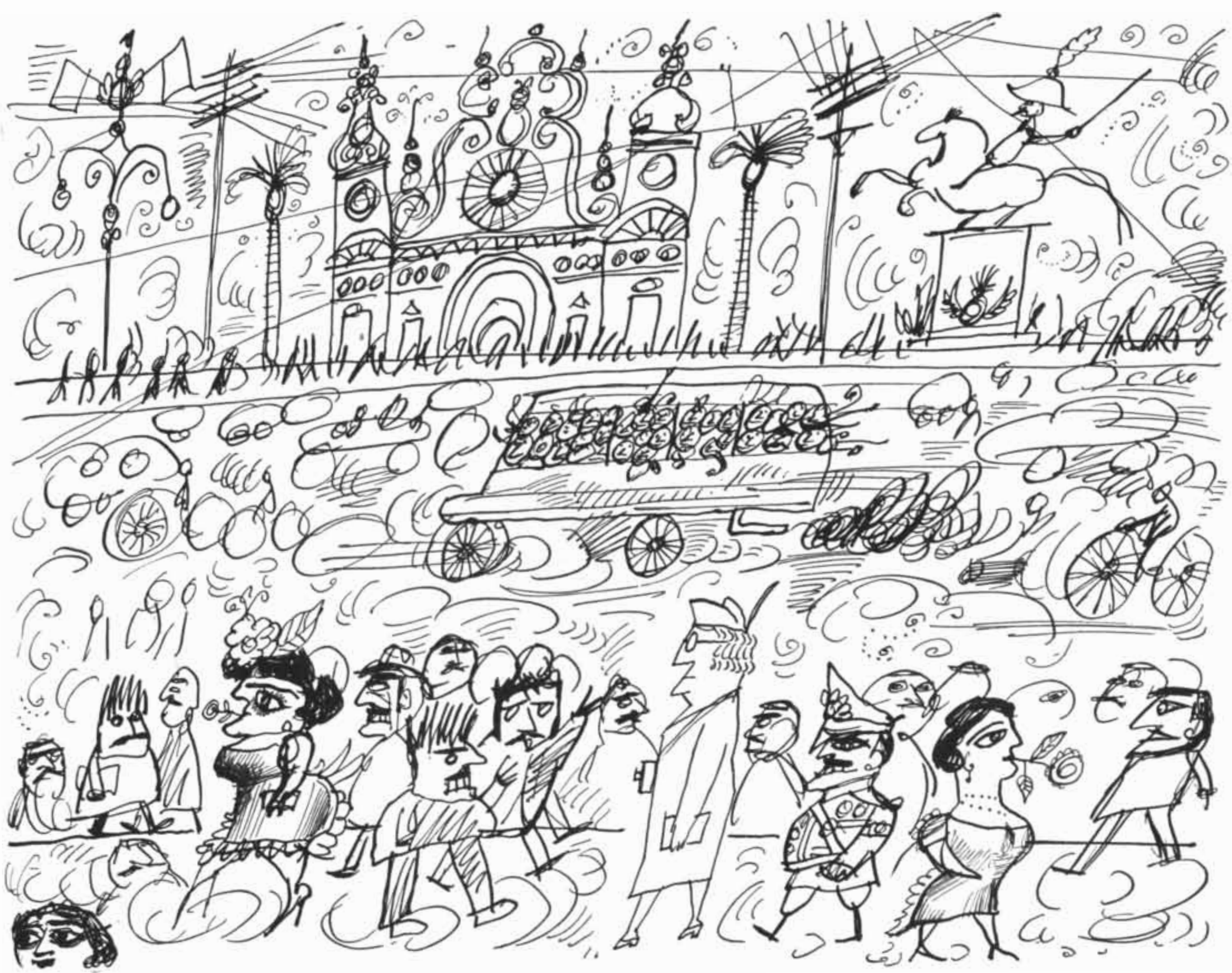
Can you remember tying your shoes this morning? Could you give the rules for when it is proper to call another person by his first name? Could you describe the gestures you make in conversation? These examples illustrate how much of our behavior is "out of awareness," and how easy it is to get into trouble in another culture.

Nobody is continually aware of the quality of his own voice, the subtleties of stress and intonation that color the meaning of his words or the posture and distance he assumes in talking to another person. Yet all these are taken as cues to the real nature of an utterance, regardless of what the words say. A simple illustration is the meaning in the tone of voice. In the U. S. we raise our voices not only when we are angry but also when we want to emphasize a point, when we are more than a certain distance from another person, when we are concluding a meeting and so on. But to the Chinese, for instance, overloudness of the voice is most characteristically associated with anger and loss of self-control. Whenever we become really interested in something, they are apt to have the feeling we are angry, in spite of many years' experience with us. Very likely most of their interviews with us, however cordial, seem to end on a sour note when we exclaim heartily: "WELL, I'M CERTAINLY GLAD YOU DROPPED IN, MR. WONG."

The Latin Americans, who as a rule take business seriously, do not understand our mixing business with informality and recreation. We like to put our feet up on the desk. If a stranger enters the office, we take our feet down. If it turns out that the stranger and we have a lot in common, up go the feet again—a cue to the other fellow that we feel at ease. If the office boy enters, the feet stay up; if the boss enters and our relationship with him is a little strained at the moment, they go down. To a Latin American this whole behavior is shocking. All he sees in it is insult or just plain rudeness.

Differences in attitudes toward space—what would be territoriality in lower forms of life—raise a number of other interesting points. U. S. women who go to live in Latin America all complain about the "waste" of space in the houses. On the other hand, U. S. visitors to the Middle East complain about crowding, in the houses and on the street cars and buses. Everywhere we go space seems to be distorted. When we see a gardener in the mountains of Italy planting a single row on each of six separate terraces, we wonder why he spreads out his crop so that he has to spend half his time climbing up and down. We overlook the complex chain of communication that would be broken if he didn't cultivate alongside his brothers and his cousin and if he didn't pass his neighbors and talk to them as he moves from one terrace to the next.

A colleague of mine was caught in a snowstorm while traveling with companions in the mountains of Lebanon. They stopped at the next house and asked to be put up for the night. The



The American in Latin America

house had only one room. Instead of distributing the guests around the room, their host placed them next to the pallet where he slept with his wife—so close that they almost touched the couple. To have done otherwise in that country would have been unnatural and unfriendly. In the U. S. we distribute ourselves more evenly than many other people. We have strong feelings about touching and being crowded; in a streetcar, bus or elevator we draw ourselves in. Toward a person who relaxes and lets himself come into full contact with others in a crowded place we usually feel reactions that could not be printed on this page. It takes years for us to train our children not to crowd and lean on us. We tell them to stand up, that it is rude to slouch, not to sit so close or not to "breathe down our necks." After a while they get the point. By the time we Americans are in our teens we can tell what relationship exists between a man and woman by how they walk or sit together.

In Latin America, where touching is more common and the basic units of space seem to be smaller, the wide automobiles made in the U. S. pose problems. People don't know where to sit. North Americans are disturbed by how close the Latin Americans stand when they converse. "Why do they have to get so close when they talk to you?" "They're so pushy." "I don't know what it is, but it's something in the way they stand next to you." And so on. The Latin Americans, for their part, complain that people in the U. S. are distant and cold—*retraídos* (withdrawing and uncommunicative).

An analysis of the handling of space during conversations shows the following: A U. S. male brought up in the Northeast stands 18 to 20 inches away when talking face to face to a man he does not know very well; talking to a woman under similar circumstances, he increases the distance about four inches. A distance of only eight to 13 inches between males is considered either very aggressive or indicative of a closeness of a type we do not ordinarily want to think about. Yet in many parts of Latin America and the Middle East distances which are almost sexual in connotation are the only ones at which people can talk comfortably. In Cuba, for instance, there is nothing suggestive in a man's talking to an educated woman at a distance of 13 inches. If you are a Latin American, talking to a North American at the distance he insists on maintaining is like trying to talk across a room.

To get a more vivid idea of this problem of the comfortable distance, try starting a conversation with a person eight or 10 feet away or one separated from you by a wide obstruction in a store or other public place. Any normally enculturated person can't help trying to close up the space, even to the extent of climbing over benches or walking around tables to arrive within comfortable distance. U. S. businessmen working in Latin America try to prevent people from getting uncomfortably close by barricading themselves behind desks, typewriters or the like, but their Latin American office visitors will often climb up on desks or over chairs and put up with loss of dignity in order to establish a spatial context in which interaction can take place for them.

The interesting thing is that neither party is specifically aware of what is wrong when the distance is not right. They merely have vague feelings of discomfort or anxiety. As the Latin American approaches and the North American backs away, both parties take offense without knowing why. When a North American, having had the problem pointed out to him, permits the Latin American to get close enough, he will immediately notice that the latter seems much more at ease.

My own studies of space and time have engendered considerable cooperation and interest on the part of friends and colleagues. One case recently reported to me had to do with a group of seven-year-olds in a crowded Sunday-school classroom. The children kept fighting. Without knowing quite what was involved, the teacher had them moved to a larger room. The fighting stopped. It is interesting to speculate as to what would have happened had the children been moved to a smaller room.

The diplomat and the "native"

The embarrassment about intimacy in space applies also to the matter of addressing people by name. Finding the proper distance in the use of names is even more difficult than in space, because the rules for first-naming are unbelievably complex. As a rule we tend to stay on the "mister" level too long with Latins and some others, but very often we swing into first naming too quickly, which amounts to talking down to them. Whereas in the U. S. we use Mr. with the surname, in Latin America the first and last names are used together and señor (Sr.) is a title. Thus when one says, "My name is Sr. So-and-So," it is interpreted to mean, "I am the Honorable, his Excellency So-and-So." It is no wonder that when we stand away, barricade ourselves behind our desks (usually a reflection of status) and call ourselves mister, our friends to the south wonder about our so-called "good-neighbor" policy and think of us as either high-hat or unbelievably rude. Fortunately most North Americans learn some of these things after living in Latin America for a while, but the aversion to being touched and to touching sometimes persists after 15 or more years of residence and even under such conditions as intermarriage.

The difference in sense of time is another thing of which we are not aware. An Iranian, for instance, is not taught that it is rude to be late in the same way that we in the U. S. are. In a general way we are conscious of this, but we fail to realize that their time system is structured differently from ours. The different cultures simply place different values on the time units.

Thus let us take as a typical case of the North European time system (which has regional variations) the situation in the urban eastern U. S. A middle-class business man meeting another of equivalent rank will ordinarily be aware of being two minutes early or late. If he is three minutes late, it will be noted as significant but usually neither will say anything. If four minutes late, he will mutter something by way of apology; at five minutes he will utter a full sentence of apology. In other words, the major unit is a five-minute block. Fifteen minutes is the smallest significant period for all sorts of arrangements and it is used very commonly. A half hour of course is very significant, and if you spend three quarters of an hour or an hour, either the business you transact or the relationship must be important. Normally it is an insult to keep a public figure or a person of significantly higher status than yourself waiting even two or three minutes, though the person of higher position can keep you waiting or even break an appointment.

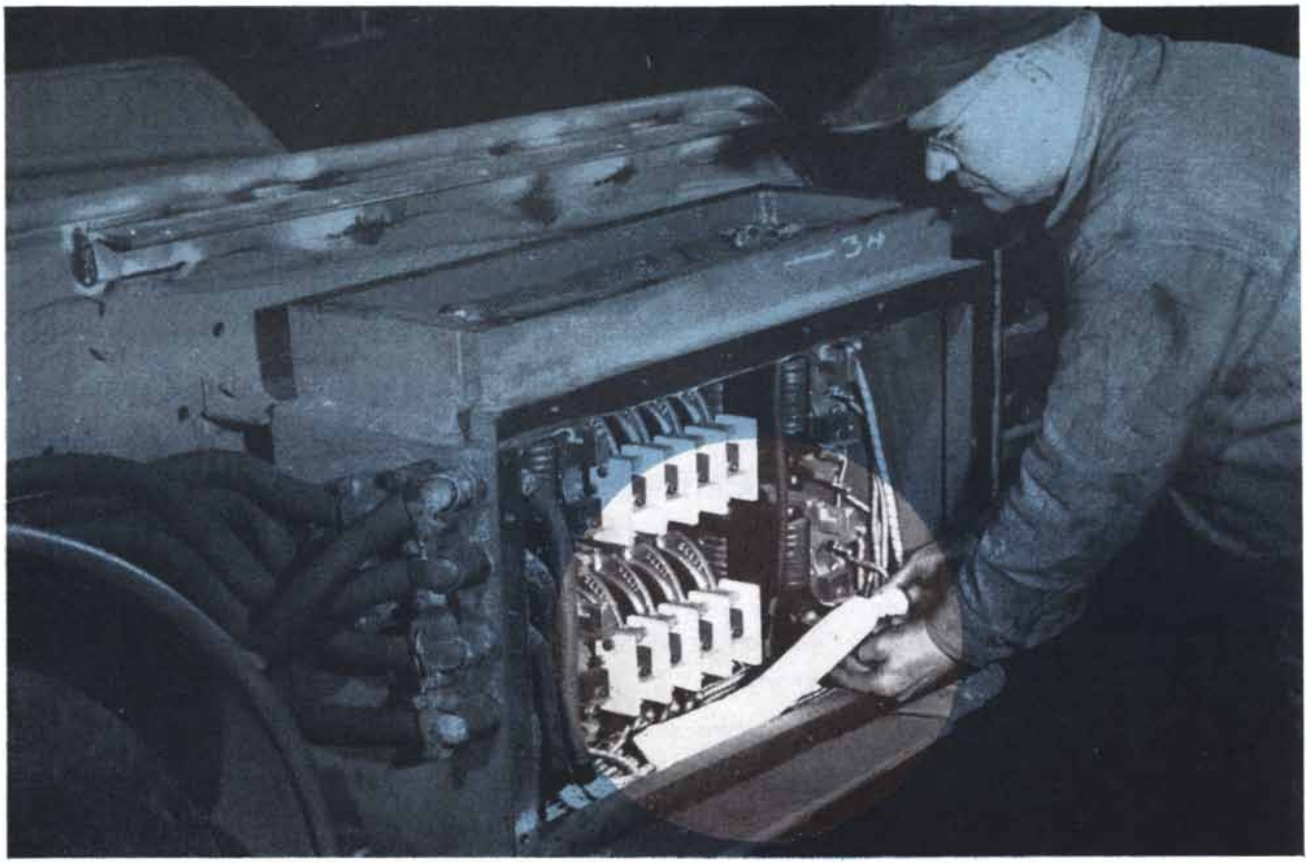
Now among urban Arabs in the Eastern Mediterranean, to take an illustrative case of another time system, the unit that corresponds to our five-minute period is 15 minutes. Thus when an Arab arrives nearly 30 minutes after the set time, by his reckoning he isn't even "10 minutes" late yet (in our time units). Stated differently, the Arab's tardiness will not amount to one significant period (15 minutes in our system). An American normally will wait no longer than 30 minutes (two significant periods) for another person to turn up in the middle of the day. Thereby he often unwittingly insults people in the Middle East who want to be his friends.

How long is one expected to stay when making a duty call at a friend's house in the U. S.? While there are regional variations, I have observed that the minimum is very close to 45 minutes, even in the face of pressing commitments elsewhere, such as a roast in the oven. We may think we can get away in 30 minutes by saying something about only stopping for "a minute," but usually we discover that we don't feel comfortable about leaving until 45 minutes have elapsed. I am referring to afternoon social calls; evening calls last much longer and operate according to a different system. In Arab countries an American paying a duty call at the house of a desert sheik causes consternation if he gets up to leave after half a day. There a duty call lasts three days—the first day to prepare the feast, the second for the feast itself and the third to taper off and say farewell. In the first half day the sheik has barely had time to slaughter the sheep for the feast. The guest's departure would leave the host frustrated.

There is a well-known story of a tribesman who came to Kabul, the capital of Afghanistan, to meet his brother. Failing to find him, he asked the merchants in the market place to tell his brother where he could be found if the brother showed up. A year later the tribesman returned and looked again. It developed that he and his brother had agreed to meet in Kabul but had failed to specify what year! If the Afghan time system were structured similarly to our own, which it apparently is not, the brother would

Western culture in the Middle East

Stop moisture on the spot



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Workman installs Dri-Pak drying unit in electrical compartment of a mining shuttle car. Manufactured by National Mine Service Company, 564 Alcoa Building, Pittsburgh 19, Pa., units use ALCOA Activated Alumina H-151 to effectively reduce moisture and corrosive effects of dampness.

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not offer a full sentence of apology until he was five years late.

Informal units of time such as "just a minute," "a while," "later," "a long time," "a spell," "a long, long time," "years" and so on provide us with the culturological equivalent of Evil-Eye Fleegle's "double-whammy" (in *Li'l Abner*). Yet these expressions are not as imprecise as they seem. Any American who has worked in an office with someone else for six months can usually tell within five minutes when that person will be back if he says, "I'll be gone for a while." It is simply a matter of learning from experience the individual's system of time indicators. A reader who is interested in communications theory can fruitfully speculate for a while on the very wonderful way in which culture provides the means whereby the receiver puts back all the redundant material that was stripped from such a message. Spelled out, the message might go somewhat as follows: "I am going downtown to see So-and-So about the Such-and-Such contract, but I don't know what the traffic conditions will be like or how long it will take me to get a place to park nor do I know what shape So-and-So will be in today, but taking all this into account I think I will be out of the office about an hour but don't like to commit myself, so if anyone calls you can say I'm not sure how long I will be; in any event I expect to be back before 4 o'clock."

Few of us realize how much we rely on built-in patterns to interpret messages of this sort. An Iranian friend of mine who came to live in the U. S. was hurt and puzzled for the first few years. The new friends he met and liked would say on parting: "Well, I'll see you later." He mournfully complained: "I kept expecting to see them, but the 'later' never came." Strangely enough we ourselves are exasperated when a Mexican can't tell us precisely what he means when he uses the expression *mañana*.

The role of the anthropologist in preparing people for service overseas is to open their eyes and sensitize them to the subtle qualities of behavior—tone of voice, gestures, space and time relationships—that so often build up feelings of frustration and hostility in other people with a different culture. Whether we are going to live in a particular foreign country or travel in many, we need a frame of reference that will enable us to observe and learn the significance of differences in manners. Progress is being made in this anthropological study, but it is also showing us how little is known about human behavior.

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THE T2 MYSTERY

T2 is a virus which dissolves bacteria. Normally its attack is followed by the appearance of a generation of new viruses. But sometimes the viruses appear to be missing. Why?

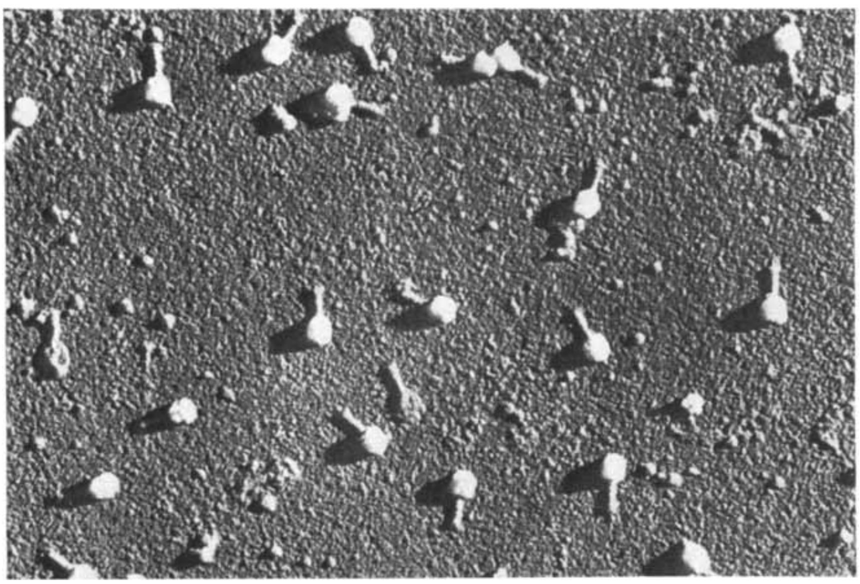
by Salvador E. Luria

Our story has as its critical episode one of those coincidences that show how discovery often depends on chance, or rather on what has been called "serendipity"—the chance observation falling on a receptive eye. The episode is a good illustration of the principle of "controlled sloppiness," which states that it often pays to do somewhat untidy experiments, provided one is aware of the element of untidiness. In this way unexpected results, sometimes real discoveries, have a chance to come up. When they do, we can trace their cause to the untidy, but known, features of the experiment.

The story has to do with bacteriophages, or bacterial viruses. The habits and reproductive cycle of these bacteria-infecting viruses are familiar to the readers of SCIENTIFIC AMERICAN. A virus particle attaches itself to a susceptible bacterium and injects its reproductive material, mainly nucleic acid; this material multiplies in the bacterial cell, and within half an hour the bacterium dissolves and out come hundreds of new mature virus particles.

In 1946, while experimenting with infection of the common colon bacterium *Escherichia coli* by the bacterial virus called T2, I noticed a peculiar violation of the usual pattern of events. Certain mutant strains of the bacterium took up the virus, were duly dissolved after the customary period but produced no detectable viruses! When the material was tested, no trace of infectious virus could be found in it. I explored this phenomenon a little further, but after playing around with it for a few weeks and getting nowhere, I shelved it in my mental files as the "T2 mystery."

In 1950 I returned to the problem. I had become interested in the study of incomplete virus particles as possible precursors of viruses, and it seemed that the juice from the bacterial mutants might be a good place to look for such precursors—arrested viruses, as it were. I proceeded to re-examine the matter with a co-worker, Mary Human.



T2 VIRUSES have polygonal heads and short tails. In this electron micrograph, made by A. E. Vatter of the University of Illinois, the virus particles are enlarged 70,000 diameters.

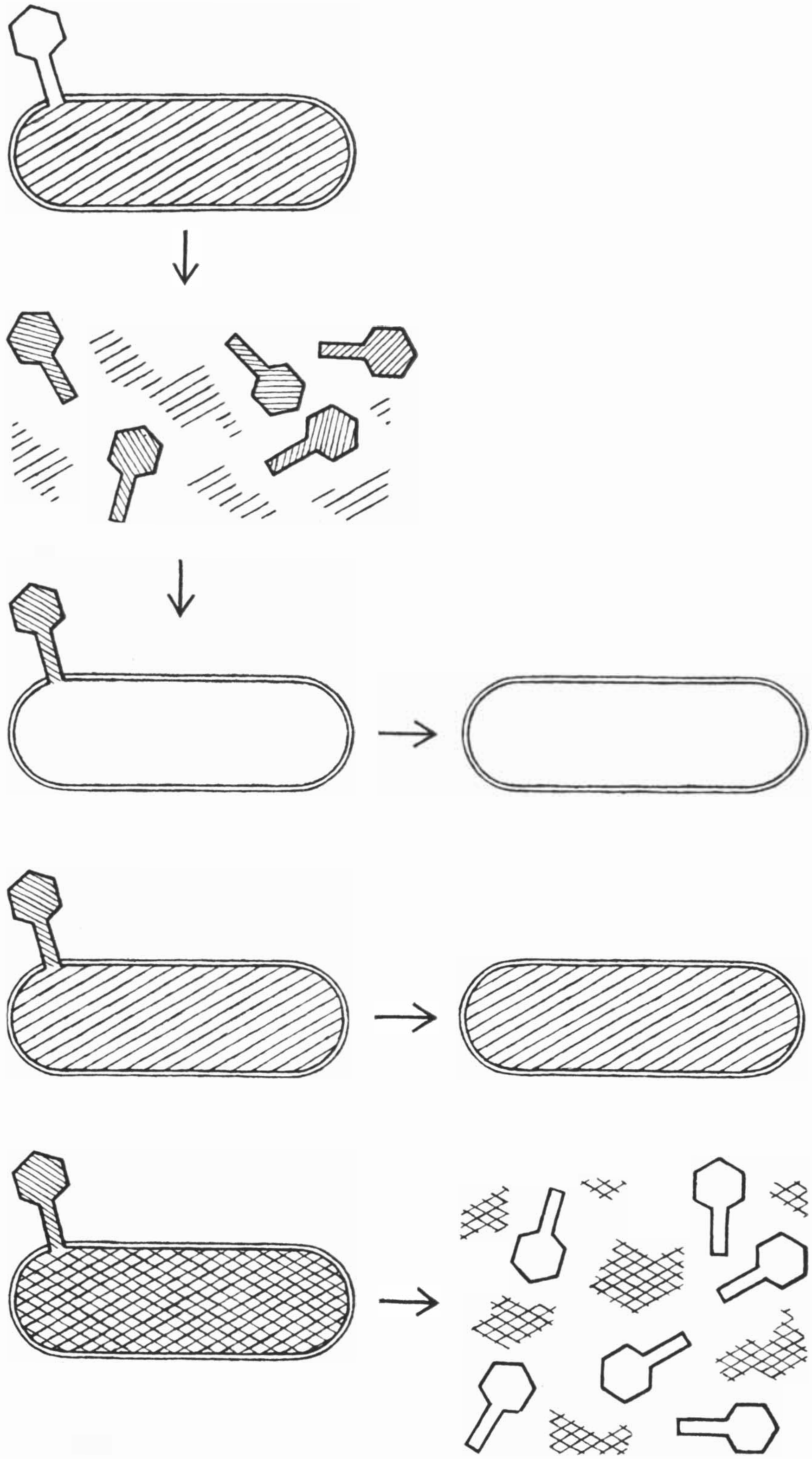
One day, in preparation for more complicated experiments, we decided to add some streptomycin to the juice from the dissolved bacteria. To carry out the measurements we planned to make, we needed bacteria resistant to streptomycin. It happened that no streptomycin-resistant culture of *Escherichia coli* had been prepared in the laboratory that day. Rather than wait, Mrs. Human decided to use an available streptomycin-resistant culture of another bacterium which is susceptible to T2: namely, the dysentery bacillus (*Shigella dysenteriae*). Of course the substitution made it not a "clean" test. But since virus T2 seemed to behave alike on both hosts, it hardly seemed to matter.

The next day the T2 mystery was solved; or rather, as often happens in science, it had been transformed into a bigger one. The juice from the dissolved coli bacteria, which had seemed virus-free, raised havoc with the dysentery bacilli. In other words, it contained plenty of infectious virus, but the virus was infectious only to the dysentery bacteria not to the coli. The mutant coli cells in which the virus had reproduced had changed it somehow. But the change was not profound: we discovered immediately that after a single cycle of reproduction in the dysentery bacilli, the virus reverted to the original T2 type—that is, it could infect coli again!

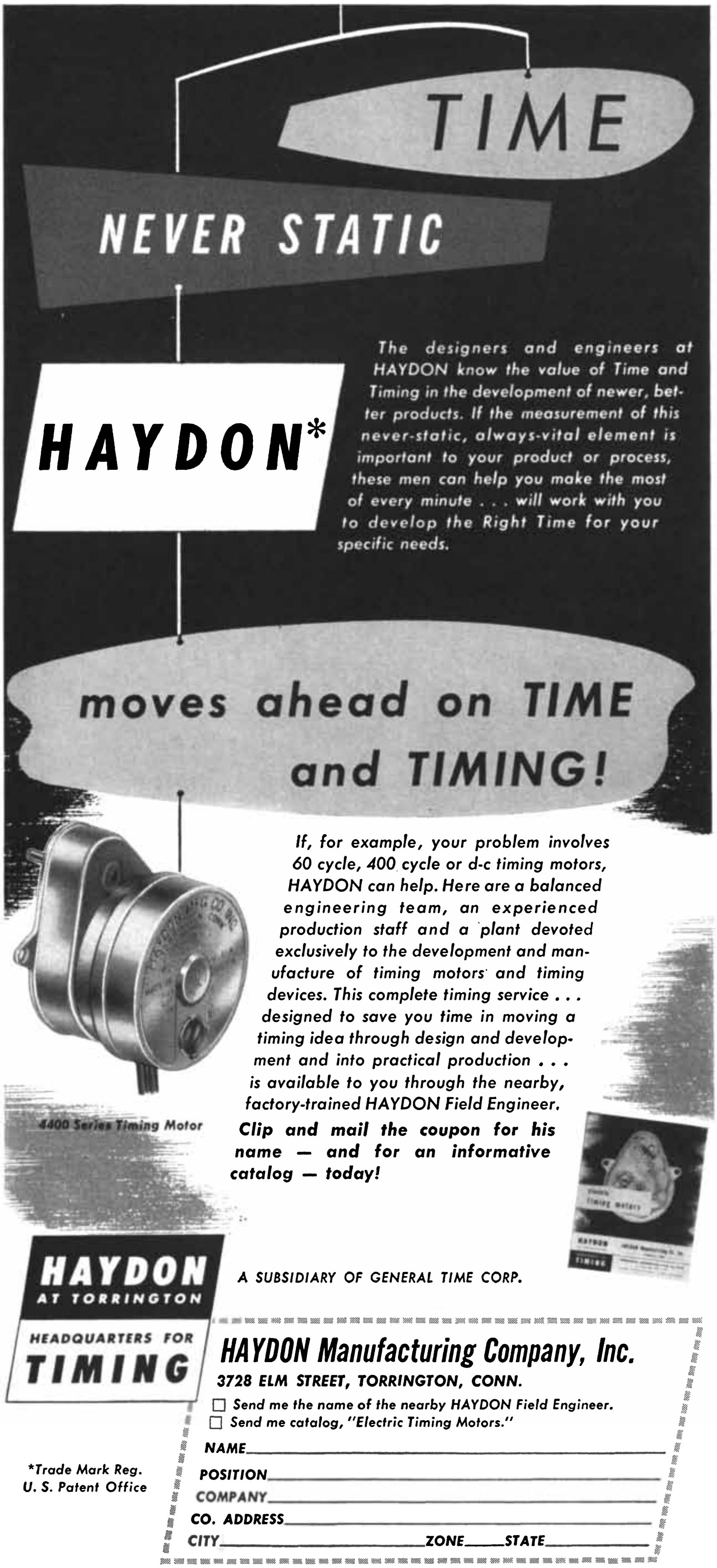
This was a great surprise. If the virus had undergone a stable, hereditary change during reproduction in the unusual, mutant coli, that would have been understandable. It is not uncommon, when a virus invades a new host, for a mutant type of virus to emerge and become dominant. In that case the host has simply favored mutant viruses which happen to be present; it has not itself modified the virus. But no mutation was involved in the change of the T2 virus to the new type and back. Every T2 particle multiplying in mutant coli produced only progeny of the modified type, and every virus of the modified type gave only progeny of the original T2 type when it reproduced in dysentery bacilli. What we had, in short, was a nonhereditary modification of the virus imposed by the host bacterium itself.

Within a few months workers in many laboratories found cases of host-induced modifications in all sorts of bacteriophages besides T2. There was one important difference, however. The modification of T2 is "nonadaptive;" that is, the modified virus cannot grow in the host that changed it. In most of the other cases the changes are adaptive: the changed virus can grow in the host that modified it but becomes unable to grow in a second host, and when occasionally a particle manages to overcome the restriction against growing in the second host, it immediately gives rise to fully adapted particles. Return to the first host erases the adaptation completely. The virus has no "memory" of any host but the very last. Each modification eliminates all the previous ones.

The discovery of the ability of bacteria to alter their parasites raised a number of questions. First of all, what property of a bacterium gives it this power? Clearly the answer lies in the genetic make-up of the bacterium. A single mutation in the common coli bacterium, for instance, transforms it into the mutant variety that modifies the T2 virus. A most remarkable thing is that viruses themselves sometimes bestow the virus-modifying property on bacteria. There is a latent form of virus known as "provirus," or "prophage" [see "The Life Cycle of a Virus," by André Lwoff; SCIENTIFIC AMERICAN, March, 1954]. The prophage, apparently incorporated in the chromosomes of the host bacterium and multiplying with them, occasionally turns into full-fledged virus and destroys the bacterium. Some prophages control the production of substances by their hosts (*e.g.*, diphtheria toxin) or have other important effects on them. Now two British bacteriologists, E. S.



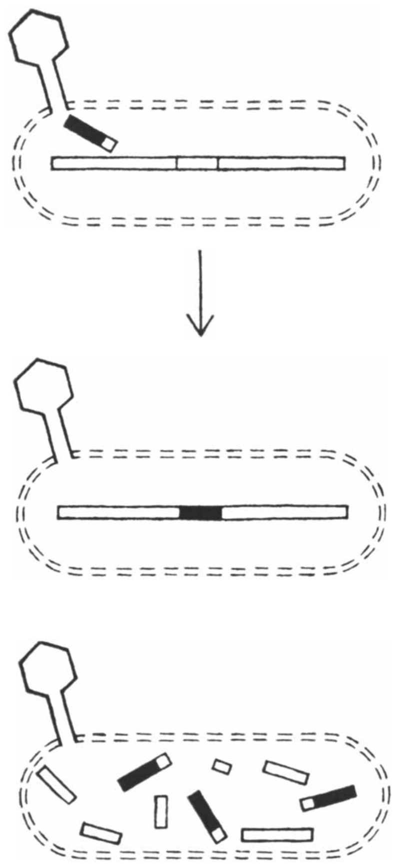
MYSTERY IS EXPLAINED by this diagram. A normal T2 virus infects a mutant variety of the bacterium *Escherichia coli* (*first horizontal row*). The bacterium dissolves, liberating not normal viruses but modified ones (*second row*). When one of these modified viruses attacks a normal bacterium (*third row, left*), the bacterium dies but no new viruses appear (*third row, right*). When a modified virus attacks a mutant bacterium (*fourth row, left*), the same thing happens (*fourth row, right*). When a modified virus attacks the entirely different bacterium *Shigella dysenteriae* (*fifth row, left*), the bacterium dissolves and liberates normal viruses like the one which attacked *Escherichia coli* (*fifth row, right*).



Anderson and A. Felix, have discovered that a prophage can cause certain typhoid bacilli to produce modifications in viruses completely unrelated to the prophage.

In our laboratory Seymour Lederberg has discovered recently that a single virus particle can possess two distinct host-induced modifications. The virus is first modified so that it can grow in a host in which it could not grow before. A second modification enables it to grow in a host containing a certain prophage. Both adaptations are reversible: they can be removed by letting the modified virus reproduce a new generation in an appropriate normal host.

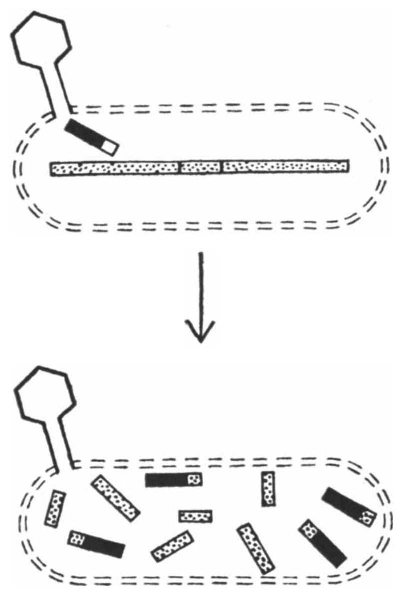
These findings prove that a bacte-



MYSTERY IS INTERPRETED at the level of the chromosome. A normal virus injects its nucleic acid into a normal bacterium (*top*). The viral nucleic acid is represented by the short rectangle; the bacterial chromosome, by the long one. The short rectangle is divided into two parts. One of them (*white*) can be modified separately by the bacterium. The segment in the middle of the bacterial chromosome is the region at which it is attacked by the viral nucleic acid. Normally one of two things might happen. The viral nucleic acid might incorporate itself into the chromosome as "prophage" (*middle*). Or the viral nucleic acid might reproduce itself and destroy the chromosome (*bottom*).

rium's modifying influence on a virus can be traced to specific portions of the host's hereditary material. Indeed, the prophage-controlled properties of bacteria may become extremely useful in the study of latent viruses and of gene action in general.

Exactly what are the changes that occur in a modified virus? We still do not know, but we can guess where to look for the differences between the original and the altered virus. The critical stage in the life cycle of a bacterial virus comes just after its hereditary material, the nucleic acid DNA, invades the bacterium. There is a good deal of circumstantial evidence that the injected virus material ordinarily establishes some contact with the nucleus of the host cell. There it takes one of two courses: it may become integrated with the host nucleus as prophage or it may begin at once to reproduce as virus. Now when a virus is modified in such a way that it cannot grow in a certain host, the halt in its development comes at this early stage. The virus's reproductive material penetrates into the host, but somehow it fails to make the proper adjustments for reproduction. It neither reproduces nor becomes prophage. The guess is that this failure is due to a change in the virus's nucleic acid which prevents it from establishing fruitful contact with the nuclear material of the host. One piece of evidence which may support this concept is that some modified viruses



NORMAL VIRUS injects its nucleic acid into a mutant bacterium. Here one part of the viral nucleic acid (*stippled*) might be modified by the bacterium. Thus the bacterium would liberate modified viruses.

CORNING GLASS BULLETIN

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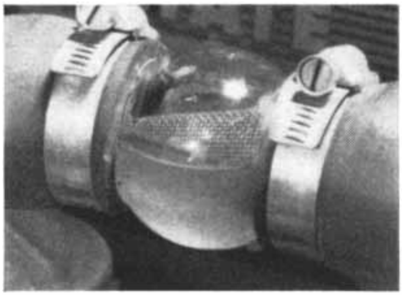

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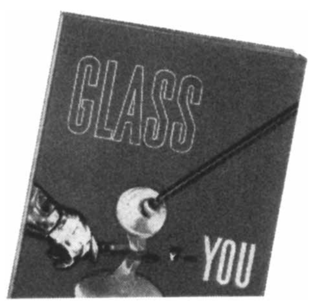

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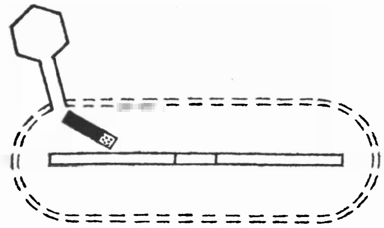
City __________ Zone ______ State ______ can be made to grow in unreceptive hosts by pretreating the host cells with ultraviolet light, which acts rather specifically on their nuclear apparatus and may facilitate successful contact.

Is it possible that modifications like those in bacterial viruses may occur in the viruses responsible for human diseases? We have no way of knowing so far; indeed, there is no evidence that the multiplication of viruses in animal cells is at all like the reproduction of bacterial viruses. Yet the Australian virologist H. J. F. Cairns has observed a suggestive parallel. When influenza virus grown in a chicken egg is transferred to the brain of a mouse, it multiplies only in the first batch of cells that it meets and no further. Cairns suggests that the brain cells may modify the virus in such a way that it ceases to be able to grow in such cells, though the modified virus can still grow in eggs—just as the modified T2 virus becomes unable to grow in the coli cells that produced it but can multiply in the dysentery bacillus.

This gives rise to some interesting speculations. If animal cells can modify viruses, they might well control the spread of viruses in animal tissues. Some viruses that have multiplied in certain organs can be stopped by others. We may even speculate about the possibility that there are viruses which transform normal cells into tumor cells and then are so modified themselves in the latter that they cannot reproduce further.

A new view of the nature of viruses is emerging. They used to be thought of solely as foreign intruders—strangers to the cells they invade and parasitize. But recent findings, including the discovery of host-induced modifications of viruses, emphasize more and more the similarity of viruses to hereditary units such as genes. Indeed, some viruses are being considered as bits of heredity in search of a chromosome.



MODIFIED VIRUS injects its nucleic acid into a normal bacterium. Here the modified viral nucleic acid is unable to make fruitful contact with the chromosome. Accordingly the virus does not reproduce.

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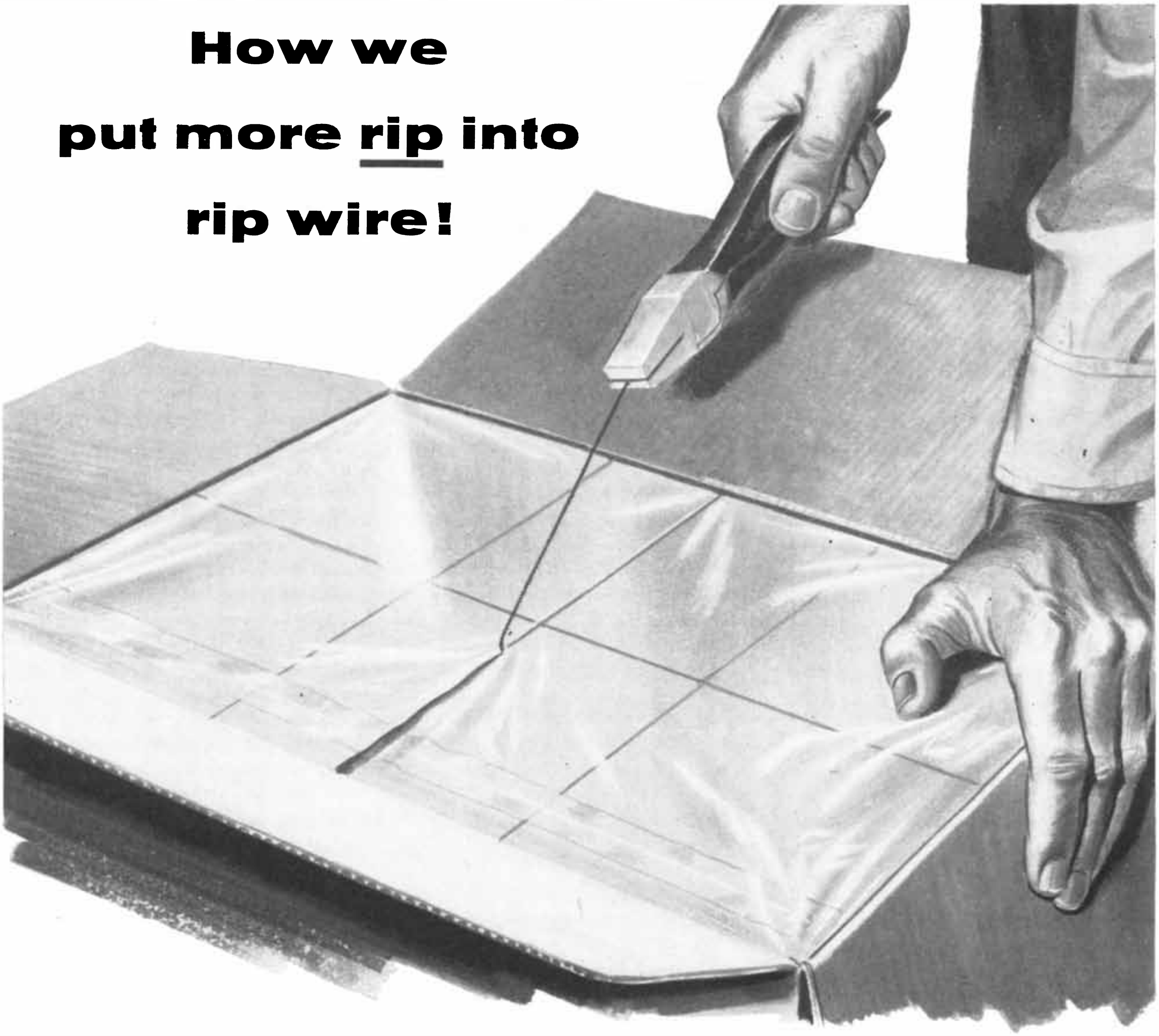

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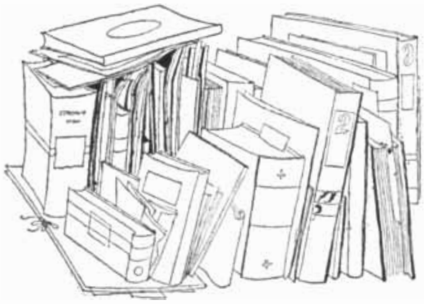

BOOKS

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by Donald A. Bloch

THE MENTAL HOSPITAL, by Alfred H. Stanton and Morris S. Schwartz. Rinehart & Company ($7.50).

Dr. Stanton, a psychiatrist, and Dr. Schwartz, a sociologist, have collaborated on a study of the social structure of a psychiatric hospital as it bears on the mental health of the patients. A mental hospital today is a place where people usually receive psychiatric treatment, but it is also a dynamic living situation whose total impact has a large effect on the patient. What happens during the "other" 23 hours of the day—the hours when the patient is not being "treated" by a doctor but is simply living in the special environment of the hospital? In this book Stanton and Schwartz examine the interactions of the hospital patients and staff in the light of modern sociological and psychological theory.

The study of mental functioning and malfunctioning from the sociological point of view has lagged behind the biological and psychological approaches. Until fairly recently social scientists lacked a fruitful conceptual basis for relating personality to culture. They tended to think of culture and personality as separate entities which "acted upon" each other in a stimulus-response manner. The environment, for instance, pushed the button and the organism responded. Now the accumulating evidence that interaction goes on between the individual and his environment constantly, each shaping the other, has led to the development of a "field theory" which has proved useful as a tool for understanding interpersonal relations. Stanton and Schwartz attempt to use this concept to study the mental hospital as a community.

One test of a mental hospital is its functioning as a "hotel"—how humanely and considerately it cares for its guests. But humane and decent care is not enough: the social structure is even more important. This was demonstrated in England during World War II when the British evacuated thousands of children from the large cities to institutions in the country, separating them from their families. The children lived in groups as in a hotel, cared for by the institutional staff. They were well treated, comforted and reassured. Despite this many children showed personality changes: they regressed to babyish behavior, lost the emotional sparkle of childhood, and there was a flat, lifeless quality about them. Their hosts, having to deal with large numbers of children, treated them fairly but impersonally, with emphasis on rules. In an attempt to provide a warmer emotional climate, Anna Freud and Dorothy Burlingham at the Hampstead Nursery set up artificial "families." Each worker became a substitute mother in exclusive charge of a small group of about four children. The result was astonishing. The children at first showed their need for mothering by bursts of tears and jealous possessiveness and then settled down to a more natural life. Their improvement was noticeable in such things as toilet training and speech development. Incidentally, this lesson was applied during the Netherlands floods of 1953, when the World Health Organization advised the Dutch to keep children with their families in spite of personal hardship rather than to evacuate them to Germany. It was the first instance of a mental health measure on an international scale.

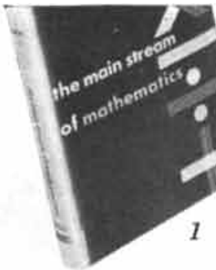
Stanton and Schwartz consider the relationship between social behavior and events of psychological significance in the mental hospital. These "events" may be any manifestation of mental functioning, including withdrawal, excitement, participation, aggressive actions, incontinence, as well as feelings, thoughts and moods. The hospital studied was a small, private mental hospital, and attention was focused particularly on the ward for disturbed women.

The investigators were participants as well as observers. Of course one cannot be a participant in personal relations without modifying the very thing one is observing. A similar dilemma exists in modern physics: the only way one can learn what certain small particles are doing is to make them do something else. If you wish to study what produces a rage attack in a patient, you need to be around to watch what happens, though the patient may become furious at being watched. You may take yourself out of the way and watch him through a one-way vision screen, but then the isolation may enrage him. This epistemological problem is best solved by following the classical dictum, "If you can't beat 'em, join 'em." The observer must participate, but he must also be alert to the effects of his participation.

During the period of the study Stanton was the administrator of the ward for disturbed women. As administrator he made the decisions about patients' privileges and in one way or another was deeply involved in all the ward activities. Schwartz, the sociologist, spent a great deal of time in the ward quietly collecting data. The patients and staff knew that a research project was going on and came to accept Schwartz as someone who had no function other than observation.

In a study of this kind it is vital to understand clearly what it means to be a mental patient. As the authors point out, one may "run the risk of minimizing the vast amount of suffering the mental patient experiences. . . . It is hard to keep in mind what it means subjectively to be a mental patient, to be so fearful that each aspect of the environment represents a threat to one's existence; to experience the world as unreal and to see the 'outside' as just a flimsy structure with no substance; to live with the feeling of restraint and being closed in, or suffocated, and to feel rebellion and resentment at this and be unable to express it in any effective way; to experience utter, desperate and unrelieved loneliness, with no hope of change; to feel that in the entire universe there is no person that will ever understand one; to believe that one's actions have no effect and that one is not affected by the actions of others."

A psychiatric hospital is a place of



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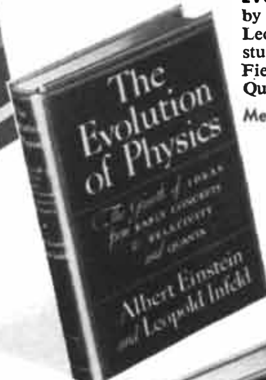

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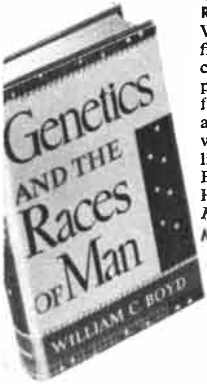

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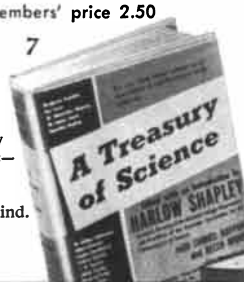

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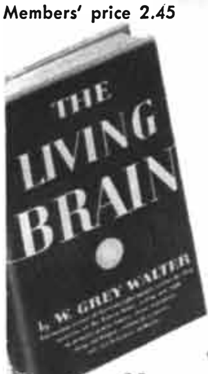

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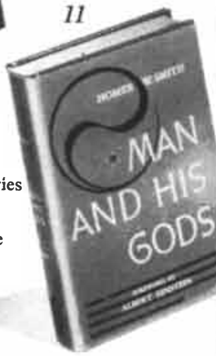

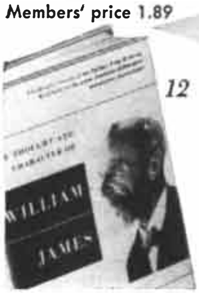

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awesome complexity. Every patient and staff member brings to it his own ways of looking at himself and his fellow man, his own hopes, loves, jealousies and terrors. This is also true of the workers in a jellybean factory, but there private emotions can largely be ignored. They cannot be ignored for a moment in a mental hospital. Moreover, the patients must be fed, housed, clothed, educated, entertained, protected and in many instances even bathed and taken to the toilet. This must be done by a staff of varying degrees of training who are, at best, frail enough when it comes to understanding the obscure communications of seriously ill patients. The result, at times, reminds me of the grimly humorous comment of a patient during a period of particular confusion: "This place is a madhouse."

A hospital may be thought of as operating at two levels: formal and informal. Nurses, for example, report formally about their patients to the supervising nurse, and discuss the patients informally with other nurses, especially when they are upset by something about the patient. Let us consider Miss A, a young schizophrenic who has been on the disturbed ward for several months. The administrator feels that she is calm enough to be moved to the convalescent ward. The patient would like to try, but feels that the world is hostile and that she is unacceptable to the "better patients downstairs." As her tension mounts with the impending transfer, she becomes more and more querulous and, seeking tokens of approval, asks for many privileges—walks on the grounds, town trips, cigarettes and so on. The nurse in charge of the disturbed ward informally notes to her friend, the charge nurse on the convalescent ward: "Miss A will be down on Wednesday, but I don't think she's ready yet. She's been very bitchy and demanding lately." On Wednesday Miss A comes down to encounter a staff braced against her "bitchiness and demandingness." The administrator, unaware of the informal communication of the patient's reputation that preceded her, may soon decide that his judgment was wrong and return the patient to the disturbed ward.

Sometimes the staff's working convenience and routine create problems unwittingly. On the disturbed women's ward it was convenient to put the patients to bed at 10 p.m. and make them stay there until 7:30 a.m., because only two workers were on duty on the night shift. Thus "the hospital in effect legislated an hour of insomnia," for the patients could not sleep nine and a half hours. The staff attributed their wakefulness to tension and treated the problem with sleeping pills.

"A mental hospital is a place where ordinary civil liberties are called privileges." The physician controls the daily life of his patients. He can decide where they will live, what they will eat, what they will wear, with whom they will talk and for how long, and what educational and recreational activities, if any, they will engage in. He is part of an apparatus which frequently holds the patient against his will, for his own protection and that of the community. The doctor must realize how his role in the hospital differs from that outside and how it affects patients' behavior.

Stanton and Schwartz discovered that patient disturbances, called "excitements," are often related to covert disagreements between two staff members over the patient's care. Two doctors may disagree, for instance, about whether a female patient should be moved to another ward. As the disagreement progresses, they unconsciously break off communication with each other, and unwittingly begin to line up allies in the medical and nursing staff. Meanwhile the patient becomes more and more restless until, at the point where communication between the two doctors has broken down completely, she is in a full-blown excitement. She cannot sleep, moans, screams or talks constantly and incoherently. She may attack others without provocation. The excitement rises to a wild crescendo which might end in the patient's death. In such an emergency the hospital throws all its resources into the breach—seclusion of the patient under special supervision, sedation, continuous tubs and so on.

The authors' discovery suggests that location of the covert disagreement and re-establishment of communication between the disagreeing staff members may help to bring such a patient out of the excitement.

All organisms from the amoeba to man modify their immediate environment to preserve their internal stability. Stability for a mental patient can mean, unfortunately, staying sick. Harry Stack Sullivan's comment that "schizophrenia is not a disease but a way of life" is pertinent here. One of the homeostatic mechanisms of human personality is "reputation." The appraisal, spoken or unspoken, that your friends make as to what kind of a person you are profoundly affects your performance. Imagine, if you will, how you would behave toward two groups, one of whom had been told beforehand that you were outgoing, friendly and warm, while the other had been informed that you were surly, hostile and suspicious. Confidence men are well aware of this feedback effect of the milieu. Once a sucker is hooked with the lure of illicit wealth easily gained, he is not allowed to meet or talk with anyone but a member of the gang until he has been fleeced. Surrounded by people constantly feeding him a distorted appraisal of himself and of the situation, he changes in personality. As his appetite grows, his judgment wanes.

Stanton and Schwartz made an experimental attempt to alter the reputation of a patient. A professional musician, she had been seriously schizophrenic for a long time. The experimenters found that she had the reputation of being hated by everybody, and that most of the staff believed her interest in music should be discouraged because it was an expression of her illness. When Stanton and Schwartz presented a severely critical analysis of this reputation to the staff, showing that a number of people really liked the patient, and that the administrator was of the opinion music would be helpful to her, the staff's new view of her had dramatic results. Within five weeks she ceased being aggressive, became continent of feces and urine, spoke coherently, took up her music, made realistic arrangements for dental care and her analyst thought she was progressing in treatment. However, a strong undercurrent of disagreement about the patient's management continued in the nursing staff, and when the administrator had to leave the ward temporarily the patient relapsed completely within two weeks. Despite this unhappy outcome, the experiment was encouraging. Quite remarkable changes in the patient had been produced by intervention in the social setting.

As a book for the general reader *The Mental Hospital* is uneven but comes out far on the credit side. Too often the writing is cumbersome and unnecessarily complex. It is not that it is difficult to understand; there is just too much of it. Writers in social science inevitably have difficulties in saying just what they mean: the language is far less precise than in the natural sciences. To my mind Stanton and Schwartz try to achieve precision by excessive modification and detail. The book could well be shorter.

I was a resident at the hospital where the study was carried on and consequently have special appreciation for the authors' skill in describing it. There is no other book, to my knowledge, which can be as highly recommended to a lay reader who wishes to learn what a mental hospital is like, who are the people that make it up, what their concerns are and how they go about performing their functions. And the book adds to the small but crucially important series of systematic studies which integrate modern psychiatric and sociological thinking.

Short Reviews

IDEAS AND OPINIONS, by Albert Einstein. Crown Publishers, Inc. ($4.00). This is a collection of Einstein's general writings, on topics ranging from pacifism to $E=mc^2$. It is remarkable how well most of the entries stand up, for many were scarcely more than spur-of-the-moment, occasional expressions. They portray clearly the sweetness of Einstein's nature, his humor and gift for agate-edged irony, his special brand of nonconformism and irreligious religiousness, his freedom from superstition and humbug, his ability in judging public questions to pierce every vulgar, irrelevant distraction. Einstein is a good writer because he manages, not without effort, but with a minimum of fuss and ornament, to say what he thinks. There are many noteworthy items in this volume: his observations on Bertrand Russell's theory of knowledge; statements on intellectual freedom, religion and science; an interview with Raymond Swing on atomic war; a letter to Sigmund Freud; a lecture on "Geometry and Experience"; essays on Newton, Kepler and Maxwell; a little known scientific paper on "The Cause of the Formation of Meanders in the Courses of Rivers." These are windows to the spacious mind of a thoroughly good man.

THE HUMAN BRAIN, by John Pfeiffer. Harper and Brothers ($3.75). A fluent journalistic report on what is known about the inside of the head. The author has read carefully, listened attentively to various specialists and gone to inspect for himself activities ranging from the administration of shock therapy to the antics of electronic computers. He describes the structure of the brain, electrophysiological research, the treatment of epilepsy, psychosurgery, the use and abuse of psychotherapy. Anecdotes, little dramas and a bouncy but inoffensive style make for a painless introduction to a painfully difficult subject.

EXPLORING MARS, by Robert S. Richardson. McGraw-Hill Book Company, Inc. ($4.00). Whether we can reach Mars by rocket and what we would find if we got there are among the questions considered in this popular, unassuming book written by an astronomer at the Mount Wilson and Palomar Observatories in California. Richardson also discusses what is known about Mercury, Jupiter, Venus, Pluto and other planets. The illustrations include shots from a recent space-travel movie which do nothing to increase one's confidence in astronautics.

COMMERCE OF THE PRAIRIES, by Josiah Gregg. University of Oklahoma Press ($7.50). Josiah Gregg, born in Tennessee in 1806 and raised on the Missouri frontier, was a jack-of-all-trades and master of one. He was a schoolteacher, student of law, explorer, bookkeeper, physician, soldier, overland trader, storekeeper, war correspondent, linguist, surveyor and amateur naturalist. He was also "the pioneer historian" of the Sante Fé Trail. Gregg was a strange, restless man, always ready to throw up whatever he was doing for something else. He was a hypochondriac and a crank, chronically dyspeptic and unamiable. When he was 25 his precarious health led his doctors to prescribe a trip on the prairies and he joined a merchant caravan at Independence, bound for Sante Fé. The outdoor life made him a new man. For 10 years he spent much of his time crossing and recrossing the Great Plains, consorting with Indian tribes, studying the land, the flora and fauna, mineral resources, the modes of travel and camp life, the traders, adventurers and others who peopled the covered-wagon trains of the trail. His scientific curiosity was insatiable, and he kept careful notes of all he saw and heard—notes constituting a "veritable encyclopedia of Western Americana." He turned the notes into a book, with some help from a young lawyer named John Bigelow, who later became a journalist on William Cullen Bryant's *Evening Post.* Only moderately successful when it first appeared in 1844, *Commerce of the Prairies* established itself within a few years as an invaluable guidebook for those who were westward bound, and as a fascinating account of the life and landscape of the buffalo country before it was transformed by towns, farms, barbed wire, roads and reservations. The book went through 14 printings in the U. S. and was published in England and Germany. But poor Gregg never saw a penny of the profits because he died in 1850, before the book hit its stride, while on an exploring trip along the mountain ranges of the Pacific Coast. His masterpiece now appears in definitive dress, edited by Max L. Moorhead, professor of history at the University of Oklahoma, who supplies an interesting biographical introduction and critical notes.

SAILING ALONE AROUND THE WORLD, by Captain Joshua Slocum. Sheridan House ($5.00). This volume is a reissue, preserving the original illustrations, of an unsurpassed record of human experience. Joshua Slocum was a Massachusetts sea captain who as a result of various misfortunes found himself in middle life without a command and without the likelihood of getting one. "At the nadir of fortune he turned author." His first book, *Voyage of the Liberdade,* printed at his own expense, was unsuccessful; nor did the second fill his pockets. For a time he worked in shipyards outfitting whalers; then in 1892 he met an old acquaintance, a whaling captain, who offered to give him a ship. "But," he added, "she wants some repairs." He spoke nothing less than the truth. The ship, a superannuated oyster boat named *Spray,* was propped up in a pasture along the Acushnet River. In 13 months Slocum rebuilt her plank by plank. On April 24, 1895, in his 37-foot sloop of nine tons which, as he said, "sat on the water like a swan," Slocum set out from Boston to sail around the world alone. On June 27, 1898, he dropped anchor in Newport, having completed a voyage of 46,000 miles. A good part of the time he had spent snug and serene in his tiny cabin reading, cooking and mending while tasty fish obliged him by flopping onto the deck and knocking themselves out and the *Spray* pushed on with her wheel lashed. But it had not been a dull voyage. He had in fact experienced almost everything that can be experienced at sea. Off the shore of Uruguay he had capsized in his dory, and at that inconvenient moment had "suddenly remembered that I could not swim." How he extricated himself from this difficulty, survived tempests, savages, mammoth waves, loneliness, williwaws and the Great Barrier Reef—all this and much more are told by Slocum in a golden story. He was to make two more voyages in the *Spray.* In 1905 he went to the West Indies; in 1909, aged 65, he set sail, alone of course, to explore the Orinoco and the Amazon. He was never seen again.

JANE'S ALL THE WORLD'S AIRCRAFT, 1954-1955, edited by Leonard Bridgman. The McGraw-Hill Book Company, Inc. ($25.00). It is only a decade, as the editor of *Jane's* points out in his preface, since gas-turbine engines began to play a part in aviation. But last year a jet-propelled fighter, the North American YF-100A, exceeded the speed of sound in level flight; the rocket-powered Bell X-1A research plane reached 1,650 miles per hour and climbed to 90,000 feet, and two radical new planes took off and landed vertically. V.T.O. aircraft (vertical take-off) are being developed vigorously in both England and the U. S. The Rolls-Royce "Flying Bedstead," which is typical, is controlled by compressed air jets discharged through nozzles fed by the compressors of the engines. Other news from *Jane's* this year: when the U.S.A.F. modernization program is completed in 1957, we shall have 40,000 planes, half of them jet-powered; it will be five years before West Germany establishes an industry to equip its air force; the U.S.S.R. has some 360 factories producing airplanes and components, and turning out some slick stuff.

SEA-BIRDS, by James Fisher and R. M. Lockley. Houghton Mifflin Company ($6.00). The North Atlantic, the locale of this book, is the foraging ground for some 118 species of birds. These include the fulmar, Cory's shearwater, the gannet, the double-crested cormorant, the great skua, the gull and the herring gull, the kittiwake, 10 varieties of tern, the noddy, the guillemot and the abundant Atlantic puffin. Two species have become extinct within the past century: the last great auk was seen in June, 1844, and the last Labrador duck is said to have been shot in 1875. One species presumed to have been exterminated has happily been rediscovered: a few years ago 13 or 14 nests of the cahow were found in Bermuda and the total population is now believed to be of the order of 100 adult birds. Fisher and Lockley are naturalists who have spent a combined total of nearly 70 years watching sea-birds. They claim to have visited every resting and breeding place, every crag and cliff, every dune, flat and shingle, every islet, stack and skerry, every inlet, bay and voe, every cave and burrow from the Canaries to Spitsbergen, from Iceland to Heligoland. A rich, exceptionally interesting book by men who know birds as India's Srinivasa Ramanujan knew numbers. Photographs, maps and color plates.

BIRDS OF THE WORLD, by Paul Barruel. Oxford University Press ($12.50). A French artist and naturalist presents a popular illustrated survey of the life and habits of the birds of the world from the Alpine accenter to the white wagtail. His book is pleasant and authoritative, full of out-of-the-way details. The peregrine in its "stoop" attains 175 miles an hour, the highest speed ever recorded for a bird. Some species of birds derive pleasure from placing boring-ants in their plumage, which seems to have a stimulating effect on the skin. Little flamingoes sit on their elbows when asleep but finally graduate to sleeping standing on one leg. The jacarina turns somersaults in the air while singing. Geese are monogamous and sometimes mate no more if one of the couple dies. The Australian rock warbler and the sunbird build their nests in spider webs. The South African social weaverbirds build huge communal nests in tree branches. Adélie penguins walk single file as far as 50 miles over pack ice to feed. The book contains a number of Barruel's bird paintings, which are agreeable but average, and a large, skillfully selected collection of action photographs, some of which are superb. A very satisfying volume.

THE BIRDS OF THE BRITISH ISLES, by David Armitage Bannerman. Oliver and Boyd (each volume 45 shillings). The first two volumes of Dr. Bannerman's survey of British birds have been published. He is a distinguished ornithologist, author of the magnificent eight-volume study, *The Birds of Tropical West Africa.* His new series on British birds has numerous full-color reproductions of paintings by the well-known bird-painter George Lodge. While not brilliant, they have a soft, gentle quality that fits the unhurried text and are in keeping with the spirit of a book intended less for reference purposes than for the fireside gratification of bird lovers.

THE BIRDS OF BURMA, by Bertram E. Smythies. Oliver and Boyd (4 pounds, 4 shillings). The first edition of this book was a casualty of the war: the 1,000 copies, printed in Rangoon in 1940 by the American Baptist Mission Press and promptly bought up by the Europeans living in Burma, were abandoned when the Europeans fled before the Japanese invasion in 1942. Many copies were later destroyed in an air raid on Tokyo; a number of the precious blocks from which the plates were made vanished and have never been found. With the cooperation of ornithologists in various parts of the world, this second edition, much more complete than the first, has been prepared. It presents in nontechnical language firsthand information, gathered bit by bit over a century, about the appearance, habitat, behavior and breeding biology of all species of the birds of Burma. There are 31 color plates, a systematic check list, a bibliography and a folding map.

DRAGONFLIES OF NORTH AMERICA, by James G. Needham and Minter J. Westfall, Jr. University of California Press ($12.50). "Dragonflies are rather large predaceous insects, of ancient lineage and of unique form and habits. They are beautiful in coloration and agile in action almost beyond comparison." Their name reflects a widespread superstitious fear of them, but they are actually man's benefactor because they gobble up mosquitoes. In the world of little insects the dragonfly is the "predator supreme," disdaining to take anything but living prey, swooping down on its victims at high speed and rending them with its powerful jaws and sharp teeth. The authors of this excellent manual classify the various species, describe their life histories, body structure, haunts and breeding habits, and furnish instructions for field study, capture and preservation. They illustrate the book with many photographs and diagrams, but only one color plate.

LIVING FOSSILS, by Maurice Burton. Thames and Hudson ($5.00). A living fossil is defined as an organism that has survived beyond its era. A standard example is the tuatara of New Zealand, which looks like a lizard but is in fact the "sole survivor of an order of reptiles which flourished in the great Age of Reptiles and is now extinct except for this one species." Other "living fossils" include the New Zealand peripatus, an arthropod with a caterpillar-like body and 40 short unjointed legs ending in hooklike claws; the lungfish; the king crab; the silverfish; the cockroach; the shark; the crocodile; the tortoise; the camel; the elephant; the giraffe, and the okapi. Maurice Burton, a deputy keeper in the British Museum who has written many popular books on natural history, discusses these and many other of the lone survivors of prehistoric times who by virtue of being brave, but not too brave, aggressive, but not too aggressive, have demonstrated their ability to foil time and overtrump natural selection. A very interesting book.

HUMAN PERSONALITY—AND ITS SURVIVAL OF BODILY DEATH, by Frederic W. H. Myers. Longmans, Green and Co. ($15.00). Myers' "great central classic" of psychical research was first published half a century ago; it is now reissued in a two-volume edition. An essayist, poet and classicist, he was also an imaginative and indefatigable investigator who acquainted himself fully with the medical and psychological knowledge of his time and followed carefully the work of Sigmund Freud and other psychiatrists. In the introduction to this work the psychologist Gardner Murphy describes Myers' major achievements as the active investigation of communications "independently of the recognized channels of sense," a process he called telepathy, and the systematic study of the phenomena of subconsciousness or unconsciousness, to which he gave the name subliminal. *Human Personality* is a huge collection and synthesis of the data Myers gathered on everything from thought transference and automatic writing to dreams, hallucinations, hypnotism and ghosts. He was neither skeptical nor very discriminating. The spasms of unhinged spinsters, the rumors propagated by obviously disturbed children and lonely servant girls, the unauthenticated reports of country doctors, the visions of religious hysterics—all are solemnly offered as testimony to the reality of psychic phenomena. Myers was a goose, but he was also brilliant, insightful and high-minded. His fascinating mish-mash of a book faithfully reflects these qualities, and while modern psychical research may be far more statistical and scientific than Myers ever dreamed of being, it possesses few workers with a tenth of his talent.

Notes

ON THE ORIGIN OF THE SOLAR SYSTEM, by H. Alfvén. Oxford-Clarendon Press ($4.80). The author's theory is that the solar system was formed from ionized, hence electrically conducting, gas, and that the gaseous protoplanets were stopped from falling in toward the central body by electromagnetic action, which accounts for the planet distances.

INTRODUCTION TO ASTRONOMY, by Cecilia Payne-Gaposchkin. Prentice Hall, Inc. ($8.00). An excellent survey for students and general readers. Dr. Payne-Gaposchkin links the scientific material with literature and history.

ADVANCES IN GENETICS, edited by M. Demerec. Academic Press Inc. ($9.80). The sixth volume of a survey, this book covers genetic changes in human populations, human blood factors, cytoplasmic inheritance, artificial inheritance and livestock improvement.

THE AMATEUR SCIENTIST

About historic and modern machines for the generation of static electricity

Conducted by Albert G. Ingalls

Near the close of the 17th century Otto von Guericke, the amateur physicist of Magdeburg, invented the world's first electrical machine—an electrostatic generator. He wrote down these instructions for building one:

"Secure one of the glass globes which are called phials, about the size of a youngster's head; fill it with sulfur, ground in a mortar and melted by the application of a flame. After it refreezes, break the phial, take out the sulfur globe and keep it in a dry place, not a moist one. Perforate it with a hole so that it can spin upon an iron axle. Thus the globe is prepared.

"To demonstrate the power developed by this globe, place it with its axis on two supports in the machine—a hand's breadth above the baseboard—and spread under it various sorts of fragments such as bits of leaves, gold dust, silver filings, snips of paper, hairs, shavings, etc. Apply a dry hand to the globe so that it is stroked or grazed two or three times or more. Now it attracts the fragments and, as it turns on its axis, carries them around with it.

"When a feather is in contact with the globe, and afterwards in the air, it puffs itself out and displays a sort of vivacity . . . and if someone places a lighted candle on the table and brings the feather to within a hand's breadth of the flame, the feather regularly darts back suddenly to the globe and, as it were, seeks sanctuary there."

After describing numerous other experiments, in some of which the globe produced light and sound, von Guericke concluded: "Now many other mysterious facts which are displayed by this globe I shall pass by without mention. Nature often presents in very commonplace things marvelous wonders which are not discerned except by those who through insight and innate curiosity consult the oracle of experimentation."

Ten generations of experimenters have consulted the oracle since von Guericke's day. So fathomless are the mysteries of his sulfur ball that its "marvelous wonders" continue to charm and sometimes baffle experimenters, whether they twiddle the controls of a Van de Graaff accelerator or merely stroke the hairs on a cat's back. But electrostatics has remained chiefly a curiosity. Most people are acquainted with it only in the form of the crackling shock you get when you touch a metal doorknob after walking across a thick carpet in winter. Those who go in for amateur radio grumble that "static is something you cuss, not study!"

Static electricity has never become economically important, probably because nature has been more generous in supplying effective conducting substances and magnetic materials than she has in providing good insulators. Our electrical technology is based on electromagnetic devices; our electrical power is generated by magnets and moving conductors. Electrostatic machines have been harnessed for only a few specialties, such as generating high voltage for laboratory experiments and producing high-energy X-rays and sterilizing drugs in medicine.

Some engineers believe that electrostatics has big technological possibilities. One of them is John G. Trump, professor of electrical engineering at the Massachusetts Institute of Technology. He points out that the forces resulting from the presence of electric charge are the most direct and powerful in nature. He and his colleagues at M.I.T. are conducting certain investigations which may produce an electrostatic power generator that one day will compete with the electromagnetic generator.

Professor Trump illustrates how the power-generating capacity of electrostatic machines may be stepped up by asking you to consider two metallic plates, 100 square inches in area, facing each other and separated by an insulator. If a voltage amounting to an electric field of 300 volts per centimeter is applied between them, the plates will be attracted to each other with a force of one 2,000th of a pound. Increase the field to 30,000 volts per centimeter and the attraction becomes half a pound. Now immerse the plates in a high vacuum—a good insulator, though one difficult to maintain—and increase the field to three million volts per centimeter. The force of attraction jumps to 5,700 pounds! "Force of this order," says Trump, "has more than passing interest for power engineers."

Trump and his associates are working on the problem of developing a practicable system of vacuum insulation which would make possible a field intensity of millions of volts per centimeter in a large machine. If they succeed, an electrostatic power generator will become a reality. The working parts of such a machine would look like an oversized variable capacitor with intermeshing leaves. Only the rotor would move. The machine could be constructed of light metal. A generator of this type, about the size of a hall bedroom and weighing only a few hundred pounds, could deliver 7,500 kilowatts of power. Its efficiency would be impressively higher than that of an electromagnetic generator.

The history of electrostatics began with the discovery of Thales of Miletus that rubbed amber attracted other objects. Through the centuries experimenters like von Guericke explored the "marvelous wonders" of static electricity with a succession of ingenious machines which amateurs may enjoy building.

One of the most important historically was Alessandro Volta's *elettroforo perpetuo*, now known as the electrophorus [*see drawings on opposite page*]. Volta wrote to Joseph Priestley of the Royal Society on June 10th, 1775: "I hereby draw your attention to a body that, after being electrified by a single brief rubbing, not only does not lose its electricity but retains obstinately the indications of its active force in spite of being touched repeatedly any number of times."

The electrophorus consists of two working parts: (1) a rectangular block of insulating material such as lucite or, preferably, polyethylene, and (2) a metal disk fitted with an insulating handle. When the lucite is wiped with a woolen cloth, electrons are removed from the cloth and deposited on the lucite—in much the same way that a dirty rag smears a clean sheet of glass. Early experimenters (who used sealing wax, hard rubber or other resinous substances instead of plastic) said that the insulator thus stroked had been "electrified by friction." They failed to observe that the cloth took on an equal and opposite charge. When electrons rub off from the wool to the lucite (because, as it happens, some of the atoms in wool hold electrons less tightly than those in lucite do), the atoms that have lost electrons become positively charged ions. Accordingly the surface of the wool is peppered with tiny areas of positive charge while the lucite has similar areas of negative charge. The charges are static—bound at the places where they are deposited—because in an insulator electrons cannot move freely about in the substance.

Ever since Benjamin Franklin named the "positive" and "negative" ends of the electric field, the field has been thought of as originating at the positive end. He might have prevented confusion if he had assigned the names the other way around, because we now have to say that the current "flows" from positive to negative, although actually the electrons flow from negative to positive!

Be that as it may, the field between a pair of opposite charges is often pictured as a pattern of curving lines that radiate into space from a region deficient in electrons and converge on one where they are in excess. The field can be thought of as a bundle of stretched rubber strands, illustrating that there is a force of attraction between the charges of opposite sign.

Von Guericke demonstrated that an electrified insulator would communicate its charge to one that is electrically neutral. We now know that it accomplishes this by sharing its excess electrons with the uncharged body at points where the two touch. Von Guericke also showed that a body can become temporarily electrified merely by entering a field of charge, without touching the charged surface. He wrote: "If a linen thread supported from above is brought near the globe and you try to touch it with your finger or any other body, the thread moves away and it is difficult to bring the finger near the thread."

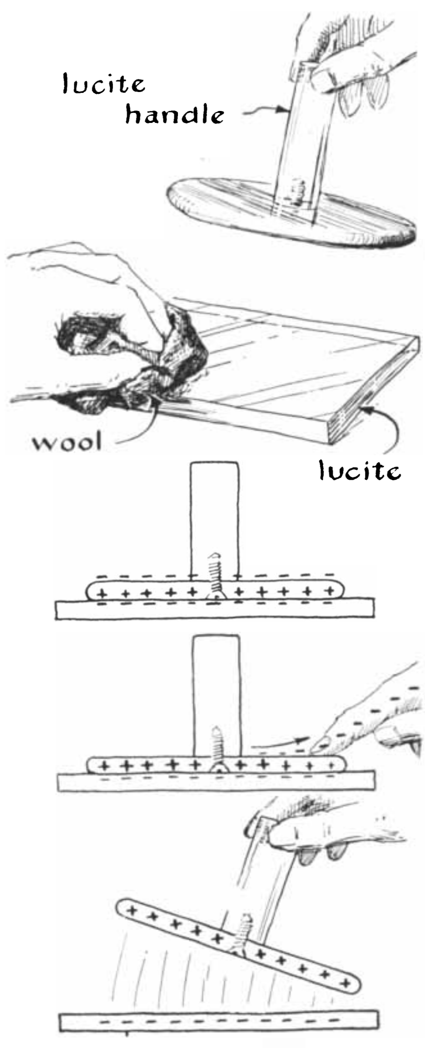
This was an important discovery. It demonstrated that charging by induction does not exhaust the charge on the body initially electrified, and also that charges of like sign repel each other. Charging by contact involves the sharing of electrons between two bodies, and each contact diminishes the number remaining on the charging objects. Charging by induction, in contrast, makes no demand on the free electrons but only on the field set up by them. The field causes the electrons of the uncharged substance to veer slightly from their normal orbits. This displacement sets up an "induced" charge in the previously uncharged substance. When the inductively charged body is removed from the exciting field, everything returns to normal and the induced charge disappears.

Induction can give a conductor a permanent charge, in the sense that the charge will remain on the conductor until it leaks off or is otherwise dissipated. All modern electrostatic generators are designed on the principle of inductive charging. And the charging process involves the transformation of mechanical energy into electrical energy. The principle is nicely demonstrated by the electrophorus.

When the metal disk is placed over the charged lucite, the lucite's negative field opposes that of the electrons near the lower surface of the disk. These electrons move away to the upper surface of the disk. Consequently the lower surface becomes positively charged and the upper surface negatively charged. If, while the top of the metal is thus charged, you touch the top with your finger, the excess electrons will flow into your body—where, electrically, things are not so crowded. Now if you take your finger away and then lift the metal disk by the insulating handle, a net positive charge is trapped in the disk.

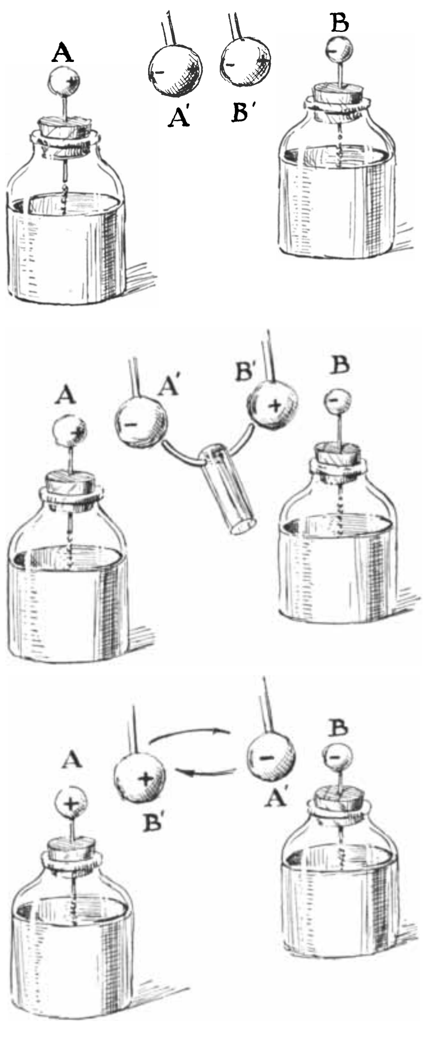
This method of charging removes no electrons from the lucite, nor does it draw on the lucite's energy. Yet the metal disk is now energized with positive electricity (many protons have been denuded of their neutralizing electrons and hence their positive fields extend out into surrounding space). The disk will now attract other bodies just as the charged lucite does. Moreover, a spark will jump between the charged disk and your finger—which you can easily observe in a darkened room. The energy expended in the spark came from your muscles when you lifted the metal from the lucite. The spark was created by electrons colliding with molecules of air in their headlong rush from your body back into the disk.

A more effective arrangement for generating electrostatic energy by induction uses two Leyden jars [*drawings on next page*]. One jar, A, has a tiny positive charge. When its positively charged terminal is brought close to a brass ball, A′, electrons in the ball are attracted to the side of the ball nearest the terminal. Similarly the terminal on another jar, B, with a small negative charge, drives away electrons in the ball B′, making the near surface positive. If the two balls are now connected by a metallic rod [*middle drawing*], electrons in B′ (repelled by the field of B and attracted by that of A) will flow to A′. Removal of the rod traps the charges—just as the removal of your finger trapped those in the disk of the electrophorus. Now suppose we change the positions of the balls,



A modern version of Volta's electrophorus moving A′ toward B and B′ toward A [*bottom drawing*]. To do this we must expend work, because A′, for instance, is repelled by B and attracted by A. This work is transformed and stored as potential electrical energy as soon as we touch A′ to B and B′ to A. The excess electrons in A′ flow into B, raising its negative charge to that of A′, and A similarly acquires an increase of positive charge. The cycle can be repeated indefinitely. In theory the amount of energy stored in the jars (capacitors) can be increased without limit. In practice, the storage is limited by the fact that electrons leak away more and more rapidly as the charge increases.

Various induction machines have been designed for performing the sequence of operations automatically and with considerable speed. In these machines the "carriers" take the form of thin metallic sheets instead of balls, and the capacitors also are metal sheets, called field plates.



A primitive induction generator

An early form of the machine, patented in 1860 by C. F. Varley of England, is easy to construct [*see opposite page*]. It consists of a pair of field plates cemented to a square slab of lucite surmounted by a rotating disk of lucite to which six or more sectors of aluminum foil are cemented. Two brushes (of tinsel) momentarily connect opposite sectors, the carriers, with their respective field plates as each carrier enters the region of its plate. A similar pair of brushes again make contact with opposing pairs of carriers as they move from the region of the field plates. A pair of "corona" combs—quarter-inch metal rods fitted with steel phonograph needles spaced half an inch apart—graze the carriers at positions intermediate between the two sets of brushes. The machine's electrical output flows from the combs to a pair of spheres an inch or so in diameter which comprise a spark gap.

The lower left diagram illustrates the action. Assume a charge on the field plates [*outer solid segments*]. Electrons flow into the carrier at the left, leaving the right-hand carrier with a positive charge. Work is now expended in moving the carriers "up the potential hill" to the opposite field plates. Here they make contact with the brushes and part of their newly acquired energy flows into the field plates; electrons enter the field plate [*top of drawing*] from the negatively charged carrier, while the opposite carrier withdraws electrons from the lower plate. The succeeding action of all carriers is similar. After a short period of operation the combs reach ionizing potential, and energy flows from the carriers to the gap, where vigorous sparking occurs.

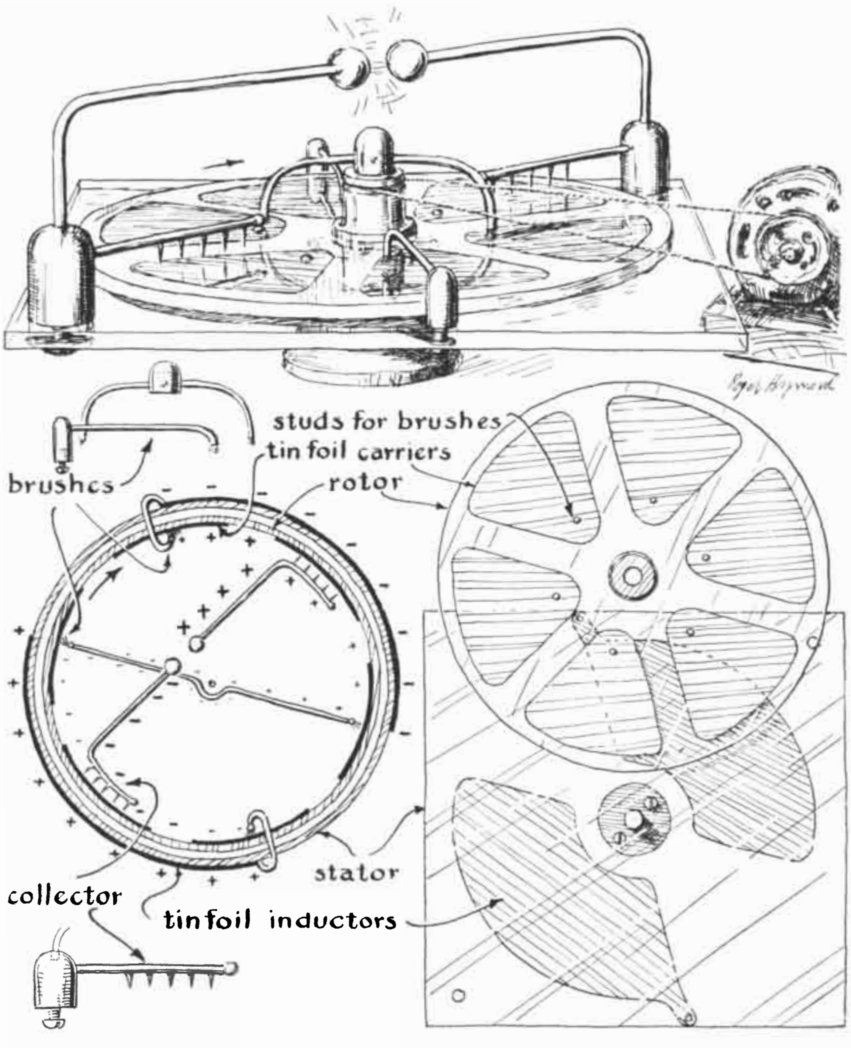
The machine is not very efficient. This can be demonstrated by observing its operation in a dark room. The rotating carriers appear as a blurred disk of phosphorescence in colors ranging from greenish-blue through violet, while the field plates are outlined sharply in purple. Corona discharge at the combs is brilliant. This display means that electrons are streaming from the thin, sharp edges of the foil and the points of the comb carrying negative charge and into those parts carrying a positive charge. Considered as an electrical "pump," the machine is leaky and thus wastes energy.

The corona effect is explained by the geometry of the machine's conducting parts. Unless distorted by another charge, the electric field radiates into space uniformly in all directions from a point charge. If the charge is enclosed by a conductor, the lines of force always emerge perpendicular to its surface. In the case of a spherical conductor (in effect, an enlarged point) the lines are, therefore, distributed uniformly over the surface. When the sphere is distorted to an egg shape, however, the lines bunch up at the little end and thin out at the big end—because they must emerge everywhere at a right angle to the surface. Crowding at the little end becomes more pronounced as the radius of the "point" is made smaller. This is another way of saying that the intensity of the field, or the potential gradient, increases inversely with respect to the radius of the conductor; in theory it would approach infinity at the point of a perfect needle. Even in practice, finely made points can concentrate fields of astonishing intensity. The exquisite needles used in field-emission microscopes [see "A New Microscope," by Erwin W. Müller, SCIENTIFIC AMERICAN, May, 1952] create field intensities of 750 million volts per inch in the immediate vicinity of the point—although the instrument operates from a power supply of only 5,000 volts! At this field intensity electrons are literally ripped from the metal point and ejected radially into space. Gas, if present in the tube, becomes heavily ionized. The collecting combs of the Varley machine similarly ionize adjacent air, negative charges being carried by dislodged electrons and positive charges by the ions.

In the early years of this century the Wimshurst generator, similar in basic principle to the Varley but carrying one or more pairs of disks that rotate in opposite directions, was a favored source of power for X-ray machines and other devices requiring relatively small amounts of current at high voltage. The largest machines carried as many as 12 pairs of disks seven feet in diameter and delivered potentials on the order of 200,000 volts.

The Wimshurst and other electrostatic generators of this era could not reach the million-volt range. By 1920 they had been largely replaced by electromagnetic induction coils and transformers as sources of high-voltage power.

The modern era of electrostatics began in 1929. In that year Robert J. Van de Graaff, a young Rhodes scholar from Oxford University who was working at Princeton as a National Research Fellow, invented the electrostatic belt generator which is now known around the world by his name. He was interested in developing a steady constant-potential voltage with which to accelerate atomic



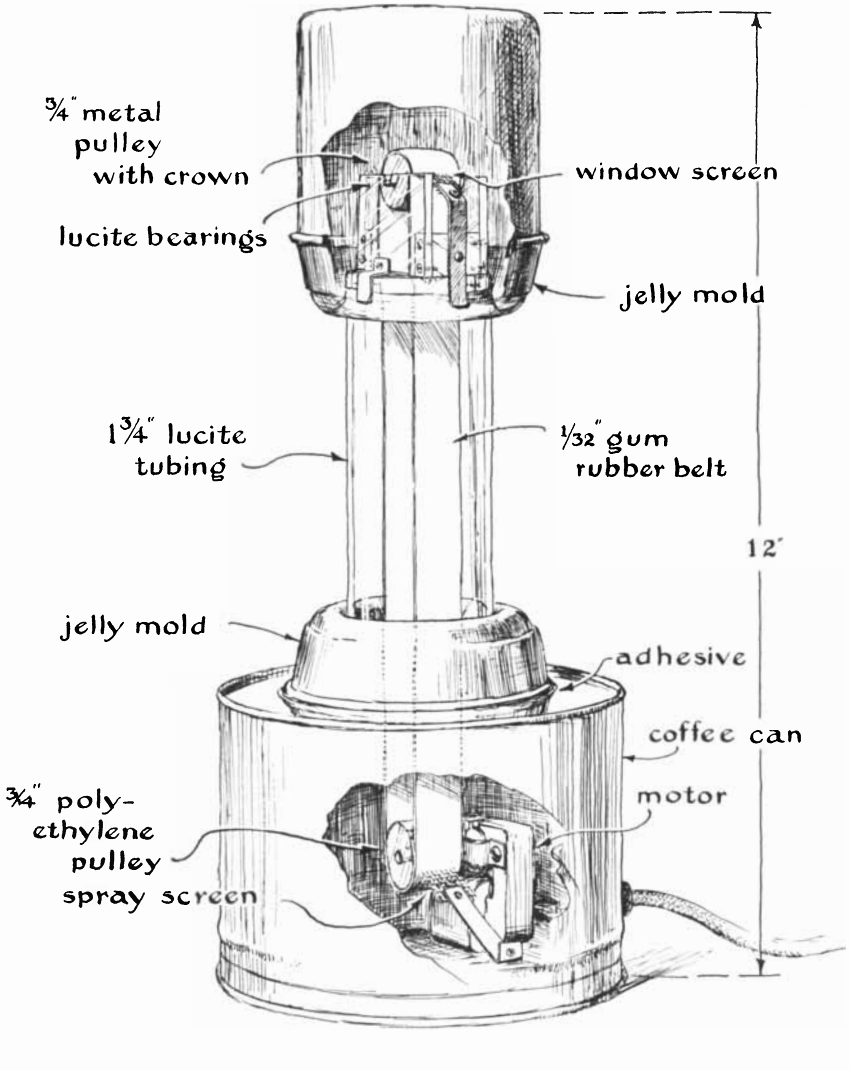
Varley's induction generator

particles to bombard nuclei in order to obtain evidence of their internal structure. Today the Van de Graaff accelerator can be found in nearly every large nuclear laboratory in the world; it is the work horse for precision research in this field. The accelerator has attained a particle energy of more than eight million volts, and this figure may soon be more than doubled. In smaller sizes the machine has found a wide variety of applications, particularly as the power source for the high-voltage X-ray treatment of disease.

One of the nicest features of the Van de Graaff generator is its relative simplicity and low cost. Robert W. Cloud of the High Voltage Research Laboratory at M.I.T. has designed a small version as a special construction project for amateurs [*see drawing on next page*]. Its action is as simple as its design. A motor developing 3,000 revolutions per minute is housed in a coffee can. It drives a gum-rubber belt which passes over an insulated pulley inside the upper terminal. Spray screens, counterparts of the Varley machine's collecting combs, are situated close to the surface of the belt at each end of its run, and each connects with the respective terminal. As the machine goes into operation, frictional contact removes electrons from the belt at the driving end and deposits them on a plastic pulley. Positive charges resulting at the sites on the belt which have thus lost electrons are then carried by the belt to a metal pulley at the other end above. Electrons flow from the metal pulley onto the electron-deficient belt. As the machine continues to run, heavy charges build up on both pulleys. After a few seconds or minutes, depending on the humidity of the air, the field originating at the pulleys reaches ionizing intensity in the vicinity of the spray screens. Electrons are then withdrawn from the upper terminal and sprayed on the belt at the beginning of its downward run. Similarly electrons en route down the belt come within the region of ionization at the lower spray screen and flow by way of its supporting bracket into the lower terminal. Through this pumping action the belt continuously exhausts electrons from the upper terminal and discharges them into the earth through the lower one. This leaves the upper terminal with a net positive charge which, because of mutual repulsion of the positive "holes," distributes itself uniformly over the terminal's outer surface. Accordingly the inner surface carries no charge. In theory, voltage across the upper and lower terminals increases without limit. As in the case of the Varley and Wimshurst machines, however, the charge is limited by the quality of the insulation. At about 100,000 volts charge leaks as corona from the upper terminal and as conduction current down the insulating column at a rate equal to the two microamperes which the belt is able to carry into the terminal. Although 100,000 volts is an impressive value, the machine creates no shock hazard because the capacity of the upper terminal to store charge is small.

If a well-rounded object is brought within an inch or so of the high-voltage terminal, a spark will jump. In this type of discharge the air is rapidly changed from a good insulator to a conductor and the spark completely discharges the terminal. Reduction of the terminal voltage permits the air to regain its insulating strength, and the terminal is recharged by the belt. If an object with sharp edges is brought near the terminal, it steadily drains charge by corona and decreases the potential. Such a device, with adjustable spacing, is often used in Van de Graaff generators to maintain a constant terminal potential.

Several manufacturers, including the South Research Laboratories, the Com-



A low-power Van de Graaff machine

bosco Scientific Company and the American Electrostatic Company, now market small air-insulated machines, similar to the one described, for demonstration purposes at prices from $25 to $100.

A continuous source of high direct-current voltage invites endless experiments. One of the most amusing is the "jumping ball" demonstration. A half dozen small balls made of pith or other light material are given a conducting surface of soot or graphite. They are placed in a cage, which may be made of a strip of transparent plastic rolled into a cylinder and capped with tops from peanut-butter jars. The caps are connected with the terminals of the Van de Graaff. As the machine goes into operation, the electrostatic field from the upper cap attracts the balls. They hop up to it, deliver their load of electrons, fall back and repeat the cycle as long as power is supplied.

Support a sewing needle by an insulator and connect it to the machine's upper terminal. Molecules of ionized air will rush from the point as though they were streaming from a jet under pressure. They easily blow out a match or candle. This electric wind can be made to drive a simple motor. Cut a swastika, with sharply pointed tips, from aluminum foil and indent its center with the pointed end of a pencil. Pivot the indentation on the point of a pin which has been thrust up through a supporting base of cardboard. The swastika will then be free to rotate on the pin point. It will do so vigorously if the pin is connected with the high-voltage terminal of the Van de Graaff. Ionized air streaming from the four points sets up the reactive force of a jet engine.

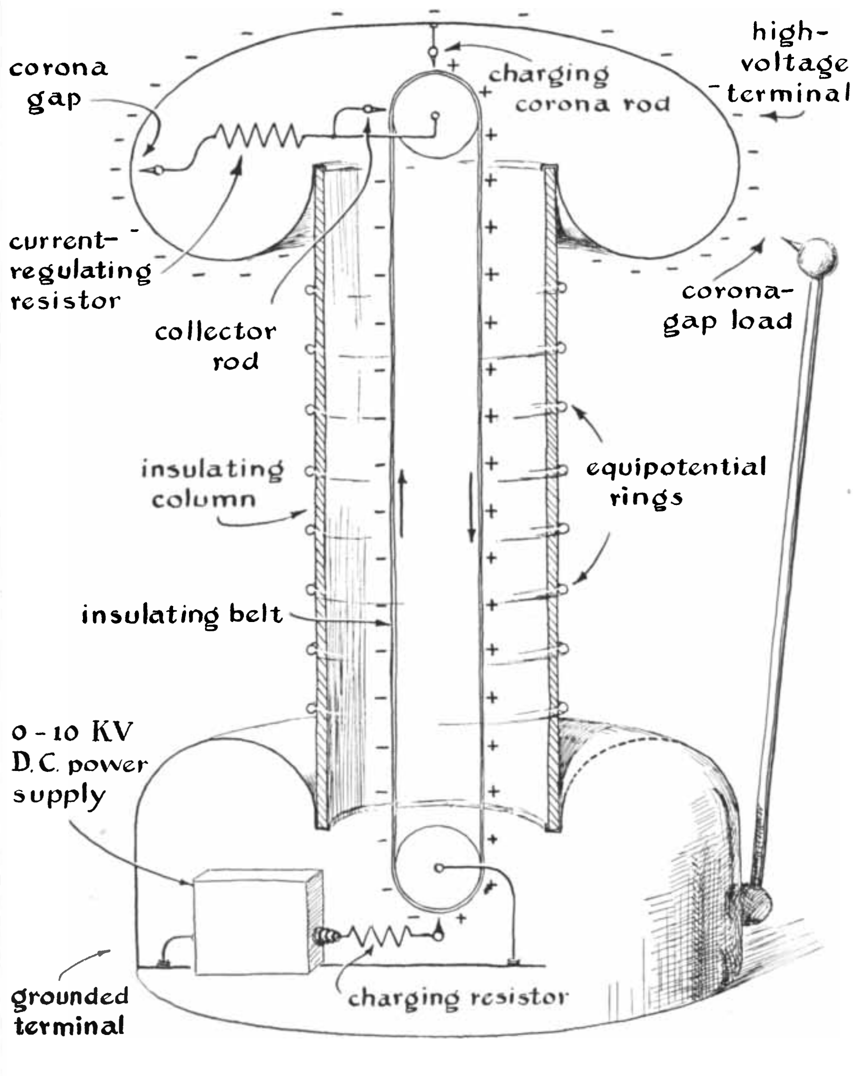
The power capacity of the Van de Graaff is enough to charge a person to about 50,000 volts. This is 20,000 volts above the ionizing point of air at atmospheric pressure. It is also enough to make the experimenter's hair stand on end. To demonstrate this effect, stand in or on a large glass bowl or a wooden platform supported by four square milk bottles. Touch the high-voltage terminal. After a few seconds your hair will slowly rise. Incidentally, the body adds capacity to the terminal, and so a somewhat larger charge than normal accumulates. When you step down or touch a grounded object, you will experience a slightly painful shock—but it is not dangerous to a person in normal health.

Fluorescent lamps will light up brilliantly where they are touched to the high-voltage terminal. If the room is not too brightly lighted, filament-type lamps also will glow in various colors depending on the kind of gas they contain. You can even manufacture a miniature aurora borealis by boiling water in a thin flask until the air is displaced by steam and then stoppering it immediately. After the steam has condensed, the rarefied air inside will glow greenish and pink when the flask is brought in contact with the Van de Graaff.

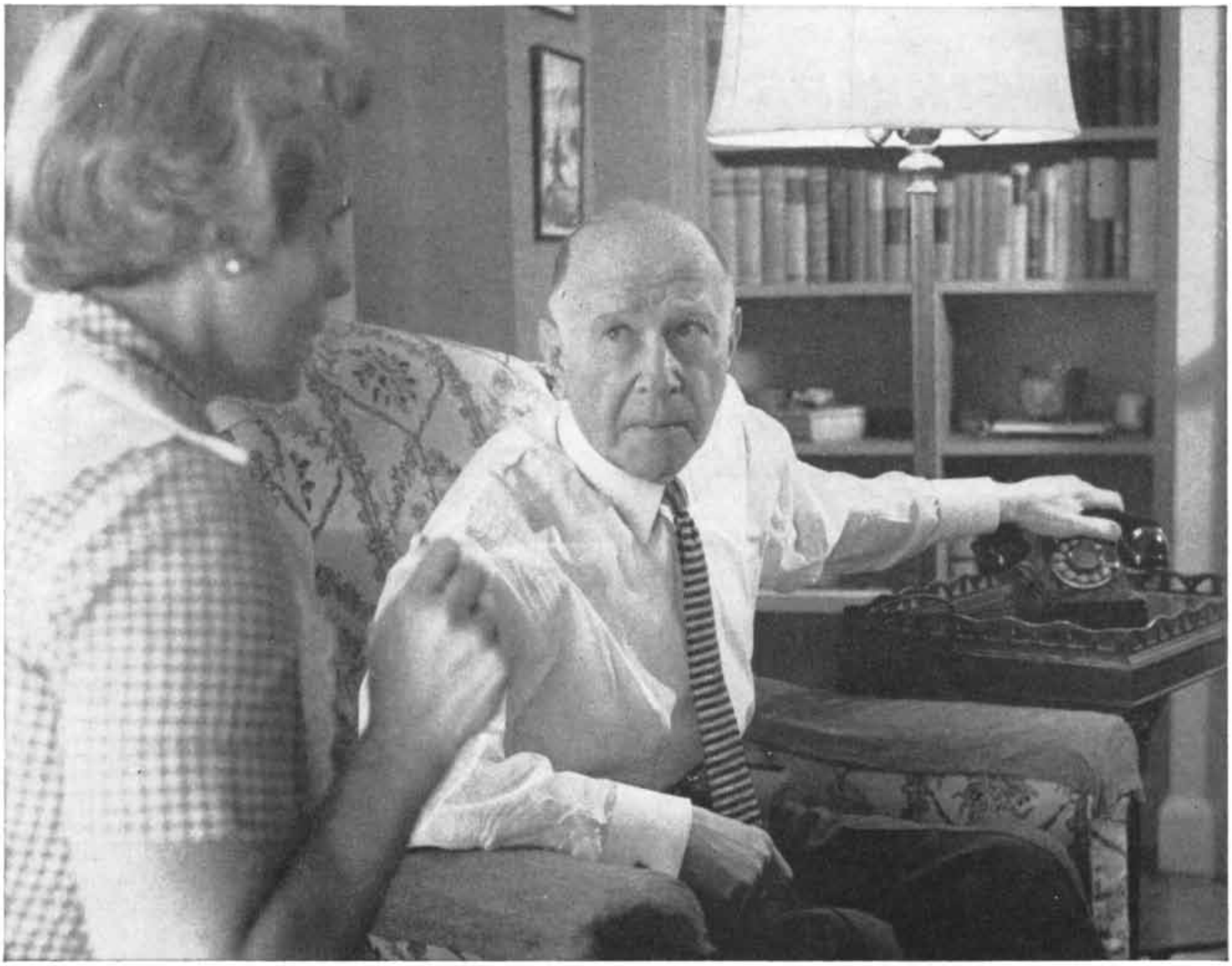
Those who can blow glass and exhaust it—or who can induce a local manufacturer of advertising signs of the glow-tube type to do so for them—may want to try their hand at assembling and operating a linear accelerator and related apparatus used for nuclear research. Such projects are on a par with amateur-built cyclotrons and, like marriage, are not to be entered upon lightly. They are, nevertheless, well within reach of amateur resources, particularly for groups.

To power such an apparatus you will require a larger version of the Van de Graaff [*see drawing below*]. It differs from the low-power design in a number of subtle, though important, particulars. The spray points for charging the upward run of the belt are supplied by a potential of 5,000 to 10,000 volts from a transformer-rectifier combination. The high-power machines employ metal pulleys at both ends of the belt, the upper one being insulated from the high-voltage terminal.

Charge is sprayed onto the belt as it passes through the corona between the lower points and the grounded driving pulley. A similar set of points, located just inside the upper terminal, removes charge from the upward belt run and conducts it to the upper pulley. After a short period of operation the upper pulley acquires a high charge and current flows to the upper terminal through a current-regulating resistor. This circuit



A high-power Van de Graaff machine



The Word We Dreaded

My husband and I were together when the phone rang. He got up to answer it and I held my breath as I heard his quiet, "Yes, Doctor?"

Then he put the receiver down carefully. His face, when he turned to me, was gaunt and lined, but he was trying to smile.

"Was it—the laboratory tests?" I asked.

He nodded. "We'd better get my bag packed," he said gently. "They want me in the hospital this evening."

We had realized for months that something was wrong. But the pressure of his business postponed action. "Guess I'm a little off my feed," was all he would say.

It took our family physician only ten minutes to change that attitude. He made an immediate appointment with a specialist. And at the end of an anguished week we knew. The laboratory tests confirmed the word we dreaded — "Cancer."

That was a year ago. Modern cancer research saved my husband. That... and the surgeon's skill, the strength of our faith and his own fighting heart. He is alive and well today. For us the story has had a happy ending.

Yet it *isn't* ended. When we think of the thousands of other families tragically broken every year, we feel we still have work to do. Many types of cancer *can be cured* if caught in time.

We tell our friends, "If there are symptoms you don't understand, see your doctor at once." And we *give* to support the constant research of the American Cancer Society in finding the causes and reducing the incidence of cancer.

Strike back at CANCER . . . man's cruelest enemy . . . GIVE

American Cancer Society ®

GENTLEMEN:

I want to help conquer Cancer.

☐ Please send me free information about Cancer.

☐ Enclosed is my contribution of $______ to the Cancer Crusade.

Name________________________

Address______________________

City____________Zone____State_____

(MAIL TO: CANCER, c/o your town's Postmaster)

1927—Covering wing of early Boeing plane, Seattle plant

1955—B-47 Stratojet assembly, Boeing Wichita Division

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Back in 1927 engineers designed airplane wings in simple terms of wood and cloth. An airplane wing of today is a complex aerodynamic structure housing a myriad of electrical, mechanical and hydraulic systems.

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may also include a corona gap near the inner surface of the terminal. A second set of spray points (charging rod), connected directly to the high-voltage terminal, is situated at the top of the pulley. The difference in potential between the upper pulley (made "live" by the voltage drop across the current regulating resistor and corona gap) and the high-voltage terminal causes these points to spray a charge of opposite sign onto the downward run of the belt. The value of the current-regulating resistor is chosen so that both sides of the belt work equally. The value of the current-regulating resistor can be computed roughly by Ohm's law. Belts for high-power machines are usually made of rubberized fabric and run at speeds of 4,000 to 6,000 feet per minute.

The capacity of the upper terminal to store charge varies with its size. Its ability to hold charge varies with shape. The ideal terminal would be spherical. Unfortunately this ideal cannot be realized because provision must be made for the entry of the belt. The shape must be such that the intensity of the field at the high-voltage terminal is always less than the value at which spark or corona discharge occurs. Hence the aperture of the terminal must have re-entrant edges and the facing sides of the upper and lower terminals should be identical. Such terminals are commonly made of aluminum spinnings.

Large Van de Graaffs in the million-volt range, intended for scientific and industrial purposes, are now nearly all mounted within a steel tank containing Freon, carbon dioxide or a similar gas at many atmospheres of pressure. The high pressure serves to increase the voltage-insulating ability of the gas manyfold and thus increases both the voltage and current capacity of the machine. Such machines are marketed by the High Voltage Engineering Corporation.

When Van de Graaff machines are designed for potentials above 200,000 volts, the distribution of charge along the insulating column (and even along the belt runs) becomes important. The columns of air-insulated machines using belts more than four inches wide should be fitted with equipotential rings spaced along the insulating column at intervals of about two inches.

Anyone undertaking the construction of a high-power Van de Graaff should remember that he is building no toy. These potentially lethal machines can reveal "marvelous wonders" beyond von Guericke's most inspired imagining, but, unlike his sulfur ball, they pack the wallop of lightning!

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BIBLIOGRAPHY

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

INTERNATIONAL COOPERATION IN NUCLEAR POWER

BRITAIN'S ATOMIC FACTORIES. K. E. B. Jay. H. M. Stationery Office, 1954.

MAJOR ACTIVITIES IN THE ATOMIC ENERGY PROGRAM. Semiannual Report of the Atomic Energy Commission to Congress, August-December, 1954. Government Printing Office, 1955.

NUCLEAR NOTES FOR INDUSTRY. Technical Information Service, Oak Ridge Institute of Nuclear Studies, 1955.

REPORT ON THE ATOM. Gordon Dean. Alfred A. Knopf, 1953.

THE SEA LAMPREY

FEEDING MECHANISM OF THE SEA LAMPREY AND ITS EFFECTS ON HOST FISHES. Robert E. Lennon in U. S. Fish and Wildlife Service *Fishery Bulletin*, Vol. 56, pages 247-293; 1954.

NATURAL HISTORY OF THE SEA LAMPREY, PETROMYZON MARINUS, IN MICHIGAN. Vernon C. Applegate. U. S. Fish and Wildlife Service, 1950.

USE OF ELECTRICITY IN THE CONTROL OF SEA LAMPREYS: ELECTROMECHANICAL WEIRS AND TRAPS AND ELECTRICAL BARRIERS. V. C. Applegate, B. R. Smith and W. L. Nielsen. U. S. Fish and Wildlife Service, 1952.

VACCINES FOR POLIOMYELITIS

STUDIES IN HUMAN SUBJECTS ON ACTIVE IMMUNIZATION AGAINST POLIOMYELITIS. Jonas E. Salk and others in *The Journal of the American Medical Association*, Vol. 151, No. 13, pages 1081-1098; March 28, 1953; and *American Journal of Public Health*, Vol. 44, No. 8, pages 994-1009; August, 1954.

MAN VIEWED AS A MACHINE

SOLVABLE AND UNSOLVABLE PROBLEMS. A. M. Turing in *Science News*, No. 31, pages 7-23. Penguin Books, 1954.

THE ECOLOGY OF DESERT PLANTS

ECOLOGY OF DESERT PLANTS. F. W. Went and M. Westergaard in *Ecology*, Vol. 29, No. 3, pages 242-253; July, 1948. Vol. 30, No. 1, pages 1-13 and 26-38; January, 1949.

VEGETATION AND FLORA OF THE SONORAN DESERT. Forrest Shreve and Ira L. Wiggins. Carnegie Institution of Washington, 1951.

THE ORIGIN OF GRANITE

THE GRANITE PROBLEM: EVIDENCE FROM THE QUARTZ AND FELDSPAR OF A TERTIARY GRANITE. O. F. Tuttle and M. L. Keith in *Geological Magazine*, Vol. 91, pages 61-72; 1954.

ORIGIN OF THE CONTRASTING MINERALOGY OF EXTRUSIVE AND PLUTONIC SALIC ROCKS. O. F. Tuttle in *Journal of Geology*, Vol. 60, No. 2, pages 107-124; March, 1952.

ORIGIN OF GRANITE. James Gilluly. Geological Society of America, 1948.

THE ANTHROPOLOGY OF MANNERS

CULTURE AND COMMUNICATION. G. L. Trager and Edward T. Hall in *Explorations*, No. 3, pages 137-149; August, 1954.

THE CHRYSANTHEMUM AND THE SWORD: PATTERNS OF JAPANESE CULTURE. Ruth Benedict. Houghton-Mifflin Company, 1946.

KINESICS AND COMMUNICATION. Ray Birdwhistell in *Explorations*, No. 3, pages 31-41; August, 1954.

THE T2 MYSTERY

GENERAL VIROLOGY. S. E. Luria. John Wiley & Sons, Inc., 1953.

HOST-INDUCED MODIFICATIONS OF VIRUSES. S. E. Luria in *Cold Spring Harbor Symposia on Quantitative Biology*, Vol. 18, pages 237-244; 1953.

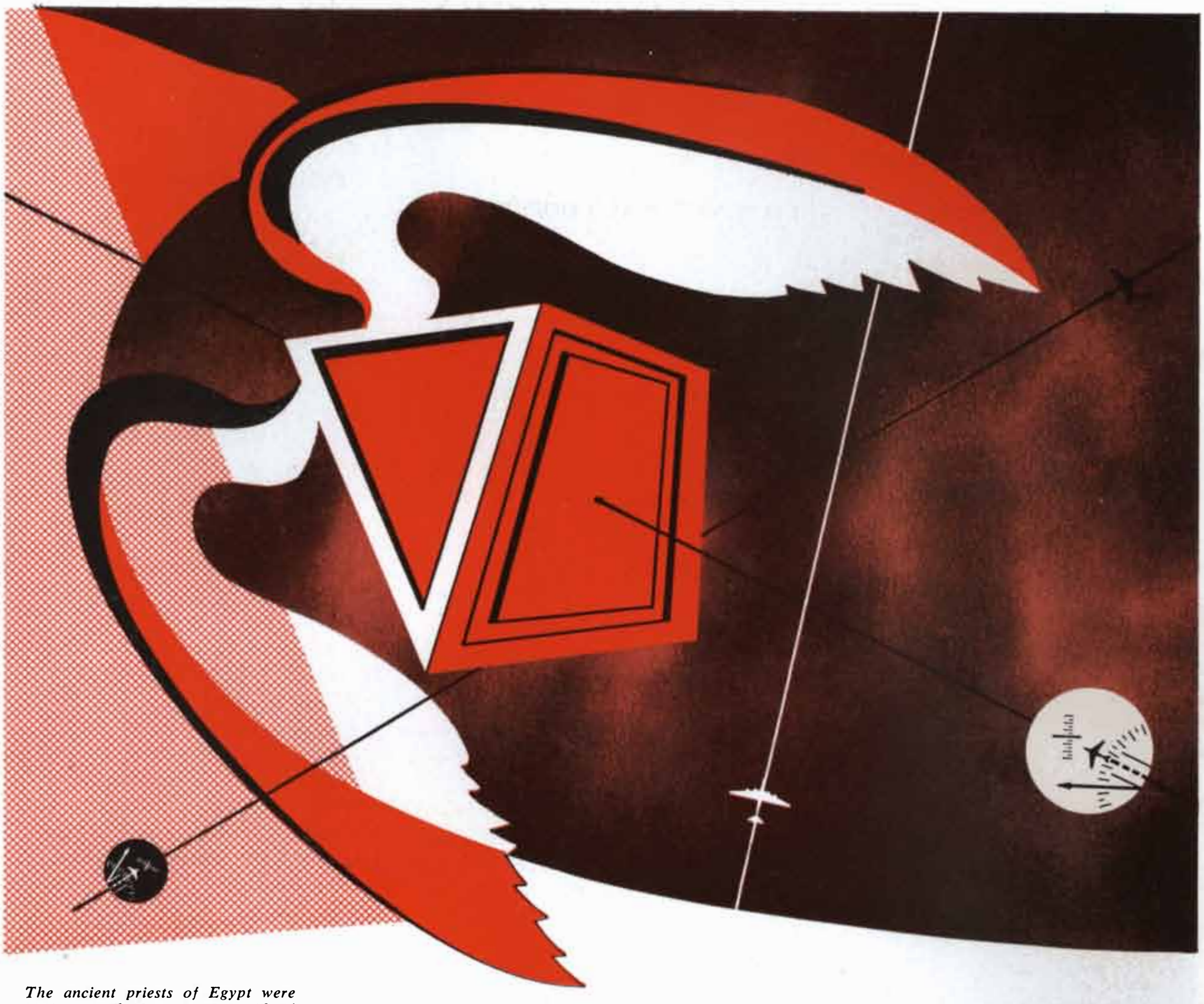
LYSOGENIC VERSUS LYTIC CYCLE OF PHAGE MULTIPLICATION. G. Bertani in *Cold Spring Harbor Symposia on Quantitative Biology*, Vol. 18, pages 65-70; 1953.

THE AMATEUR SCIENTIST

ELECTROSTATIC SOURCES OF ELECTRIC POWER. John G. Trump in *Electrical Engineering*, Vol. 66, No. 6, pages 525-534; June, 1947.

ELECTROSTATIC SOURCES OF IONIZING ENERGY. J. G. Trump in *Transactions of the American Institute of Electrical Engineers*, Vol. 70, Part 1, pages 1021-1027; 1951.

PHYSICS PRINCIPLES. Stanley S. Ballard, Edgar P. Slack and Erich Hausman. D. Van Nostrand Company, Inc., 1954.



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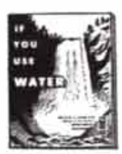

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