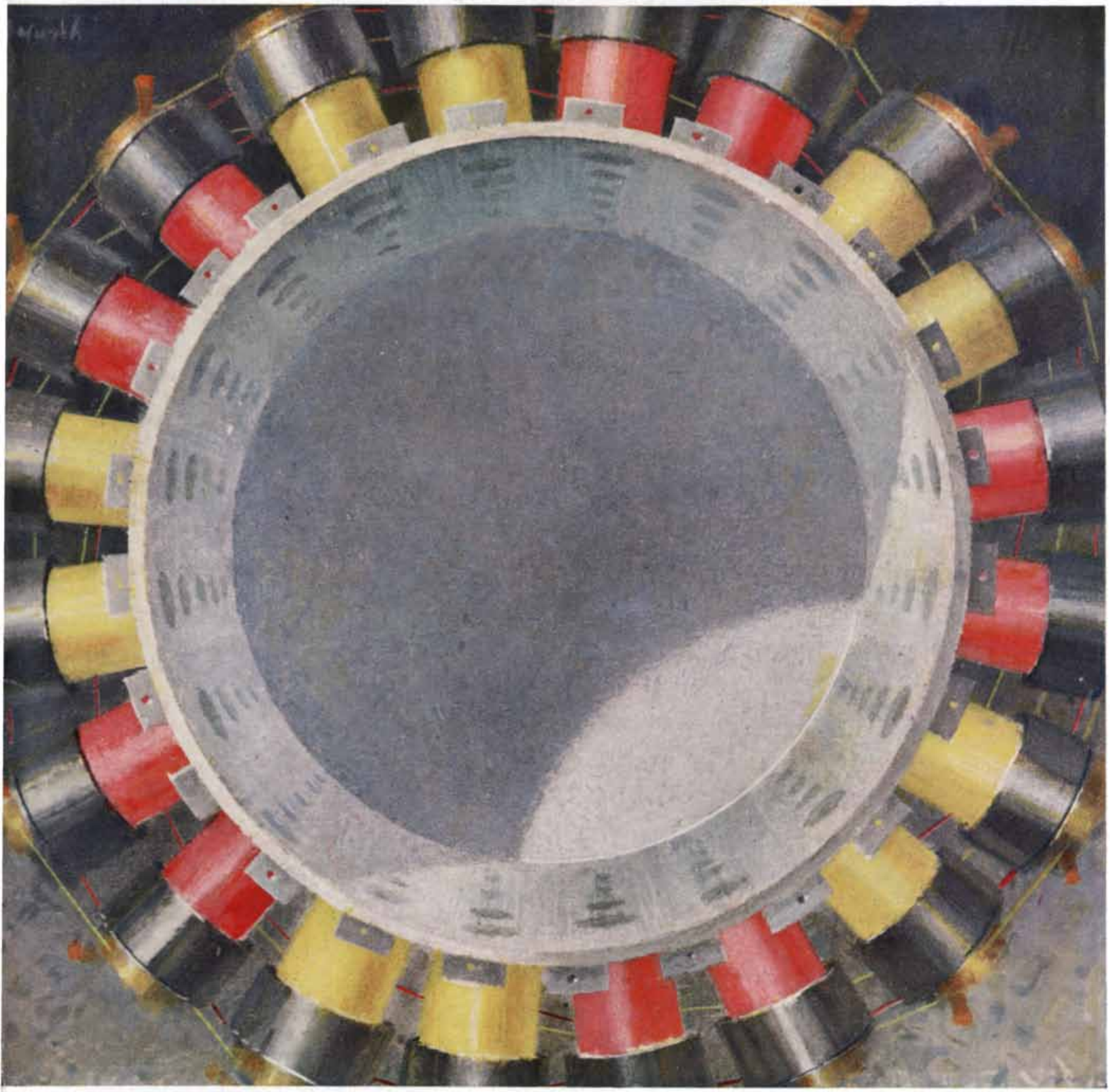
SCIENTIFIC AMERICAN



GIANT SCINTILLATION COUNTER

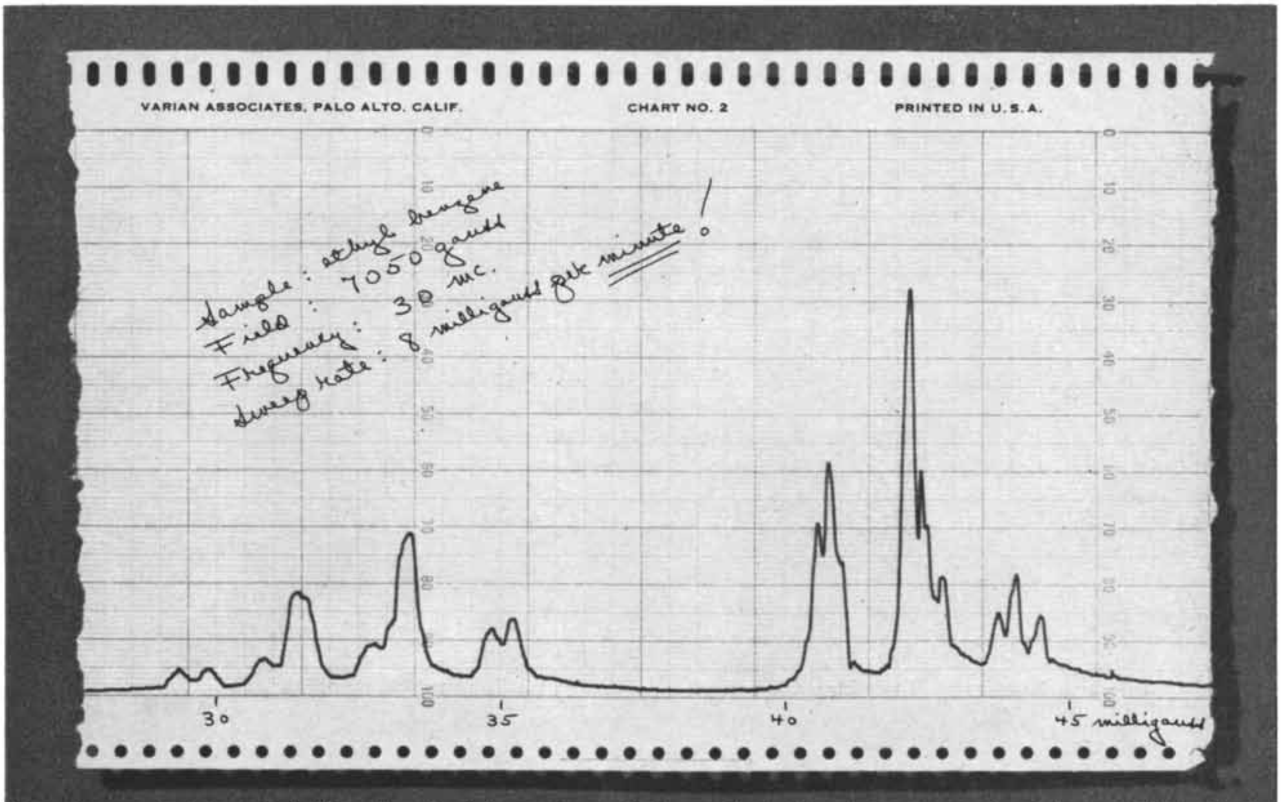
FIFTY CENTS

January 1956

now commercially available...

A SUPER HIGH RESOLUTION

N-M-R SPECTROMETER



The spectrum reproduced above is the N-M-R signal from the ethyl group protons in ethyl benzene. The signal from the benzene ring protons is at zero on the horizontal scale.

VARIAN announces another important N-M-R "first"... the *super* high resolution N-M-R (nuclear magnetic resonance) spectrometer. A new accessory, developed for the Varian 12-inch laboratory magnet system, extends time stability of the applied dc field to the unprecedented region of 1 part in 100 million. This exceptional stability enables use of a conventional strip chart recorder using slow sweeps... results in a new standard of resolving power and signal-to-noise ratio.

Now available with the Model V-4300B spectrometer and fully compatible with the many Varian high resolution N-M-R spectrometers in daily use, this device offers significant new advantages for the study of chemical systems. With *super* high resolution N-M-R, complex structural features of chemical compounds containing such nuclei as H^1, F^{19}, P^{31} and B^{11} can now be more readily determined... techniques for quantitative analyses substantially simplified and improved.

ANOTHER MILESTONE IN PRACTICAL N-M-R INSTRUMENTATION ... *super* high resolution represents the latest advance in the field of N-M-R spectroscopy, dating from Varian's delivery of the first commercial N-M-R spectrometer in 1950... the first high resolution N-M-R spectrometer in 1952. Today, many of these Varian instruments are making significant research contributions in the laboratories of chemical, petroleum and industrial firms, universities, government agencies and research institutes throughout the world.

COMPLETE INFORMATION about *super* high resolution N-M-R and the Varian Model V-4300B spectrometer will be sent to you on request.

The mark of leadership

Special Products Division

VARIAN associates

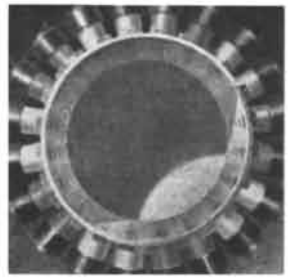
PALO ALTO 7, CALIFORNIA

KLYSTRONS, TRAVELING WAVE TUBES, BACKWARD WAVE OSCILLATORS, LINEAR ACCELERATORS, MICROWAVE SYSTEM COMPONENTS, R. F. SPECTROMETERS, MAGNETS, MAGNETOMETERS, STALOS, POWER AMPLIFIERS, GRAPHIC RECORDERS, RESEARCH AND DEVELOPMENT SERVICES

Established 1845 SCIENTIFIC AMERICAN January, 1956 Volume 194 Number 1

ARTICLES

DEPARTMENTS



THE COVER

The painting on the cover is a top view of a large scintillation counter used in an attempt to detect an elusive particle of modern physics: the neutrino (*see page 58*). The tank of the counter, the top of which has been removed, is 28 inches high and 28 inches in diameter. The sides of the tank are perforated with holes, at each of which is a photomultiplier tube. During an experiment the tank is filled with a liquid which emits a small flash of light when it is penetrated by an ionizing particle or ray. The flash is detected by the photomultiplier tubes, amplified and finally registered by a counter. A photograph of the same device appears on page 58. It was built at the Los Alamos Scientific Laboratory, where an even larger counting device has now been made to detect neutrinos.

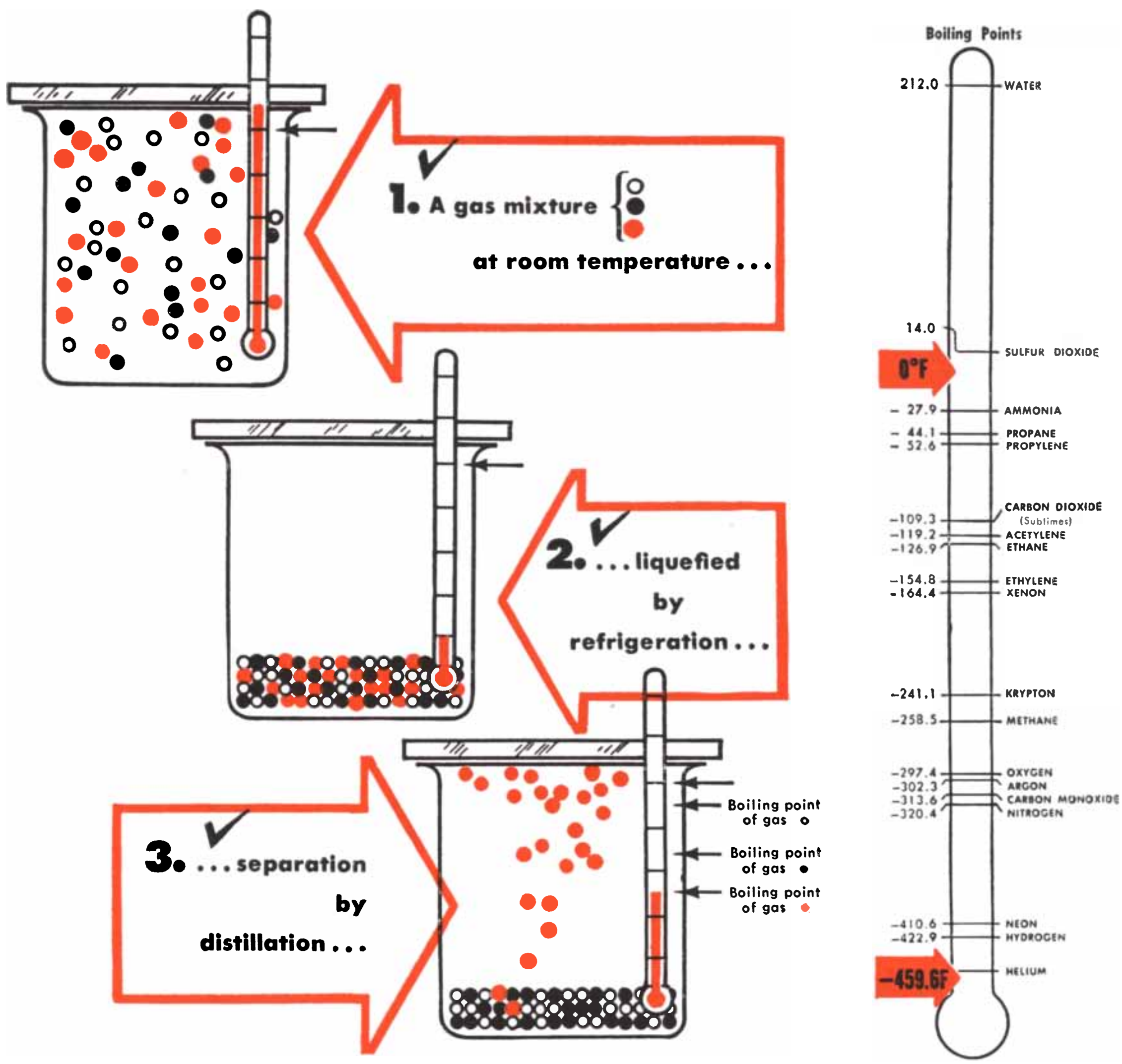
THE ILLUSTRATIONS

Cover painting by Walter Murch

Page	Source
30-31	Anthony G. Oettinger, Harvard University; courtesy John Wiley & Sons, Inc.
32	Massachusetts Institute of Technology
33	Paul Weller
34-36	James Egleson
37	Amy Kasai
39-42	Eric Mose
58	Atomic Energy Commission
60-68	James Egleson
70-75	Bernarda Bryson
80	J. J. Wolken, University of Pittsburgh
81-82	Amy Kasai
84	Bunji Tagawa
86	Paul Weller
90	Bodleian Library
92-96	New York Academy of Medicine
99	Irving Geis
100	Paul Weller
102-104	Irving Geis
120-128	Roger Hayward

LOW-TEMPERATURE PROCESSING

—a basic method for separating components from gas mixtures



The production of oxygen and nitrogen in unlimited quantities from the free air is accomplished most economically by "low-temperature processing". So, too, is the separation of industrial waste gases and fluid flows into their valuable components.

The method is basic. A gas mixture is liquefied by refrigeration—produced by expansion of the compressed mixture. The temperature of the mixture is then allowed to rise to the boiling points of the constituent gases, one by one.

As the temperature reaches the boiling point of each gas successively, the particular component can be drawn off from the mixture (fractional distillation). Basically, low-temperature gas separation processes depend on changing the state of matter. This is also the genesis of other low-temperature separation processes—removing solids from liquids, and making solids from gases. Dewaxing oil and freezing xylenes out of petroleum products are examples of the first; making dry ice out of waste carbon dioxide, an example of the second.

Engineering and production executives interested in this process may obtain more complete information by requesting (on company letter-head, please) a free copy of our booklet "Low-Temperature Processing of Gases, Liquids, Solids".

Air Products
INCORPORATED
Dept. R, Box 538 Allentown, Pa.

LETTERS

Sirs:

I feel impelled to take issue with the conclusions reached by Solomon E. Asch in his article "Opinions and Social Pressure" [SCIENTIFIC AMERICAN, November, 1955]. The constant readiness to be proven wrong constitutes the most indispensable prerequisite for a scientist. On all matters of sense perception, capable of objective measurement and verification, a true scientist will invariably question and reject his own subjective impressions when confronted with objective evidence to the contrary, such as actual physical measurement. Even more striking results could have been obtained by actual measurement with two unequal, "fixed" measuring rods. Under the conditions of the stated experiments, the closest approach to objective verification available to the subject was the near unanimous judgment of his equals. One could thus make a strong case for a thesis contrary to that implied by the author: That the highest trait favoring the scientific progress of our society is the unflinching readiness to be proven wrong as adjudged by the best available methods of verification.

Stubborn attachment to disproven pet theories (which the article would dub "capacity for independence" or "individualism") is unworthy of intelligent men. Furthermore, the unselfish willingness to accept the best available objective evidence in preference to one's own subjective impressions by no means im-

Scientific American, January, 1956; Vol. 194, No. 1. Published monthly by Scientific American, Inc., 2 West 45th Street, New York 36, N. Y.; Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer.

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

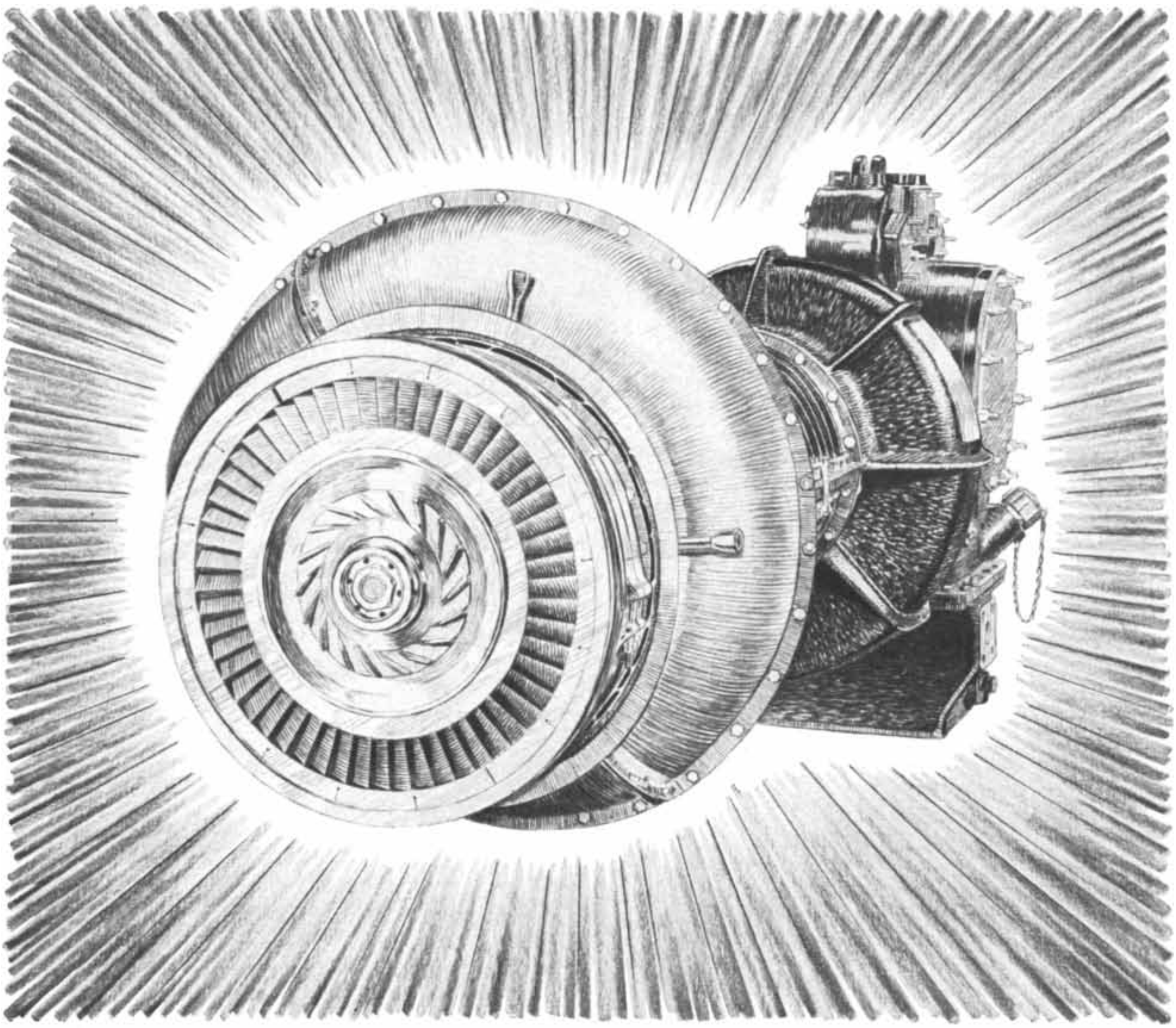
Advertising correspondence should be addressed to Martin M. Davidson, Advertising Manager, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y.

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

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

Subscription rates for U.S.A. and possessions: 1 year, $5; 2 years, $9; 3 years, $12.50. Canada and Latin America: 1 year, $6; 2 years, $11; 3 years, $15. All other countries: 1 year, $8; 2 years, $14; 3 years, $18.

POWER PLANT OF THE FUTURE



The Solar "Jupiter" Gas Turbine Engine

DEPENDABLE, INSTANT POWER in hot or cold weather is supplied by the Solar Jupiter 500 hp gas turbine. Compact and light weight, the Jupiter engine offers easy portability; its ruggedness and simplicity cut maintenance problems. Solar builds both variable and constant speed, as well as air bleed versions, of this engine. Your forward planning should include this remarkable power plant, as well as its companion engine, the Solar "Mars"® 50 hp gas turbine. For data about Solar turbines, write today to Solar Aircraft Co., Dept. B-101, 2200 Pacific Hwy., San Diego 12, Cal.

SOLAR
AIRCRAFT COMPANY
SOLAR
SAN DIEGO DES MOINES

ENGINEERS WANTED *Unlimited opportunities in Solar's expanding gas turbine program! Write today, giving your experience.*

DESIGNERS, DEVELOPERS AND MANUFACTURERS OF METAL ALLOY PRODUCTS • GAS TURBINES • BELLOWS • CONTROLS • HIGH TEMPERATURE COATINGS • AIRCRAFT COMPONENTS plies conformist behavior in the fields of ethical, moral, political and social principles and convictions.

A well-rounded person cannot do without a blend of both character ingredients: some measure of reliance on the common achievements of his fellow men, as well as some measure of critical independence. The results of these experiments thus prove nothing whatever to a natural scientist, and point to no conclusion or lesson. Their value, if any, lies exclusively in the determination of quantitative orders of magnitude for very specialized sets of conditions.

KURT EISEMANN

New York, N. Y.

Sirs:

It comes as a surprise that the investigation of social pressure could be interpreted as confusing independence with dogmatic attachment to one's views. The comments of Mr. Eisemann neglect a modest but vital fact about the experimental situation: It was the task of the person who served as observer to report what *he* saw, not what others were seeing. His role was that of a person testifying to a fact within his experience, and analogous to that of a member of a jury who is expected to consider the views of others but who may not delegate his responsibility. This was clearly understood by all.

Indeed, our observations show that the problem of the observer was not restricted to deciding whether the majority was accurate. There were persons who, although convinced that the majority was judging correctly and that their own judgments were wrong, remained completely independent. There were others who complied with the majority although convinced that it was wrong. These observations cannot be reconciled with the view that independence under the present conditions marked a failure to show a decent respect for the opinion of others, and that conformity was the sign of an unselfish scientific temper. The evidence points in a different direction: independence required a measure of strength, while failure of independence was connected with self-distrust and fear.

Mr. Eisemann's letter raises a wider and a humanly more important issue. If I understand him rightly, he comes close at some points to saying that agreement among persons is at times tantamount to proof and the best criterion of truth, placing upon other individuals the obli-

Inside THE FIRST SATELLITE...

A new era of technical progress is born. Components, instruments, *entire* systems must be created to withstand the *violent* forces that will be encountered.

Micro-miniaturization, a vital new design concept, will pack this complex, super-reliable, electronic equipment into fractions of inches—grams will make the difference. In the unriddling of these problems lies an important contribution to the success of man's first invasion of outer space

Thus, the engineer faces new technical problems of almost overwhelming magnitude. His ultimate conquests can come only as the culmination of a series of supporting victories on the drawing board, in the laboratory and in his own mind. Today's engineer has learned to look to Gulton Industries—and its five integrated companies—for the unconventional approach and spirit of co-ordinated talents that facilitate technical advances. One of the most recent is the GLENNITE® KAT-1, Self-Recording Accelerometer System, the in-flight environmental measuring instrument that supposedly couldn't be built. Original from sensing element to recording unit, it contains five complete electronic instruments that would normally occupy ten to twenty times its tiny volume. The KAT-1 was created by Gulton Mfg. Corp. to meet a unique testing requirement for a virtually shock-proof, self-recording device.

In all Gulton Industries' developments, the dominant motivating theme is Research-on-the-Production-Line—a flexible technique which permits instant tailoring of basic materials and instruments to fill difficult requirements. This and other advanced techniques including molecular engineering, enable Gulton Industries to offer an unusually wide variety of products — high reliability, subminiature ceramic capacitors; ultrasensitive, pivotless electrical meters of extreme accuracy and ruggedness; new ultrasonic devices; improved transducers and dielectrics; nuclear instrumentation—in addition to specialized engineering services for the development of the smallest component or the most complex system.

No matter how difficult or diversified your problem, consult Gulton Industries.

Gi

FREE—The complete story of products produced by Research-on-the-Production-Line ... send for Brochure G-101 today!

GLENNITE MODEL KAT-1
SELF-RECORDING ACCELEROMETER

Official U. S. Navy Photogra

GULTON INDUSTRIES, INC.

METUCHEN, NEW JERSEY

Gulton Mfg. Corp., Glenco Corporation, Vibro-Ceramics Corporation, Thermistor Corporation of America (Metuchen, N. J.), Greibach Instruments Corporation (Metuchen, N. J. and New Rochelle, N. Y.), Engineered Magnetics Division of Gulton Mfg. Corp. (Culver City, Calif.). In Canada: Titania Electric Corporation of Canada, Ltd., Gananoque, Ontario.

PIONEERS IN MATERIALS RESEARCH, ELECTRONIC COMPONENTS, PRECISION INSTRUMENTS AND SYSTEMS ENGINEERING gation to acknowledge it. Had he limited his claim to suggesting that we ought to take into account and examine the views of others, one could hardly quarrel with it. But the history of human affairs—and of science itself—establishes sufficiently that error and distortion can have quite a following. Apparently we need to discriminate between valid and baseless consensus. And what other means of doing so have we than our own understanding? I prefer to say that agreement is not proof, that consensus is baseless unless it is independently confirmed in the experience and insights of each person. Our individual "subjective impressions" may be all too frail, but they are all we have.

SOLOMON E. ASCH

Cambridge, Mass.

Sirs:

I plead guilty in depriving the fifth decimal place in the number pi of one unit as it was correctly noticed and versified by Mr. Theodore Malnechuck ["Letters," SCIENTIFIC AMERICAN, November, 1955]. But my excuse is my notoriously bad spelling which had resulted once in the past in accusing the editors of the "MacMillan Modern Dictionary" in missing the word APPLE in the volume. As it turned out later, I was looking for APPEL which would be more correct and besides was used by Anglosaxon writers long before Sheckspear.

In present case my mistake was due to spelling french word APPRENDRE with one P only. In fact, thinking about number pi, I always remember a french nursery rithm which I have learned as a small boy.

Que j aim à faire apprendre
Un nombre utile aux sages.
Immortel Archimedes, artist ingeniour
Qui de ton jugement peux priser la
valeur,
Pour moîs ton probleme
A les parelles avantages!

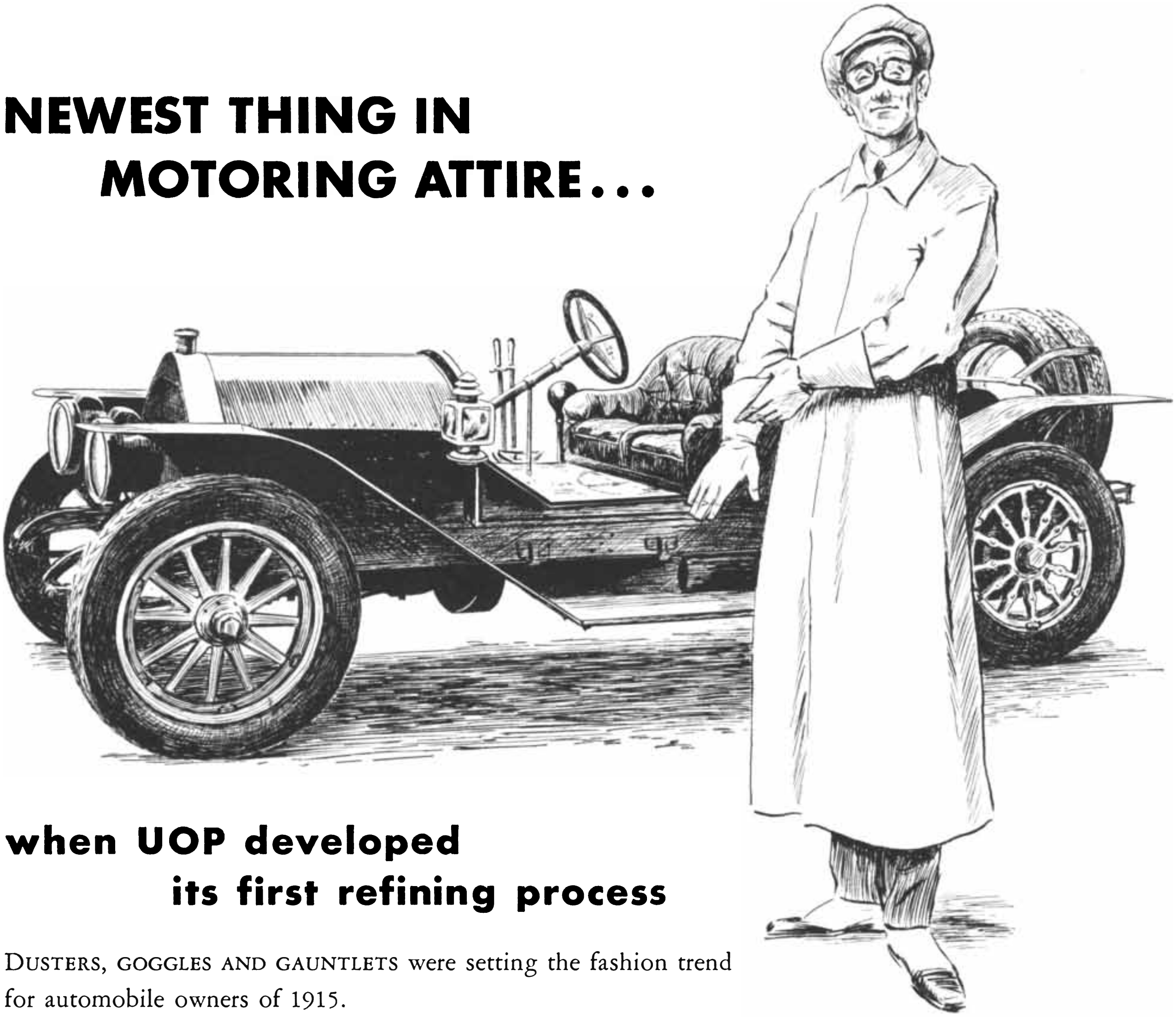
The number pi is obtained by counting the number of letters in the words of this verse, and, writing APRENDRE I counted eight letters instead of nine. C'est terrible!

G. GAMOW

Washington, D. C.

P. S. But, please let nobody use the verse for figuring more decimals in π before consulting french dictionary!

NEWEST THING IN MOTORING ATTIRE...

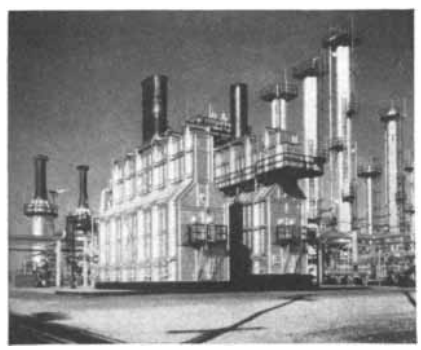


when UOP developed its first refining process

DUSTERS, GOGGLES AND GAUNTLETS were setting the fashion trend for automobile owners of 1915.

And there was a new trend in petroleum refining in those days. A radical improvement in processing methods had just been announced by Universal Oil Products Company, and refiners were taking a look at the new continuous method for making more and better gasoline. It wasn't long before the industry had accepted UOP's thermal cracking process as the practical way to improve refining operations.

For four decades refiners have continued to accept UOP processes as the most modern methods for making better gasoline at costs consistent with the industry's economic needs. It has been forty years of progress for refiners who have depended upon Universal's scientific and technical skill to help them make more and better products from petroleum.

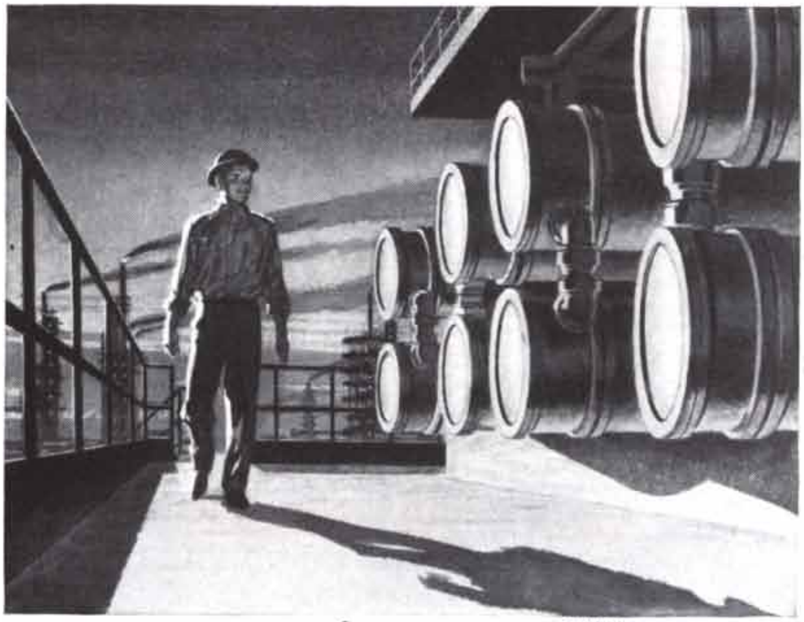


PLATFORMING . . . originated and developed by UOP . . . the industry's first catalytic reforming process that pioneered the use of a platinum-bearing catalyst. Now the leading reforming process in worldwide use.

UNIVERSAL OIL PRODUCTS COMPANY

UOP® 30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

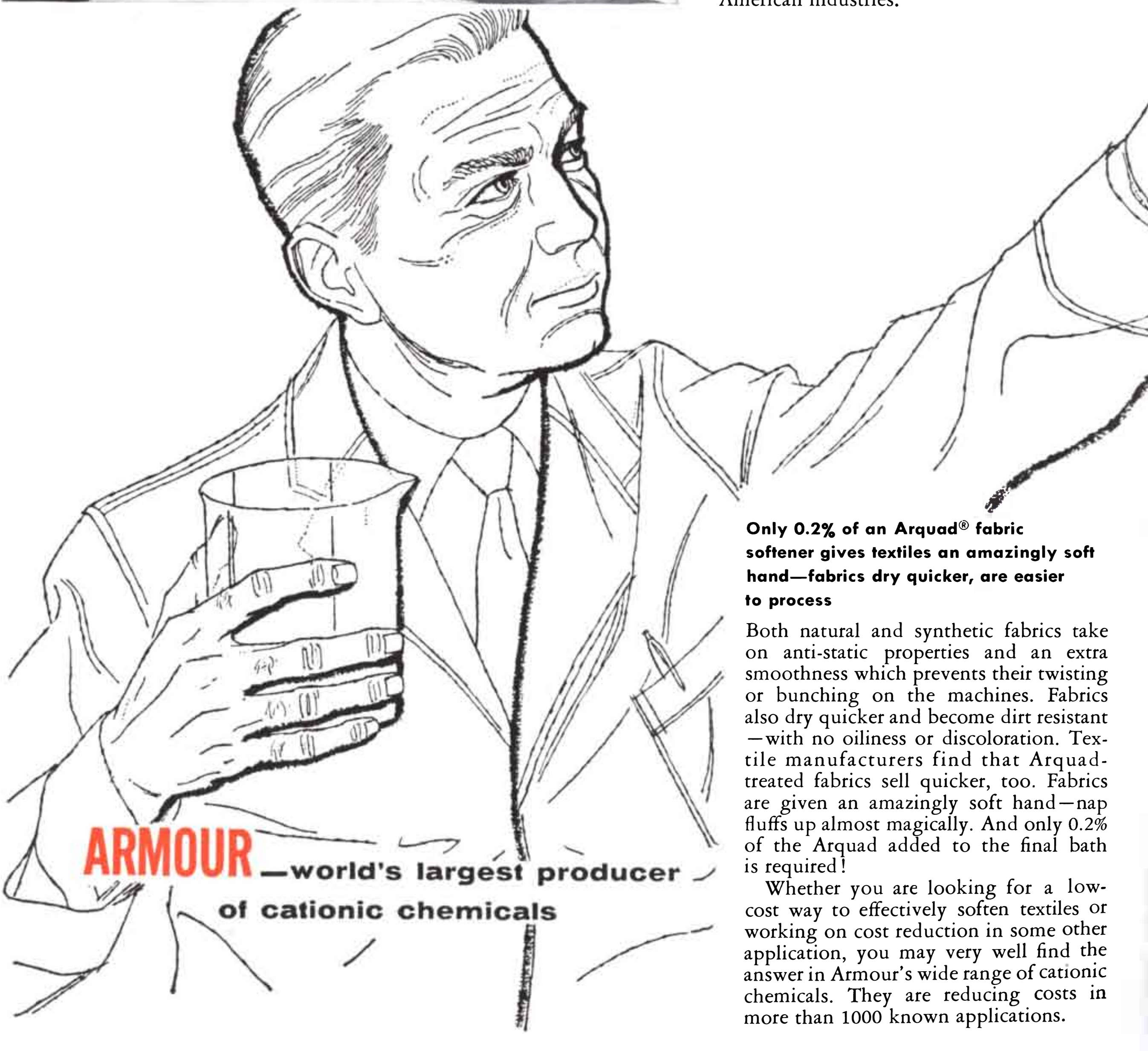
Forty Years Of Leadership In Petroleum Refining Technology



Minute quantities of an Armeen® stops corrosion in leading oil producer's equipment—increases throughput 20%

Corrosion residue, collecting in gasoline casing-head condenser tubes was creating a severe and costly problem for a West Coast oil producer just two years ago. Frequent shutdowns for cleaning were necessary. The corrosion rate was so high, condensers had to be replaced every 18 months. Then an Armour cationic corrosion inhibitor—one of the many Armeens—was put to work. Almost immediately, corrosion decreased 97%. Throughput increased 20%. Condenser life has been lengthened to 10 years. And less than one tablespoonful of an Armeen per tank wagon of gasoline did the job!

Armour makes over 100 cationics. Corrosion inhibition is just one of their 1000 known applications. Effective at low concentrations, they are increasing production and profits for a broad range of American industries.



ARMOUR—world's largest producer of cationic chemicals

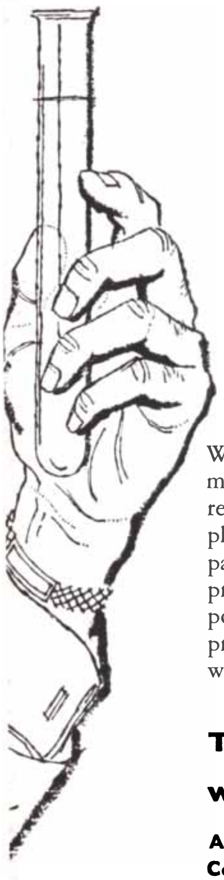
Only 0.2% of an Arquad® fabric softener gives textiles an amazingly soft hand—fabrics dry quicker, are easier to process

Both natural and synthetic fabrics take on anti-static properties and an extra smoothness which prevents their twisting or bunching on the machines. Fabrics also dry quicker and become dirt resistant—with no oiliness or discoloration. Textile manufacturers find that Arquad-treated fabrics sell quicker, too. Fabrics are given an amazingly soft hand—nap fluffs up almost magically. And only 0.2% of the Arquad added to the final bath is required!

Whether you are looking for a low-cost way to effectively soften textiles or working on cost reduction in some other application, you may very well find the answer in Armour's wide range of cationic chemicals. They are reducing costs in more than 1000 known applications.

PRODUCTION PROBLEMS?

COST PROBLEMS?



Armour cationics solved both in these two widely diverse fields. New applications are constantly being developed and added to the hundreds already known. Perhaps these unique chemicals can help you.

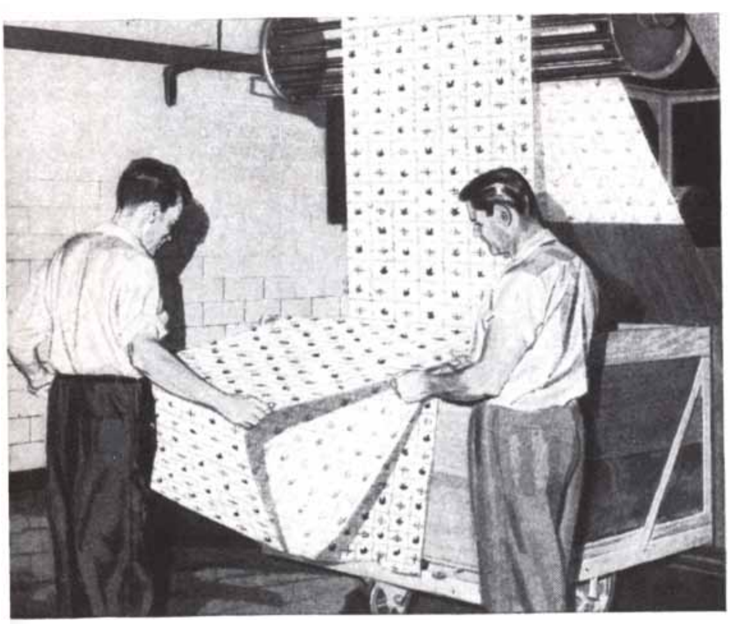
Whether your business is rubber processing or mineral recovery, paper manufacturing or petroleum refining—whether you make germicides, paints, plastics or products for many other fields—it will pay you to include Armour cationics in your testing program. Extremely low concentrations of these powerful chemicals are increasing efficiency and profits for industries in at least a thousand different ways. Today, there are more than 100 different Armour cationics. One of them may be the chemical you've been looking for.

Let Armour cationic specialists help speed your search. Our research people will recommend cationics which have delivered outstanding results in your field. Or, they will work with your staff to develop a profitable new cationic application for you. Simply write us a description of your problem or send the coupon below, today.

This brief list of proved applications will suggest many areas where testing of Armour cationics may prove profitable for you!

Anti-statics • Emulsifiers • Asphalt Additives • Textile Softeners • Corrosion inhibitors in water systems Corrosion inhibitors in oil systems • Pigment wetting • Bactericides • Hard rubber mold release agents Algaecides • Buffing compound additives • Vinyl mold release agent • Latex foam sensitizers Flotation reagents • Nitrile rubber plasticizers and softeners

For information on any of the hundreds of proved uses for Armour cationics—and for current data on possible new areas of application—fill in the coupon below.



MAIL THIS COUPON TODAY!

Please send me information on Armour cationics for the following applications:____________________

____

____

*Name*________________________________

*Firm*________________________________

*Address*______________________________

*City*__________________ *State*__________

ARMOUR CHEMICAL DIVISION

© Armour and Company
1355 West 31st St. • Chicago 9, Illinois

SA 1

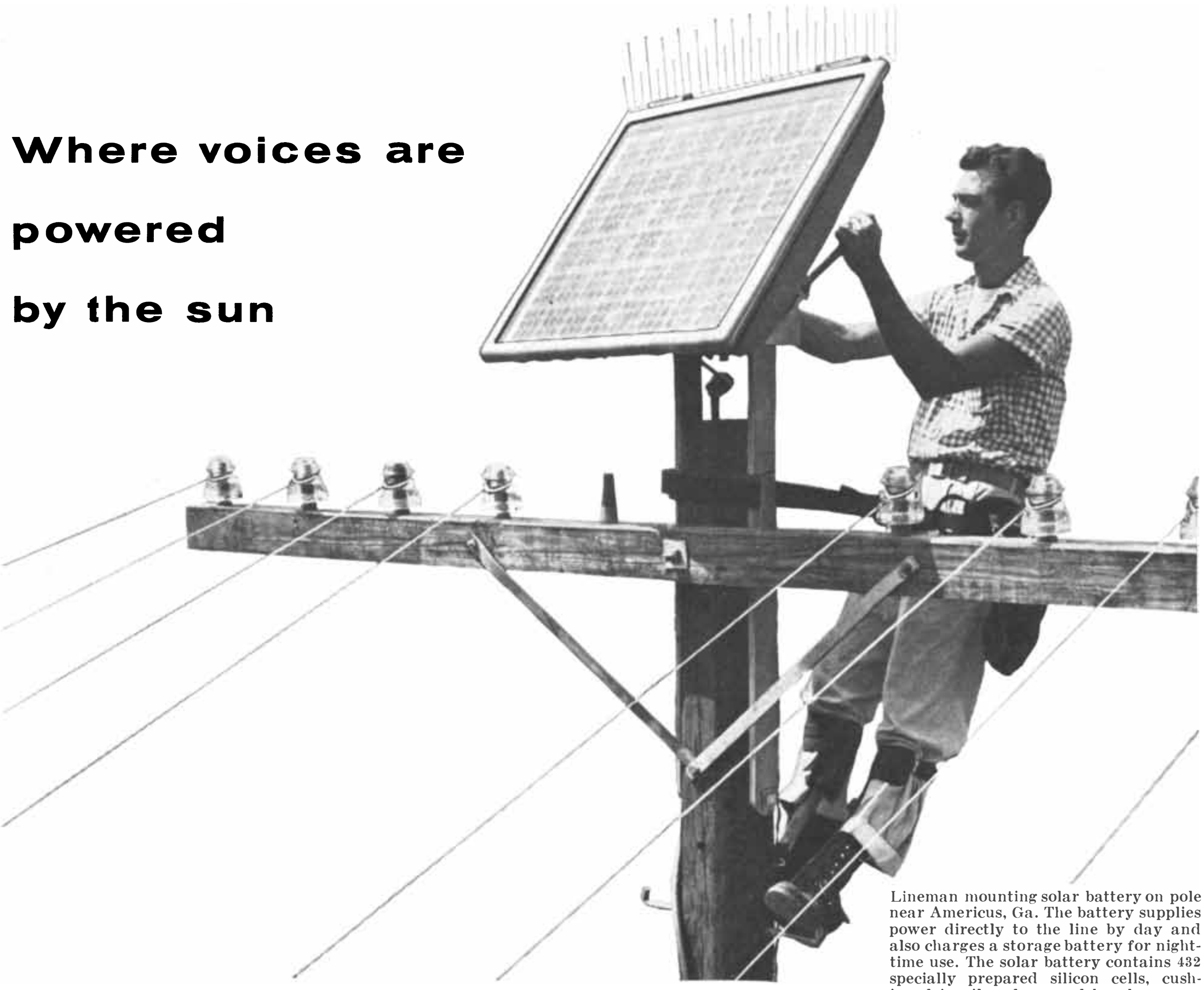
50 AND 100 YEARS AGO

SCIENTIFIC AMERICAN

JANUARY, 1906: "A Parisian automobile paper recently published a letter from the Wright brothers to Capt. Ferber of the French army, in which statements are made that certainly need some public substantiation from the Wright brothers. In the letter in question it is alleged that on September 26 the Wright motor-driven aeroplane covered a distance of 17.961 kilometers in 18 minutes and 9 seconds, and that its further progress was stopped by lack of gasoline. On September 30 the machine traveled 16 kilometers in 17 minutes and 15 seconds; this time a hot bearing prevented further progress. On October 5 an eye-opening record was set when a distance of 38.956 kilometers was covered in 33 minutes and 3 seconds (cause of stoppage, exhaustion of gasoline supply). It seems that these alleged experiments were made at Dayton, Ohio, a fairly large town, and that the newspapers of the United States allowed these sensational performances to escape their notice. When it is considered that Langley never even successfully launched his man-carrying machine, that Langley's experimental model never flew more than a mile, and that Wright's mysterious aeroplane covered a reputed distance of 38 kilometers at the rate of one kilometer a minute, we have the right to exact further information before we place reliance on these French reports."

"The Bulletin of the Société Astronomique states that in an excursion which the Russian artist M. Borrissoff made lately to the Strait of Matochkin, between the two islands of Novaya Zemlya, he discovered underneath a case a box containing two thermometers, one a maximum and the other a minimum recording thermometer. It is supposed that these instruments belonged to Höfer, an Austrian geologist, who made an expedition to this spot in 1872. One of the thermometers was found to have registered 15 deg. C. as a maximum, while the second instrument showed that the greatest cold had been –70

Where voices are powered by the sun

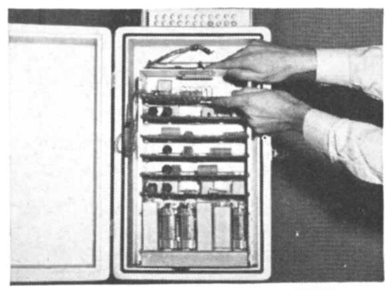


Lineman mounting solar battery on pole near Americus, Ga. The battery supplies power directly to the line by day and also charges a storage battery for night-time use. The solar battery contains 432 specially prepared silicon cells, cushioned in oil and covered by glass.

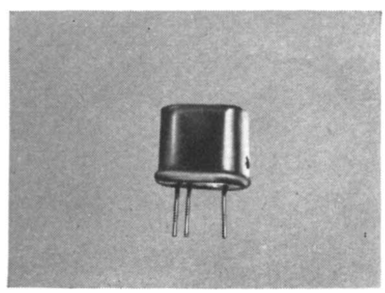
A new kind of telephone system developed by Bell Telephone Laboratories for rural areas is being operated experimentally by electric current derived from sunlight. Electric current is generated as sunlight falls on the Bell Solar Battery, which a lineman is seen adjusting in position.

The exciting achievement is made possible by two Laboratories inventions—the solar battery and the transistor. The new system uses transistors to the complete exclusion of electron tubes. Transistors require little power and this power can be easily supplied by the solar battery.

Compact and economical, the transistorized system can carry several voices simultaneously without interference. It has proved its ruggedness by standing up to heat, cold, rain and lightning. It promises more and improved telephone service for rural areas and it typifies the Laboratories' continuing efforts to make American telephony still better each year.



In sending and receiving terminals, transistors are used as oscillators, amplifiers and regulators, and for signaling.



One of the transistors (actual size) used in the new system. New ideas, new tools, new equipment and new methods had to be developed for this project.

BELL TELEPHONE LABORATORIES

IMPROVING AMERICA'S TELEPHONE SERVICE PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS deg. C. This value seems to be the extreme cold which has been reached in this region for thirty years past."

"For the purposes of studying the causes of *soroche* or mountain sickness and the influence of the temperature and climate of high altitudes upon general nutrition, two eminent French medical authorities, Drs. Guillemard and Moog, during last July made a stay at the Mont Blanc observatory with the astronomer M. Janssen. According to the results of their investigations the diminished tensions of the oxygen in the atmosphere clogs the processes of oxidation, and this sets up an elaboration of toxic substances, the retention of which causes autointoxication and accounts for the symptoms of mountain sickness. Acclimatization, however, results in a few days, and the symptoms pass away under circumstances resembling those accompanying the passing of the crisis in infectious maladies."

SCIENTIFIC AMERICAN

JANUARY, 1856: "At a late meeting of the American Geographical Society in New York the interest of the proceedings was enhanced by the presence of Dr. Kane, the Arctic explorer, who gave an outline of some of his discoveries. His remarks commenced by allusions to the mountain ranges in North Greenland:— 'After leaving New York, we made the coast of Greenland at its most southern point. We then continued to Smith Sound, and then pushed on in our ship further to the northward. From this point our vessel was forced up to our winter harbor. With great difficulty here we were enabled to travel by sledges, and in this way we reached the latitude of 80 degs.—the most northern point which has yet been reached. At this point our parties were compelled to return for the winter. In our winter harbor we established an observatory, by means of a theodolite and a common pocket glass. We took magnetic and meteorological observations, which are now deposited in the office of the Coast Survey. Our lowest recorded temperature was between 70 and 80 degrees below zero. We found that Greenland, at this point, unexpectedly presented a coast running almost east and west. Here we discovered a range of mountains that stretched out, apparently, far to the north. In the latter portion of this travel we found be-

Rare Earths by Ion Exchange

a new system which produces "rare" rare earths
in purities up to 99.99% for research and industrial use

a report by LINDSAY

TALK about excitement! Here at Lindsay we're as thrilled as a kid with a new toy—our new ion exchange unit is a big success and already the talk of the industry.

What's it all about? Well, the "rare" rare earths, as you know, are so identical in their atomic structure that separation by the common fractional crystallization method is impractical for most of them. Yet there has been an increasing number of inquiries from scientists throughout the country for the salts of some of these rare earths in quantities and purities not available commercially.

Fortunately, two gifted gentlemen, Drs. Spedding and Powell of the Ames Institute for Atomic Research, had developed a process for the separation of rare earths by ion exchange. Their pilot plant work demonstrated that highly pure rare earth salts could be produced in commercial quantities.

So this was the solution to our problem! In August we installed a battery of ion exchange columns in our West Chicago plant. The results were spectacular. We have successfully separated commercial quantities of these highly gregarious elements: samarium, europium, gadolinium, terbium, dysprosium, erbium, thulium, ytterbium, yttrium, lutetium and holmium.

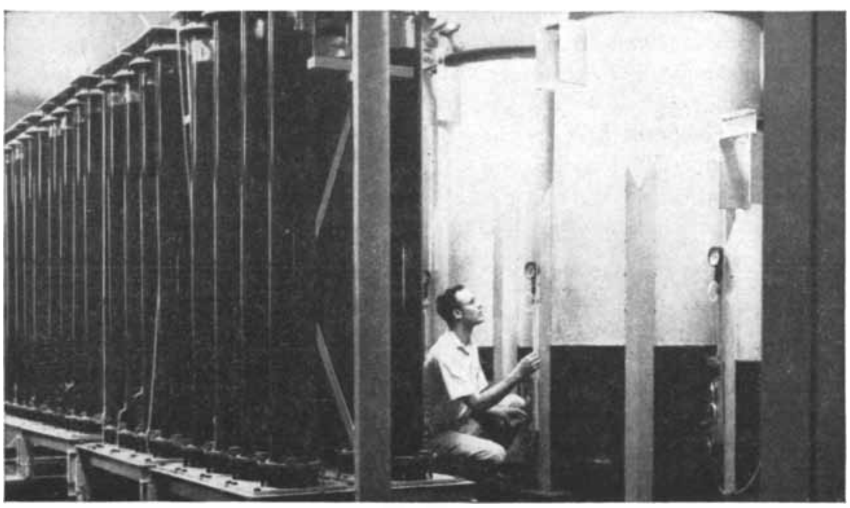
Our first ion exchange unit has been operating at capacity since the installation, and we are now adding a second unit.

Lindsay's ion exchange process works like this. Monazite ore tailings are dissolved in nitric acid and are then treated with oxalic acid to remove impurities. The rare earths are precipitated out as oxalates which are ignited to trivalent oxides. These oxides, dissolved in hydrochloric acid, become a "charge" for the ion exchange column which contains a bed of synthetic resin (sulfonated styrene-divinylbenzene copolymer). Positive ions on the active points of the resin are exchanged for ionized rare earth atoms which are held by the resin and become concentrated near the top of the column.

Separation occurs through elution with an ammonium salt of ethylenediaminetetracetic acid. The least strongly held rare earth is released first and emerges alone at the bottom of the column completely separated from the others and in highly pure form. It is followed by the next strongly held and so on.

We are proud of this addition to our production facilities which marks a milestone of progress for us, for science, and for industry. We feel sure that these highly pure rare earths, now available from our ion exchange production will have significant effect on the improvement of many industrial processes and the advancement of scientific knowledge.

If you are interested in any of these elements for research or industrial use, we suggest that you tell us of your requirements. In the meantime, we are continuing our regular production of other rare earth and thorium chemicals.



Portion of Lindsay's Ion Exchange Plant

LINDSAY CHEMICAL COMPANY

264 ANN ST., WEST CHICAGO, ILLINOIS

fore us a field of ice, and beyond this we found open water, which has since been called the open Polar Sea.' "

"The year that is gone has been prolific in invention, discovery, and industrial improvement. No less than 1,946 patents (not including 49 reissues) were granted by our Patent Office from the second of January last year, up to the date of the current list of patent claims. This is the greatest number ever issued in one year from the Office—1,902 being the number issued in 1854. Our country now ranks high for almost every kind of machinery, and for some kinds it stands without a peer. Only last week two English gentlemen, extensively engaged in agricultural pursuits in Australia, called upon us, and in the course of conversation, stated that after witnessing some of our implements at the World's Fair, in 1851, they had resolved then to visit our country at some future time. When they arrived here they found that the number and excellence of our machines far exceeded their expectations; this led them to prolong their visit, and greatly increase their purchases. They confessed that for all kinds of agricultural implements and machines, the United States were very far in advance of every other country on the globe."

"We learn that M. Boneli, of Turin, Italy, has invented a method of telegraphing in a railroad train running at any speed. He has recently made some experiments in France, especially one on the St. Cloud and Paris Railroad. Instead of the ordinary telegraphic wires, he placed a thin half-inch iron band or ribbon along the center of the track, between the two rails, and pinned it to insulators about two inches above the ground. The telegraph apparatus was placed in the locomotive, and by touching a key, a metal spring was brought into contact with the band or conductor along the track, and thus closed and broke the circuit with the battery, thereby easily writing messages in the locomotive while running. The experiments were performed in the presence of the French minister of public works, and a large number of scientific gentlemen, amongst them several Americans. A train was first sent on in advance, presently followed by a second, which later stopped and commenced an interchange of signals with the first train, still in motion. Bye and bye the first train despatched orders to the second to follow it and in this position, both trains proceeding at full speed, a constant exchange of signals was kept up."

THE AUTHORS

WILLIAM N. LOCKE ("Translation by Machine") is head of the department of modern languages at the Massachusetts Institute of Technology. A 1949 memorandum by Warren Weaver of the Rockefeller Foundation first lured him into the investigation of the possible use of computers to translate languages. He had studied at the Harvard University Graduate School and the Sorbonne, taught French at Harvard before World War II, and worked on propaganda leaflets for the U. S. Army during the War. The basic purpose of his research at M.I.T. on machine translation, he says, is "to mechanize routine operations so that man can work on a more creative level while probing deeper into the working of his mind through a better understanding of how he creates and uses language."

L. R. O. STOREY ("Whistlers") is an English radio physicist who is working at present at the Telecommunications Establishment of the Defence Research Board of Canada. After graduating at the University of Cambridge in 1948 with double first-class honors in natural science, he started pursuing radio whistlers while doing postgraduate work at the Cavendish Laboratory under J. A. Ratcliffe. He left to work for four years in the British Radar Research Establishment at Malvern as a way of "occupying the years of sunspot minimum." Now, however, Storey notes that "sunspots are active again and the whistler hunting season has definitely reopened, so I have resumed work on them in preparation for the International Geophysical Year."

WILLIAM R. THOMPSON AND RONALD MELZACK ("Early Environment") are psychologists who worked together at McGill University in Montreal. Thompson took his B.A. and M.A. at the University of Toronto and his Ph.D. at the University of Chicago in 1951. He was a research associate at McGill from 1951 to 1954 and is now at Queen's University as a lecturer. He is especially interested in the inheritance of behavior traits. Melzack did his undergraduate and graduate work at McGill, taking his Ph.D. there in 1954. He is now doing research on a Commonwealth Fund fellowship at the University of Oregon Medical School. He started by studying the effect of early painful experiences on animals' fears of strange but

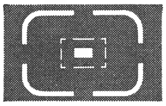
harmless objects. He writes: "W. K. Livingston's article 'What Is Pain?' in the March, 1953, issue of SCIENTIFIC AMERICAN stimulated me to write to him, and our correspondence led to my coming to his laboratory, where I am working now."

PHILIP MORRISON ("The Neutrino") is associate professor of physics and nuclear studies at Cornell University. He graduated from the Carnegie Institute of Technology in 1936, then did graduate work at the University of California at Berkeley under J. Robert Oppenheimer, taking a Ph.D. in theoretical physics in 1940. After a few years of teaching he began a "long and intense tour of duty" in the Manhattan District, which took him from Chicago to Washington, Los Alamos, Alamogordo, the Marianas and Japan. He has been at Cornell since 1946. He reports that he is "currently involved in studies on the origin of cosmic rays, nuclear structure theory and, with no very hopeful progress, experiments on the nature of information transfer in cells."

A. V. WOLF ("Thirst") is chief of the renal section at the Institute of Research of the Walter Reed Army Medical Center in Washington. He was born in New York City and took a B.S. at the College of the City of New York in 1938. His measurements of the urine flow of earthworms led him to examine the kidneys of mammals. In 1942 he received a Ph.D. in physiology from the University of Rochester Medical School. He spent that summer with a party in the deserts of California and Arizona studying thirst for the Army. Later he taught physiology at Albany Medical College. In his current work he is attempting to relate thirst, dehydration and urinary function to the problems of castaways at sea.

SYLVIA FRANK ("Carotenoids"), a plant biochemist, is assistant professor of biology at the Washington Square College of New York University. As an undergraduate at the University of Rochester she studied with the botanist David R. Goddard and caught from him a "permanent enthusiasm for plants and molecules." She took her Ph.D. at Columbia University, working in the biophysics laboratory of the late Selig Hecht; she was the only woman among Hecht's 10 Ph.D. students. "My eyes," she writes, "were one of the pairs used in Hecht's classical research showing how many quanta are necessary to see (only three!). To participate in this work I had to spend a good deal of time *in design and precision*

there's nothing like a LEICA

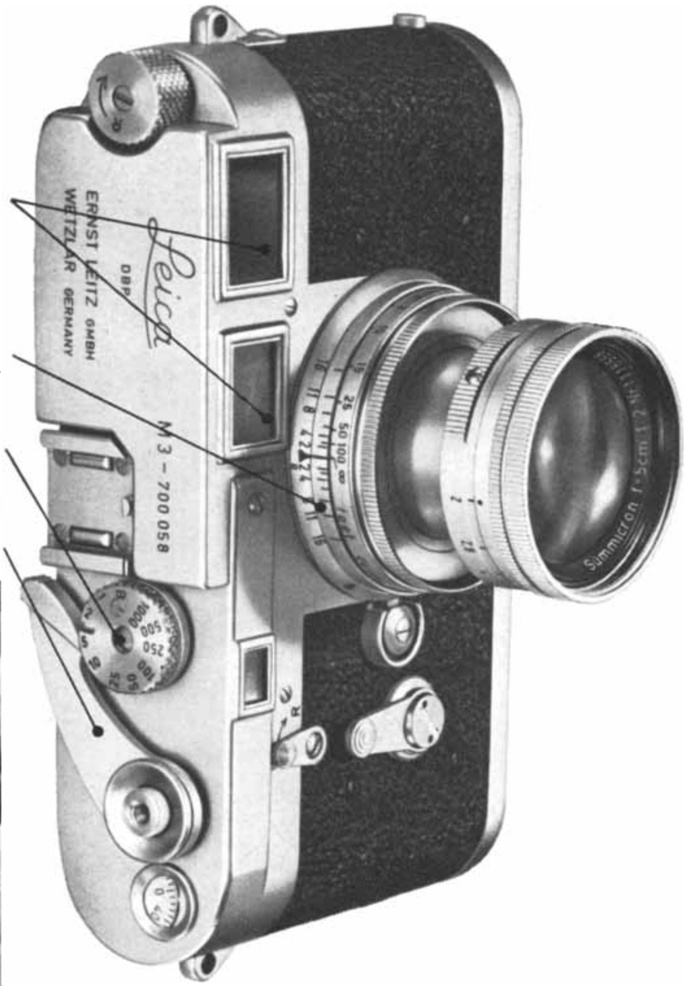


Bright-line frame outlines exact field of view. Frame changes automatically with insertion of different lenses. Automatic parallax correction for all lenses.

Precision bayonet quick-change mount for complete range of interchangeable lenses, combines speed and convenience of bayonet mount with safety and rigidity of thread mount. Thread mount LEICA lenses can be used, with proper adapters.

Shutter speed dial with click stops from 1 to 1/1000th sec. and Bulb.

Lever for rapid film advance and simultaneous cocking of shutter—prevents double exposures.



Life-size viewfinder and rangefinder combined in one large viewing window.

Two flash outlets (back of camera) provide full and automatic synchronization for flash bulbs and electronic flash.

Exposure meter with extreme sensitivity range couples directly to shutter speed dial for quick, automatic settings.

These are just a few of the many outstanding features of the new LEICA M-3.

The 35mm LEICA M-3 is the world's most advanced camera. Made by the manufacturers of famous Leitz microscopes, it represents a unique achievement in camera craftsmanship. Let your LEICA dealer show you the many automatic features that make it the world's most advanced camera.

NEW Leica M-3

lifetime investment in perfect photography

E. LEITZ, INC., 468 FOURTH AVENUE, NEW YORK 16, N. Y.
Distributors of the world-famous products of Ernst Leitz, Wetzlar, Germany
LENSES • CAMERAS • MICROSCOPES • BINOCULARS

07453

in a dark room, being exposed to little spots of light. The rest of the time I was exposed to the bright spots of Hecht's stimulating personality. Now I put plants into dark rooms and expose *them* to spots of light." Her husband is Stanley Levey, a reporter on the New York *Times*.

SIR GEOFFREY KEYNES ("Ambroise Paré"), the younger brother of the famous economist John Maynard Keynes, is a surgeon and a writer. Born in 1887, he was educated at Rugby School, the University of Cambridge and St. Bartholomew's Hospital, served as an army surgeon in the First World War and as senior consulting surgeon to the Royal Air Force with the rank of Acting Air Vice Marshal in World War II. His literary work has included assembling bibliographies of the works of his favorite authors: William Harvey, Sir Thomas Browne, John Ray and various literary figures from John Donne to his own Rugby classmate Rupert Brooke. Last June he was knighted by Queen Elizabeth for services to surgery and literature. During 1956, as the Sims Commonwealth Travelling Professor, he plans to visit medical centers in Africa and Canada.

JOHN H. RYTHER ("The Sargasso Sea") is a marine biologist at the Woods Hole Oceanographic Institution. After serving with the Air Force as a pilot during World War II, he got his undergraduate and Ph.D. degrees at Harvard University and joined the Woods Hole staff in 1951. He is now working under a grant from the National Science Foundation on a study of the basic productivity of the sea, his main interest being the marine algae—"the ultimate source of virtually all life in the sea." He works in the Sargasso Sea out of the Bermuda Biological Station: "One can eat breakfast at the laboratory, set out on its vessel *Palinurus* and reach the deep waters of the Sargasso Sea in a couple of hours."

CLIFFORD GROBSTEIN, the reviewer of John Tyler Bonner's *Cells and Societies*, is a biologist with the U. S. Public Health Service. He graduated from the College of the City of New York in 1936 and did his graduate work at the University of California at Los Angeles, taking a Ph.D. in zoology in 1940. After teaching zoology at Oregon State College and serving in the Army Air Forces, he became a senior research fellow at the National Cancer Institute in 1946 and joined the Public Health Service a year later.

ANACONDA
ALUMINUM

Now Anaconda is pouring aluminum—120,000,000 pounds a year

EXPANDING USES for aluminum have kept demand above supply. That is why Anaconda, producer of many nonferrous metals, became—on August 15—a major producer of primary aluminum.

Already the first ingots have been poured in Anaconda's new plant at Columbia Falls, Montana. Soon production will hit an annual rate of 120,000,000 pounds.

ANACONDA'S CONTRIBUTION: Anaconda approached aluminum with the thoroughness and imagination that brought it leadership in copper.

Anaconda metallurgists and production experts scoured the world for advanced manufacturing techniques. As a result, the great new plant near Hungry Horse Dam is turning out commercial aluminum of the finest grade at a new low rate of power consumption.

WHERE WILL THE METAL GO? Part will go to the Anaconda Wire & Cable Company, already in production with a broad line of aluminum wire and cable for electrical purposes. Five strategically located mills make it available on a nationwide basis. Some will go to Anaconda's other subsidiary, The American Brass Company, to become strips, sheets, tubes, rods, special shapes for industry. A big share will be sold to other manufacturers.

In aluminum, Anaconda follows the traditions of quality and service established in copper and its alloys for over 60 years. Whatever your problem in nonferrous metals, the *Man from Anaconda* can help you. See him soon. The Anaconda Company, 25 Broadway, New York 4, N.Y.

55219

ANACONDA®

Established 1845 SCIENTIFIC AMERICAN January, 1956 Volume 194 Number 1

Translation by Machine

Its wide study has been stimulated by the need of scientists to keep abreast of publications in several languages. Although a mechanical translator still does not exist, encouraging progress has been made

by William N. Locke

Suppose you became interested in working in a new field opening up in your line of work. Your first step would be to get all the background you could on the subject. To take a concrete example, let us say that the new field was the design of electrical switching networks. Looking through the literature, you would certainly find the pioneer 1938 paper by Claude Shannon on the theory of such networks, and a number of other, less important, papers. But how likely would you be to discover a Russian paper entitled ПРИЛОЖЕНИЕ МАТРИЧНОЙ БУЛЕВСКОЙ АЛГЕБРЫ К АНАЛИЗУ И СИНТЕЗУ РЕЛЕЙНО-КОНТАКТНЫХ СХЕМ? And even if you saw listed somewhere an English translation of its title ("The Application of Boolean Matrix Algebra to the Analysis and Synthesis of Relay Contact Networks"), how could you know that this article in the Russian language was the most important contribution to the field next to Shannon's original paper?

The question is not an idle one. Groups of people in several companies in the U. S. did in fact work for five frustrating years on the very points cleared up by this paper before discovering it. The article, by A. G. Lunts, was published in the journal of the U. S. S. R. Academy of Sciences in 1950. Even though this journal is available in the U. S., the article that would have saved so much time and work was overlooked until 1955, simply because most U. S. scientists and engineers cannot read Russian. Considering the time put in on the problems in question by a number of first-rate people, we can estimate that ignorance of the article cost the companies involved easily $200,000, not to speak of the five-year delay in certain switching-circuit developments.

What I have just cited is but one small example of the great cost to mankind of the language barrier—just in the fields of science and technology. The Russian example is not an exceptional case. Even in German and French, which theoretically a great many Americans can read, how many important papers await discovery, how many basic ideas have never been translated or recognized in this country?

Only 50 per cent of the world's scientific papers are published in English. More and more technical material is being published in more and more languages other than English. How are we going to get access even to just the high lights of this material? Translation is expensive—about $6 per page on the average. And good translators are not plentiful. Add to that the fact that a translator of scientific material must first of all know the subject he is translating; in order to translate papers in physics, for example, you practically have to be a physicist. Finally, even if we had plenty of expert translators, they would have an extremely difficult time choosing the material worth translating. The head of a government laboratory's translation section put it succinctly: "Our problem is to know what to translate."

There is the picture. What is the solution? We are practically driven to the answer that always suggests itself when we are faced with a need for mass production: Machines. To translate languages by machine is a little less easy than falling off a log, but the need is so great that in less than a decade since it was first seriously suggested many groups of people have gone to work on the problem.

In 1946 Warren Weaver of the Rockefeller Foundation read a sentence in an English physicist's report suggesting that computing machines might be adapted to translate languages. Weaver was so intrigued that he went to see the paper's author, A. D. Booth, and followed up with a letter to Norbert Wiener at the Massachusetts Institute of Technology. Weaver, having had some experience in deciphering codes, reasoned that languages are codes and should be capable of being decoded by a machine. Wiener's reply was disappointing: "I frankly am afraid that boundaries of words in different languages are too vague and the emotional and international connotations are too extensive to make any quasi-mechanical translation scheme very hopeful."

Weaver was not discouraged. In 1949 he circulated to some 200 of his friends a memorandum, entitled "Translation," which directly inspired most of the work that has since been done in this country on machine translation. Projects to investigate the possibility were started, with Rockefeller Foundation support, in three universities. At the University of Washington Erwin Reifler looked into the basic semantic equivalents of languages. At the University of California at Los Angeles Victor A. Oswald and Stuart L. Fletcher, Jr., analyzed German syntax and in 1951 published the first paper devoted to machine translation: "Proposals for the Mechanical Resolution of German Syntax Patterns." At M.I.T. Yehoshua Bar-Hillel began an attempt to identify the universal grammar elements in various languages and also gave some thought to translating idioms.

Meanwhile Booth, collaborating with D. H. V. Britten at the Institute for Advanced Study in Princeton and later with R. H. Richens (a plant geneticist and linguist) in London, was working on a scheme of dictionary, or word-for-word, translation by a computer. Richens suggested that case and tense endings of words should be considered separately. Suppose, for example, that the word to be translated was *heiss*. This is the German word for "hot," but it is also the stem, and imperative singular, of the verb *heissen*, meaning variously "to call, to command, to be called, to mean." The computer would deliver the various meanings stored in its memory for *heiss*, and the reader of the output would choose the meaning that made most sense in the context. If the word to be translated was *heissen*, the machine would also give all the possible meanings of the ending *-en*, and the reader would have to select the one that made the most sense.

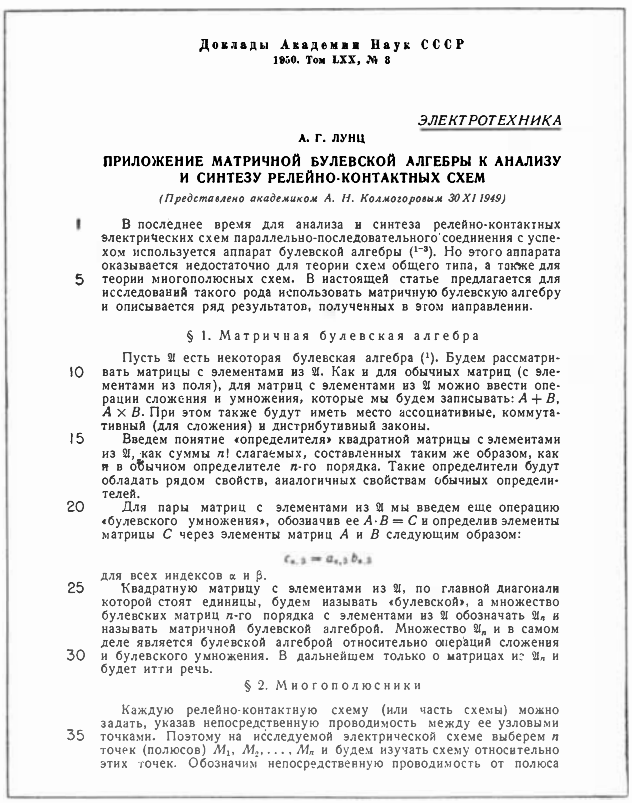
The multiplicity of possible meanings is an obvious weakness of any word-by-word translation system. Still it is only fair to mention that the *-en* ending is one of the most versatile in the German language. If we had taken *heisst*, the *-t* would have been much easier to handle. It has been estimated that German stems have an average of about one and a half meanings each.

In his famous memorandum Weaver put forth the suggestion that a machine might select the correct meaning of a word by taking into account one or more words on each side of it. Examining this proposal, Abraham Kaplan of the Rand Corporation later found that maximum information about the meaning of a word comes from the first two words on either side of it.

By 1952 so many people were interested in machine translation that Bar-Hillel organized a conference on the subject at M.I.T., financed by the Rockefeller Foundation. The Conference itself proved to be a study in the difficulties of communication. Gradually, however, the specialists in different fields—computer engineers, linguists, logicians and mathematicians—learned one another's language and came to a realistic view of the problems to be solved. Few had realized the costs involved. I remember the stunned silence that followed the statement that a computer such as was needed for translation might rent for around $30,000 a month.

After three days everyone felt that further research was certainly worthwhile and that limited objectives could be accomplished. It looked as though the best approach would be to start with the automatic dictionary idea, translating text a word at a time. Such translation would be crude in the extreme, but many scientists believe it would be intelligible to specialists in the field of the article. This is, of course, just the way most human beginners go about translating.

Since the 1952 conference a journal, *Mechanical Translation*, has been founded at M.I.T. by Victor H. Yngve and the author of this article, and Booth and I have edited a book, *Machine Translation*


Доклады Академии Наук СССР
1950. Том LXX, № 8

ЭЛЕКТРОТЕХНИКА

А. Г. ЛУНЦ

ПРИЛОЖЕНИЕ МАТРИЧНОЙ БУЛЕВСКОЙ АЛГЕБРЫ К АНАЛИЗУ И СИНТЕЗУ РЕЛЕЙНО-КОНТАКТНЫХ СХЕМ

(Представлено академиком А. Н. Колмогоровым 30 XI 1949)

В последнее время для анализа и синтеза релейно-контактных электрических схем параллельно-последовательного соединения с успехом используется аппарат булевской алгебры ([1-3]). Но этого аппарата оказывается недостаточно для теории схем общего типа, а также для теории многополюсных схем. В настоящей статье предлагается для исследований такого рода использовать матричную булевскую алгебру и описывается ряд результатов, полученных в этом направлении.

§ 1. Матричная булевская алгебра

Пусть $\mathfrak{A}$ есть некоторая булевская алгебра ([1]). Будем рассматривать матрицы с элементами из $\mathfrak{A}$. Как и для обычных матриц (с элементами из поля), для матриц с элементами из $\mathfrak{A}$ можно ввести операции сложения и умножения, которые мы будем записывать: $A + B$, $A \times B$. При этом также будут иметь место ассоциативные, коммутативный (для сложения) и дистрибутивный законы.

Введем понятие «определителя» квадратной матрицы с элементами из $\mathfrak{A}$, как суммы $n!$ слагаемых, составленных таким же образом, как в обычном определителе n-го порядка. Такие определители будут обладать рядом свойств, аналогичных свойствам обычных определителей.

Для пары матриц с элементами из $\mathfrak{A}$ мы введем еще операцию «булевского умножения», обозначив ее $A \cdot B = C$ и определив элементы матрицы C через элементы матриц A и B следующим образом:

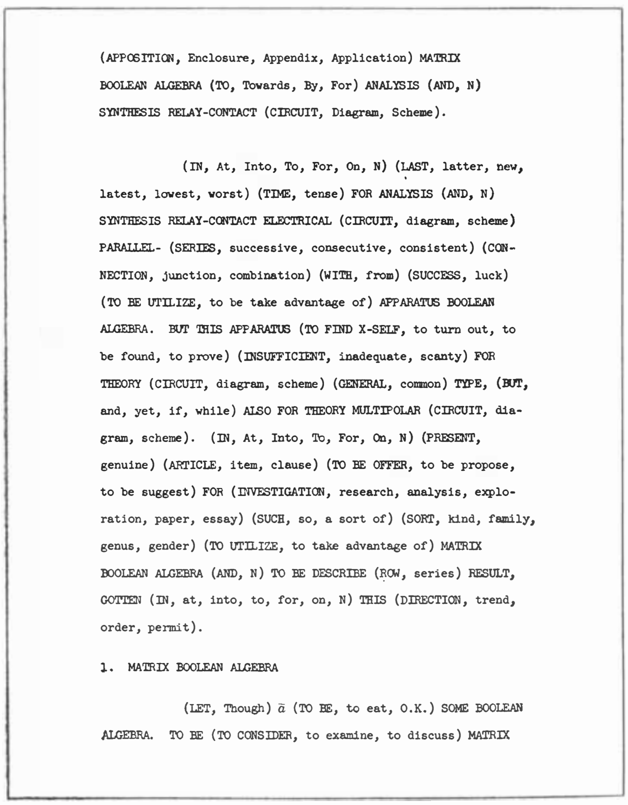
$$c_{\alpha\beta} = a_{\alpha\beta} b_{\alpha\beta}$$

для всех индексов α и β.

Квадратную матрицу с элементами из $\mathfrak{A}$, по главной диагонали которой стоят единицы, будем называть «булевской», а множество булевских матриц n-го порядка с элементами из $\mathfrak{A}$ обозначать $\mathfrak{A}_n$ и называть матричной булевской алгеброй. Множество $\mathfrak{A}_n$ и в самом деле является булевской алгеброй относительно операций сложения и булевского умножения. В дальнейшем только о матрицах из $\mathfrak{A}_n$ и будет итти речь.

§ 2. Многополюсники

Каждую релейно-контактную схему (или часть схемы) можно задать, указав непосредственную проводимость между ее узловыми точками. Поэтому на исследуемой электрической схеме выберем n точек (полюсов) $M_1, M_2, \ldots, M_n$ и будем изучать схему относительно этих точек. Обозначим непосредственную проводимость от полюса


(APPOSITION, Enclosure, Appendix, Application) MATRIX BOOLEAN ALGEBRA (TO, Towards, By, For) ANALYSIS (AND, N) SYNTHESIS RELAY-CONTACT (CIRCUIT, Diagram, Scheme).

(IN, At, Into, To, For, On, N) (LAST, latter, new, latest, lowest, worst) (TIME, tense) FOR ANALYSIS (AND, N) SYNTHESIS RELAY-CONTACT ELECTRICAL (CIRCUIT, diagram, scheme) PARALLEL- (SERIES, successive, consecutive, consistent) (CONNECTION, junction, combination) (WITH, from) (SUCCESS, luck) (TO BE UTILIZE, to be take advantage of) APPARATUS BOOLEAN ALGEBRA. BUT THIS APPARATUS (TO FIND X-SELF, to turn out, to be found, to prove) (INSUFFICIENT, inadequate, scanty) FOR THEORY (CIRCUIT, diagram, scheme) (GENERAL, common) TYPE, (BUT, and, yet, if, while) ALSO FOR THEORY MULTIPOLAR (CIRCUIT, diagram, scheme). (IN, At, Into, To, For, On, N) (PRESENT, genuine) (ARTICLE, item, clause) (TO BE OFFER, to be propose, to be suggest) FOR (INVESTIGATION, research, analysis, exploration, paper, essay) (SUCH, so, a sort of) (SORT, kind, family, genus, gender) (TO UTILIZE, to take advantage of) MATRIX BOOLEAN ALGEBRA (AND, N) TO BE DESCRIBE (ROW, series) RESULT, GOTTEN (IN, at, into, to, for, on, N) THIS (DIRECTION, trend, order, permit).

1. MATRIX BOOLEAN ALGEBRA

(LET, Though) ā (TO BE, to eat, O.K.) SOME BOOLEAN ALGEBRA. TO BE (TO CONSIDER, to examine, to discuss) MATRIX

AUTOMATIC DICTIONARY for the word-for-word translation of Russian into English has been investigated by Anthony G. Oettinger of Harvard University. At the left is a Russian scientific paper. Second from the left is a word-for-word translation. Third is a sheet

of Languages, with essays contributed by practically every active worker in the field. Besides the book, 56 articles on the subject have been published to date.

Now that we have quickly reviewed the history of this idea from its birth in 1946 to the present, let us take a close look at the concepts involved in machine translation. The process must involve five basic steps: (1) feeding the original text—written or spoken—into the machine; (2) transforming this text into symbols the machine can handle; (3) translating the meaning from one language to another; (4) turning the translation back into conventional words or other units in the new language; and (5) presenting the translated text in readable or audible form. Various groups of workers have concentrated on one or another step, and we can conveniently consider the steps one at a time.

Some of those working on step 1 have felt that the limitations of machines demand that the text be reduced to a digestible form before it is fed into the machine. Translation would be easy if authors of scientific papers in all languages would write in a universal syntax, so that only the words needed to be translated. But it is more or less generally agreed that you simply couldn't force authors all over the world to change their style of writing because their work might be translated by machine. Various workers, notably Reifler, have suggested instead that pre-editors be employed to rewrite or code the texts of articles before they are fed into the machine. The main trouble with this idea is that the salary of a pre-editor plus the expense per word of the machine would almost surely be as costly as a human translator's services.

The input problem may, however, be made easier by developments in step 2—the reading of the text by the machine itself.

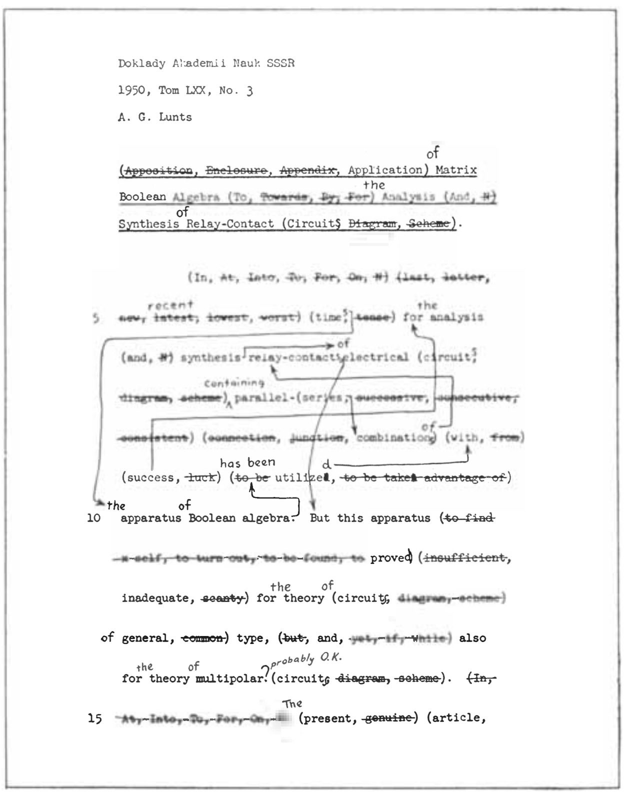
A number of investigators in the U. S. and abroad are working on the problem of direct recognition of written or spoken text by a machine, not for translation but for commercial purposes. At least three companies are developing automatic check-reading machines for banks, and one or more such machines will soon be on the market. There is a great financial incentive here: a New York bank has estimated that it could save more than $2 million a year if it could mechanize the tabulation and sorting of checks.

This task involves the reading of numbers. Recognition of letters or words by a machine is a more complex problem, but work is going forward on this too. When the feat is accomplished, as it should be within a few years, it will be possible for a translating machine to read text directly from the printed page, without any operator or pre-editor.

Of course letter recognition will have to cope with the many different fonts of type, headings, italics and special symbols that are used in printed publications. But untranslatable symbols, and even diagrams and illustrations, can simply be reproduced unchanged in the output, just as a human translator copies them as they appear in the original.

Translation of the sounds of spoken language into a machine code (which is closely comparable to a secretary translating dictation into shorthand) is another active field at present. Millions of dollars are being spent by the Bell Telephone Laboratories and others trying to build a machine to do this. It may be that by analysis of the meaningful elements in spoken language we shall be able to write equations to program machine translation of speech either into the written form of the same language or into the written or spoken form of a different language.

This brings us to step 3—the actual translation by the computer. It is clear that computer components already

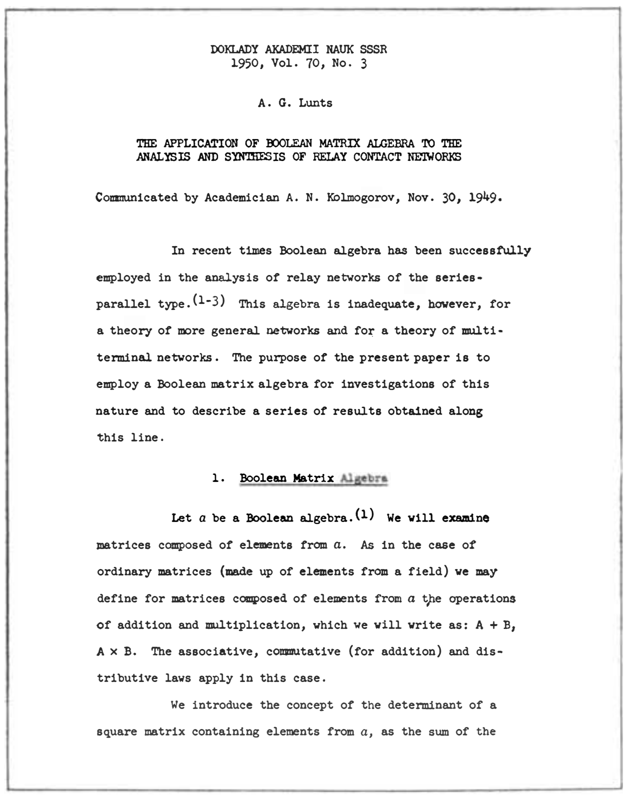

Doklady Akademii Nauk SSSR

1950, Tom LXX, No. 3

A. G. Lunts

(~~Apposition, Enclosure, Appendix,~~ Application) of Matrix Boolean Algebra (To, ~~Towards, By, For~~) the Analysis (And, ~~#~~) of Synthesis Relay-Contact (Circuits ~~Diagram, Scheme~~).

(In, ~~At, Into, To, For, On, #~~) (~~last, latter,~~ ~~new, latest, lowest, worst~~ recent) (times ~~tense~~) for the analysis (and, ~~#~~) synthesis of relay-contact electrical (circuits ~~diagram, scheme~~) containing parallel-(series ~~successive, consecutive, consistent~~) (~~connection, junction,~~ combinations) of (with, ~~from~~) (success, ~~luck~~) has been (~~to be~~ utilized, ~~to be taken advantage of~~) the apparatus of Boolean algebra. But this apparatus (~~to find a self, to turn out, to be found, to~~ proved) (~~insufficient,~~ inadequate, ~~scanty~~) for the theory of (circuits ~~diagram, scheme~~) of general, ~~common~~) type, (~~but,~~ and, ~~yet, if, while~~) also for the theory of multipolar? probably O.K. (circuits ~~diagram, scheme~~). (~~In, At, Into, To, For, On, #~~ The) (present, ~~genuine~~) (article,


DOKLADY AKADEMII NAUK SSSR
1950, Vol. 70, No. 3

A. G. Lunts

THE APPLICATION OF BOOLEAN MATRIX ALGEBRA TO THE ANALYSIS AND SYNTHESIS OF RELAY CONTACT NETWORKS

Communicated by Academician A. N. Kolmogorov, Nov. 30, 1949.

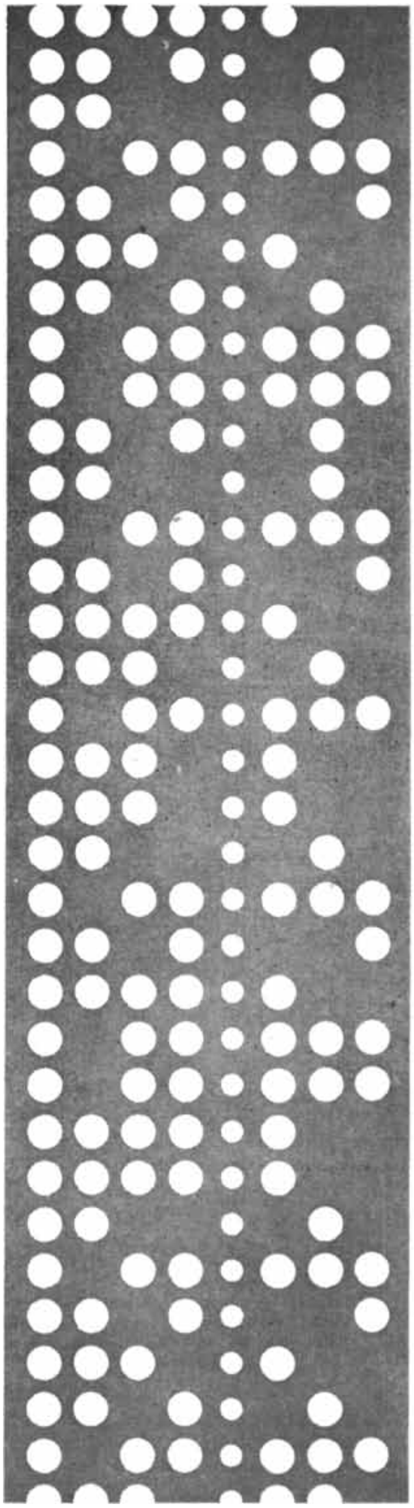
In recent times Boolean algebra has been successfully employed in the analysis of relay networks of the series-parallel type.(1-3) This algebra is inadequate, however, for a theory of more general networks and for a theory of multi-terminal networks. The purpose of the present paper is to employ a Boolean matrix algebra for investigations of this nature and to describe a series of results obtained along this line.

1. Boolean Matrix Algebra

Let a be a Boolean algebra.(1) We will examine matrices composed of elements from a. As in the case of ordinary matrices (made up of elements from a field) we may define for matrices composed of elements from a the operations of addition and multiplication, which we will write as: A + B, A × B. The associative, commutative (for addition) and distributive laws apply in this case.

We introduce the concept of the determinant of a square matrix containing elements from a, as the sum of the

in which the comprehension of a reader was tested. Fourth is an expert translation. These samples appear in *Machine Translation of Languages*, published by John Wiley & Sons, Inc., and the Technology Press of the Massachusetts Institute of Technology.



PUNCHED TAPE was used to program the Massachusetts Institute of Technology computer *Whirlwind* for the demonstration depicted on the opposite page. A foreign language and instructions for translating it might be fed into the machine by the same means. Because this would require the cumbersome translation of written language into tape language, students of machine translation hope for the development of devices which could read from the printed page.

existing or under development will be able to handle the job of translation once the input can be fed in in suitable form. General-purpose computers now on the market can be programmed to do translation; in fact, more than one already has been. In January, 1954, the IBM 701 translated a number of Russian sentences as a test. It used a 250-word vocabulary and five Russian syntax constructions. The words were translated and their order was changed automatically to make the output acceptable English. At Harvard University Anthony Oettinger has programmed the Mark IV computer to split Russian words into stems and endings and derive the grammatical meanings from the endings. Booth in London has done similar work. At Washington Reifler has had a small special computer built to test translation procedures.

One of the most difficult problems, engaging the concentrated efforts of a number of investigators, is the inflection of words. In an inflected language such as Russian or German, practically all the important information-bearing words are varied in meaning by prefixes, suffixes or even infixes. Dictionaries usually list a word in one of its inflected forms—the nominative singular of a noun, the infinitive of a verb. Several workers on the machine translation problem have suggested that for a machine we shall need instead of the ordinary dictionary a dictionary of word stems. These stems (*e.g.*, the German *heiss*) would be listed in the machine's memory. A word fed into the machine would be identified immediately if it was the same as a stored stem. If it did not match any stored entry, the machine would strip off its letters one by one until an identifiable stem was found. The stripping process would start backward from the last letter of the word, and if that did not work, it would begin again with the first letter to remove a possible prefix.

Oettinger has carried this approach to an elegant conclusion. He employs the following procedure. A Russian word is fed into the machine. The machine has built-in circuits for identifying inflectional endings immediately, and if the word has one, it strips the ending off. Then the machine looks up the remaining stem in its memory. If it is listed there, the machine can give its English meaning. Meanwhile, to complete the meaning of the word, the machine also hunts up in a separate memory the sense of the stripped-off inflectional ending.

Irregular words will be no problem at all for the machine, although they give a human translator the most trouble. They will simply be entered in toto in the memory and translated directly. For example, the German *war* and the French *était* will be translated at once as the English "was."

Some years ago there was considerable worry about whether a computer could have a large enough memory to store all the stems, plus the various endings, plus the irregular words, plus the grammar rules, plus the programming instructions. But it looks now as though computers will soon have plenty of fast storage capacity in the form of magnetic drums, tape or photographic film.

When all is said and done, word-by-word rendition will be only a halfway house toward satisfactory translation. To give really usable performance, translating machines will have to consider a whole sentence, at least, as a unit. This means that it will have to be concerned with the structure of words in groups.

Yngve, who is in charge of the machine translation project at M.I.T., has developed an original and very promising approach to this problem. Like other workers in the field, he was struck by the fact that the words in a sentence fall into two general classes: high-frequency words which carry comparatively little meaning (such as "the," "of," "by" and so on) and the lower-frequency verbs and nouns which convey most of the information. The meaning of the latter can be translated word for word. But a sentence makes sense only when they are related to one another by the high-frequency structural words. In other words, the high-frequency words of comparatively little meaning provide the structural framework of a sentence: *e.g.*, "By the (law) of (Archimedes), the (weight) of a (submerged object) must (equal) the (weight) of the (displaced water)." Following up this idea, Yngve and a group of four linguists at M.I.T. are endeavoring to write rules for making the information contained in a language's syntax (or sentence structure) completely explicit. Combining such sets of rules for two languages with word dictionaries, we should have the linguistic basis for translation by machine.

The fourth and fifth steps of the machine translation process have received less attention than the first three, but they seem to present no great difficulties. Present computers already print their output in forms which appear to be satisfactory for our purposes, and undoubtedly there will be improvements in speed. As for the last step—the polish-

CATHODE-RAY TUBE displays three Russian words and their word-for-word translation. The tube is one output of *Whirlwind*, which was especially programmed to construct these symbols. Similar programming might be used in the output of a translating machine. As each set of symbols (which would be smaller and more numerous than they are here) appeared they could be photographed.

ing of the machine's output into the final text in the new language—there is a difference of opinion. Reifler has suggested a post-editor to make the text more readable. Whether a human editor will enter the picture will depend on how badly we need him and what he will cost.

How good a translation could be produced by machine? The perfect translation would be one in which all the ideas (and esthetic values) of the original text were reproduced faithfully in the new language. How closely it will be possible to approach that ideal we are unable to say at present. The indications are, from the work of Yngve and others, that we shall succeed almost immediately in getting better than a word-for-word rendition. Even a crude translation may be good enough to enable specialists in the same field, who already have a considerable common background of understanding, to communicate with one another. For this reason, as well as the great need, everyone interested in machine translation is concentrating on scientific and technical material. As the quality of the machine output improves, the translations will become understandable to wider and wider circles of readers. Eventually it may become possible to advance from expository technical writing into narrative and other types of literature.

Although it is only nine years since the idea was born, many people are hard at work on specific features of the design for a translating machine. On the "hardware" side, engineers are developing devices for recognition of written characters and the sounds of speech, large and rapid computer memories, logical circuits, high-speed printers and automatic composing machines. On the linguistic side, experts are analyzing vocabulary and grammar as they have never been analyzed before.

In answer to the question "When shall we see a machine translate?" my best guess is, within five years. By that time there should be in operation one or more models turning out a good deal better than a word-by-word translation.

WHISTLERS

They are musical sounds that may be heard in a radio receiver tuned to very low frequencies. Originating in the atmosphere, they provide a new method for exploring its outlying regions

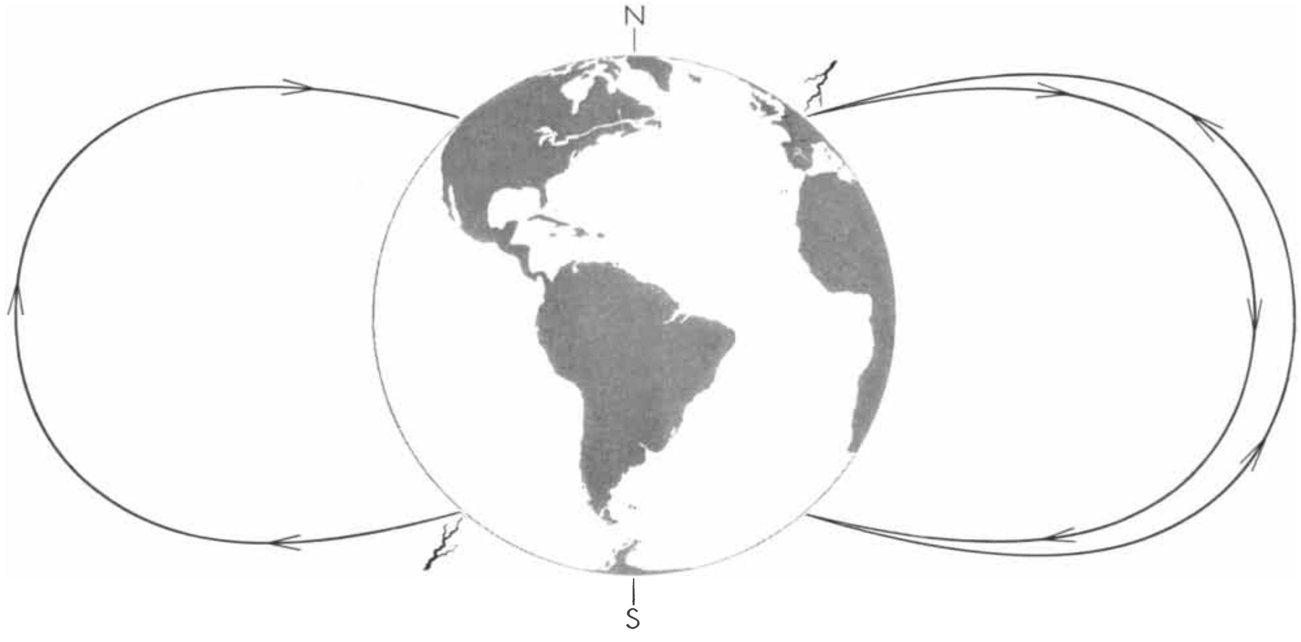
by L. R. O. Storey

As plans go forward for launching the first man-made satellites of the Earth, we have suddenly become confronted with a compelling need to know more about the outer reaches of our atmosphere. Where does the Earth's atmosphere end and space begin? What is the upper air composed of? What is its temperature, its density, its physical condition?

Up to about 200 miles the atmosphere has been thoroughly explored by radio sounding [see "The Ionosphere," by T. N. Gautier; SCIENTIFIC AMERICAN, September]. But beyond that the atmospheric "country" is still largely unknown. The ionosphere thins out so that it no longer reflects radio waves back to us. We have had no other instrument that could probe the outer regions. Recently, however, it was discovered that Nature herself is continually sounding the outer atmosphere in a way that we can follow, and thereby hangs the tale of this article.

The tale begins with an accidental observation on the battlefield during World War I. Behind the German lines the physicist Heinrich Barkhausen (discoverer of the Barkhausen effect in magnetism) was "wire tapping" Allied field telephone conversations at a distance with some ingeniously simple equipment. Two prods, stuck in the ground several hundred yards apart, picked up minute electric currents leaking into the ground from the Allied telephone wires; these signals were conveyed by cables to a sensitive amplifier, and Barkhausen was able to hear the telephone talk with headphones. During his eavesdropping he occasionally heard curious whistling sounds which completely swamped the military chatter. He was sufficiently impressed with the phenomenon to report it later in a paper: "A very remarkable whistling note is heard in the telephone. At the front it was said that one hears 'the grenades fly.' "

Barkhausen's first reaction was that the whistles probably originated in his apparatus, but when all attempts to eliminate them failed, he decided that they must be coming from the atmosphere. He was right. It was to be many



LIGHTNING causes an atmospheric radio disturbance which is propagated along a magnetic line of force (*arrows*). A lightning stroke in the Southern Hemisphere (*lower left*) is heard in the Northern Hemisphere as a short whistler. A stroke in the Northern Hemisphere (*upper right*) is heard nearby as a long whistler. In the case of the long whistler the disturbance has made a round trip.

years, however, before much further attention was paid to them or anyone really understood what they meant.

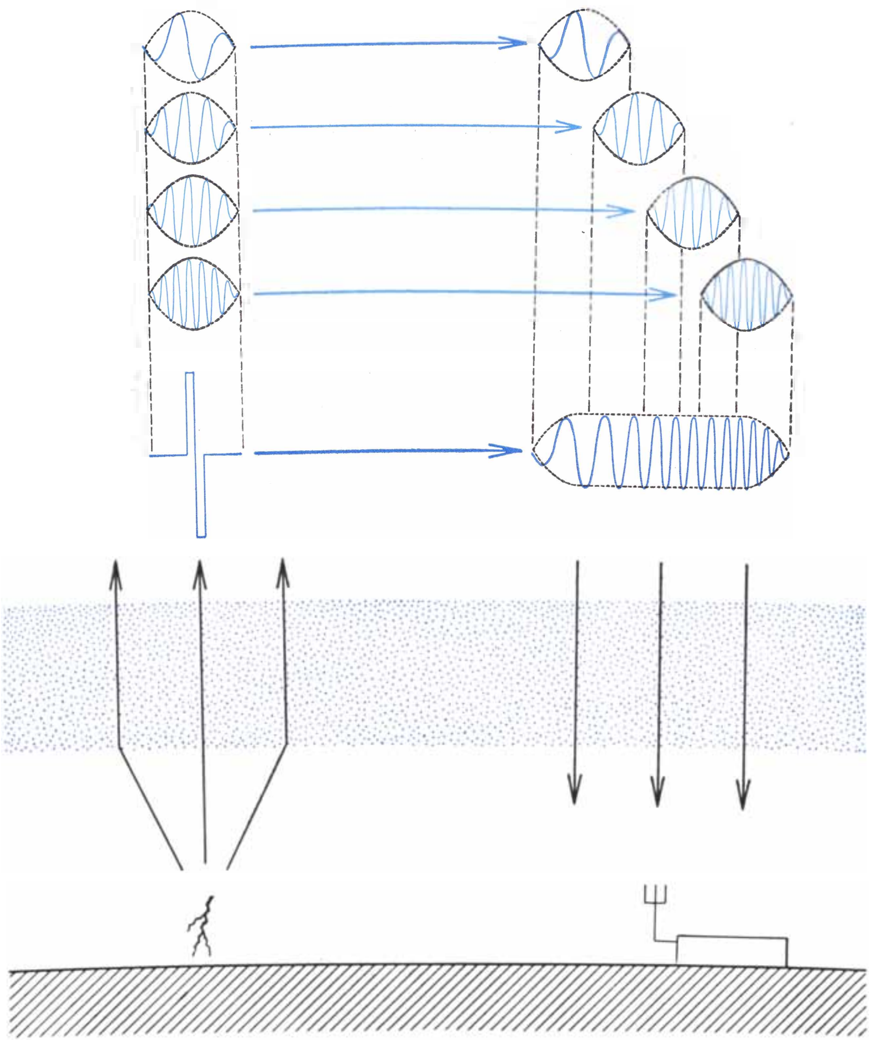
In the form of static on the radio from a nearby thunderstorm, atmospheric radio signals are familiar enough. But the whistles Barkhausen heard were not in the ordinary broadcasting wavebands. They were low-frequency (long-wave) signals below the lowest broadcasting frequencies. Radio engineers now know that off this end of the broadcast spectrum various odd atmospheric signals are there for the hearing. Hearing is the right word, for the frequencies of these waves are so low that they fall within the sound range—the range of the human ear. To hear them we need only the simplest of apparatus: basically just an aerial to pick up the atmospheric electrical oscillations and an audio amplifier like the one in a phonograph to convert the oscillations directly into sound.

And what do we hear when we turn the amplifier on? Well, most of the time just the same clicks as in the broadcast bands. But now and again we are favored with relatively musical noises, which have acquired quaint onomatopoetic names. There is the "tweek" or "chink"—a brief, metallic note produced by waves bouncing up and down between the earth and the ionosphere. There is the "dawn chorus"—an unexplained twittering noise which occurs during a magnetic storm. And there are Barkhausen's whistlers.

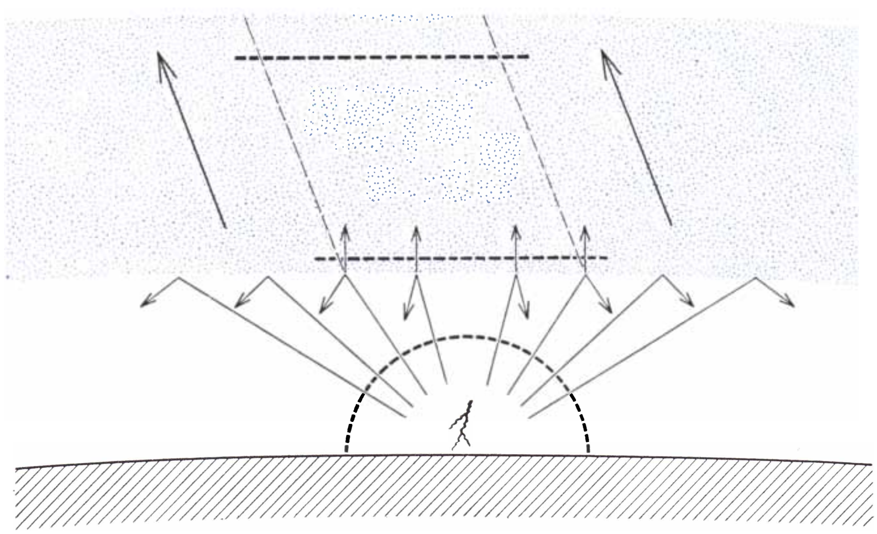
Starting above the upper limit of hearing, the whistling tone falls steadily in pitch, at first rapidly, then more slowly at the lower frequencies. The sound sweeps down through several octaves in a second or two.

Whistlers were studied to some extent in the 1920s and 1930s, notably by E. T. Burton and E. M. Boardman at the Bell Telephone Laboratories and by T. L. Eckersley of the Marconi Wireless Telegraph Company in England. These workers noted that a whistler often (though not always) appeared about a second or so after a loud atmospheric click. Apparently whistlers were connected in some way with clicks. The source of the clicks themselves was in doubt at that time, but in any case here was a promising lead to investigate. It seemed that the whistler might be an echo of the click, returning from the ionosphere. The question was: How could a click be converted into a whistler?

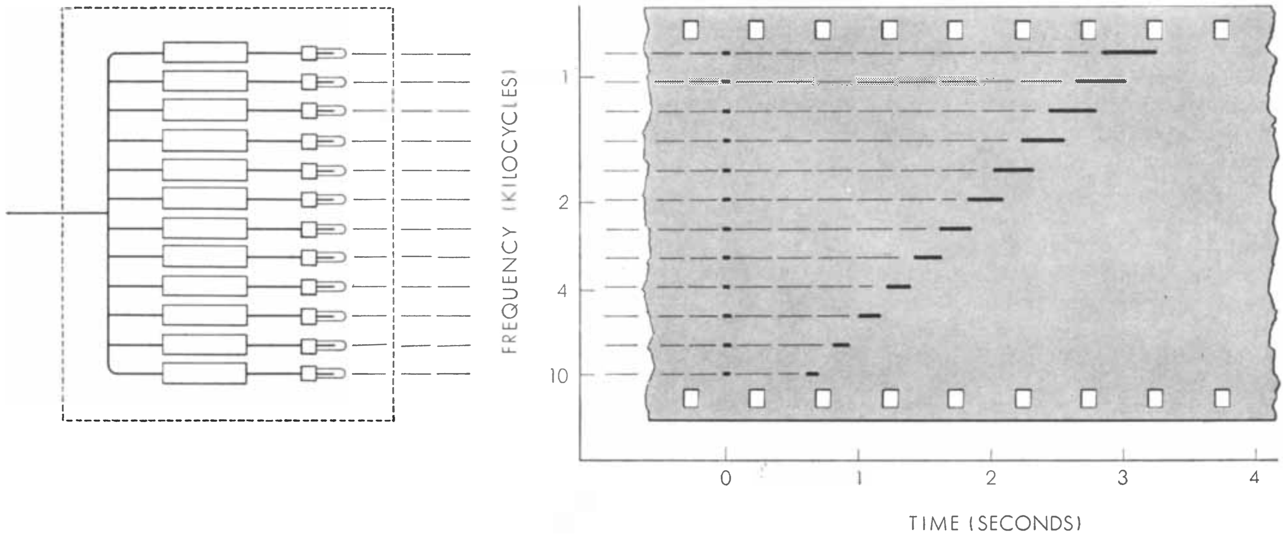
Barkhausen and Eckersley independently conceived an explanation which experiments later proved correct. It was



LIGHTNING STROKE (*lower left*) is heard at a receiving station (*lower right*) as a click (*rectangular wave form at left center*) composed of many different wavelengths (*wave forms at upper left*). In the ionosphere (*stippled area*) the short wavelengths travel faster than the long (*upper right*), giving rise to the whistler (*right center*) heard at the same station.



DISTURBANCE spreads in all directions from the lightning flash. When it encounters the ionosphere, some of it is reflected and some refracted. The latter phenomenon concentrates the disturbance in a beam (*horizontal dotted lines*), which follows the Earth's magnetic field.



SOUND SPECTROGRAPH used to analyze clicks and whistlers is essentially a set of filters (*small rectangles at left*), each of which passes a narrow band of frequencies. Connected to each filter is a small neon lamp. Beneath the lamps passes a strip of photographic film (*right*). When a click is heard, all the lamps flash simultaneously and make the vertical row of spots at the left end of the record. When the whistler returns, the higher frequencies are detected first and give rise to the diagonal row of spots at the right.

clear that a click must be composed of a number of different frequencies, for the same click could be detected all over the broadcast band, and indeed in the range of sound waves as well. It was also known that radio waves of different frequency travel at different speeds through the ionosphere. Suppose that, as a click moved through the ionosphere, its component frequencies were spread out, the highest frequency traveling fastest and the lower ones strung out behind. If the click traveled far enough so that its frequencies were well separated, an observer should receive a drawn-out signal—a whistling tone of steadily falling pitch.

Eckersley proceeded to translate this conception into numbers and equations. He calculated that a certain type of radio wave should pass through the ionosphere without being reflected by it, that it should be slowed in the ionosphere to one twentieth or less of its usual velocity, and that its speed should depend on several factors: its frequency, its direction of travel in relation to the Earth's magnetic field, the strength of the magnetic field and the density of electrons in the region through which it was passing. Considering frequency alone, the speed of waves of this kind through the ionosphere should vary in proportion to the square root of the frequency: *e.g.*, a wave of four times the frequency of another wave should travel with twice the speed, other things being equal. Thus in the case of a click traversing a given path through the ionosphere, the velocities of the component frequencies should have the simple square-root ratio. This means that the time taken by the various frequencies to cover the course should vary inversely with the square root of the frequency.

To check this prediction, all one needs to do is to separate the frequencies in a whistler with a frequency analyzer and determine whether the several frequencies' times of arrival after the click do in fact obey the postulated ratio. Eckersley found that they did almost exactly.

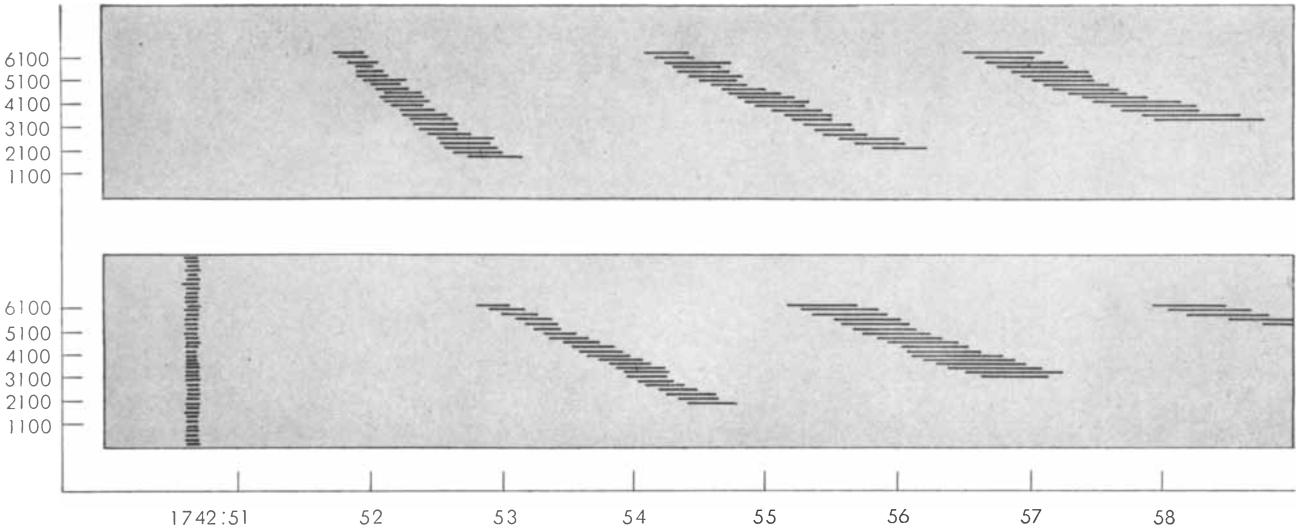
The next important question was: How long is the path traveled by a whistler? The answer, of course, lies in the amount of dispersion of the frequencies (the length to which the whistling tone is drawn out). But it is impossible to make an exact estimate of the travel distance from this, because the dispersion also depends in part on the average electron density and magnetic field strength along the route, which are unknown quantities. However, we can compute very roughly the minimum distance whistlers must travel. Leaving the variation of the magnetic field out of account and assuming the highest possible electron density throughout the route (equal to that of the densest layer in the ionosphere), one calculates the path length for whistlers showing a typical amount of dispersion. The answer is the astonishing figure of 15,000 miles. Apparently the whistlers go far beyond what has previously been thought to be the limits of the Earth's atmosphere.

When I began to look into whistlers in the Cavendish Laboratory at the University of Cambridge in 1950, there seemed to be two problems outstanding: firstly, what caused the clicks, and secondly, where the path went and how the waves were reflected at the end of it.

It appeared highly probable by this time that the clicks originated in lightning. To study them we enlisted the help of the British Air Ministry Meteorological Office which has a "Sferic" organization that monitors atmospherics to locate thunderstorms. Four widely-spaced stations in the United Kingdom pinpoint the sources of atmospheric clicks. We arranged to receive a telephone signal from these stations the moment the position of a click was fixed. We recorded these signals, noted whether a whistler followed each click, made a map of the fixes and later were able to correlate the loudness of each whistler with the distance of the click source from our receiver.

These observations and analysis of the wave forms left no doubt that the clicks were produced by lightning strokes. From lightning within 600 miles of us we invariably received loud whistlers; from points farther away the whistlers steadily grew weaker, until, beyond 1,200 miles, we seldom received any at all. That is to say, we could detect no echo from a click that originated more than 1,200 miles from us.

This was most curious. One would expect waves to spread out widely, yet here were waves which traveled at least 15,000 miles and after journeying that great distance returned as an echo to a limited area no more than 1,200 miles in radius. What mechanism in the atmosphere could focus them in this manner?



SPECTROGRAPH RECORDS of an experiment by Millett G. Morgan and G. McK. Allcock are depicted in this drawing. The lower record was made in New Zealand on August 28. At its left is a click; at its right is a long whistler and two echoes. The upper record was made simultaneously in the Aleutian Islands. It shows a short whistler and two echoes from the same click. The numbers at left give the frequency in cycles; those at bottom, the time in seconds after 17 hours, 42 minutes, 51 seconds Greenwich Mean Time.

Let us try to trace their journey. When a lightning stroke occurs, it sends out radio waves in all directions, and some go upward to the ionosphere. When the radio rays traverse the boundary between ordinary air and the ionized region, they are bent, just as a ray of light is refracted when it passes from air to some other medium. Whatever the angle at which the radio waves strike the ionosphere, all of them are bent toward the vertical. As we have already noted, the refractive (slowing) effect of the ionosphere on these waves is very pronounced. Consequently the rays coming in from all angles are concentrated in a narrow vertical beam.

As it rises into the ionosphere, however, the beamed pulse of energy does not continue in the vertical direction. It follows the lines of the Earth's magnetic field, because this is the direction in which the waves travel fastest. And as it goes, the pulse or click is drawn out into a whistler.

If it is indeed true that the whistler follows a line of magnetic force, then we have some notion where its path will go. From the Earth's surface in England a line of magnetic force sweeps southward around the globe, crosses the magnetic equator at a height of about 7,000 miles and comes down to Earth again in the Southern Hemisphere. A whistler traveling this path might be reflected from the ground and return along the same line of force to the area in England from which it came.

The thought sends us back immediately to our records and our listening posts, and a fresh look at the evidence soon confirms this reasoning. Firstly, there is the hitherto puzzling fact that sometimes a whistler is heard without any preceding click. We can guess now that such a whistler comes directly from the Southern Hemisphere—not an echo but a single-trip message from a Southern lightning flash. The click itself, traveling in the lower atmosphere, is unheard because it is absorbed before it reaches us. If the whistler has made only one journey through the ionosphere, it should be only half as drawn out as one preceded by a click (which makes the round trip). Measurements confirm the prediction.

Secondly, almost from the beginning it was noticed that sometimes a single click fathers not one but a train of whistlers, each weaker and longer drawn out than the one before. They follow one another at short, regularly-spaced intervals. Quite evidently these must be reverberations of the same echo, bouncing back and forth like a tennis ball between the two hemispheres. That this is the case has been verified by the finding that the lengthening of the successive whistlers is proportional to the number of trips: when they follow a click, the dispersion ratios are 2:4:6:8; when no click is heard, indicating that the signal started in the other hemisphere, the ratios are, as expected, 1:3:5:7.

Last summer, in a direct test, individual whistlers were actually caught bouncing back and forth by observers who made synchronized recordings at the two ends of a line of magnetic force—one in the Aleutian Islands, the other in New Zealand [*see illustration above*]. On each successive trip the whistler was drawn out further by the predicted amount.

The big surprise is what whistlers tell us about the height of the atmosphere. It must extend out to at least 7,000 miles—several times farther than had previously been thought. The atmosphere was supposed to end at about 1,500 miles. But now it appears, from the dispersion of whistlers, that 7,000 miles out there must still be about 400 electrons per cubic centimeter.

This may mean various things. If we suppose that the electrons come from ionization of gases typical of our atmosphere (oxygen and nitrogen), then to produce this ionization the temperature of the outer atmosphere would have to be at least 7,000 degrees—a figure far too high to be believed. J. W. Dungey of the University of Pennsylvania has suggested instead that the ions may come from outside the atmosphere: that in its passage through space the Earth picks up ionized hydrogen and holds it by the force of its magnetic field. Some recent estimates put the hydrogen content of "empty" space near the Earth's orbit as high as 600 particles per cubic centimeter, so Dungey's theory seems reasonable. But the issue is far from settled.

The only certain thing is that whistlers still have much to tell us. During the forthcoming International Geophysical Year observers all over the world will be listening for these strange messages from the outer atmosphere.

Early Environment

How do environmental influences at the beginning of life shape the behavior of an animal? Some clues are found by experiments in which Scottish terriers are raised in restricted surroundings

by William R. Thompson and Ronald Melzack

The child, as the poets say, "is father of the man," but we still know all too little about how the child is molded. It is a controversial as well as an interesting subject. Is intelligence, for instance, determined solely by heredity or can it be modified by the child's early environment? Although this question has been much studied, the evidence is ambiguous. And our understanding of the formation of the child's personality and emotional pattern is even more uncertain.

We do have some clear and definite information about the development of lower animals. While animals do not necessarily behave like human beings, experimental studies of them can shed light on basic reactions of organisms to their environment. From them a psychologist hopes to derive ideas which will help in studies of human beings.

The study we shall describe represents an attempt to find out how an animal is affected by severe restriction of its opportunities for development and learning during its first few months of life. Our subjects were Scottish terriers. We were interested in learning whether early upbringing in a barren environment would have permanent effects upon the dogs' intelligence, activity, emotional reactions and social behavior. The research was carried out over a period of five years in the psychological laboratory of McGill University with the help of a Rockefeller Foundation grant.

As soon as each litter of Scotties was weaned (at the age of four weeks), it was divided into two groups. One group was then raised normally as controls: the dogs were either farmed out to Montreal families or, in a few cases, reared as free pups in the laboratory. The members of the other group, who served as the experimental subjects, were all confined in cages—one dog to a cage. The cage was closed in with opaque sides and in some cases an opaque top, so that the dog could not see outside. Each day its food was placed in a small adjoining box with a sliding door. The door was opened from outside to let the dog into its "dining" room; then it was closed and the cage was cleaned. Thus the dog never saw its keepers.

The experimental animals lived in this blank, isolated environment until they were between seven and 10 months old. At the end of that time they were let out and given the same handling and daily exercise as the controls, which were brought back from their homes to the laboratory. The two groups were then observed and given various psychological tests.

It was immediately obvious even to a casual observer that restriction had had a profound and surprising effect on the experimental Scotties. After their release these dogs were exceptionally active and playful, showing a puppylike exuberance that belied their physical maturity. This behavior was almost opposite to what one might have expected, because it is commonly supposed that early separation from contacts with others has a depressing effect. Visitors to the laboratory, on being asked to pick out the restricted dogs from those raised normally, almost invariably chose the more sedate and subdued normal dogs.

We designed several tests to measure the Scotties' activity level systematically. In the first, each animal was put into a small room and observed for 30 minutes to see how much time it spent exploring the room, as opposed to merely sitting or lying down. This test was given four times, on four consecutive days, to seven normal and 11 restricted dogs. The normal dogs soon became bored with the monotony of the room and quietly relaxed, but those that had had a restricted upbringing went on exploring for a considerably longer time.

The amount of activity also varied inversely with age. Older dogs became bored much more readily than younger animals. This supports the idea that the behavior of the experimentals was a sign of immaturity.

In a second activity test, the experimental and the normal Scotties were invited to explore a maze. They were observed for four 10-minute sessions. At first both groups were equally curious. But the novelty of the situation wore off much more quickly for the normal animals, and their exploratory inspection of the maze rapidly declined, whereas the dogs that had been starved of experience in their early lives continued to run about in it more actively. Even several years after they had left their early cages, experimental Scotties still showed more activity in the tests than normally raised dogs of the same age—an indication that the effects of their early restriction were enduring.

These findings should not be interpreted to mean that maturity or a rich early life dulls curiosity. Rather they decrease over-curiosity. They produce an animal which is just as curious about any new situation, but which has the means to satisfy its curiosity quickly. In other words, the experienced animal exhibits more intelligence. There may be something delightful about a child who can spend an hour completely absorbed in a clothespin, but this is not intelligent, adult behavior.

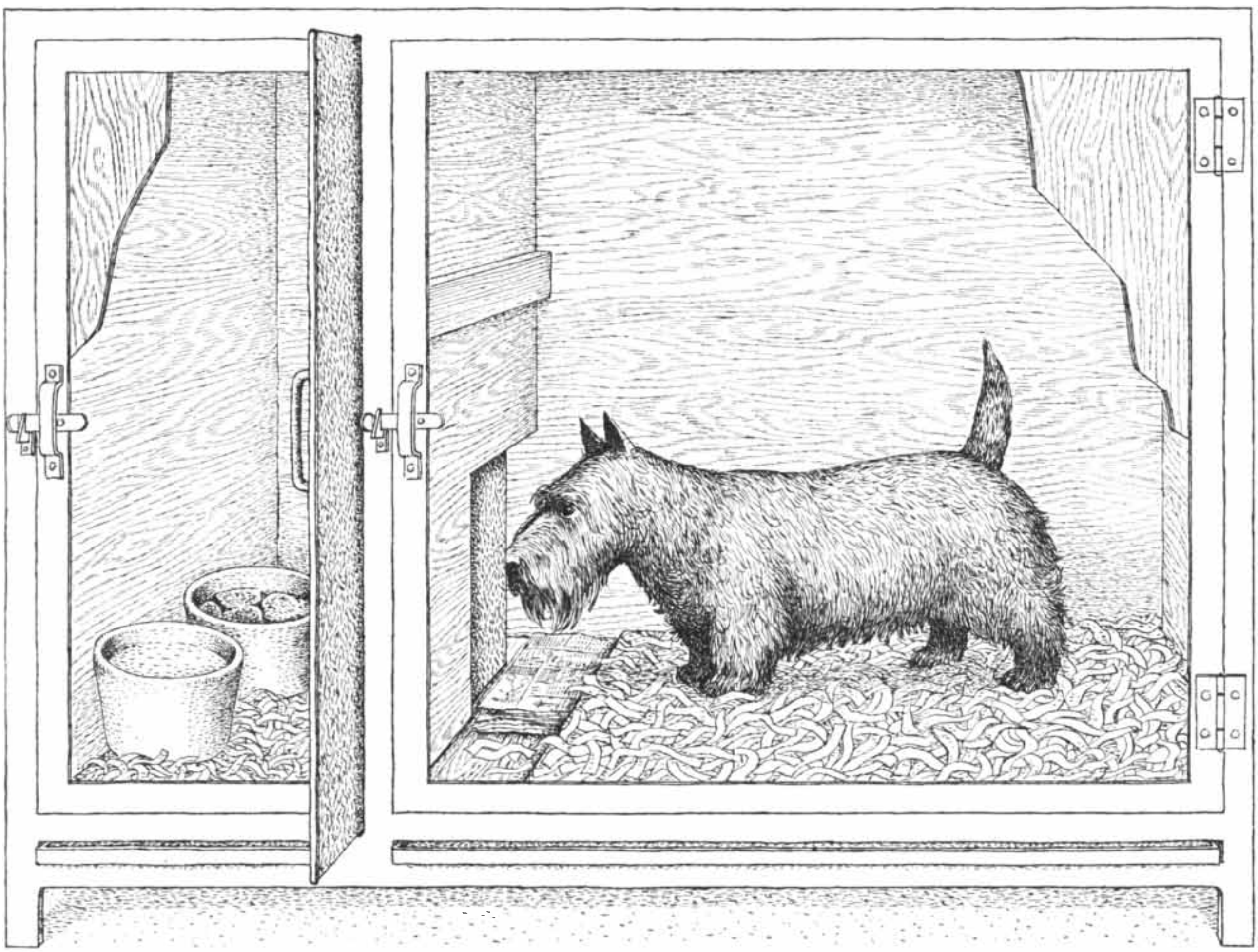
We next examined the Scotties' emotional behavior. The severely limited early upbringing of the experimental dogs gave us a good opportunity to investigate the origin of so-called "irrational" or "spontaneous" fears, which have recently attracted much attention from psychologists.

It used to be thought that all fears of objects or stimuli were "conditioned"—an idea espoused by the behaviorist John B. Watson. The association of pain, a fall or a loud noise with an object may cause a child to fear it thereafter, even if the object is harmless. But many psychologists now are convinced that there is a type of fear which cannot be explained in terms of conditioning. Fear may be evoked simply by the unusual or the unexpected—a leaf suddenly swirling past one's face on a dark country road, a knock on a window at night, any mysterious happening or behavior. There is a classic case of a three-year-old girl who was severely frightened by her father when he dressed up as an elephant, even though she knew it was her father. D. O. Hebb of McGill University, investigating this type of fear systematically in chimpanzees, has found that they often show violent fear at the first sight of a strange person, a skull, a snake or a death mask of another chimpanzee. Charles Darwin long ago noticed the same phenomenon in dogs: in *The Descent of Man* he described how he had watched his dog avoid an open parasol being blown along the lawn by a breeze and had speculated on the dog's behavior. Darwin thought the dog must have reasoned unconsciously to itself "that movement without apparent cause indicated the presence of some strange living agent." It is doubtful that Darwin's dog, even after long association with a genius, could have reasoned in this way. Nonetheless, the significant fact Darwin recognized was that an animal with a highly developed brain may fear the mysterious.

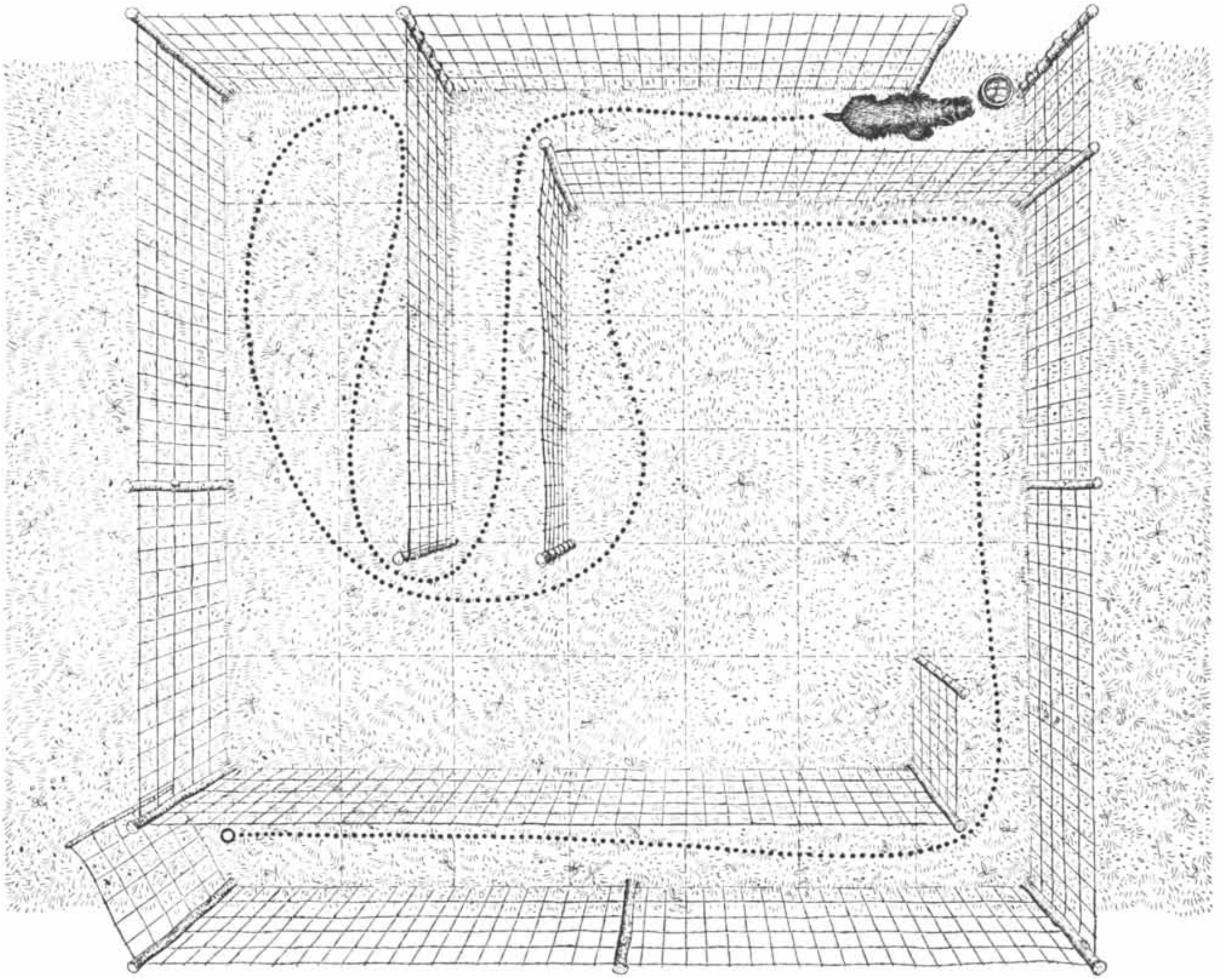
Are such fears "innate" or developed? Helen Mahut of McGill University tested the reactions of various breeds of dogs, all reared normally, to certain harmless but emotion-evoking objects, and she discovered that each breed responded to these objects in a characteristic way. Thus the emotional behavior clearly must have some hereditary basis. Yet we can hardly assume that an animal is born with innate fears of specific objects or people. Obviously the animal's experiences determine to a large degree what is unusual and what is not. With our experimental Scotties, whose early experience had been extremely meager, we had an excellent opportunity to study the interaction of heredity and learning in determining emotional behavior.

About three weeks after the restricted dogs had been released from their cages, we exposed them to various strange phenomena, such as a human skull, a slowly swelling balloon, an opening umbrella and so on. Normally-reared young Scotties usually run away from such objects, without showing much excitement. But the restricted Scotties behaved very differently. They became highly agitated, jumped back and forth near the object, whirled around it, "stalked" it and generally displayed much excitement but little purposeful activity. Their behavior may be called "diffuse" or "undifferentiated"—they appeared not to know what to do about the object.

A year later the restricted and normal



EXPERIMENTAL SCOTTIES were placed after weaning in a closed cage, the front of which is cut away in this drawing. They remained in the cage until they had reached an age of seven to 10 months. The cage has two compartments for feeding and cleaning.



MAZE was used to compare the curiosity of normal and restricted Scotties. The dogs were released at lower left and encouraged to find the food at upper right. The performance of each animal was scored by tabulating the number of times it entered an "error zone."

dogs were again tested with the same objects. The normal dogs now added a new response to their earlier avoidance: they attacked the object with a playful aggression—growling, barking, snapping and sometimes biting. The restricted dogs still showed considerable excitement of a diffuse kind, but they had also developed a purposeful pattern of avoidance. That is to say, they had reached a stage of response somewhat like that which the normal dogs had achieved a year earlier.

The experiment indicated that the hereditary pattern of adaptive emotional behavior, such as avoidance and aggression, emerges only after an animal has had considerable experience with a stimulating environment, acquired over a long period. Without such experience, the animal expends a great deal of undirected and ineffectual energy.

This experiment led to an even more interesting question: How will an animal deprived of experience respond to a stimulus which is painful rather than harmless? Is avoidance of pain a simple reflex reaction that comes naturally to any animal, as many psychologists have long assumed? Further experiments showed in the clearest possible fashion that it is not.

In one of these experiments the dogs were pursued by a toy car which gave them an electric shock when it hit them. Normal dogs quickly learned to avoid being hit. After six shocks, on the average, the experimenter no longer was able to touch them with the car. Moreover, they reacted to the threat calmly and deliberately: they sat watching the car, flicked aside a leg or the tail to avoid it, and jumped up to run away only at the last moment when the car came directly at them.

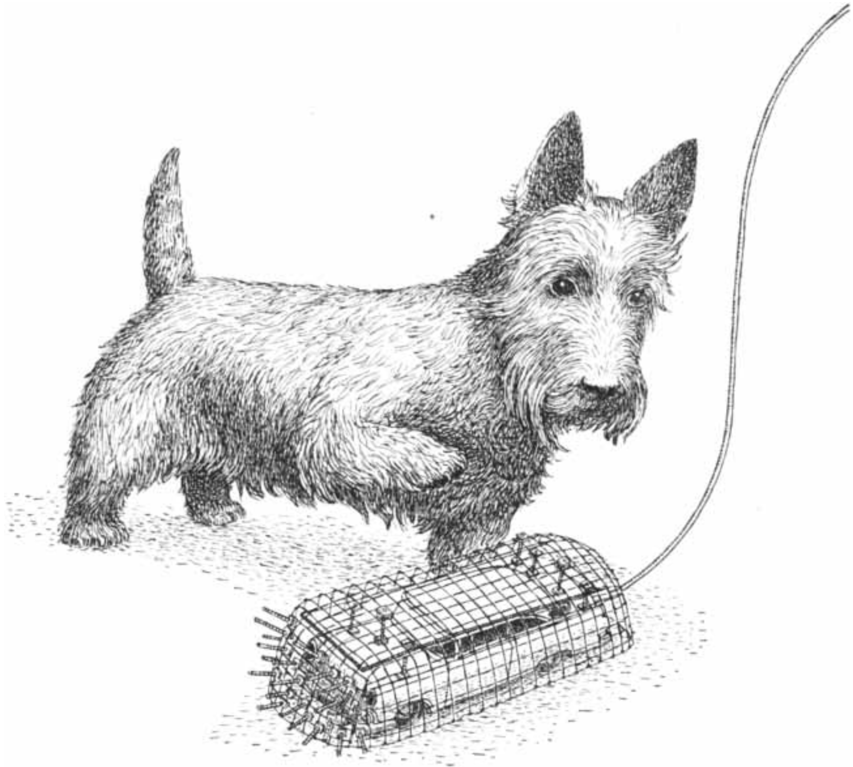
In contrast, the restricted dogs behaved wildly and aimlessly. They jumped about, galloped in circles and actually ran into the car when it was held still in their path. It took these dogs an average of 25 shocks each to learn to avoid the car, and even then they became excited whenever they saw it. Two of the experimental dogs were subjected to the test again two years after they had been released from restriction. They still reacted to the electric shock with the same wild agitation, and one of them learned to avoid the car only after 23 shocks.

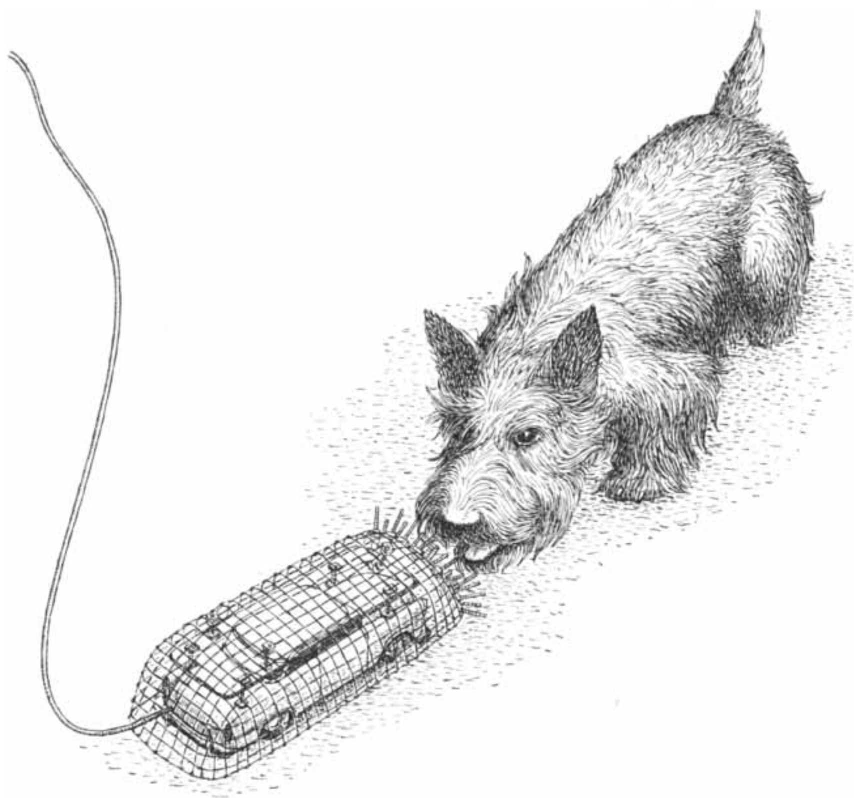
In this and other tests of their responses to painful stimuli, some of which could have injured them seriously, most of the restricted dogs behaved as if they were unaware that the source of the pain was in the environment; they might have reacted in the same way to a bellyache. Whereas normal dogs usually dashed away from the pain-causing object, the restricted dogs spent considerably more time around it after they had been hurt than before. To the astonishment of the experimenters, these dogs often toyed with a painful stimulus and frequently walked into it. For example, they repeatedly struck their heads against some water pipes along the walls in one of the testing rooms: one dog banged his head against these pipes more than 30 times, by actual count, in a single hour. The dogs gave no sign of pain when they ran into the pipes.

These experiments support a great deal of other recent evidence that pain-avoidance is by no means the simple protective "instinct" it was long thought to be. It is not a mere matter of nerve stimulation and response. Both the perception of pain and the response to it are complex processes, in which the brain plays an important part. The appropriate response to pain is acquired, at least in part, by learning. And if an animal does not learn it in infancy, apparently it is unlikely ever to achieve the calm, precise response of a normal adult.

We made a number of direct tests of the restricted dogs' intelligence, or problem-solving ability. In one simple test the dogs were first trained to get food by running along a wall of a room from one corner to the next. Then the experimenter placed the food in some other corner of the room. This was done in full sight of the dog, and the experimenter called emphatic attention to the new position by banging the food pan on the floor. A normal dog usually ran straight to the new position. But the restricted dogs almost invariably ran pell-mell toward the old corner; at best they might veer off before they reached it and get to the correct goal by a roundabout route. In a variation of this test, a chicken-wire barrier was placed in front of the food to see whether the dog would be intelligent enough to go around the barrier. Again the restricted animals showed strikingly unintelligent behavior. Normal dogs usually learned to go around after one or two trials, but the puppylike restricteds repeatedly dashed up to the barrier, pawed at it and tried to push their muzzles through the mesh in a vain and frantic attempt to get at the food.

A more difficult delayed-response test measured the Scotties' ability to note and remember the location of food. Each dog was allowed to watch the experimenter put some food in one of a pair of boxes and to sniff the food. The dog was taken away and then released after a short time to test whether he would remember the correct box. Normal dogs, on the average, were able to choose the food box consistently after delays of up to four minutes. But the restricted dogs, as a rule, could not select the correct box





TOY AUTOMOBILE which could be controlled remotely by the experimenter was fitted with prongs through which the Scotties would receive a mild electric shock. The normal dog (*top*) quickly learned to avoid the automobile without excitement. The restricted dog (*bottom*) took much longer to learn this lesson, and was excited when it saw the automobile.

reliably even when they were released without any delay at all.

The final test was a set of 18 different maze problems. The Scotties were scored on the number of errors they made and the time it took them to solve each maze and reach the food at the end of it. Two features of this series of tests seem to us especially noteworthy. In the first place, the 18 different mazes tested a wide range of abilities. And secondly, all the dogs were trained beforehand on simpler mazes so that they had practice and were proficient in solving the maze type of problem. This meant that the conditions were analogous to those obtaining in human intelligence tests, for the persons taking them have had previous training in answering questions of the sort asked in the test. Just as in testing human intelligence, one can hardly expect to appraise an animal's intelligence properly by presenting it with a single problem of a kind it has never encountered before, as is often done in laboratory maze tests.

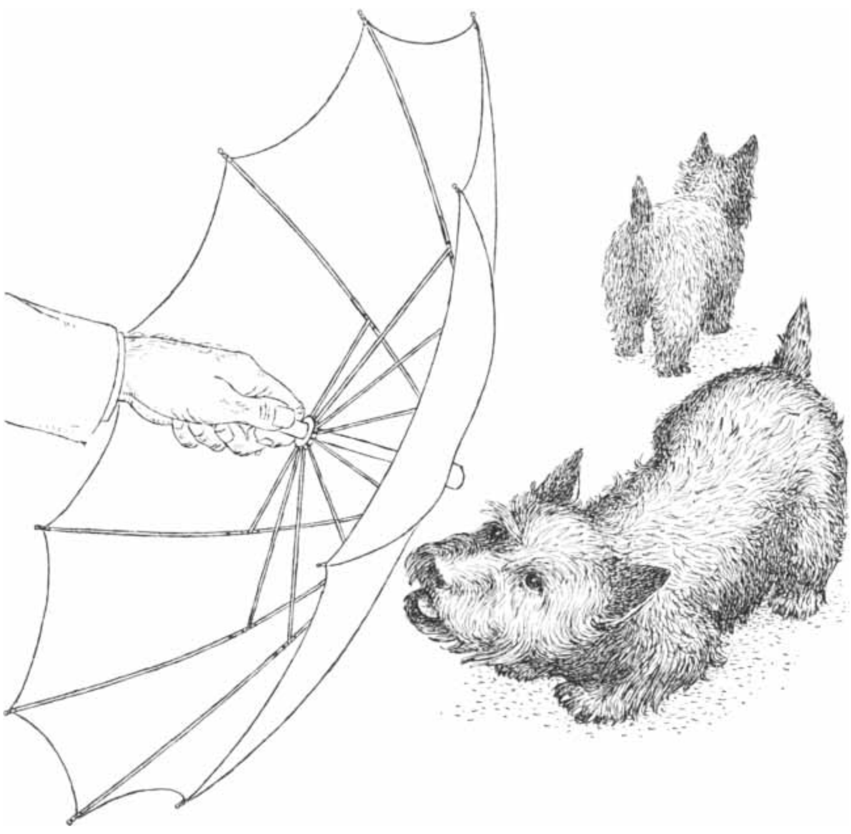
As we expected, the restricted Scotties' performance on the 18 maze problems was substantially inferior to that of their normally reared littermates. They made about 50 per cent more errors on the series of problems. Even dogs which had been out of restriction for several years scored lower than their contemporaries, which seems to indicate that the retardation imposed by their early restriction was more or less permanent.

Having examined the effects of a barren early upbringing on the dogs' activity, emotionality and intelligence, we were curious to know how it would shape their social behavior. The social life of dogs is rather elementary compared with that of human beings. As any dog-owner can testify, the domestic dog is not a particularly social animal, as far as association with others of its own kind is concerned. Yet dogs certainy do interact socially when they have the opportunity. Their social behavior is determined partly by heredity (some breeds are notoriously more aggressive than others) and partly by upbringing.

We first studied the effect of a restricted upbringing on the trait of dominance (or submissiveness). The test situation was simple: a restricted dog and a normally raised dog were allowed to compete for a bone. Almost without exception the normal dogs dominated the restricted animals in this competition. Upbringing even overcame the powerful factor of seniority, for normal animals dominated the restricted ones that were considerably older.

The dogs were also compared on a test designed to measure "sociability." Each subject was released in a large room containing two other dogs, enclosed in separate chicken-wire pens in opposite corners of the room. The subject's interest in socializing was not difficult to measure. A sociable subject typically would approach one of the pens, stare at the animal inside, wag its tail and bark. Others ignored the occupants of the pens and sometimes even urinated on a pen as if there were no one inside. Our measure of sociability was the amount of time spent by the subject in taking social notice of the penned dogs during a 10-minute session.

In this test the normal Scotties proved to be much more sociable than those with a restricted upbringing. The latter paid little attention to the dogs in the pens, especially during the first session, and spent most of their time exploring the room itself. They were apparently a great deal more interested in the inanimate physical aspects of the room than in its live occupants. This lack of interest in companionship persisted years after the experimental dogs had been released from their early restriction.



IRRATIONAL FEARS of normal and restricted dogs were compared by exposing them to an emotion-evoking object such as an opening umbrella. Here again the normal dog (*background*) soon accepted the object, while the restricted dog continued to be frightened by it.

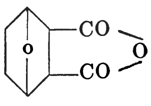
The experiments we have described clearly indicate that a rich and stimulating environment in early life is an important condition for normal development. Restriction of experience during this crucial period can result in enduring retardation of an animal in various psychological traits. It must be emphasized that our studies of Scotties have little specific bearing on human beings, for the environmental situations are drastically different. But the experiments bring out clearly that any animal needs varied sensory stimulation in order to develop normally, just as it needs food and drink. This is a fact that has frequently been neglected by psychologists. It has long been assumed, either explicitly or implicitly, that all behavior is governed by a basic need to minimize tensions and disturbances in order to preserve the stability of the organism. This is evidently not so. Organisms like to be disturbed (as by an exciting novel, climbing a mountain and so on). And indeed they cannot live normally and fully if they are not. Especially during the early, plastic period of life, they must have a good deal of stimulation in their environment. If they do not, they may remain forever immature.

Kodak reports to laboratories on:

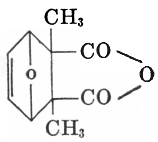
an unusual endoxo structure . . . a large plus, two medium-sized pluses, and a standoff . . . riding the new speed *vs.* sharpness curve

Even Hippocrates knew

7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic Anhydride (Eastman 7126) is also known as norcantharidin because cantharidin can be formalistically regarded as derived from it by partial dehydrogenation and methylation.

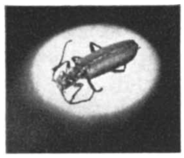


norcantharidin



cantharidin

This is idle theorizing about a compound which even Hippocrates knew as the virulent, vesicant essence of the blood of certain species of insects. Cantharides is one of the few drugs the old fellow mentions. Today it is little more than a pathetic but dangerous relic of the days of heroic medicine.



Lytta vesicatoria (L.) (Cantharidae)

Cantharidin nobody can accuse us of selling, but for the benefit of any chemist fascinated by its strange oxygen bridge across the ring, there is now Eastman 7126 at $2 a gram.

Eastman 7126 has some 3500 bedfellows on our stock shelves. They're cataloged in our Eastman Organic Chemicals List No. 39, which you get from Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (*Division of Eastman Kodak Company*).

The oscillograph paper game

Various objects fly through the air these days in order to provide signals, either directly or by delayed playback from magnetic tape, that govern the quiverings of little galvanometer mirrors. The mirrors reflect light beams onto moving strips of photographic paper. The paper is then generally run through machines called stabilization processors to emerge with lines on them.

We have the honor to provide some of this photographic paper. Now we are soliciting more of this business for the new *Kodak Linagraph 1344 Paper* on the following grounds:

1) It comes out of stabilization processing without the brownish-pink stain characteristic of high speed photorecording paper. This should make it easier on the eyes of those who have to look at the traces all day long and easier to copy on duplicating machines.

2) It responds to a galvanometer light beam sweeping over it as fast as 1,000 in./sec. The trace therefore does not become uncertain just where a fast transient makes it most interesting.

3) There are few blackened silver grains over the line from where the beam went by. The sharpness justifies the use of optical aid in measuring the exact position of the trace.

4) At last, we have seen the folly of our ways in the matter of paper thickness. Now nobody beats us at getting the most footage into the least roll diameter. Strong paper it is too, good enough to reassure the last lifted eyebrow in the paper mill where we make our own base.

In order, then—a large plus, two medium-sized pluses, and a standoff. Where would technology be without competition?

Any photo-oscillographic questions? For the answers, write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

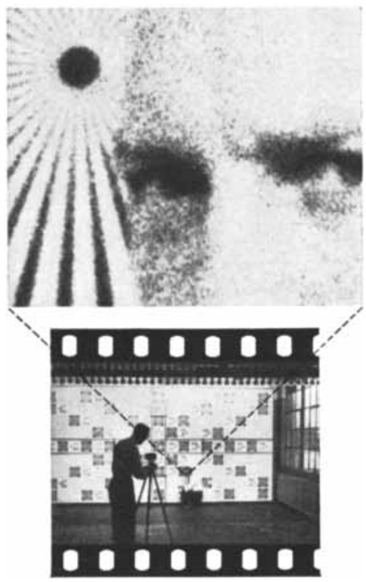
Enlarging the breakthrough

Looked back at now, the film emulsion-making practices of, say 1953, seem unsophisticated. We shall have to let the remark stand at that. The fact is that there has been an abrupt rise in a quasi-quantitative quantity, the product of film speed and sharpness.

About measuring speed there is a lot to be said, but we won't say it here, except that the *Kodak Tri-X Film* which we introduced a year or so ago has significantly expanded the scope of photography.

Sharpness, a subjective impression, has now likewise had a metric imposed on it. There is a mathematical statement—termed acutance—of the density variation across the photographic image of a knife edge. It is quite different from resolving power, a quantity related to the smallest repetitive detail distinguishably reproducible, whether the detail looks sharp or not.

Riding the new speed *vs.* sharpness curve, we here announce reactivation of the name *Kodak Panatomic-X Film* to apply now to our sharpest roll film, 35mm and other sizes, for general photography. Its Exposure Indexes are 25 for daylight and 20 for tungsten. Its emulsion is less than half as thick as usual in negative film. This shortening of the path along which light can scatter on its way down is part of the reason for the greater sharpness, but only part. The thinness also speeds processing. As for resolving power, witness the following demonstration, as filtered through the press that printed this page:



Kodak Panatomic-X is an extreme, as is *Kodak Tri-X*. For those who have been getting along just fine with the speed of *Kodak Super-XX*, but want the sharpness benefit of the 1954 breakthrough, we recommend a new 35mm and 70mm film we are calling by the old name *Kodak Plus-X*. The noble old name *Super-XX* is being retired, except for sheet and aerial film.

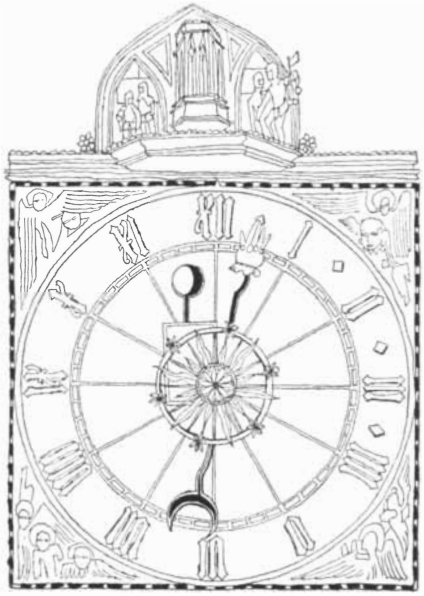
Already both of these new films are among the most widely distributed manufactured products in the United States.

Price quoted is subject to change without notice.

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

Kodak
TRADE MARK

SCIENCE AND



UN Radiation Study

The effects of radiation on man and his environment will be studied by an international committee set up by the United Nations General Assembly. The committee will have one scientist from each of the following countries: Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, Egypt, France, India, Japan, Mexico, Sweden, United Kingdom, U. S. and U.S.S.R. Their representatives will meet in Washington January 23 to form the framework of the new agency.

The resolution establishing the worldwide radiation study, originally sponsored by the U. S., Canada, Australia and the U. K., was passed unanimously after amendment by the 59 members of the General Assembly's Political Committee. Two amendments introduced by India were defeated by narrow margins. One would have authorized the scientific group to collect information from all sources, including such nonmember nations as Communist China. The other would have directed the UN Secretary-General to furnish its reports to anyone who wanted them.

National Observatory

The National Science Foundation has decided to sponsor a national observatory whose facilities will be open to all properly qualified U. S. astronomers. A study is now being conducted by the University of Michigan, under a $279,000 grant from the Foundation, to determine the best site for the installation. It will probably be located in Arizona or New Mexico, which have clear atmospheres and better winter seeing conditions than California.

Manpower

That drastic measures are needed to meet the shortage of scientists and engineers in the U. S. was urged by several national figures last month. Lewis L. Strauss, chairman of the Atomic Energy Commission, proposed that "every engineer and scientist in the country" be enlisted as a part-time high-school science teacher. In addition, he told a conference on the scientific manpower shortage held by the Thomas Alva Edison Foundation, he would have all colleges require physics and chemistry for entrance, so that students would be forced to study these subjects in secondary school. Dean John R. Dunning of Columbia University's School of Engineering, who also attended the conference, urged that the national expenditure for education be doubled, with some Federal aid.

The National Science Foundation last month published a monograph entitled *Scientific Personnel Resources*, its first attempt at a complete inventory of scientific manpower. According to the report, there were about 200,000 scientists and 650,000 engineers in the U. S. in 1954. Of the scientists, 63 per cent were trained in the physical sciences, 12 per cent in the earth sciences and 25 per cent in biological. Almost 80 per cent of the physical scientists were chemists; 15 per cent were physicists and 4 per cent mathematicians. The division among engineers was: 24 per cent civil, 24 per cent mechanical, 20 per cent electrical, 8 per cent industrial, 6 per cent chemical, 4 per cent mining and metallurgical and 14 per cent other.

The Foundation noted that shortages in manpower will become "critical" if defense requirements are increased substantially. Yet the capacity of the U. S. educational system to turn out well-trained scientists and engineers is decreasing rather than increasing. The number of college graduates qualified to teach science in high schools has declined annually since 1950. In 1954 some 4,000 graduates were qualified, but surveys indicate that little more than half of these would become teachers. Only about 46 per cent of youngsters with an I.Q. of 130 or over get a college education, and only 1.7 per cent take Ph.D. degrees.

An experimental program for improving science teaching in high schools was announced by the National Academy of Sciences and National Research Council. It is being tried in Arlington, Va. Under the plan a scholarship fund will be raised by the Parent-Teacher Association and other civic groups to enable Arlington high-school teachers to do graduate study at local universities. The N.A.S. is cooperating with these institutions to develop courses which will help the teachers in their classroom work and will count toward advanced degrees in education or science. A second feature of the program is to find summer employment for the teachers in industrial or government research laboratories. The jobs will provide useful training as well as extra income.

In connection with its manpower census, the National Science Foundation noted that "certain other countries" are rapidly approaching the U. S. in the number of technically trained personnel and we may soon "be surpassed." Documenting the assertion was a second Foundation publication, *Soviet Professional Manpower*, by Nicholas DeWitt of the Russian Research Center at Harvard University. The author found that the Soviet Union has turned out almost twice as many technical specialists as the U. S. during the past 25 years: 682,000 engineers as against 480,000 in the U. S.; 244,000 agricultural specialists as against 133,000; 320,000 physicians as against 148,000. There are nearly six million college graduates in the U. S., only two million in the Soviet Union. But the number of Soviet applied scientists with higher education is already equal to or greater than the number in the U. S.

Off to Antarctica

Never before in history have the Antarctic seas borne such heavy traffic. In the month of November alone four ships sailed for Antarctica carrying men and supplies to set up observation stations for the International Geophysical Year in 1957-1958.

The 8,600-ton U.S.S. *Glacier*, the Navy's newest and most powerful icebreaker, is transporting 93 officers, enlisted men and scientific observers along with a remarkable assortment of equipment. In addition to three amphibious reconnaissance vehicles, the *Glacier* carries two "snowcats," two helicopters and an airplane equipped with both wheels and skis. The icebreaker is towing a 174-foot harbor oiler filled with 200,000 gallons of aviation fuel.

The *Theron*, a Canadian sealing ship, left from London with a British Commonwealth expedition which will stop at New Zealand to pick up Sir Edmund Hillary, the climber of Mount Everest. A week later the *Theron* was followed by the *Tottan*, a 540-ton motor vessel chartered by Royal Society scientists who plan to investigate the aurora and other aspects of the atmosphere.

As the month closed the giant of the international Antarctic fleet, the 12,500-ton Diesel-electric motorship *Ob*, left from Kaliningrad with the advance guard of the U.S.S.R. expedition. The Soviet scientists will establish three bases, one in the center of the continent near the South Pole.

The Deuterium Song

A new note has been reported in the medley of radio waves pouring in on the earth from the space outside. Its wavelength is 91.6 centimeters and it is broadcast by atoms of deuterium (heavy hydrogen).

The hydrogen in interstellar space, if it is like the material found on earth, should contain a small amount of the heavy isotope. Ever since the 21-centimeter radiation from interstellar hydrogen was discovered, astronomers have realized that there should also be a deuterium signal, which calculations showed to have a wavelength of 91.6 centimeters. It was thought, however, that space contains only about one atom of deuterium to every 6,000 atoms of normal hydrogen, in which case the signal would be too faint to detect. At a recent symposium on radio astronomy at the University of Manchester in England a delegation from the U.S.S.R. announced that Soviet observers had picked up a deuterium absorption line in the strong radio emission coming from the center of the Milky Way. The strength of the reported effect indicates that the ratio of deuterium to hydrogen in the direction of the center of our galaxy may be as high as one to 400. G. G. Getmanzev, K. S. Stankevitch and V. S. Troitsky were credited with the discovery.

Commenting on the announcement in *Sky and Telescope*, Harvard University

AL Stainless Steels for the Process Industries

VARIOUS TYPES—Generally speaking, stainless steels are divided into three groups: chromium, chromium nickel, and chromium-manganese-low nickel steels. Their corrosion resistance, hardenability, tensile strength, etc., varies with the proportion of chromium, nickel and other alloying elements each type contains.

The chromium stainless grades are divided into two types: martensitic steels, which are hardenable; and ferritic non-hardenable steels. Both types are magnetic. The chromium nickel and chromium-manganese-low nickel stainless grades are austenitic steels, hardenable only by coldworking, and are non-magnetic.

The principal chromium stainless steels of chemical industry significance are Types 410, 431 and 440A martensitic grades, and Types 405, 430, 442 and 446 ferritic steels. Chromium nickel austenitic steels of principal importance are Types 302, 304, 316, 317, 347, 309 and 310. In the more recently developed chromium-manganese-low nickel austenitic group, Type 202 has physical and mechanical properties closely approximating those of Type 302—with the advantage of much lower nickel content and more ready availability in times of nickel shortage.

PRINCIPAL GRADES—Industry has called for quite an extensive range of chemical and physical properties in stainless steels. To meet these requirements, types have been developed which are best suited for a particular application: such as Types 316 and 317 for extra corrosion resistance, Types 309 and 310 for extra high temperature service, etc. Knowledge of these stainless steel qualities is essential for engineers and designers to create a product that will best do the work for which it was intended. Complete data on AL Stainless Steels is available in the various publications listed below.

Of all the stainless steels, the grades most used in the chemical and allied industries are Types 304, 316, 317 and 347 chromium nickel steels. The first three grades are also available in extra low carbon varieties to meet extreme conditions of fabrication or service which might carry the threat of intergranular corrosion. Designated Types 304L, 316L and 317L, these low carbon stainless steels are practically immune to carbide precipitation in the as-welded condition. Like Type 347, they permit the field-welding and stress-relieving of material of any thickness, for example, without the hazard of intergranular corrosion.

REGULARLY SUPPLIED FORMS—Allegheny Ludlum Steel Corporation is in position to furnish the various grades of stainless steel in all of the commercial forms required by fabricators of these metals. These include:

- Plates, including formed heads
- Sheets, either coiled or straight cut lengths
- Strip, either coiled or straight cut lengths
- Bars, rounds . . . flats . . . hexagons . . . octagons . . . squares or special shapes
- Billets, for forging or upsetting
- Angles
- Wire
- Tubing, seamless or welded
- Castings and smooth-hammered Forgings
- Extrusions
- Clad stainless

Information as to size ranges and mill tolerances are available in literature devoted to detailed discussions of AL Stainless Steels.

SPECIAL REQUIREMENTS—When selecting a grade of corrosion and heat resisting steel for a given application, it should always be borne in mind that laboratory tests, however carefully performed, can be expected at best to be only indicative of field performance. Variations in actual service conditions are so wide that a special study of the case at hand may be necessary at times. To that end, Allegheny Ludlum engineers and technical men are available for consultation on unusual problems involving stainless applications.

FABRICATION—AL Stainless Steels may be easily fabricated by any of the usual processes—welding, drawing, blanking, machining, spinning, forging, riveting, shearing, soldering, etc. In some instances, however, care must be exercised in handling of the material to preserve its corrosion or heat resisting properties. No one should undertake to fabricate any of the stainless steels without a full understanding of these handling procedures. Proper processing is fully discussed in Allegheny Ludlum literature—available on request.

RESISTANCE TO ATTACK—There is a wide range of conditions under which AL Stainless Steels operate in resisting corrosive attack at normal and elevated temperatures. Detailed information regarding their resistance to various media, heat resistance and strength will be sent upon request. See the publication list below.

STAINLESS CLAD STEEL—Allegheny Ludlum Stainless Clad is available commercially in the following commodities:

- Double Clad—Stainless both surfaces with carbon steel core. In plates, sheets and strip.
- Single Clad—Stainless one side only; plates only 3/16″ and heavier.

Special clad materials on application.

PUBLICATIONS AVAILABLE

The following list of technical and service literature is freely available on request; just ask for the bulletins which contain the type of information you need.

Blue Sheets—An individual Blue Sheet, containing certified laboratory data on physical and chemical properties, etc. is available on each grade of AL Stainless Steel.

Fabrication of Stainless Steels—Contains valuable data for your shop men on various methods of handling, forming and finishing stainless steel.

AL Stainless Steel in Chemical Processing—36 pages on various applications, advantages, etc. of stainless in the chemical industry.

Stainless Steel Handbook—A case-bound book of 124 pages, containing complete data leading to the proper selection and fabrication, etc. of the correct grade of stainless for each application.

• Write to *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

ADDRESS DEPT. NO. SC-73

W&D 5787

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL STAINLESS STEEL ®

Warehouse stocks carried by all Ryerson Steel plants

astronomer Bart J. Bok said the observation "obviously required checking and confirmation, but there is no doubt of its great importance, possibly ranking with the discovery in 1951 of the 21-centimeter line by H. I. Ewen and E. M. Purcell."

Cosmic Synchrotron

A gigantic natural synchrotron, powerful enough to account for the extremely high energies of cosmic rays, has been found in the Crab Nebula.

This nebula, the gaseous remainder of a supernova which exploded in the year 1054 A.D., has long been an object of curiosity. Its light is unusual in that it forms a continuous spectrum, rather than a line spectrum. Recently astronomers in the U.S.S.R. announced the still more surprising fact that the light is also partly polarized. The discovery has been confirmed by the Dutch astronomer Jan H. Oort and by Walter Baade of the Mount Wilson and Palomar Observatories. In fact, they found the light from some parts of the nebula to be almost 100 per cent polarized.

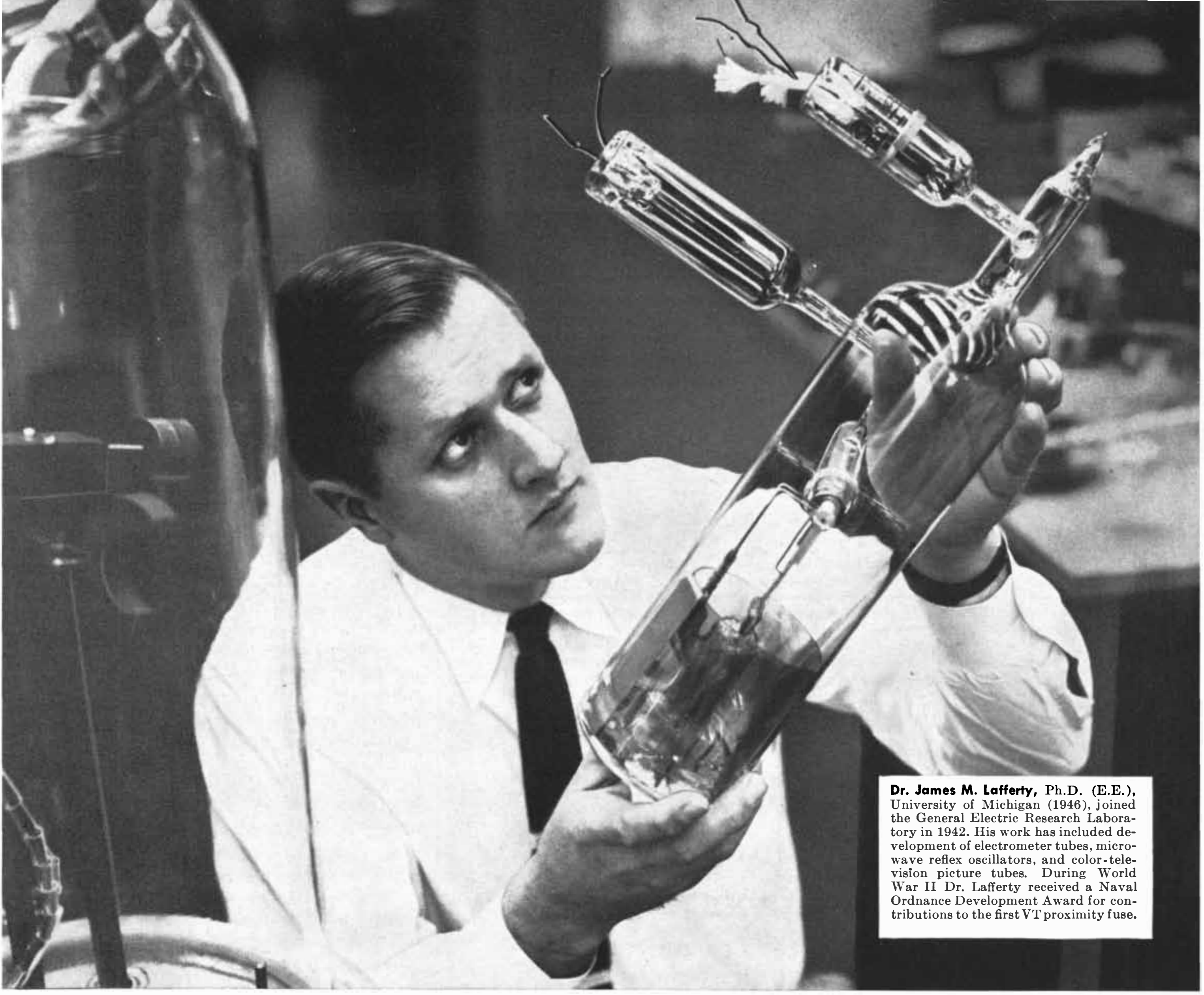
The only explanation physicists can think of for the continuous, polarized spectrum is that the light is radiated from very high-speed electrons being accelerated in a magnetic field. Such radiation, which is predicted by electromagnetic theory, can be seen in electron synchrotrons. Apparently the supernova must have produced a source of high-energy electrons, and these particles are now being bent into curved paths by the weak magnetic fields of interstellar space.

If the nebula contains fast electrons, it probably also contains fast protons. The heavy protons would not radiate visible light and so could not be directly detected. But if they are there and if they are traveling as fast as the electrons, they might well reach the earth with the energy of primary cosmic rays.

Sunpower

An international conference on solar energy in Arizona last month drew 700 scientists from 36 countries. Similar meetings two years ago in Wisconsin and last year in India had only 30 participants each. The 1955 conference was sponsored jointly by the Stanford Research Institute, the University of Arizona and the Association for Applied Solar Energy.

The consensus of the discussions was that small-capacity solar units will soon be supplying substantial quantities of



Dr. James M. Lafferty, Ph.D. (E.E.), University of Michigan (1946), joined the General Electric Research Laboratory in 1942. His work has included development of electrometer tubes, microwave reflex oscillators, and color-television picture tubes. During World War II Dr. Lafferty received a Naval Ordnance Development Award for contributions to the first VT proximity fuse.

New stability for cathodes

General Electric's Dr. James M. Lafferty uses metal compounds to achieve reliable electron emission

For as long as they have known how to make vacuum tubes, scientists have been seeking cathodes combining high emission with low evaporation—materials that will give off many electrons, but few atoms. Because of their emission efficiency, oxide cathodes always have received most of the research attention. Now, however, Dr. James M. Lafferty of the General Electric Research Laboratory is taking an entirely new look at the problem. He has developed cathodes made of metallic compounds which are chemically stable and demonstrate low evaporation rates at current densities where oxide cathodes evaporate too quickly to be useful. These features have made Dr. Lafferty's *lanthanum boride emitters* indispensable in the electron guns used for high-energy accelerators and other systems where stability is required under difficult conditions. Using interstitial compounds, scientists can build a cagelike framework around the atoms of metals known to be good emitters; the framework acts as a "sieve," which lets electrons pass through, but holds back evaporation of the atoms themselves. Dr. Lafferty's metallic emitters are now beginning to approach oxide cathodes in efficiency, while surpassing them in long-life reliability.

Progress Is Our Most Important Product

GENERAL ELECTRIC

power in hot, sunny regions for such purposes as irrigation, refrigeration and lighting small villages.

Among the technical developments announced at the meeting:

H. Tabor of the National Physical Laboratory in Israel has designed a glass plate which absorbs solar energy so efficiently that it can generate low-pressure steam—something no other plate collector had ever accomplished. One side of the plate has semicylindrical ribs which focus the sun's rays into narrow lines at the opposite surface. This surface is silvered everywhere except along the focus lines. Hence the focused energy gets through to the space beneath the glass and most of it is trapped there because of the silvering over the plate's surface.

Engineers in the U.S.S.R. have built a steam generator with a 33-foot parabolic mirror. The boiler produces 107 pounds of steam per hour at a pressure of 110 pounds per square inch and a temperature of 367 degrees Fahrenheit. Another Soviet paper disclosed plans for a much larger unit which will make 13 tons of steam per hour at a temperature of 660 degrees and a pressure of 240 pounds per square inch. Its mirrors, with a total reflecting surface of 215,000 square feet, will be mounted on railroad cars traveling on circular tracks to follow the sun.

The French delegation, the largest foreign group at the conference, described work on solar furnaces. Using mirrors to concentrate solar energy on a small area, the French have developed temperatures up to 6,300 degrees Fahrenheit. They claim a number of practical advantages for the solar furnace over the electric arc furnace now most commonly used to obtain such temperatures. The French researchers announced a commercially feasible process, using the solar furnace, for producing 99.5 per cent pure zirconium oxide, a refractory material with a melting point of 4,900 degrees.

Matted Metals

Metallurgists have borrowed techniques from the paper industry to make a new form of metal which is light and porous, yet exceptionally strong. The process, developed at the Armour Research Foundation, is called fiber metallurgy. It starts with a sludge of metal fibers, pours them on a screen and then drains away the liquid, leaving a tenacious felt of matted metal strands. Pressing or sintering joins the strands more firmly and strengthens the felt. Fiber metals and their most promising

applications are described in the current issue of *Materials and Methods* by A. G. Metcalfe and C. H. Sump of Armour. They point out that fiber metals are easy to shape into the most complex forms. In this respect they are like metal parts pressed from powder. But the "woody" structure of the fiber metals is inherently much tougher.

The problems of making parts from metal fibers are much like those of making paper or cloth from plant fibers. Fabricators must take into account such properties of the individual fiber as length, diameter, kinkiness and surface roughness. Barbed fibers, for example, tend to interlock mechanically and make the finished felt stronger.

One important application the authors foresee is in reinforcing ceramics. The refractory materials used in jet-engine linings and other high-temperature service tend to be brittle. When bonded with fiber metal sheets, they have much greater impact strength.

Why Skis Slide

A report on a study of the physics of skiing, with practical suggestions to skiers, was published recently by a leading British expert on friction, F. P. Bowden, in *Nature*.

Frictional heat generated by the moving ski, said Bowden, is the chief factor in promoting sliding. The ski sticks at the start, but once it is moving rapidly and melting the snow surface beneath it, it will slide easily over the coldest snow.

Waxing helps because it makes the ski water-repellent and reduces friction with the film of water. Bowden has discovered that a plastic called polytetrafluorethylene, much more water-repellent than waxed wood, makes skis faster. On one gentle 700-foot slope in the Alps a skier reduced his time from 61 seconds to 42 seconds with the new skis.

The Cause of Fever

Many physiologists suspect that there is one basic cause of fever. Injured tissue, they postulate, releases a substance that upsets the temperature-regulating function of the hypothalamus. This would account for fever being a symptom common to such diverse disorders as infections, wounds, malignancies, allergic reactions and others.

Although no one has ever found a fever-producing substance in the bloodstream, there is now a good deal of evidence that it exists. An extract of certain white blood cells has been found to cause fever. And early this year Elisha

Atkins of Yale University and W. Barry Wood, Jr., of Johns Hopkins University showed that typhoid vaccine injections released a fever producer in the blood of rabbits sensitive to the vaccine.

Now Atkins and Wood have proved that their newly discovered fever producer is not a part of the vaccine, but rather a substance produced by the body in response to vaccination. They report their experiments in the current issue of *The Journal of Experimental Medicine.*

The researchers used two groups of rabbits: donors, which got typhoid vaccine, and receivers, which got blood transfusions from the donors. The vaccine made the donors run a fever. When blood was taken from a donor as long as an hour afterward, after it had become free of vaccine, it still made receivers feverish, even in the cases where the receiver was immune to the vaccine itself. From this evidence Atkins and Wood conclude that the vaccine liberates some fever-producing substance which is normally present in the body but inactive.

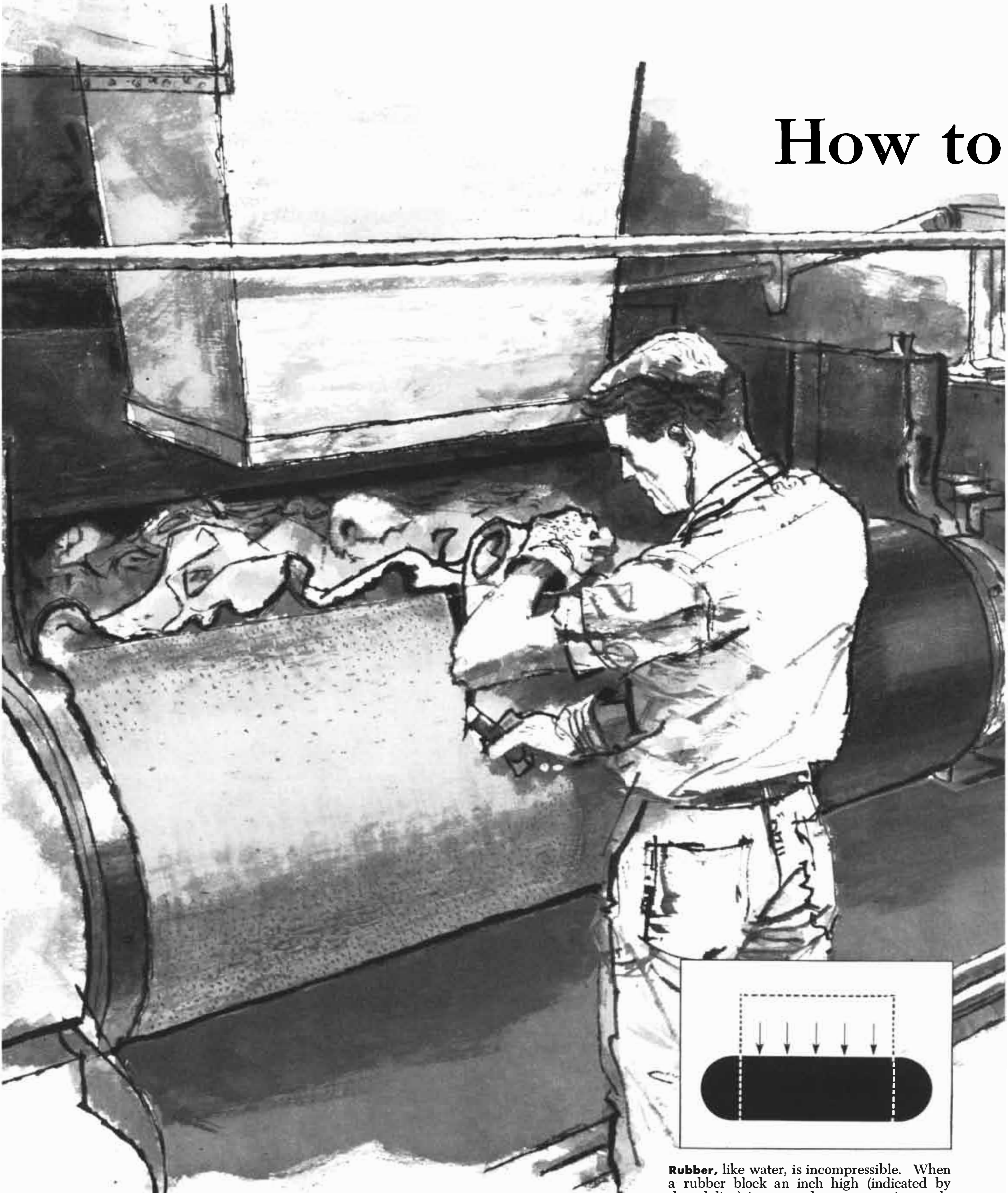
Polio Vaccine Report

The mass vaccination of children with the Salk polio vaccine last season was a definite success, according to a report to the American Public Health Association in Kansas City last month. Alexander Langmuir, U. S. Public Health Service epidemiologist, reported that the vaccine had been 75 per cent effective in preventing paralytic polio among children aged five to nine. He based his calculations on figures from 11 states.

The program might have been even more successful had more of the children received all of the three shots that are prescribed. Gordon C. Brown of the University of Michigan measured the antibodies in the blood of 119 Michigan children who had been vaccinated in 1954 and had received booster shots last summer. Writing in the *American Journal of Public Health,* he reports that the polio antibodies declined during the year between vaccinations and then increased sharply after the second shots. The booster was especially effective for children who had not been thoroughly immunized by the first vaccination.

Equally favorable reports came from eight other countries which administered polio vaccine on a smaller scale. In Canada, where 860,000 young children were vaccinated, the paralytic polio rate among the immunized dropped from 5.39 per 100,000 to 1.07 per 100,000. Denmark reported no cases among 425,000 vaccinated children.

How to



Giant mill blends raw synthetic rubber and ground cork. Material will next be put into molds and vulcanized, then sliced into sheets.

Rubber, like water, is incompressible. When a rubber block an inch high (indicated by dotted line) is put under pressure, it merely deflects, or flows. Though now only one-half-inch high, actual volume is the same.

make rubber compressible

Rubber: you can twist it, stretch it, or flex it **. . . but you can't compress it.**

That's a fact that will surprise many people, for it's easy to confuse "give" or "squeezeability" with compressibility. Actually, when a chunk of soft rubber is squeezed, it just changes shape. It "flows," because rubber—like water—is a hydraulic material. Pressure can't reduce its volume.

Mix ground cork into rubber, however, and the picture is completely different.

That's because cork is one of nature's most compressible substances. It's so compressible, in fact, that a block of it can be squeezed to less than half its original volume. Cork, like air, is a pneumatic material.

Armstrong research chemists found that when you combine the compressible material, cork, with the incompressible material, rubber, you get a product that falls between the two. That is, when pressure is put on it, the new material flows some — and compresses some. How much it compresses depends upon how much cork is added.

But why make rubber compressible at all? The answer is, so rubber can do more jobs and do them better. For example, synthetic rubber alone has desirable properties as a gasket. For one thing, it's impervious . . . liquids and gases can't pass through it. But when an all-rubber gasket is used to seal between two flat surfaces, it may "flow" or creep out of position when the bolts are tightened. Result: a leaking joint.

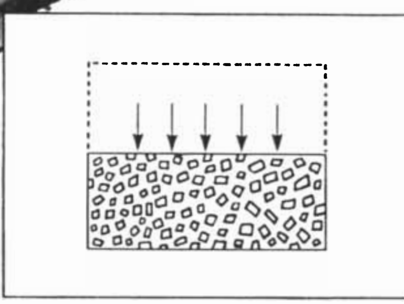
You don't have that trouble, of course, with a gasket made of the right combination of cork and rubber. It stops liquids and gases as well as a gasket made from the rubber alone. Under pressure, however, it merely squeezes down; it won't flow enough to skid out of position. On the other hand, an engineer may want some sideways flow, to fill in around the threads of a bolt, for instance. Again, the right combination of cork and rubber will do the job.

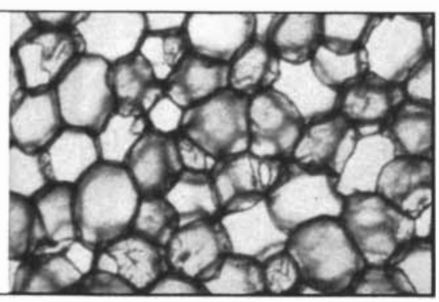
If you manufacture products that use gaskets, perhaps one of the many cork-and-rubber materials pioneered by Armstrong can help you solve a sealing problem. While you're thinking about gaskets, remember, too, that cork-and-rubber is only one part of the Armstrong line of resilient materials. Others include cork composition, synthetic rubber, and Accopac® fiber sheet packing. For information and technical literature, write Armstrong Cork Company, Industrial Division, 8201 Inland Road, Lancaster, Pa.

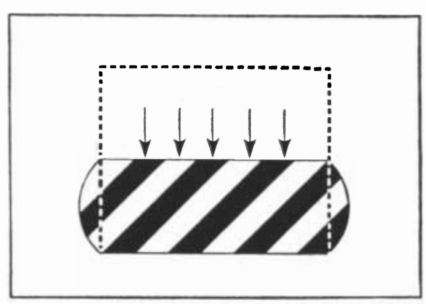
Armstrong Industrial Products

. . . used wherever performance counts

adhesives • cork composition • cork-and-rubber • felt papers • friction materials

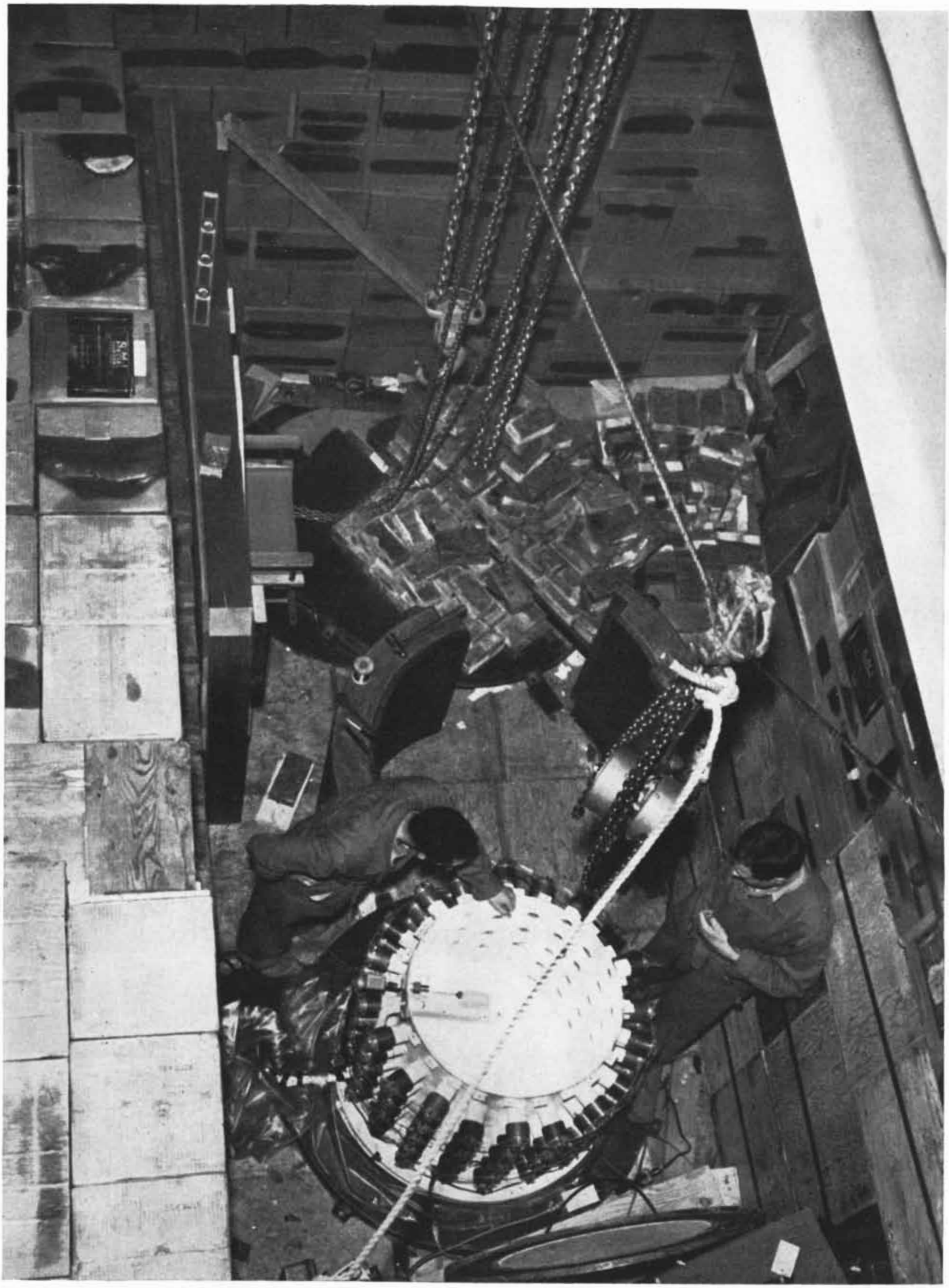






Cork, on the other hand, is a pneumatic or compressible substance. An inch-high block compressed to one-half inch reduces in volume by one half. The secret lies in cork's unique 14-sided cells—called tetrakaidecahedrons. Photomicrograph of cork slice shows how cells are made up of thin skins enclosing microscopic bits of air. Under pressure, this air is compressed, and the cells actually become smaller.

A block of cork-and-rubber under pressure both compresses and flows. By changing the ratio of cork to rubber, it can be made more cork-like or more rubber-like in its compressibility-flow properties.



SCINTILLATION COUNTER was used by Frederick Reines, Clyde L. Cowan, Jr., and colleagues in an attempt to detect the neutrino. The counter is the cylindrical object at the bottom. It was set up near a reactor at the Hanford Works of the Atomic Energy Commission. Since this experiment was performed, Reines and Cowan have designed a new experiment using even larger equipment.

THE NEUTRINO

For 25 years the theoretical structure of physics has assumed a fundamental particle which has never actually been detected. Its existence may now be confirmed by a remarkable experiment

by Philip Morrison

The full triumph of classical mechanics came one clear night in the fall of 1846. On that night a German astronomer named Johann Galle pointed the telescope of the Berlin Observatory toward a spot in the heavens where he had been told to look, and there first saw the faint disk of the planet we now call Neptune. His discovery was the most dramatic possible confirmation of Newton's laws of gravitation, and of the calculations of the mathematician Urbain Leverrier, who had predicted from the perturbations in the movement of the planet Uranus that a new planet must lie where Galle found it.

Physics today is looking expectantly for another such discovery. There is a Neptune among its fundamental particles—a strange particle which is on every physicist's list, whose measurements and properties are well known, but which has not yet been "discovered." The particle is called the neutrino. Recognizing that all physical "facts" of nature are no more than inferences, physicists are almost as sure of the existence of the neutrino as they are of anything, but still we will not like to admit that it has really been discovered until it signals its presence by some track or click in our apparatus.

For Christmas not long ago one of the Los Alamos physicists who have been laying ingenious plans to trap the neutrino gave his colleagues a present. Under the gift wrapping they came to a neatly decorated matchbox, clearly labeled: "Guaranteed to contain at least 100 neutrinos." They looked into it warily, and saw a simple empty box. The conceit did not come home until the gift-giver explained it to his friends. The label was literally correct. Such a volume, any such volume on earth, whether a box or your hand or a cupful of water, contains neutrinos. They are moving through it, as they always move, in straight lines at the speed of light.

The neutrinos in us and all around us come from the deep interior of the sun, where they are born in the same nuclear reactions that make the sun shine. Unlike other particles emerging from these reactions, the neutrinos go clean through the sun's great layers, more transparent to them than is the clearest air to the golden terrestrial sunlight, and move out into space. Perhaps 6 or 8 per cent of the total energy released by the sun is in this transcendent form, passing without change or effect through star and space and planet. Even at night neutrinos come streaming to us from the hidden sun, traveling right through the massy earth as though it were not there. The neutrino flux from the sun carries 40,000 times more energy than moonlight, and yet we have never seen, heard or felt its presence.

How such a paradox of a particle has been pressed for decades upon the physicists by hard experience, and how it is today proposed to catch it at last, are the main topics of this article.

The Law of Conservation

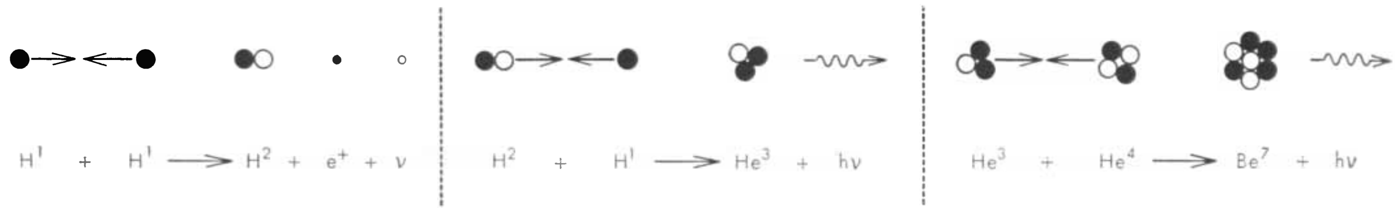
The keystone of physics is the law of conservation of energy. Yet for three decades there has lain within the well-accepted facts of nuclear physics a carefully studied phenomenon which a rigorous and candid observer would have to cite as a *prima facie* contradiction to the famous law. This scandal lies in a strange disappearance of energy when a neutron sheds an electron—the phenomenon known as beta-decay.

A wide variety of evidence indicates that the uncharged neutron, like its charged fellows the proton and the electron, has a perfectly definite mass. Now the neutron, building block though it is, is not fully stable. It spontaneously decays into a proton and an electron. The neutron's half-life is some 12 minutes, which is to say that if 1,000 neutrons are kept free from any interaction with the outside world, after 12 minutes only 500 will remain neutrons, and after about 24 minutes, only 250.

By the principle of the convertibility of mass into energy, the total energy content of a stationary neutron is just the energy equivalent of its mass. Now the products of its decay—proton and electron—do not add up in mass to the initial mass of the neutron. The missing mass has been converted into energy, and this appears as kinetic energy of the two product particles, which fly apart after the neutron's disintegration.

The law of the conservation of energy says that the kinetic energy shared by the neutron's decay products (the lion's share goes to the light electron) must be precisely equivalent to the lost mass. Their kinetic energy has been measured, and its maximum value has been determined to be about 780,000 electron-volts. But the numerous measurements have shown that comparatively seldom does the kinetic energy released by a neutron's decay reach this value. Sometimes the proton plus electron have a total kinetic energy of only a few thousand electron-volts. The decay energies observed range over the whole spectrum from zero to 780,000 electron-volts. On the average, only a fraction of the maximum expected energy release appears when a neutron (or any radioactive atomic nucleus) splits by beta-decay.

What happens to the missing energy? Decades ago nuclear physicists came to the plausible conclusion that it must go off with some undetected particle. They



PROTON-PROTON SEQUENCE is one of two nuclear processes in the sun which are assumed to shower the earth with neutrinos. In the first reaction of the sequence two protons (*nuclei of hydrogen 1, or* H^1) collide to yield a deuteron (*nucleus of hydrogen 2, or* H^2), a positive electron (e^+) and a neutrino (ν). In the second reaction the deuteron collides with a proton to yield a triton (*nucleus of hydrogen 3, or* H^3) and a gamma ray ($h\nu$). In the third reaction the triton collides with an alpha particle (*nucleus of helium*

tried hard to catch the invisible particle in their best counters, and in a foot or two of lead. But they failed. And in a dark year there came the thought that perhaps here in the fundamental processes of the nucleus the conservation of energy actually failed.

After the successes of the quantum theory, which no less than classical physics is based upon energy conservation, Wolfgang Pauli first sketched and Enrico Fermi later worked out in detail the properties of the presumed particle that must fly off in beta-decay if energy was to be conserved. It was easy to see what some of these properties must be.

First, the particle must have no charge, for balancing charges (the positive proton and negative electron) come out of the decaying neutron. Secondly, the particle must be practically weightless, according to careful measurements of the energy and mass relations of the various particles involved. For simplicity it is considered to have zero mass. Thirdly, the particle must have angular momentum, *i.e.*, spin. The neutron's angular momentum is one half a quantum unit; when it decays it produces two particles each with one-half unit spin; so to conserve angular momentum the invisible particle should have one-half unit spin.

Such a particle, with no charge, no mass, spin one half and birth only in beta-decay, was postulated by Pauli and by Fermi. It became known as the neutrino—"little neutral one"—in the beautiful language of Fermi.

But now we are on thin ice. Faced with a failure of energy conservation, physicists refuse to admit it but instead postulate an unseen and perhaps unseeable particle—a little neutral one so cunningly designed that it has no properties other than those which will preserve the laws of conservation. How does this differ from plain failure of the conservation laws?

The Challenge

The first attempt at an answer was to examine carefully the scene of the crime. The particles issuing from a decaying neutron or atomic nucleus carry momentum as well as energy; hence they should recoil from each other, just as the firing of a shell causes the cannon to recoil. If only a proton and an electron came off, conservation of momentum would require them to move in opposite directions along one straight line. But if a neutrino carrying momentum also comes out, the other pair must recoil from *it*, and their tracks should form a V. A number of elegant experiments recording the beta-decay of various nuclei and of the neutron itself have proved that this is indeed the form that the tracks actually take.

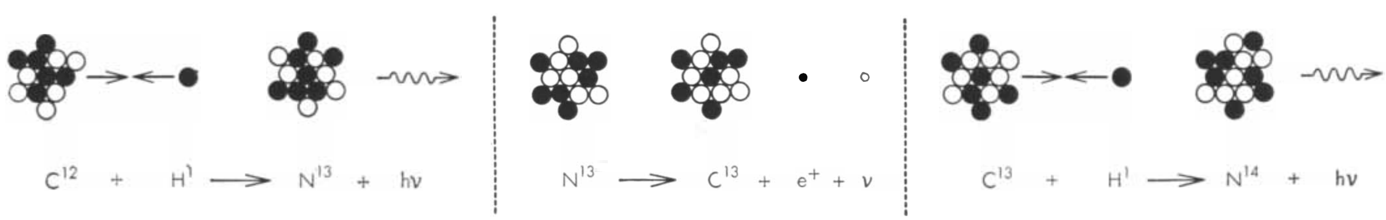
The critics can still say: Momentum and energy are intimately connected, so your recoil experiment proves nothing except that both energy and momentum are lost in a single parcel. Until you can somehow trace the missing energy, momentum and the rest, you are merely balancing the books with a fictitious entry.

There is only one sure answer to the criticism. The missing energy, the "little neutral one," must be caught. The energy it carries must be reconverted into some measurable form, or the neutrino, however universally accepted, remains but a sign of the physicist's ignorance.

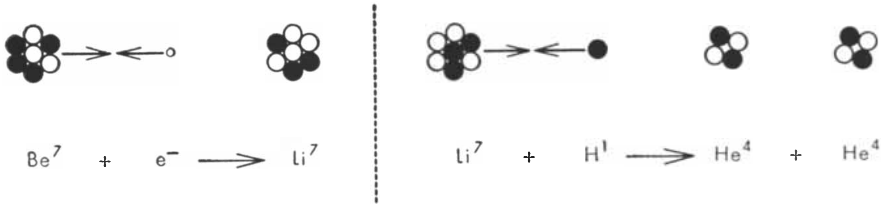
Of course the neutrino theory has by no means been unfruitful. It has provided a basis for interpreting various measurable features of beta-decay, for predicting the approximate lifetimes of all beta-decaying nuclei, and so on. We could not give up the real triumphs of the neutrino postulate without tearing the present closely webbed fabric of nuclear physics. But still the challenge to track down the neutrino itself remains.

The behavior of physicists in the face of this challenge may seem unworthy. For a generation we have been satisfied to use the neutrino theory and explore its manifold ramifications, but slow to respond to the challenge to deliver up the thing itself as a legitimate member of the particle family, not a mere bookkeeper's evasion. Why have we been so laggard in seeking out the neutrino directly?

The answer is simple, and yet in some ways wondrous. Compared to other nuclear events, beta-decay is fantastically slow, and therefore rare. It takes a neutron some 18 minutes on the average to emit an electron; with the same energy available, a gamma ray would come out in a millionth of a billionth of a second.



CARBON CYCLE is the second solar nuclear process which may produce neutrinos. In the first reaction of the cycle carbon 12 (C^{12}) collides with a proton to yield nitrogen 13 (N^{13}) and a gamma ray. In the second reaction nitrogen 13 decays spontaneously into carbon 13 (C^{13}), a positive electron and a neutrino. In the third reaction carbon 13 collides with a proton to yield nitrogen 14 (N^{14})



4, *or* He^4) to yield beryllium 7 (Be^7) and a gamma ray. In the fourth reaction the beryllium 7 collides with a negative electron (e^-) to yield lithium 7 (Li^7). In the fifth and final reaction of the sequence lithium 7 collides with a proton to yield two alpha particles. The protons are represented by the larger black balls; the neutrons, by white balls of the same size.

The prodigiously slow beta process has a far smaller probability than any other method of nuclear decay. Beta-decay is much rarer, on the nuclear time scale, than death by meteorite bombardment among men. It is only the chance that some nuclei are immortal except for beta-decay that allows us to observe this event at all.

Now this slowness of decay implies that the opposite process, the capture of a passing neutrino by a nucleus, also is slow and rare. Gamma rays, which are notoriously unlikely to interact with nuclei, will travel on the average through eight or 10 feet of lead before they do so. But a neutrino, to interact with a nucleus, must travel on the average through about 50 light-years of solid lead! A shielding wall capable of thinning out a beam of neutrinos would have to be as thick as a hundred million stars. To all intents and purposes neutrinos simply do not see solid matter at all. Here is the nub of the difficulty. The neutrino is almost uncapturable.

The Challenge Accepted

Deterred by the logic of the matter, physicists did not begin to think seriously about hunting neutrinos until great masses of radioactive material became available in the fission products of uranium reactors. With a truly prodigal effort, they now seek to catch the almost uncatchable neutrino. From the high-power reactors stream currents of neutrinos which rival the sun's beam. They pass through the shielding walls and fly in perfectly undeviating straight lines from the place of their birth to outer space. Patrolling these great beams near their source, physicists hope to capture an occasional unlucky neutrino. Last month a group of workers began the vigil by placing their neutrino detectors in the beam from the most powerful reactors in the world—those at the Savannah River plant of the Atomic Energy Commission.

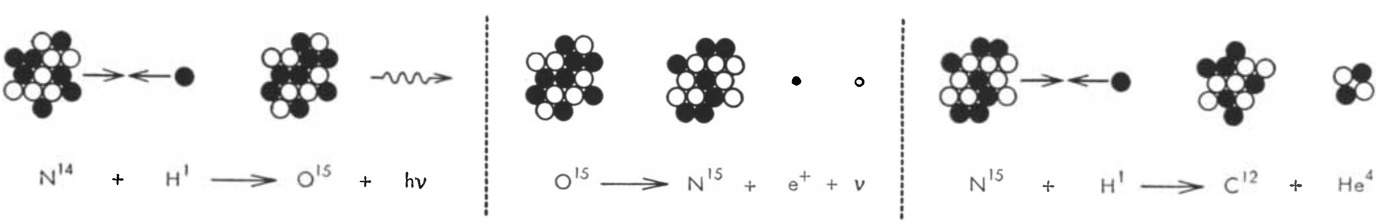
The more spectacular of two schemes for trapping the little neutral ones is based on the technique of scintillation counting. Tireless photocells will keep a continuous surveillance over a large tank full of a clear scintillating liquid, recording the flashes of light that signal ionizations among the nuclei in the liquid. A Geiger counter can record only the ionizing events occurring in a few milligrams of gas; the scintillation tank scheme makes it possible to patrol tons of nuclei at a time.

But the capture of the neutrino is a rare event indeed, and when one looks for the highly improbable, he must be prepared to see many other events, probable and improbable, which are irrelevant to what he is looking for. The tons of scintillator liquid will flash many times—from traces of radioactive dirt within the liquid, from cosmic rays, from escaping particles other than neutrinos which may come from the reactor. It is not enough simply to look for flashes; it is necessary to discriminate between those which arise from neutrino capture and those which arise from various other rare but much less interesting causes.

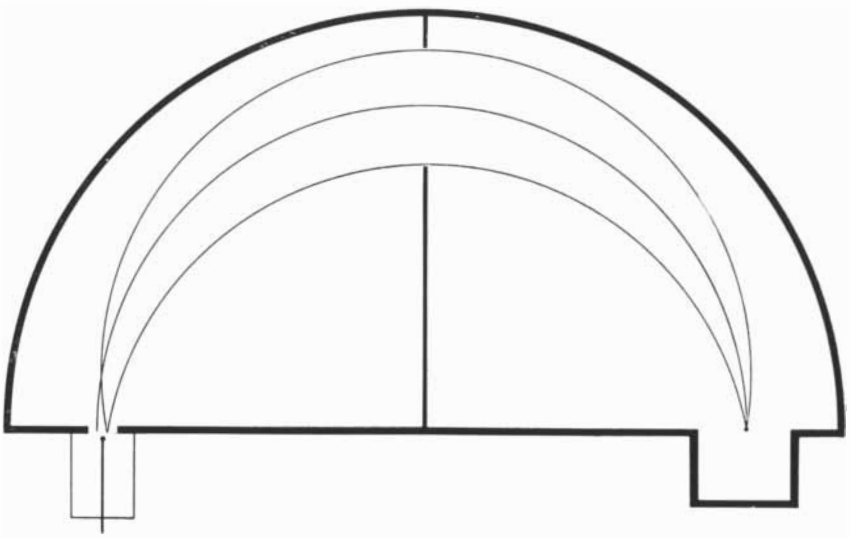
A group of Los Alamos investigators led by Clyde L. Cowan, Jr., Francis B. Harrison and Frederick Reines invented, and is pursuing with true virtuosity, an ingenious scheme to perform this feat. The reasoning is as follows. Capture of a neutrino being the reverse of its emission, the precise opposite of beta-decay must occur: that is to say, a proton plus an electron plus a neutrino plus energy combine to form a neutron. Now there is another type of "beta-decay" reaction in which, instead of a negative electron being absorbed, a positive electron, or positron, is emitted. Electric charge is conserved equally well in either case: in the second case the positive proton becomes a neutral particle not by absorbing a balancing negative charge but simply by releasing its own positive charge in the form of a positron. That such reactions actually occur has been verified by experiments. And so we can rewrite the equation for neutrino capture to say that a proton plus a neutrino plus energy may combine to yield a neutron and a positron. The ingenious Los Alamos group proposes to detect this event by observing its products—the neutron and the positron.

A Subtle Detection

The energy necessary to convert a proton into neutron and positron is supplied by the incoming neutrino. Neutrinos emerging from the fission products in a reactor are estimated to have, as a rule, something of the order of one million electron-volts more energy than is required for this conversion. The excess energy goes off as kinetic energy of the product neutron and positron—most of it in the positron, since it is much lighter. The charged positron ionizes atoms in its path as it goes, and thereby produces a good-sized flash in a scintillating liquid. After it has traveled a centimeter or two, which takes no more than a hundredth of a billionth of a second or so, the posi-



and a gamma ray. In the fourth reaction nitrogen 14 collides with a proton to yield oxygen 15 (O^{15}) and a gamma ray. In the fifth reaction oxygen 15 decays into nitrogen 15 (N^{15}), a positive electron and a neutrino. In the sixth reaction nitrogen 15 collides with a proton to yield carbon 12 and an alpha particle. The cycle makes an alpha particle, two electrons, three gamma rays and two neutrinos.



SPECTROMETER is used to measure the energies of beta particles. The apparatus in this diagram is placed in a magnetic field, in which the lines of force are perpendicular to the page. The particles emitted by the small sample at right describe curved paths and are counted at left. Particles of the same energy come to a focus at the same point. Thus the counter may be used to scan the various particle energies by changing the strength of the magnetic field.

tron comes to rest, having spent all its kinetic energy.

The flash from ionization by the moving positron is the first visible sign of the neutrino's capture, but it is by no means the last: there is more to come. The moment it comes to rest, the positron combines with an electron (there are plenty handy). When it does, the mass of the pair is instantly annihilated and turned into energy. The energy flies off as two gamma rays, traveling in opposite directions from the source and each amounting to about one half million electron-volts. After moving a foot or two, each gamma ray gives rise to an ionizing electron which produces a flash in the counter. So every neutrino capture that gives birth to an energetic positron should be signaled by three virtually simultaneous flashes in the scintillating liquid—a flash from ionization by the moving positron and a pair of flashes in different spots from the gamma rays.

Meanwhile the newborn neutron itself has moved off slowly, with very little kinetic energy. There is no flash to mark its passage, for the neutral particle cannot ionize. It wanders about the liquid in its usual random walk, slowing down to thermal motion as it goes. Eventually it is captured by some nucleus. Now the canny experimenter may add to his liquid scintillator some cadmium, which has a pronounced affinity for slowed neutrons. The cadmium nucleus seizes a neutron so vigorously that a few gamma rays are emitted in the process. In this moment of capture, therefore, the neutron signals its presence by a flash, as the positron did earlier. The neutron signal comes after a considerable delay, because the particle has traveled a yard or two, at a relatively slow speed, before its capture. This delay is some 10 or more microseconds, and it can be measured accurately by electronic techniques.

The plan of the experiment at the Savannah River plant is this. A layer of liquid containing protons and doped with cadmium is placed like a sandwich filling between two thick scintillating layers sensitive to gamma rays. Photomultipliers watch all carefully. When a neutrino is captured by a proton, the resulting birth of a positron is instantly signaled by a flash in the sandwich layer. Practically simultaneously, after a time too short to measure, there comes a flash in each of the two "bread" layers, produced by the two gamma rays from the annihilation of the positron. A few millionths of a second later the capture of the wandering neutron by cadmium releases gamma rays whose flashes are seen in all three layers. In short, every neutrino capture is marked by two sets of flashes in all three layers, one following the other after a precisely stipulated interval. Moreover, the energy of the positron-annihilation flash helps to identify the event: it should total about one million electron-volts.

Combinations of events which simulate this pattern may occur by accident in the counter, but they are too infrequent to cause real trouble. Their spuriousness can, and will, be established by control experiments. Cosmic ray particles can cause spurious events (and did so seriously in the earliest versions of this experiment). These fast charged particles may trigger all three layers, and in addition liberate a neutron which will give a delayed pulse. But the energy they give to each layer is large, and the first flash will be too bright, and give away the spurious character of the event.

The whole apparatus is of prodigious size. Where most experiments of the kind use half a dozen photomultiplier tubes and their associated amplifiers, the neutrino searchers use 500. Where scintillation counters are normally counted big if they use a few gallons of liquid, this experiment uses 10 or 12 tons. The needs of the project have led to a whole complex of ingenious and painstaking developments. The chemical firm producing the scintillating liquid, which used to make it in quart amounts, has been persuaded to manufacture and purify it by the ton. A special tank truck has been built to transport the precious fluid in an inert atmosphere from the factory to the scene of the experiment; it must be kept minutely clean and oxygen-free throughout the long journey. The tank where the experiments are performed must be lined with a special glossy-white coating, to lose next to no light at all. A chemical must be added to the scintillating liquid to give the flashes a color which will be reflected most efficiently by the gleaming tank walls. The flashes that carry all the information for which the neutrino hunters are searching are too faint to be seen by the naked eye, and no effort must be spared to make sure that all of them are detected by the sensitive photomultipliers. Hundreds of the latter are required, and whole banks of other electronic gear. The detector tank itself is encased in lead and buried deep in the building housing the great Savannah River reactor.

After building and testing all this equipment, the experimenters began to install it at Savannah River last month. There they will count patiently, hour after hour, waiting for the evidence which they hope will restore the conservation of energy to honesty and will help them play the Galle to Fermi's Leverrier in the physics of the 20th century.

The Search by Chemists

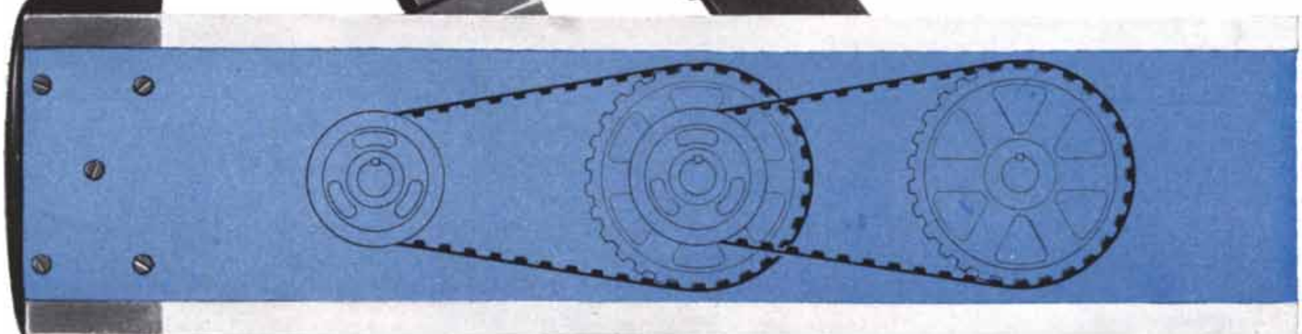
Meanwhile another group pursues the search by a very different method. Just as the scintillation-counter plan is a *tour de force* of modern physical technique,

New freedom of design with U. S. PowerGrip "TIMING" BELTS

SMALLER PULLEYS • NO MORE OIL-RETAINING HOUSINGS
LONGER SERVICE LIFE • GREATER MACHINE EFFICIENCY

The designer shakes himself free of many obstacles when he can work with U. S. PowerGrip TIMING® Belts. These split-second power transmitters are used on hundreds of such machines as lathes, drill presses, electric typewriters, floor washing machines, saws. *The list grows day by day*. Check points below!

FAST DELIVERY
COMPLETE ENGINEERING SERVICE
FULL STOCKS



Absolutely no slippage or creep in the belt • No need for lubricants, oil-retaining housings—because there is no metal-to-metal contact • Very small pulleys can be used, thus permitting very short centers and high ratios. No take-up needed because belt is practically stretchless • H.P. range is 1/100 to 300 or more. *Stock* drives go up to 50 H.P., but wider belts and pulleys can be made to order in standard lengths and diameters • U. S. PowerGrip TIMING Belt permits lighter bearings, lighter metals—cuts costs • Immediate delivery from coast-to-coast offices.

Send for descriptive literature. Get in touch with any of the 27 United States Rubber Company District Sales Offices, or write to us at Rockefeller Center, New York 20, N. Y.

US RUBBER

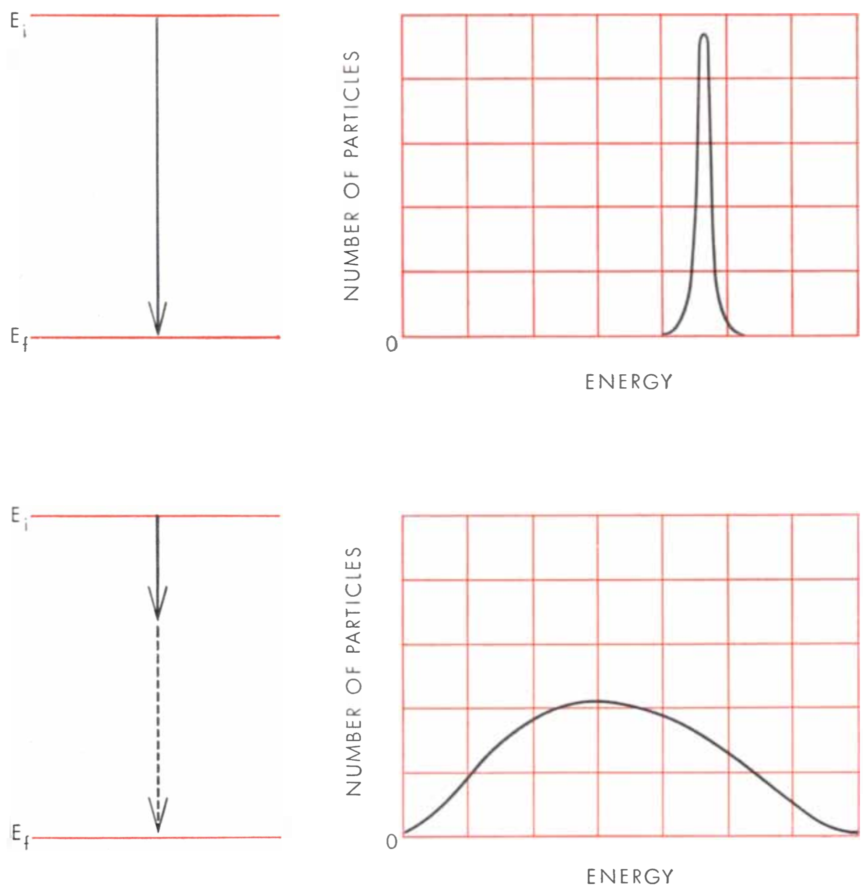
Mechanical Goods Division

United States Rubber

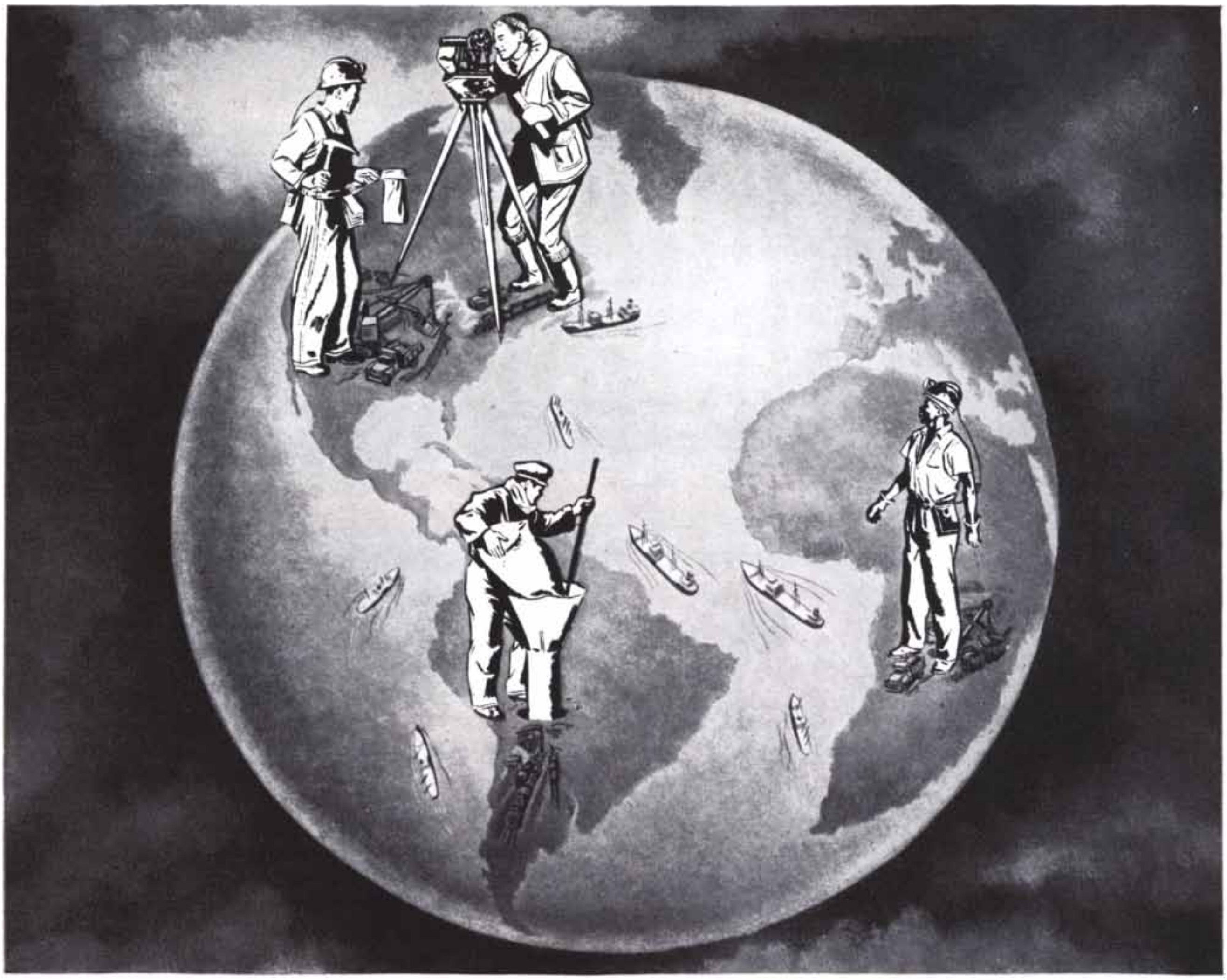
so there is a related piece of consummate skill which belongs to the chemist. The trick of identifying the capture of neutrinos by detecting products of the reaction may, it is hoped, be performed by chemical means. In this case the targets are not protons but nuclei of chlorine atoms. The isotope chlorine 37 may capture a neutrino and turn into an atom of the rare gas argon, emitting a negative electron in the process. The atom so produced, argon 37, is itself radioactive.

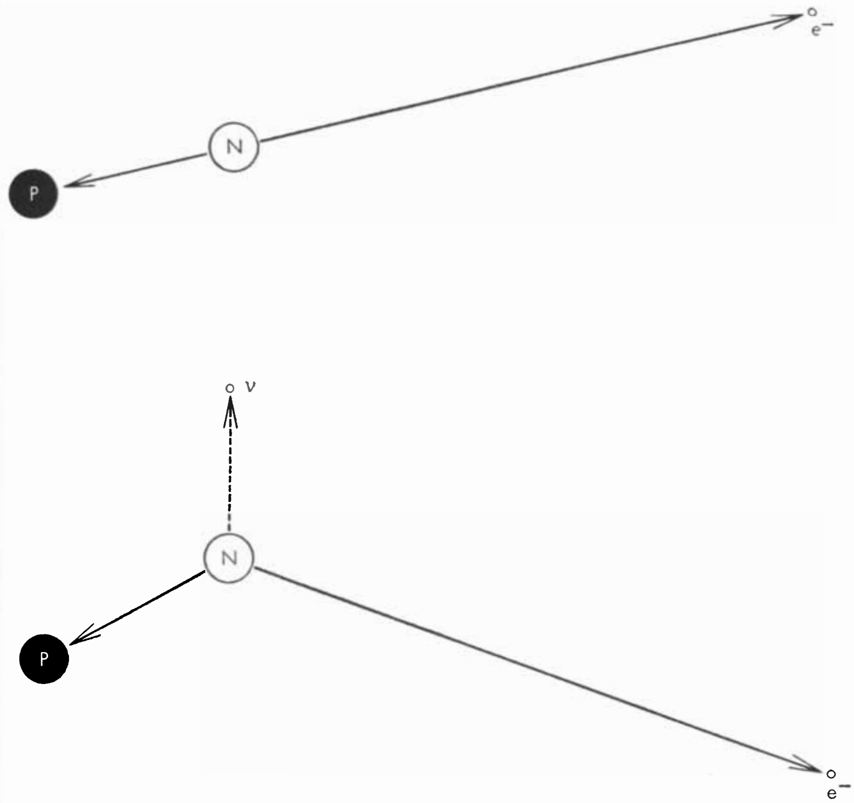
Its creation may be detected by a simple plan. A large tankful of a liquid containing chlorine is swept clean of argon (certainly of any radioactive argon) by a stream of helium bubbled through it, and then the liquid is exposed to neutrinos from a reactor. After some days' exposure, the tank again is swept with helium gas to bring out any argon that may have been formed. The argon (of which there must always be at least a slight trace) is separated from the helium by well-known techniques of physical chemistry, and a Geiger counter is used to see if there is any radioactive argon in the sample.

This method is based on such a refined chemical search for a few atoms in a great vat of solvent that it is surely the archetype of all needle-in-the-haystack endeavors. There are against it two objections. The first, of course, is that it leaves open the question of just what did make the active argon. Careful controls might dispose of this question. But then there is left a more fundamental, if not more serious, objection flowing from the theory of fundamental particles. If we reverse the neutrino-capture reaction, the theory says that the decay products must be chlorine 37, a neutrino and a positron rather than an electron. This



ALPHA- AND BETA-DECAY are accompanied by changes in the energy level of the nucleus. The diagram at upper left depicts the energy levels of a typical alpha-emitting isotope before and after decay. The curve at upper right shows how the energies of particles from this isotope are distributed. The fact that the particles occupy a narrow range of energies indicates that the difference between the initial energy of a single nucleus (E_i) and the final energy (E_f) is always accounted for by the energy of an alpha particle (*arrow*). The diagram at lower left depicts the energy levels of a typical beta-emitting isotope before and after decay. The curve at lower right shows how the energies of particles from this isotope are distributed. The fact that the particles occupy a broad range of energies indicates that the difference between the initial energy and the final energy is seldom accounted for by a beta particle (*solid arrow*). The missing energy is presumably carried off by a neutrino.





RADIOACTIVE DECAY OF THE NEUTRON also requires the neutrino. If the neutron (N) simply decayed into a proton (P) and a negative electron (e^-), the conservation of linear momentum would require that the decay particles go off in exactly opposite directions (*top drawing*). Actually they go off at an angle to each other (*bottom drawing*). This indicates that the missing linear momentum is carried off by a neutrino (*broken arrow*).

means that the neutrino is not precisely the same as in a normal beta-decay. Consequently the beta-decay neutrinos sent out by a reactor may not transmute chlorine into argon. However, it is possible that the two kinds of neutrino are actually equivalent in every respect, so that the experiment will really work.

Raymond Davis, Jr., of the Brookhaven National Laboratory will measure the argon activity induced in some four tons of carbon tetrachloride in a tank at the Savannah pile. It is a happy circumstance that both the scintillation counter and the chlorine experiments are being carried on at the same time and the same place, for the two should complement each other.

It would be ungracious not to mention that these are not the first experiments to seek out the neutrino directly. Quite a few brave experimenters have tried before, but on too small a scale. The chlorine experiment was first planned at Chalk River in Canada by Bruno Pontecorvo, who may for all we know now be completing it near some big reactor in the U.S.S.R. The proton-capture experiment in a smaller version was tried by the Los Alamos group at Hanford last year, and a doubtful positive result obtained. Most physicists will be willing to base conclusions only upon the really powerful effort now under way.

A New Astronomy

The neutrino provides in principle a new kind of astronomy. Until now the only radiations from outer space that we have studied are visible light and microwave radio. The neutrino beam from the sun and stars also comes to us bearing information about the universe, and we shall surely some day read a part of that text. The chlorine-capture experiment, with an increase of a factor of a hundred or so in bulk, and a well-shielded mine or the deep sea to work in, might measure the sun's neutrino flux. Modifications in the scintillation scheme also are under consideration. It is not too much to hope that some day we may directly verify the nuclear reactions in the sun's center by a study of their neutrino emission.

But suppose the experiments do not work? Suppose no neutrino counts are seen? The logical chain is pretty tight;

FORD INSTRUMENT

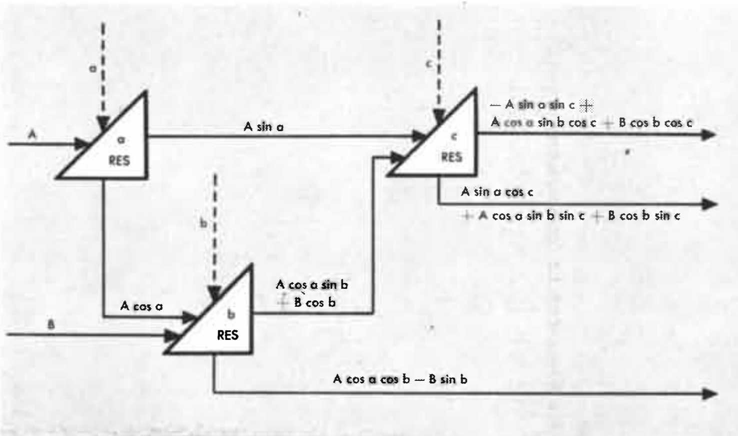
solved one design problem by

CASCADING RESOLVERS WITHOUT ISOLATION AMPLIFIERS

To get around a problem that arises in almost every resolver application Ford engineers recently designed a computer which, among other things, employed a chain of cascaded resolvers to solve complex trigonometric equations, without the use of isolation amplifiers. They solved such an equation as:

A sin a cos c + A cos a sin b sin c + B cos b sin c

This was successfully done, without use of vacuum tubes or amplifiers in this circuit:



In view of the widespread use of resolvers to generate sine and cosine functions in modern electro-mechanical analogue computers, it is of great practical significance. Resolvers produced by the Ford Instrument Company have now reached such a high degree of precision, that it is possible to obtain, from an unloaded resolver (which accommodates a single angular quantity only), an accuracy to within less than one tenth of one percent. But most computing circuits call for the use of several resolvers, and once an ordinary resolver is loaded by another resolver, no matter how high its precision, the overall accuracy of the resolver cascade is seriously affected.

The conventional method of avoiding this difficulty is to use an isolation amplifier for each resolver, so that the resolver continues to operate under no-load conditions regardless of the size of the cascade. The importance of cascading without amplifiers is readily appreciated if we realize that the isolation amplifier usually increases the cost of the equipment, more than doubles the size and generates many times more heat that must be dissipated to prevent breakdown of the components. Furthermore, the use of vacuum-tube amplifiers always raises the problem of tube ruggedness and reliability, and requires an additional source of d-c plate voltage.

Have you problems which the engineers at Ford might solve by designing and manufacturing computers, controls or their elements? Write for further information.

85

FORD INSTRUMENT COMPANY

Division of Sperry Rand Corporation

31-10 Thomson Ave., Long Island City 1, N. Y.

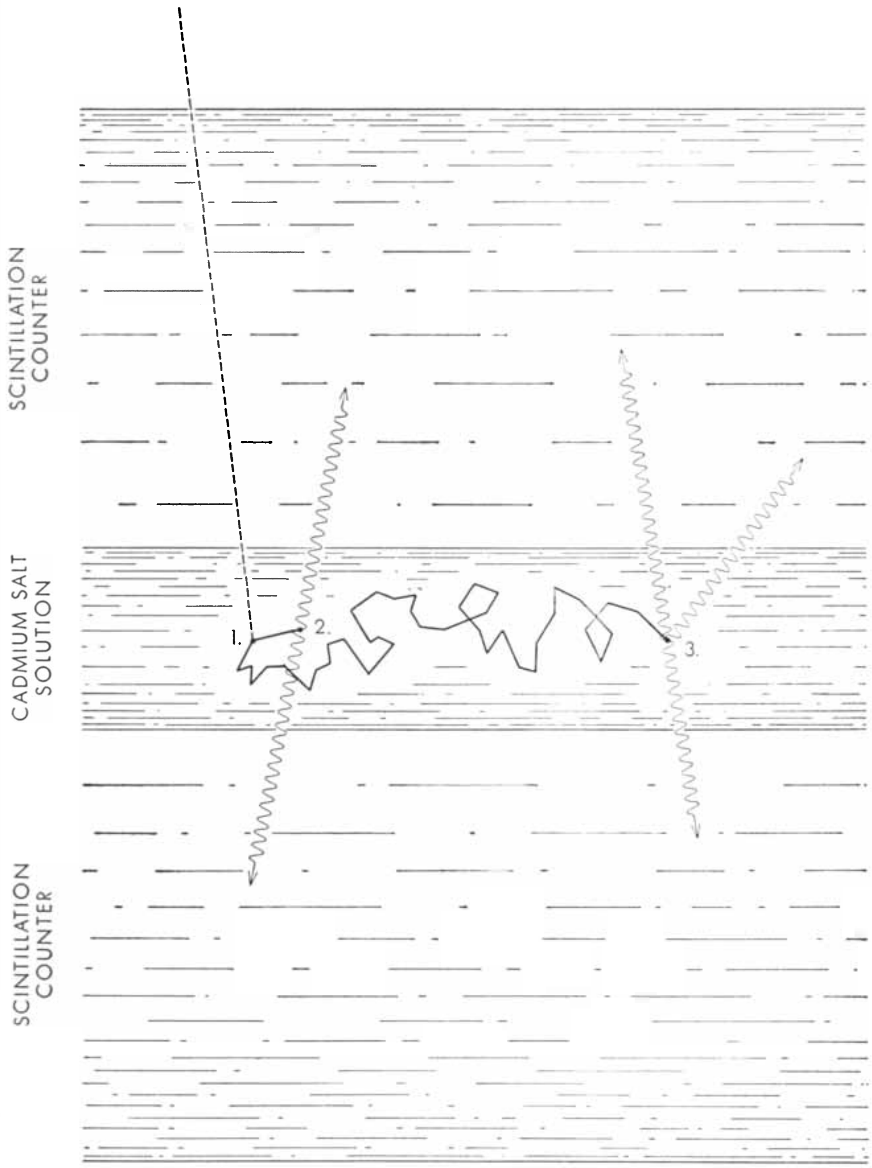
Ford's capabilities are among the finest in the country

One of the Ford laboratories where a particular design project has called for careful study of resolvers and resolver cascading. Two of the engineers assigned to this project are here checking results. From this work will come one of the new, highly classified weapon systems for the armed forces.

For accuracy and reliability—both vitally necessary in military instruments—experienced machinists must work to fine precision—in the order of .0005 of an inch. Here in one section of the shops of Ford Instrument Company, men are milling parts for an airborne computer.

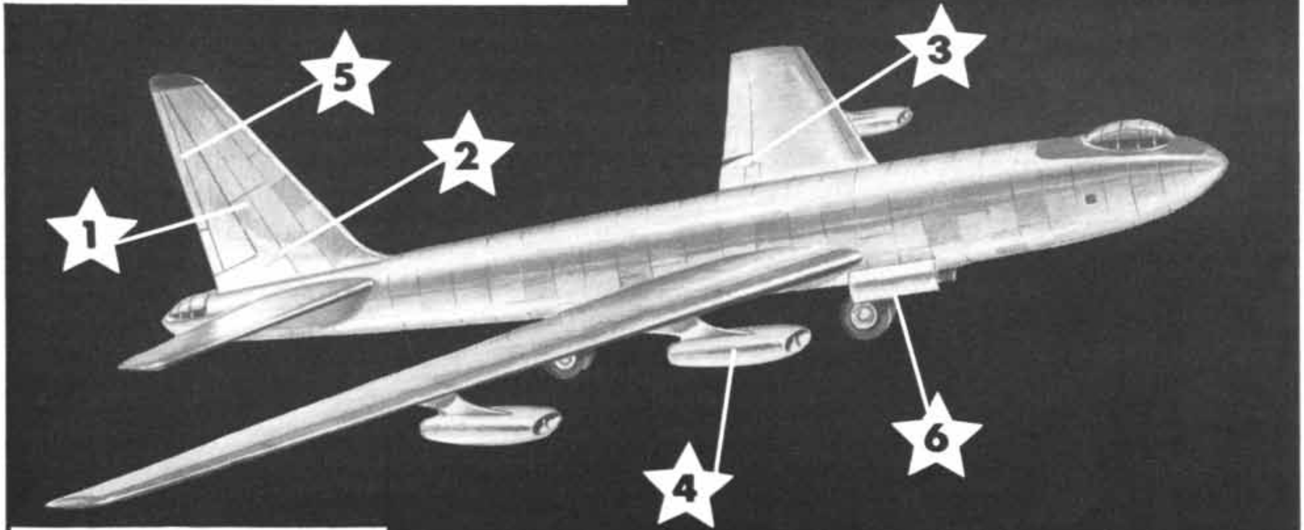
During the past year Ford Instrument Company has been busy working on many contracts for the U. S. Air Force and the U. S. Navy Bureau of Aeronautics, designing and manufacturing complex computers, controls and their components. For over forty years, Ford Instrument Company has devoted most of its efforts in working for the government to the many problems of weapon controls.

the defeat would mean to many that energy conservation had at last really failed us, or, almost as bad for our theories, that a reaction was not accompanied by its inverse among the fundamental particles. We should be loath to accept either of these conclusions. So far I have thought of only one way out—a desperate evasion. The neutrino might leave the scene of its birth all right, starting life as a perfectly proper Fermi neutrino. But it might be unstable and decay into three other neutrinos (two is forbidden for dynamical reasons), which could of course not all be simultaneously caught at the other end to invert the reaction, because their directions would slightly diverge. This possible behavior would leave the beta-decay theory intact. But it would make the neutrino even more evanescent a notion than it now is, and would only pass the trouble on to later generations of physicists. It will be far better if the patient experimenters are successful, and if their scintillator clearly displays those few oscilloscope traces each hour which will mean that the fugitive neutrino has been caught at last.

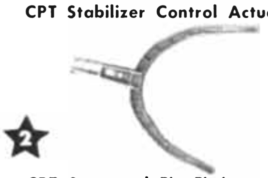


DETECTION OF THE NEUTRINO is planned by Cowan and Reines on the basis of the events outlined in this diagram. A neutrino (*dotted line*) encounters a proton (1), causing it to change into a neutron (*zigzag path*) and a positive electron. In passing through the cadmium salt solution the positive electron causes a pulse of ionization. Then it is annihilated in an encounter with a negative electron (2). This gives rise to two gamma rays (*wavy lines*), one of which causes a pulse in the top scintillation counter and the other a pulse in the bottom scintillation counter. The neutron wanders for several microseconds until it is absorbed by a cadmium nucleus (3). This gives rise to three gamma rays. Thus when two consecutive pulses, separated by an interval of several microseconds, occur in both the cadmium solution and the scintillation counters, a neutrino is assumed to have been detected.

CPT Creative Pioneers in Transport



CPT Stabilizer Control Actuator



CPT Structural Fin Fitting

CPT Ball-screw Flap Actuator

CPT Afterburner Actuator

CPT Rudder Control Actuator

CPT Landing Gear

CPT STARS IN AIRCRAFT LANDING GEAR ACTUATORS AND STRUCTURAL COMPONENTS

More aircraft rely on CPT Landing Gears than all other makes combined.

More vital aircraft equipment is operated by CPT ball-screw mechanisms than all other makes combined.

CPT has a unique combination of experiences. Engineering and production facilities have led all the top aircraft builders in bringing their designs to CPT. They rely on CPT for finished assemblies on schedule.

You can count on CPT's experience as the pioneer in landing gears. And the leading producer of all types of ball-screws. And the outstanding designer of actuators. You can also make good use of CPT's outstanding facilities for large-scale resistance welding, heat treatment, Kellering, and special machining. Call us before you begin your project.

CPT

CLEVELAND PNEUMATIC

TOOL COMPANY • Dept. D-156 • Cleveland 5, Ohio

For additional information write to any of the sales offices listed below:
Los Angeles; Levittown, L. I.; Fort Worth—Dallas.

CPT Abilities and Facilities Assure the finest in Precision Performance

THIRST

Exactly how does the need for water give rise to this familiar, and occasionally excruciating, sensation? The reader is advised to begin this article only if he has a cool drink near at hand

by A. V. Wolf

My thirst was the tallest tree in a forest of pain.
—Richard Evelyn Byrd

Sometimes it is best not to try to define the term that stands for the phenomenon one is talking about. Charles Darwin, working on Chapter 8 of *Origin of Species*—the famous one on "Instinct"—appears so to have found it, for he remarked: "I will not attempt any definition . . . every one understands what is meant." So it is with the word thirst. Its meaning, as anyone who attends to it soon finds out, shifts about. Thirst for water is a desire, an urge, a sensation, a drive, a reflex, an appetite, a disease.

The cruel thirst suffered by a wounded soldier is legendary. If his liquids are rationed for medical reasons, he develops "great craftiness in prevailing upon compassionate neighbors and attendants for small sips of any fluid or for pieces of ice." He will "quaff heartily from flower vases, emesis basins or urinals, with great stealth and cunning." The behavior of an individual with diabetes insipidus, a relatively rare disease involving the pituitary gland, may be astounding. Here is a description of such a case from a communication by Thomas Atkinson to a medical journal in 1856:

"Although a sober man, he was the most intemperate drinker I ever knew, from *four to six gallons* of water being required to keep him comfortable during the night, while his daily ration of this, to him literal 'aqua vitae,' amounted to not less than from *eight to 12 gallons*. He always placed a large tubful near his bed, on retiring for the night, which often proving insufficient, he was forced to hurry to the spring to obtain relief from the intense suffering occasioned by the scanty supply. He has frequently driven the hogs from mud holes in the road, and slaked his thirst with the semiliquid element in which they had been rolling, himself *luxuriating* in that which had afforded only a moderate degree of enjoyment to the swine."

It was Walter B. Cannon of Harvard who was largely responsible for provoking experimental investigation of the thirst phenomenon. Many scientists had regarded thirst as a "general" sense, like hunger and the sexual faculty. In this view thirst was the manifestation of a general impoverishment of water in the whole body. Cannon, however, having become convinced that the hunger sen-

FIVE STAGES OF DESERT THIRST were described by W. J. McGee. The first drawing illustrates the "clamorous" stage (loss of 3 to 5 per cent of the body water), characterized by discomfort, irritability and querulous complaint. The second drawing depicts the "cotton mouth" stage (water loss 5 to 10 per cent), in which a lump seems to rise in the throat and sation arose from the "local" stimulus of the empty stomach's contractions ("pangs"), reasoned accordingly that thirst was nothing more than it seemed: namely, a local sensation resulting from the drying of the mouth and throat. He related that atropine, a drug which stops the flow of saliva and makes the mouth dry, produced in him a sensation indistinguishable from thirst.

The "dry mouth" theory, as it came to be called, had serious defects. Many people disagreed with Cannon's reaction, claiming that *they* were perfectly able to distinguish a dry mouth from thirst. Moreover, dogs, with little bias in the matter, consumed no more than the normal daily amount of water when they were given atropine. We must be careful, to be sure, not to confuse drinking with thirst. Since the sensation of thirst is subjective, we can usefully examine the sensation only in ourselves. In any case the drug pilocarpine, which causes a profuse flow of saliva, does not greatly lessen a dehydrated person's desire for water. The dry-mouth theory also has trouble with the fact that an individual may become thirsty promptly after chewing sweet chocolate or swallowing a salty anchovy, even while his mouth is "wet."

If we know anything, we know when we are thirsty. But if a dry mouth is not the real sign, what is? A burning sensation in the throat? Extreme thirst is often described in terms appropriate to a conflagration: we read of people suffering with "burning" or "raging" thirst and of how its "fire" is quenched only by water. But the throat may "burn" with the soreness of a cold, and this sensation is rarely misconstrued as thirst, nor is it relieved by water.

We know that thirst is usually associated with dehydration of the body. There are two types of dehydration. "Absolute" dehydration is a simple loss of water, reducing the level in the body to less than normal. Play a game of tennis in the hot sun and you will be absolutely dehydrated and probably thirsty. But you may also suffer a kind of dehydration when your body contains more water than is normal. This will happen if you eat a great deal of salty food which enhances thirst and drinking. Certain patients with heart disease, if allowed unrestricted access to salt, drink more water than they can excrete, becoming waterlogged in a characteristic way, with swollen legs and belly. It appears that thirst depends less on the absolute water content of the body than on its water content *relative* to certain solid constituents, notably salts. A person taking excessive quantities of salt tends to be relatively dehydrated, meaning that the salt concentration in his body fluids is higher than normal. Barkeepers exploit relative dehydration when they set out "free" salted pretzels, potato chips or popcorn. As a patron consumes the proffered salt, requirement for water (available as beer on tap) rises in accordance with well-known "equations of thirst."

Relative dehydration is the basis of a modern, sophisticated "beer and pretzel" theory of thirst. Some years ago

the face feels strangely full. The victim may have hallucinations and discard some of his clothes. The third drawing shows the "shriveled tongue" stage (water loss 10 to 20 per cent), in which the eyelids stiffen and the face becomes numb. The sufferer may cast off more of his clothes, tear at his scalp, bite his arm. The fourth drawing suggests the "blood sweat" stage (water loss more than 20 per cent), in which the skin cracks and oozes blood serum. The fifth drawing represents the final, or "living death," stage.

STRATAGEMS FOR THIRSTY CASTAWAYS are the subject of some debate. The man in the background fishes; the French physician Alain Bombard, who sailed across the Atlantic in a life raft without a supply of fresh water, recommends squeezing fish and drinking their juice. The man at left wets his shirt in the sea; this is advised to retard the evaporation of water from the body. The man in the foreground covers his head with a cloth; this also retards evaporation by shielding him against some of the sun's radiation.

E. B. Verney in England was studying factors influencing the release of a pituitary hormone which regulates the excretion of water by the kidneys. His ingenious techniques showed that somewhere in the brain, in the bed of the carotid artery, there were receptors sensitive to slight changes in the osmotic pressure of the blood. Stimulation of these "osmoreceptors" appeared to lead to secretion of the hormone.

About three years later I encountered what seemed to be similar receptors while I was using quite different methods on another problem. I was studying the effect on thirst of intravenous injections of solutions of common salt. Steady injection of such a solution (*e.g.*, 5 per cent salt) after a time would cause a man to become thirsty fairly suddenly. This "thirst threshold" was reached when the osmotic pressure of his body fluids had risen 1 to 2 per cent, which is equivalent to saying that the cells of the body had lost that per cent of their water. Now this was just about the change in pressure that Verney had found would stimulate the osmoreceptors controlling the secretion of hormone. The similarity of the thirst threshold to the threshold of pituitary stimulation led to the suggestion that the postulated osmoreceptors might be sensory organs of a "thirst reflex" system in the body.

In 1952 B. Andersson in Sweden reported that injection of minute quantities of a strong salt solution directly into a region in the hypothalamus of goats caused them almost immediately to drink. The same injection into other areas of the brain did not have this effect. This and other evidence suggests that the hypothalamus is the site of a thirst or drinking "center."

Let us conceive of a primitive thirst reflex originating in osmoreceptors in the hypothalamus. When these receptors are shrunk beyond a certain threshold, because of loss of water from the body or relative dehydration through an excess of salt, nerve impulses from the receptors pass to higher brain centers, producing the sensation of thirst, and also activate the drinking response. Now it is known that dehydration also tends to reduce the flow of saliva in the mouth. A dry mouth therefore has become associated with thirst. As a result, drying of the mouth from any cause, regardless of whether osmoreceptors are stimulated, may be interpreted as thirst. In this view dry-mouth thirst may arise without dehydration as a "conditioned reflex." If sweet chocolate or a salty anchovy in the wet mouth "burns" in the right way, this sensation also will be interpreted as thirst. Once the material has left the mouth, and if not enough is swallowed to produce a systemic effect on osmotic pressure, the urge to drink passes off, because the primitive thirst reflex is not activated.

Among the dozens of theories of thirst, the type based on a physiological mechanism of this kind has never wanted for advocates and is fairly useful. Nevertheless, puzzling facts remain. In 1933 a Dr. Kunstmann in Heidelberg published the results of a curious and heroic experiment. (The experiment was of a sort not likely soon to be repeated: among other details, Kunstmann had pieces of his breast muscle cut out for tissue analysis.) He had forced himself to drink an average of 10 quarts of water daily for 127 days, taking as much as 18 quarts in 24 hours. Strangely, after eight days he developed a thirst so compelling that he would wake at night to drink more. Actually this is not too surprising, for Kunstmann was losing salt from his body in the large daily urine volume, and it is well known that salt deficiency produces a kind of thirst. It can be relieved, however, only by salt. Some physiologists feel that the existence of this kind of thirst weakens the osmoreceptor theory. We can, of course, say that it is not "true" thirst, because it is not relieved by water, but this involves defining thirst—a matter we shall avoid in this article.

A rat, curiously, may survive longer (13 days) with food and no water than with water and no food (8.5 days). This is not true generally of larger animals such as the dog or man. Men have gone without food for well over 30 days, but they cannot last nearly as long without water. How long one can survive depends on the conditions. Antonio Viterbi, a condemned political prisoner of the French Restoration who committed suicide by denying himself all food and drink, lasted 17 days. But a man in a hot desert without water may be brought within the grasp of death in a few hours. Simply walking in the sun, he may sweat a quart of water per hour. When he has lost 1 per cent of his body weight, he begins to feel thirst. After the loss of 5 to 8 per cent, he is weary and a candidate for physical collapse; after 10 per

ANOTHER STRATAGEM for thirsty castaways is recommended in case of rain. By holding his head over a vessel and allowing the rain to stream down his hair, the castaway can increase the water collected. He can also spread clothes and wring them out.

How we work steel to make steel work for you

Why don't they invent a better SMOKESTACK?

A. O. Smith has!

Introduces longer life Permaglas smokestack of glass-protected steel

Wherever this *new* smokestack goes up, industry's costs come down. No more sending good money up in *smoke*stack replacement every few years!

The new *Permaglas* smokestack is glass-lined inside and out to shrug off ever-present acid condensates that quickly corrode and ruin ordinary unlined stacks. Glass eliminates costly maintenance.

Lightweight sections bolt together easily . . . cut cost of field erection. Furthermore, glass-lining permits steel wall thickness of only ¼ in. maximum. You save five to ten inches of other lining material . . . and there's no need for heavier supporting foundations.

You'll want to know more about the *Permaglas* smokestack—developed by the world's largest producer of glass-protected steel products. Write today for free technical report . . . and for booklet which shows *how we work steel to make steel work for you.*

PERMAGLAS SMOKESTACK FACTS:

- **Two coats of acid-resistant glass inside and out . . . fused to ¼-inch steel at 1600° F.**
- **Standard diameters — size range up to 8 feet in 6-inch increments.**
- **Flanged section lengths — to 20 feet.**

Through research . . . a better way

A.O.Smith
CORPORATION

MILWAUKEE 1, WISCONSIN

12 plants in New Jersey, Pennsylvania, Ohio, Wisconsin, Illinois, Texas and California

International Division: Milwaukee 1, Wisconsin cent, gross physical and mental deterioration begins to set in. It is estimated that a man cannot survive when he has lost water amounting to 20 per cent of his body weight.

At the turn of the century W. J. McGee, a geologist of large experience in the deserts of the U. S. and Mexico, described five stages of desert thirst. In the first (loss of 3 to 5 per cent of the body water), a man becomes uncomfortable, irritable and complaining; his condition excites "hilarity rather than pity" among his companions. In the second stage (5 to 10 per cent) his mouth feels like cotton; his tongue may cling to his teeth; he starts endless swallowing motions to dislodge an apparent lump in his throat; his face feels full because of the shrinking of his skin; he begins to talk to himself and have hallucinations. In the third stage (10 to 20 per cent) his tongue hardens to a numb weight; his eyelids stiffen and eyes stare without winking; he cannot speak but only moan or bellow hoarsely; he may suck his own blood (*cf.* the Ancient Mariner: "I bit my arm, I sucked the blood") or even drink his own urine. In the last two stages (more than 20 per cent loss) his skin cracks; a blood sweat oozes from his body; his eyes weep tears of blood; he becomes a "senseless automaton" digging desperately in the sand; and he passes beyond any possible revival by water.

When the air temperature is higher than skin temperature, a man can maintain his normal body temperature only by dissipating heat through the evaporation of sweat. For every 1,000 kilogram calories of heat he must get rid of, he has to evaporate nearly two quarts of water. This necessity precludes any possibility of training to get along for a protracted period on less than the usual water requirement, and it also makes futile the "rationing" of a scarce supply.

How a man or animal knows when to stop drinking is not now encompassed by any theory of "thirst." A dog or a burro drinks until it has all the water it requires. But a dehydrated man does not drink back more than about half of his deficit on his first refilling. He may become satiated even before the osmotic pressure in his body tissues is lowered. This satiety may derive in part from distention of his stomach, in part from the fact that his throat and esophagus meter the water as it passes down. In any case, he waits until after he has had food and rest before completing his drinking.

Tradition and physiology generally argue against drinking sea water. The literature of the sea abounds in tales of how this drink leads to sickness, diarrhea, unutterable extremities of thirst and madness. Edgar Allan Poe's gruesome *Narrative of Arthur Gordon Pym* is matched by less fictitious accounts such as *Wreck of the Dumaru.* And the U. S. Navy sternly enjoins its men: "Never drink sea water!"

The physiologist points to the fact that most mammals, including man, cannot get rid of salt in the urine at the rate of more than about 2 per cent. Average "open ocean" water is approximately 3.5 per cent salt. If a man drank 100 cubic centimeters of sea water, he would have to excrete 175 cubic centimeters of water in urine to eliminate the excess salt by that route.

The general biologist's argument is even simpler. Seals and other seagoing mammals (including mermaids, according to some) do not drink sea water; ergo, man would be best advised to follow their example. It will do no good to cite the bony marine fishes that drink sea water, for they are equipped with a salt-removing mechanism in the gills; nor the kangaroo rat, which could tolerate sea water but only because its kidneys are capable of producing an exceptionally salty urine.

A castaway who imitates the seal, eating fish as his sole source of water, will be in another kind of trouble. He must eliminate a substantial part of the nitrogenous material in the fish tissues,

EXTRAORDINARY THIRST was recorded by Thomas Atkinson in 1856. A sufferer from the rare disease diabetes insipidus drank eight to 12 gallons of water during the day and four to six gallons during the night.

and he can do so only by excreting relatively large volumes of urine. Thus eating raw fish tends to deplete his body of water. The seal can afford to eat fish without drinking because, among other reasons, it eliminates nitrogen more efficiently in its urine and loses no water by sweating.

The classical admonitions against the use of sea water have recently been challenged. The French physician Alain Bombard, during his 65-day crossing of the Atlantic on a life raft, subsisted on rain water, sea water and the juice of fish obtained by squeezing the flesh in a fruit press. Although it is unfortunately not possible to judge from his accounts the general feasibility of this regimen, it does appear that he was able to go for a three-week period without a drop of fresh water, drinking only fish juice. The juice of fish may sustain a man's water need if it is relatively free of nitrogenous tissue debris.

William Willis, who crossed the Pacific on a raft from Peru to Samoa, lost almost all of his water supply early. He recalled that old sailors sometimes took sea water as a laxative, and that he had drunk some without ill effects. Believing he did not have enough fresh water for his long journey, he drank one and one-half cups of fresh water and an almost equal amount of sea water each day, until he ran into rain much later. He mentions no serious thirst and attributed his increasing weakness to incessant labor and sleeplessness. Thor Heyerdahl, writing of the voyage of the *Kon-Tiki,* also indicated that at times sea water mixed with fresh water surprisingly assuaged thirst.

These reports notwithstanding, men who stake their lives at sea must be cautious about accepting conclusions drawn from such experiences. Some physiologists categorically advise that castaways never use sea water at all. There is an important difference between taking sea water when one has luxurious supplies of fresh water and taking it when there is no extra insurance supply to fall back on if a body deficit develops.

The value of fish juice, and of mixing sea water with fresh water to eke it out, are being investigated experimentally. It may turn out that certain mixtures of sea and fresh water will work in some circumstances; yet the saving of fresh water involved may be too small to count. We do not yet know.

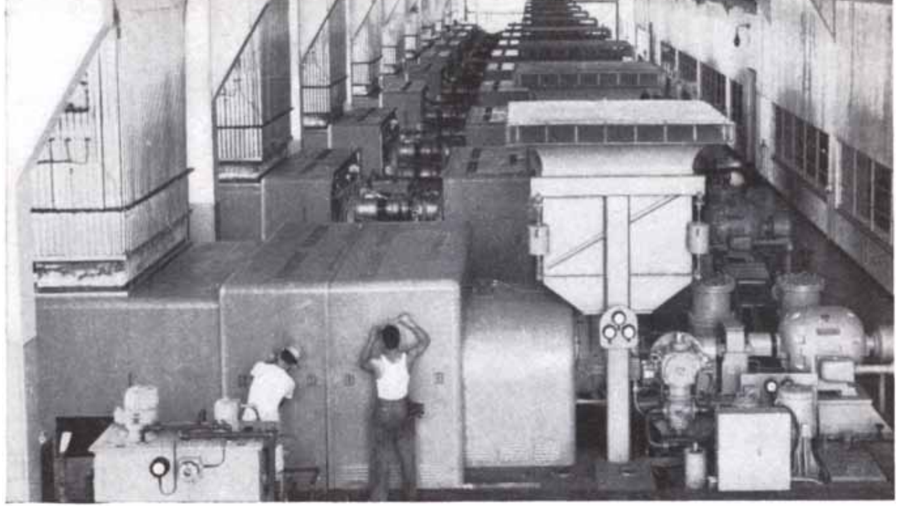
"For the thirst there is need of a powerful remedy," wrote Aretaeus of Cappadocia. More than 1,700 years have passed and we still have no substitute for water.

CELESTIAL NAVIGATION—Link Aviation's high-speed, high altitude celestial navigation trainer; only such trainer capable of simulating trans-Polar flight. Trains navigators in techniques of guiding planes by the stars.

Vital Controls

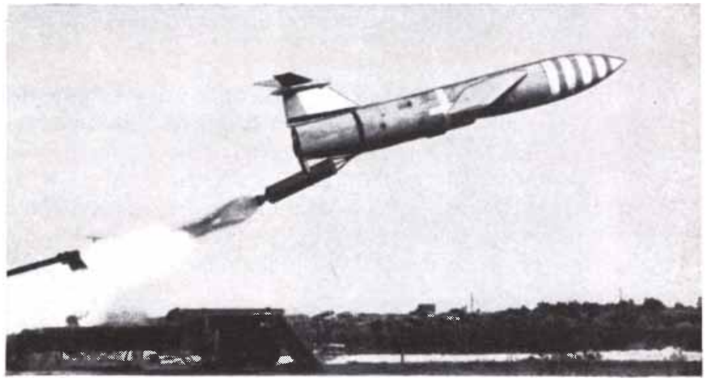
The controls on the world's fastest submarine; the most advanced airborne navigation system known to exist; other similarly advanced military systems and equally advanced industrial equipment and control systems are outstanding examples of the work of the producing companies of General Precision Equipment Corporation. More than a dozen major industries are served by instrumentation and systems designed, developed and produced by GPE Companies.

Ten of the companies in the GPE Group — notably Askania, Kearfott, Librascope and Link Aviation—devote substantial resources to the development and manufacture of instruments, servos and controls. These are used in equipment and systems developed by these companies



PROCESS CONTROL—Askania controls regulate speed of the ten turbines which develop compression to maintain gas suction pressure in Creole Petroleum Corporation's giant, pile-supported oil drilling operation on Lake Maracaibo, Venezuela.

SUBMARINE OPERATION — Controls developed and produced by Askania Regulator Company are utilized to govern operation of U. S. Navy's modern Guppy type submarines.



MISSILE GUIDANCE —One of the many guided missiles equipped with Kearfott basic gyro reference systems, the B-61 Matador—U. S. Air Force's first successful ground-to-ground tactical weapon.

GPE CAPACITIES

● Manufacturing
●● Manufacturing and product development
●●● Manufacturing, product development and research
□●● Pilot manufacturing, product development and research

	KEARFOTT COMPANY, INC	INTERNATIONAL PROJECTOR CORPORATION	BLUDWORTH MARINE DIVISION	GENERAL PRECISION LABORATORY INCORPORATED	THE GRISCOM-RUSSELL COMPANY	LINK AVIATION INC	THE HERTNER ELECTRIC COMPANY	THE STRONG ELECTRIC CORPORATION	J. E. McAULEY MFG CO	ASKANIA REGULATOR COMPANY	AMPRO CORPORATION	LIBRASCOPE INCORPORATED
PRECISION MECHANICS, OPTICAL DEVICES, CERAMICS	●●●	●●	●●	□●●	●●	●●●	●●	●●●	●●	●●	●●	●●●
ELECTRICAL EQUIPMENT and COMPONENTS	●●●	●	●			●●●	●●●	●●	●	●●	●	●●●
ELECTRONICS	●●●	●●	●●●	●●●		●●●	●	●●		●●●	●●	●●●
HYDRAULICS, LIQUIDS PROCESSING, HEAT EXCHANGE		●●			●●●					●●●		
TELEVISION Studio, Theatre, Educational, Business, Industrial	●	●		●●●		●				●		
INSTRUMENTS, SERVOS, CONTROLS Hydraulic, Pneumatic, Magnetic, Electronic	●●●	●	●●	□●●		●●●	●●	●●		●●●	●	●●●
AIRCRAFT and MISSILE GUIDANCE, CONTROL, SIMULATION	●●●	●		●●●		●●●	●			●●	●	●●●
AUTOMATIC COMPUTERS and COMPONENTS	●●●	●	●	□●●		●●●				●●●		●●●
RADAR, MICROWAVE, ULTRASONICS	●●●	●	●●	●●●		●●		●		●		
MOTION PICTURE and AUDIO EQUIPMENT		●●●		□●●			●●	●●●	●●●		●●●	
NUCLEAR POWER COMPONENTS and CONTROLS	●●●				●●					●●		●●●
SYSTEMS ENGINEERING Aeronautical, Naval, Industrial	●●●			●●●	●●●	●●●				●●●		●●●

themselves, as well as in systems and equipment developed and produced by other manufacturers of advanced technological equipment.

All GPE Producing Companies work in the advanced areas of highly specialized fields and are engaged in the design, development, manufacture and sale of equipment which is closely related from a technical point of view. It is all precision equipment; it derives from similar fields of technical competence; it saves labor, increases productivity or achieves results which cannot be achieved with even limited use of on-the-spot manpower. The chart here shows the specialized fields in which the key GPE Producing Companies work.

In addition to specialization in its particular products and fields of technical competence, each of these companies has at its command, as required, the facilities and specialized techniques of the other GPE Companies in their respective fields. Interrelation of their resources is achieved through GPE's basic operating policy, GPE Coordinated Precision Technology. In all areas in which GPE Companies work, this coordination has been responsible for a wide variety of precision equipment of superior design and performance, embodying new, advanced principles.

A brochure relative to the work of the GPE Companies and GPE Coordinated Precision Technology is available. Address your request, or specific inquiries, to: General Precision Equipment Corporation — 92 Gold Street, New York 38, N. Y.

Carotenoids

Carotene, the pigment named after the carrot, belongs to a large family of biological molecules. These are found in a spectacular assortment of organisms, but their function is little understood

by Sylvia Frank

The living world is full of color in infinite variety: the vivid red of the tomato, the subtle green of the avocado, the orange of the carrot, the pink of the shrimp, the blue of the goose barnacle's gonads, the inky gray of the squid's sheltering fluid, the brilliant hues of the butterfly. Yet all the varieties of biological color are composed from a palette containing just a few kinds of biochemical pigments. The colors mentioned above, for example, are all produced by a single chemical family of pigments called the carotenoids.

The carotenoids turn up in every major class of plants and animals. They are found in bacteria and fungi and flowers, in sponges, crustaceans, insects, fishes, birds and mammals, in fact in most animals from protozoa to man (with the curious exception of the whale!). Just as

CHLOROPLAST of a plant contains carotenoids as well as chlorophyll. This electron micrograph by J. J. Wolken of the University of Pittsburgh shows a small section of the photosynthetic microorganism *Poteriochromonas stipitata*. At right is a chloroplast, its layered structure shown in cross section (*see drawings on page 84*). The large object at the top is the cell nucleus; the smaller bodies around it are mitochondria, in which the chemical reactions of respiration occur. The structures are enlarged some 50,000 diameters.

chlorophyll is responsible for much of the green in our living world, the carotenoids account for most of the other colors. (Red hair, however, is due not to a carotenoid but to an iron-containing pigment, so technically a redhead should be nicknamed "Rusty," not "Carrottop.")

In short, carotenoids seem to be the most ubiquitous of all pigments in nature. There must be something here that goes to the root of life itself. How is it that the carotenoids have marched all the way with evolution and become firmly established throughout the plant and animal kingdoms? Surely they must have some function other than mere decoration. It is hard to believe that these substances would have become so woven into the fabric of living things if they did not perform some service generally useful to all classes of organisms.

And yet if the carotenoids do have such a general function, it has not been discovered. Biologists view the carotenoids with esthetic appreciation, bafflement and a certain degree of exasperation. We know their chemistry, their properties, their distribution in plants and animals from bottom to top of the evolutionary tree; but we have no clue to why they are so common.

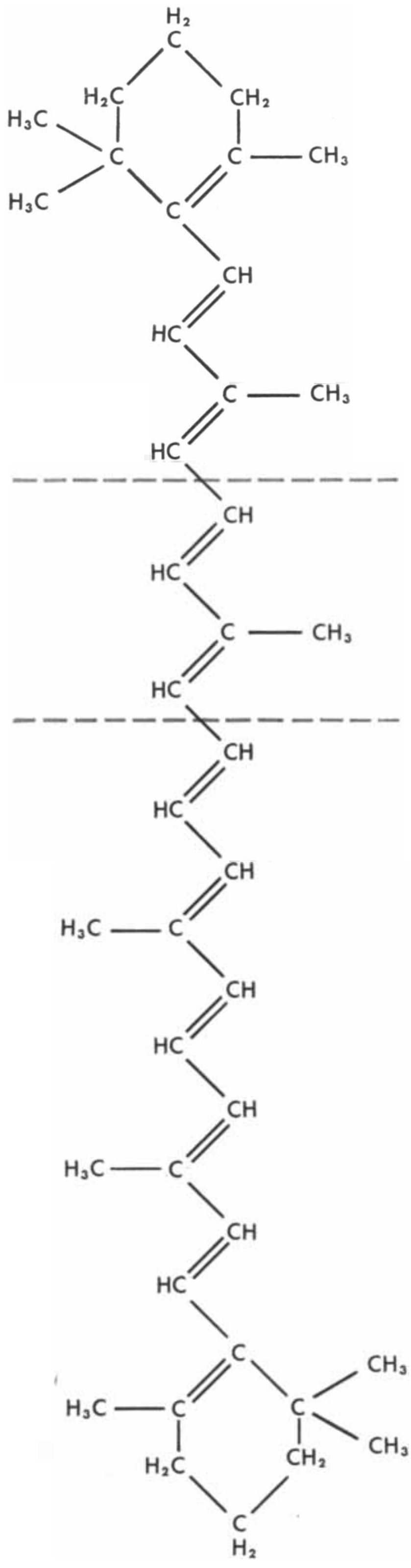
This is not to say that investigation has turned up no useful carotenoid functions at all. The carotenoids are known, or suspected, to play a biological role in several specific situations. For example, the retina of the eye owes its sensitivity to light to the presence of carotenoid pigments. From carotenoids in their food animals synthesize vitamin A, without which they could not see. It has also been suggested, although this is only a hypothesis, that carotenoids may play a part in sexual reproduction. Concentrations of carotenoids are found in reproductive organs of many plants and animals—in pollen and fruits, in eggs and the gonad glands. Some animals are well known to change color dramatically during breeding. In the snail *Patella*, for example, the male gonads turn a brick red after spawning, while the female gonads lose carotenoids and become pale—sexual reproduction in technicolor! Still, it may be that carotenoids have nothing to do with reproduction but merely tend to accumulate in sexual organs because these have considerable fat, in which carotenoids are soluble.

Among the possible functions of the carotenoids one of the most intriguing is their relation to the photosynthesis of plants. Here we have chemical clues which have led to some interesting laboratory experiments. In photosynthesis the key role is played by the green pigment chlorophyll. But sitting alongside chlorophyll in the plant cells are yellow carotenoids. Are they involved somehow in photosynthesis, either as partners of chlorophyll or as building blocks? A very striking chemical coincidence suggested that they might be.

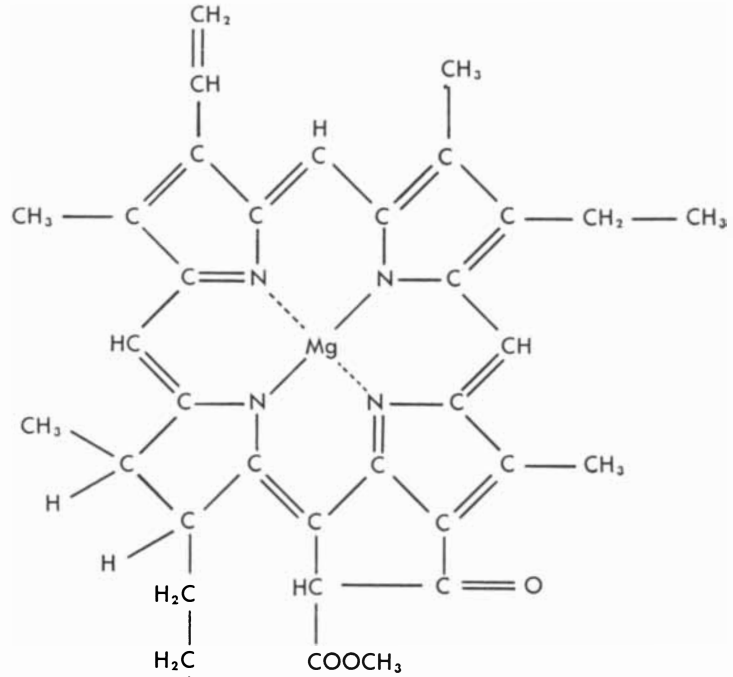
The carotenoid molecule is made of eight units, called isoprene units, strung in a chain [*see diagram in the next column*]. All the carotenoids, of which there are more than 70 varieties, have the same structure and the same 40 carbon atoms; they vary only in the attachment of hydrogen or other groups at certain positions, these slight variations accounting for their differences in color. Now the chlorophyll molecule has a tail, known as the phytol chain, which is very like the carotenoid chain except that it is only half as long and has extra hydrogen atoms in place of the double bonds between carbon atoms.

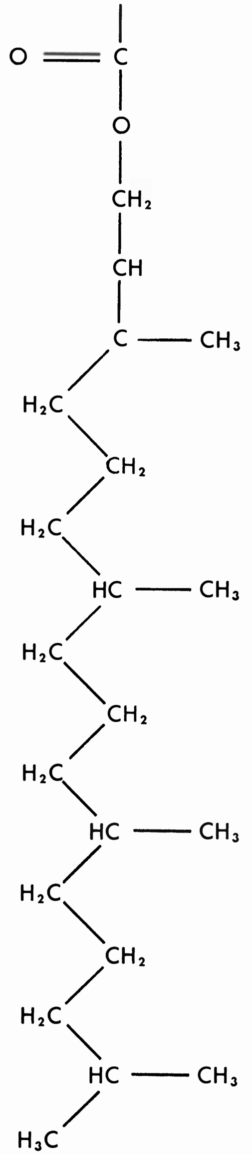
It would seem that the similarity between the carotenoid chain and chlorophyll's tail must be more than a coincidence. Plant physiologists at first supposed that carotenoids might be made from the phytol tails of chlorophyll, because they had noticed that large quantities of carotenoids appear when chlorophyll disappears in ripening fruits. But much more carotenoid is made than can be accounted for by the amount of phytol released. So we turned this thought around and began to investigate the reverse possibility: that the phytol part of the chlorophyll molecule might be synthesized from carotenoids.

Young oat seedlings grown in the dark manufacture carotenoids but no chlorophyll. We found that when such seedlings were exposed to light, the amount of carotenoids declined just as chlorophyll began to be formed. Here was a first indication that carotenoids might be entering into the making of chlorophyll. Then we learned that the dark-grown seedlings contained a pale green substance with light-absorbing powers remarkably similar to those of chlorophyll. It became clear that this substance was a precursor of chlorophyll. Later James H. C. Smith and his co-workers at Stanford University definitely identified the same substance (in barley plants) as a "protochlorophyll" which lacked only hydrogen atoms at two positions on the porphyrin ring of being a complete chlorophyll molecule. Meanwhile Sam Granick at the Rockefeller Institute for Medical Research had been working out



BETA CAROTENE MOLECULE, like all other carotenoid molecules, contains 40 carbon atoms (C). The molecule is further characterized by repeating isoprene units, one of which is between the two dotted lines.





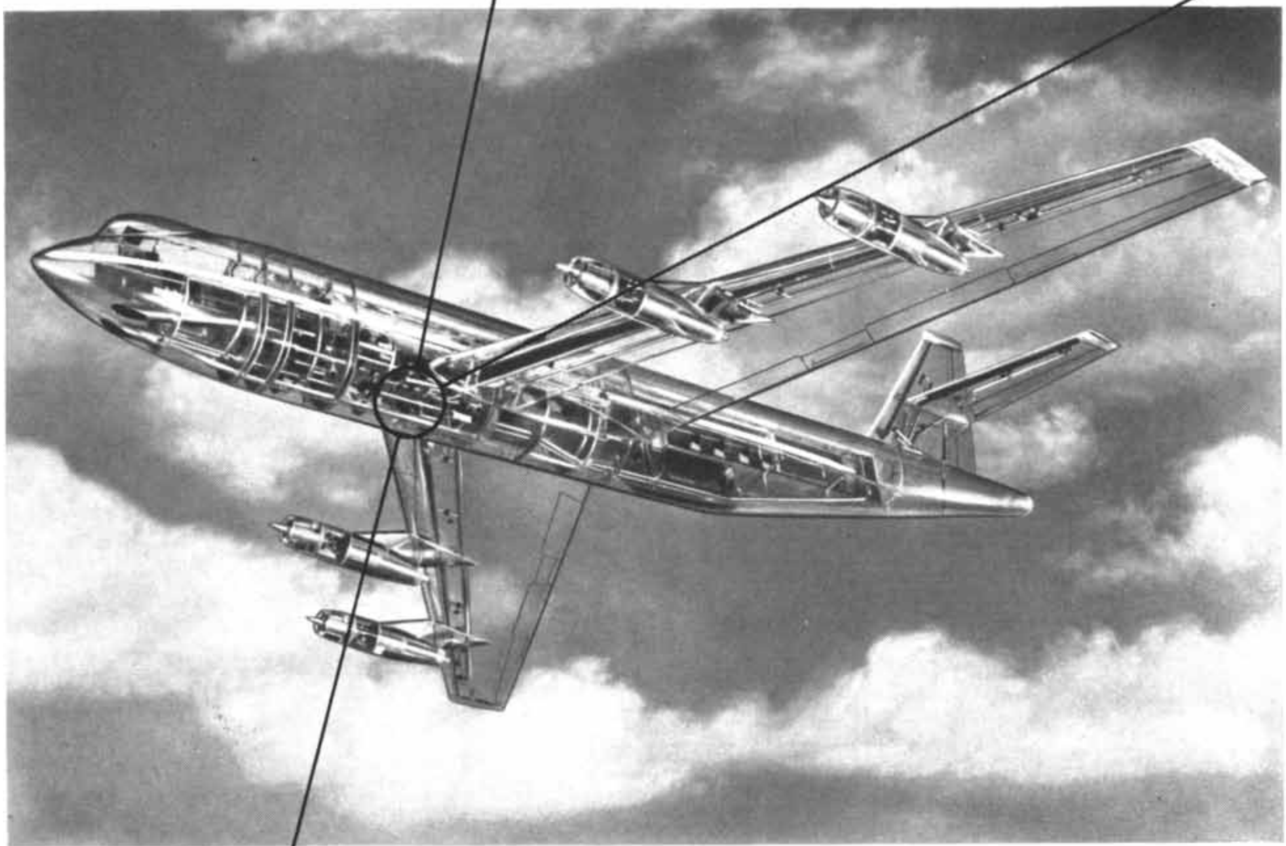
CHLOROPHYLL MOLECULE consists of a porphyrin ring (*above*) and a phytol chain (*left*). The structure of the phytol chain resembles that of the carotenoids. It is half as long and has extra hydrogens in place of the double bonds between carbons.

the sequence of steps in the synthesis of chlorophyll by means of experiments with green algae. As he reconstructed the scheme, the next to last step in the making of chlorophyll by plants was the hitching of the phytol tail onto the porphyrin head. Thus it appears that the final steps in the formation of chlorophyll are the attachment of phytol to the magnesium porphyrin ring (a brownish pigment) and then the addition of two hydrogens to the ring, this last step requiring the assistance of light.

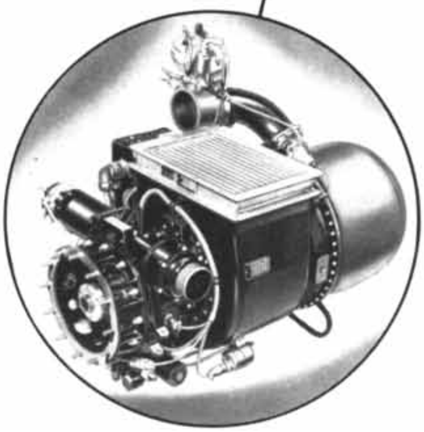
Now we were left with the problem of connecting the carotenoids more definitely with the synthesis of chlorophyll. This we explored indirectly by examining the chemical response of oat seedlings to light of selected wavelengths, or colors. We found that the wavelengths most efficient in reducing the amount of carotenoid in plant leaves were precisely those which were most efficient in promoting the synthesis of chlorophyll. Furthermore, these were the wavelengths known to be absorbed most strongly by protochlorophyll. It looks, then, as if the formation of chlorophyll from protochlorophyll brings about the transformation of the carotenoids.

The observed facts suggest that the process goes as follows. A plant continu-

Complete auxiliary power



in one system



This self-contained power system provides economical and efficient operation of vital components on aircraft and missiles. Power to start main engines . . . power for cabin air conditioning on the ground and in flight . . . power for electronics, electrical and hydraulic applications . . . emergency power for operating control systems.

As in other AiResearch aircraft and missile systems, the components in this pneumatic power system are designed and manufactured to operate with absolute compatibility with one another. This insures top performance and ease of maintenance — a unique advantage because only AiResearch has the broad range of development, manufacturing operational, and service experience to make it possible.

• *Qualified engineers in the fields listed below are needed now. Write for information.*

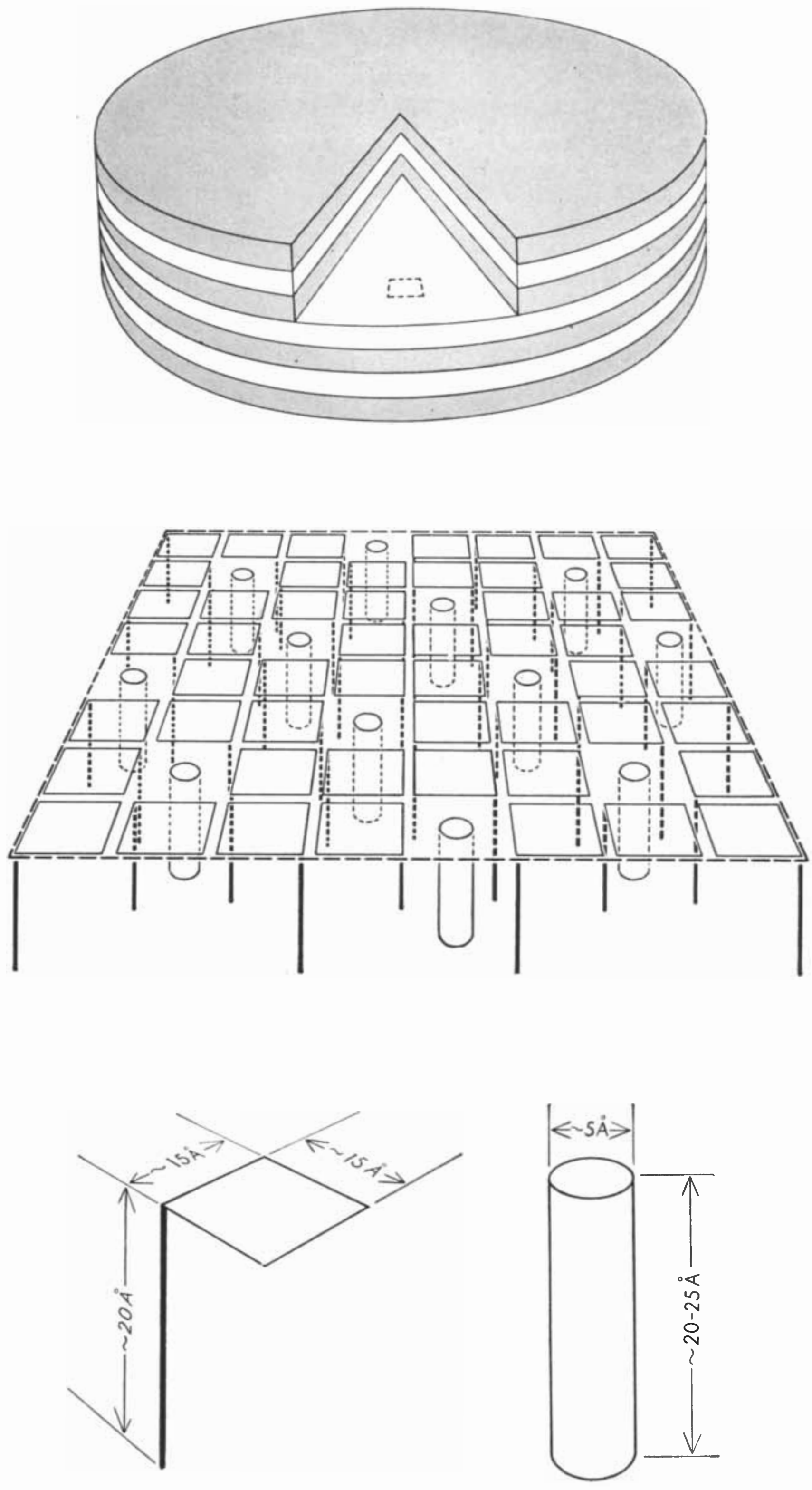
HEART OF THE AIRESEARCH AUXILIARY POWER SYSTEM

This small gas turbine compressor power unit supplies both compressed air and shaft power, has proven diversity on the ground as well as in the air.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions *Los Angeles 45, California • Phoenix, Arizona*

Designers and manufacturers of aircraft systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS



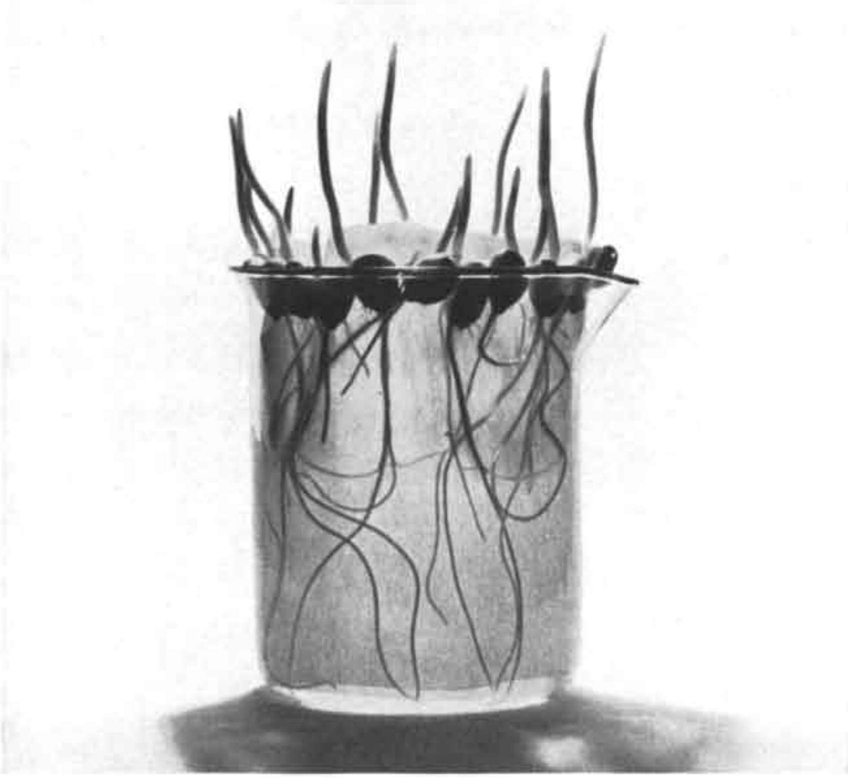
CHLOROPLAST MODEL proposed by Wolken (*see electron micrograph on page 80*) suggests how chlorophyll and carotenoid molecules are fitted together in this small structure. At the top is a schematic drawing of an entire chloroplast. The white layers in the drawing represent protein; the gray layers, lipid (fat). Three of the layers have been cut away to mark off a small area on the top of one protein layer. At the lower left is a simplified drawing of the chlorophyll molecule, with the plane of the porphyrin ring at a right angle to the phytol chain. At the lower right is a similar drawing of the carotenoid molecule. The approximate dimensions are in Angstrom units (A). The middle drawing indicates to scale how the molecules may be arranged in the area marked off in the top drawing.

ally produces yellow carotenoids, which serve as a pool for the phytol part of chlorophyll. The carotenoid molecule—a chain 40 carbon atoms long—splits into two 20-carbon chains. Each, taking up hydrogen atoms at the double bonds, becomes a phytol chain. It joins a magnesium porphyrin ring and forms a protochlorophyll molecule. The latter in turn absorbs light, takes on two hydrogen atoms and becomes a molecule of chlorophyll. As these conversions proceed and phytol is used up, further conversion of carotenoids replenishes the phytol pool. If the theory is correct, we should expect that the carotenoids in a plant will break down into phytol only if the supply of phytol is reduced by synthesis of chlorophyll. Experiments in fact bear this out. When young seedlings are grown in light too dim to produce any measurable amount of chlorophyll, the amount of carotenoids in the plant increases substantially. That is, the carotenoids the plant is producing presumably fail to change into phytol because no phytol is being removed for synthesis of chlorophyll.

Now one may well ask: Why does a plant have to keep making chlorophyll? The pigment acts only as a catalyst in photosynthesis; that is, it takes up the energy of sunlight to help the plant make sugar from carbon dioxide and water, but the chlorophyll itself is not used up in this process. Why, then, is chlorophyll continually synthesized in a growing plant? We can only answer that chlorophyll, like most other substances in living things, must be constantly breaking down and re-forming—following the rule of the dynamic, restless processes of life. That it does follow this rule is proved by the fact that when a green plant is placed in the dark, it soon loses its green color. In the dark the plant stops making chlorophyll, and so it fails to replace the chlorophyll that is constantly being destroyed.

We were interested to find out whether during this breakdown chlorophyll retraces in reverse the same stages by which it is synthesized: *i.e.*, whether chlorophyll first changes to protochlorophyll, then separates into phytol and the porphyrin ring and finally yields carotenoids. We placed green corn seedlings in the dark for a while and then analyzed their contents. After 120 hours in the dark at a little above normal room temperature, the chlorophyll was completely gone. But there was no increase in carotenoids; in fact, the amount of this substance declined. So it seems that the destruction of the chlorophyll molecule

NEW G-E Small Particle Detector Helps Solve Air Pollution Problems
Now General Electric offers a simple, reliable means of measuring the number and size of airborne condensation nuclei. The G-E Small Particle Detector counts all condensation nuclei larger than a selected minimum size and indicates *directly* in nuclei per cubic centimeter.
LIGHTWEIGHT AND PORTABLE, the detector weighs only 14 pounds complete with foot-operated vacuum pump. Power is supplied by inexpensive, self-contained batteries.
MANY APPLICATIONS. In industry, municipalities, research laboratories and wherever air pollution is a problem, the G-E Small Particle Detector is an inexpensive step toward solution.
LOW IN PRICE, the detector costs only $650.00.* For more information call your nearest General Electric Apparatus Sales Office or write for bulletin GEA-6429 to Section 585-28, General Electric Co., Schenectady 5, New York.
*Manufacturer's suggested resale price.
GENERAL ELECTRIC
CONDENSATION NUCLEI
OFF
IN
OUT
WIDE RANGE. The G-E Small Particle Detector counts all condensation nuclei in the range of 8 x 10⁻⁸ to 10⁻⁵ centimeters radius and indicates directly in number of nuclei over a range of 2 x 10² to 1 x 10⁷ nuclei per cubic centimeter.

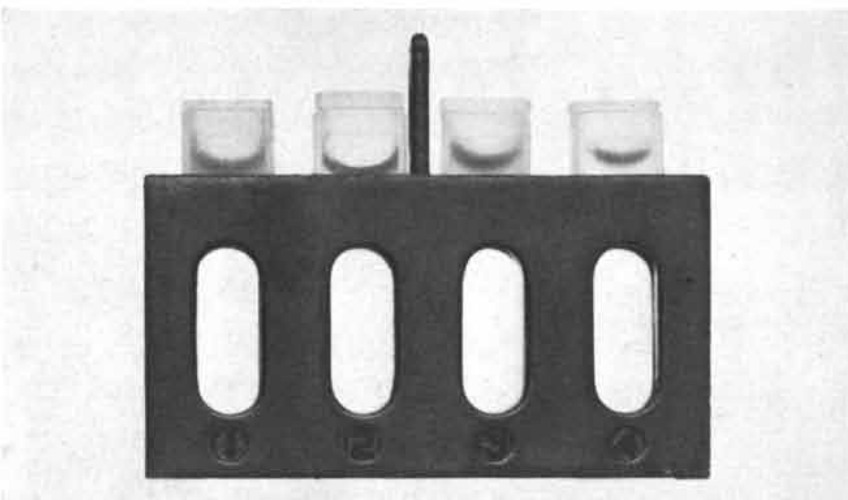


CORN SEEDLINGS are grown between filter paper and the inside of a beaker in one carotenoid experiment. When they are placed in the dark, their chlorophyll gradually disappears. This disappearance is not accompanied by an increase in carotenoids. This indicates that, though chlorophyll is synthesized from carotenoids, the process is not reversible.

does not go back over the same pathway followed in its construction.

The fabric of fact and theory that we have woven together from the work on chlorophyll allows us to add one more possible function to the list of the carotenoids' useful activities: namely, they may help produce the agent of photosynthesis. As noted earlier, they may be involved in sexual reproduction by plants and animals. They surely play a part in animal vision. And there are vague leads to other specific functions.

But biologists are still hunting for a much more general activity of the carotenoids. They cannot help feeling that investigation of these ubiquitous, colorful molecules will lead some day to a fundamental discovery about the processes of life at the molecular level.



CAROTENOIDS ARE ANALYZED in this cell. When a carotenoid solution is put into one of the four vessels, and the cell placed in a spectrophotometer, the spectrum of the molecule is detected. The amount of carotenoid may also be measured by the amount of absorption.

You might wait forever for another opportunity like this . . .

Here is a once-in-a lifetime opportunity for you if you are an ambitious engineer or scientist. Westinghouse has just received additional new contracts to develop, design and build atomic power plants to propel naval vessels. That means unusual professional openings for a few talented engineers and scientists. If you are interested in a creative job, solving some of today's most challenging problems . . . a chance to use all your training and experience . . . the opportunity to carve a career in today's most dynamic industry . . . and you'll want to investigate Westinghouse Atomic Power *today*. You might wait forever for another opportunity like this.

For many of these jobs you do not need previous experience in atomic power. Can you qualify for one of these assignments?

PHYSICISTS-MATHEMATICIANS Experimental Physicists for Research Studies with Nuclear Reactors; Theoretical Physicists for General Reactor Theory Development and Dynamics. Mathematicians—Research in Applied Mathematics, Numerical Analysis, and Digital Computing Techniques relating to Nuclear Power Reactors.

METALLURGISTS Basic Research in Physical Metallurgy, Corrosion and Radiation Effects on Metals; Applied Research and Development on Materials and Fabrication Processes for Reactor Fuel Components, Power Metallurgy and Metal Working; Non-Destructive Testing.

MECHANICAL ENGINEERS To Design Power Plant Components—Heat Exchangers, Pumps, Valves, etc.; Experimental and Theoretical Heat Transfer and Fluid Flow; Analytical Development in Mechanisms, Applied Mechanics, and Stress Analysis.

NUCLEAR ENGINEERS We Will Train Graduate Mechanical, Electrical and Chemical Engineers with Analytical and Design Talents to Assume Capacities as Nuclear Engineers.

RADIO CHEMISTS To Perform and Supervise Analysis for Fission Products, Transuranic Elements and Other Activities.

NEW ATOMIC EDUCATION PROGRAM

1. Atomic Power Fellowship Program in conjunction with the University of Pittsburgh for selected engineers and physicists permits qualified personnel to obtain MS or PhD degrees, while receiving FULL PAY.

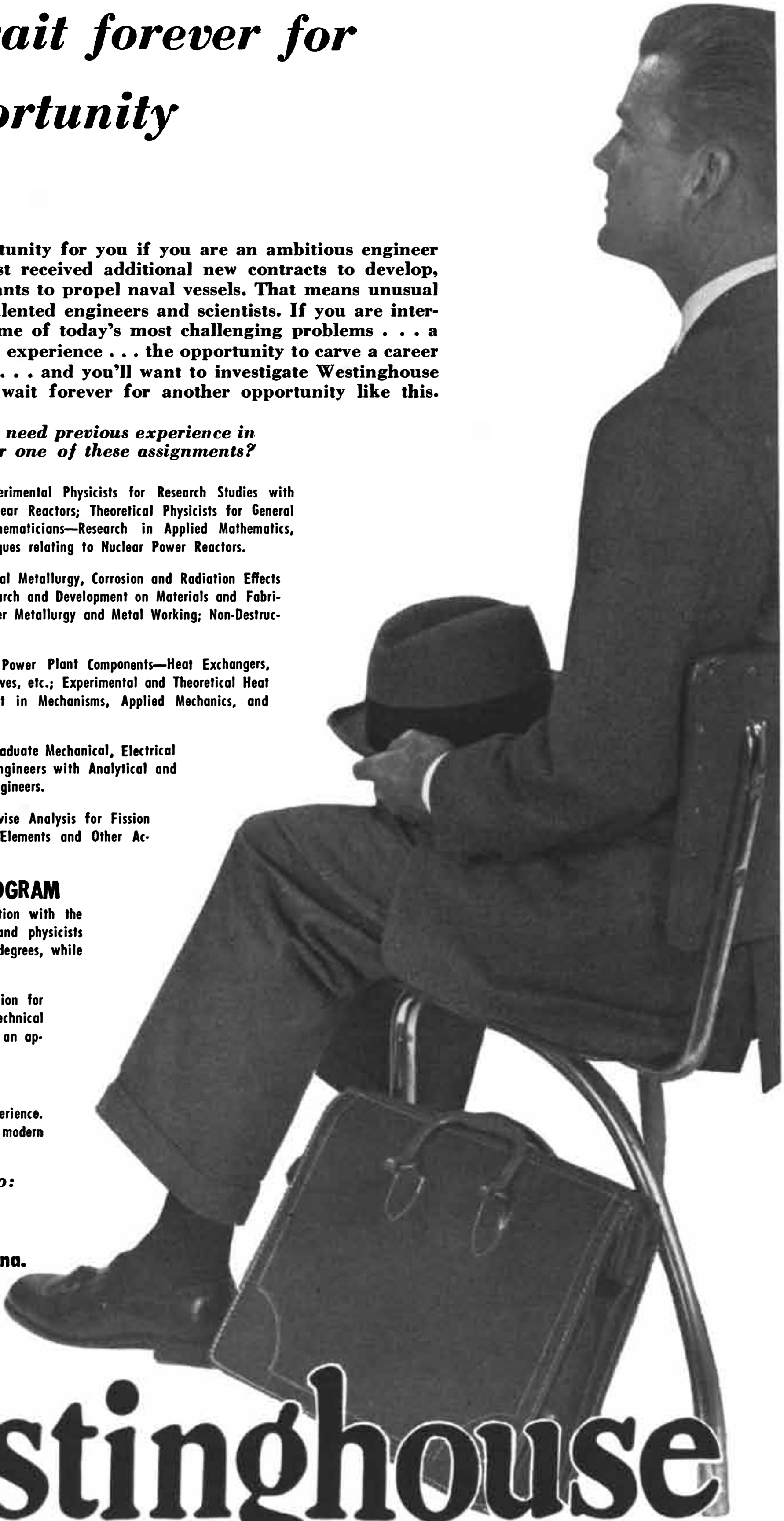
2. Westinghouse will also pay one-half of the tuition for part-time graduate courses completed for all technical employees. The other half will be refunded when an approved advanced degree is earned.

SALARIES OPEN

Starting salaries depend on your education and experience. Ample attractive housing reasonably priced in modern suburban community 15 minutes from plant.

Send Complete Resume Today To:

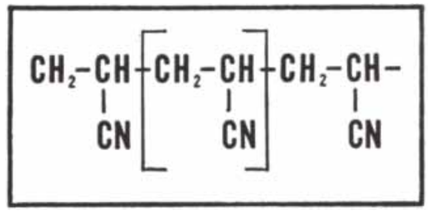
MR. A. M. JOHNSTON
WESTINGHOUSE BETTIS PLANT
P.O. Box 1468, Pittsburgh 30, Penna.



Westinghouse

First in Atomic Power

Life ...on the Chemical Newsfront



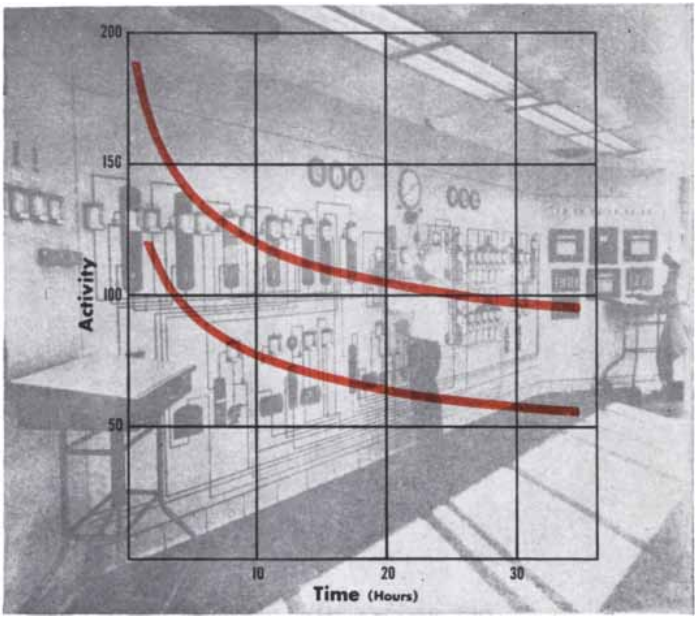
POLYACRYLONITRILE, ANOTHER NEW CHEMICAL, offers some interesting properties you may find worth-while evaluating. It is a white, free-flowing powder of extremely fine and uniform particle size, with a molecular weight of 130,000. Relatively heat stable, it is hard and is a good insulator. Polyacrylonitrile is insoluble in most solvents except highly active ones such as dimethylformamide, γ-butyrolactone, and ethylene carbonate. Although considered inert, polyacrylonitrile may be altered by modification of the nitrile groups through such reactions as hydrolysis or hydrogenation. If you see possibilities in polyacrylonitrile, let us send you a sample. **(New Product Development Department, Section A)**

Chemistry makes news in Cosmetics

NEW SHAMPOO FORMULATIONS that clean without depleting the scalp and hair of their natural oils can be compounded with Cyanamid's new AEROSOL® 22 Surface Active Agent. Detergency tests of AEROSOL 22 on wool show high removal of soil and low removal of oil. Additions of up to 20% of AEROSOL 22 to liquid detergents, such as triethanolamine lauryl sulfate and nonyl phenolethylene oxide condensates, reduce their drying or defatting action on the skin. A new bulletin on AEROSOL 22, containing suggested formulations and describing other applications, will be sent on request. **(Industrial Chemicals Division, Dept. A)**

THE FIRST PLASTIC AEROSOL DISPENSER is making news in the toiletries industry. Developed by Colt's Manufacturing Company, Hartford, Conn., in collaboration with Cyanamid, it is molded of Melamine Molding Compound 1077. Melamine allows precision molding to close tolerances with the necessary stability to hold its dimensions under pressure. The spray package is rigid, break resistant, corrosion resistant, light, convenient to fill and ship. It offers unusual design possibilities in any color. Only nonplastic component is a stainless steel spring activating the collet. **(Plastics and Resins Division)**

FEEDING OF AUREOMYCIN® Chlortetracycline to lambs and beef cattle from start to market helps prevent disease, produces healthier animals and promotes faster weight gains. Five years of extensive research at experimental stations shows that AUREOMYCIN Chlortetracycline lowers the incidence of disease, as well as mortality and morbidity. Two new AUROFAC® feed supplements, containing 1.8 milligrams of AUREOMYCIN Chlortetracycline, are being introduced through feed manufacturers to improve feeding programs. (Fine Chemicals Division)



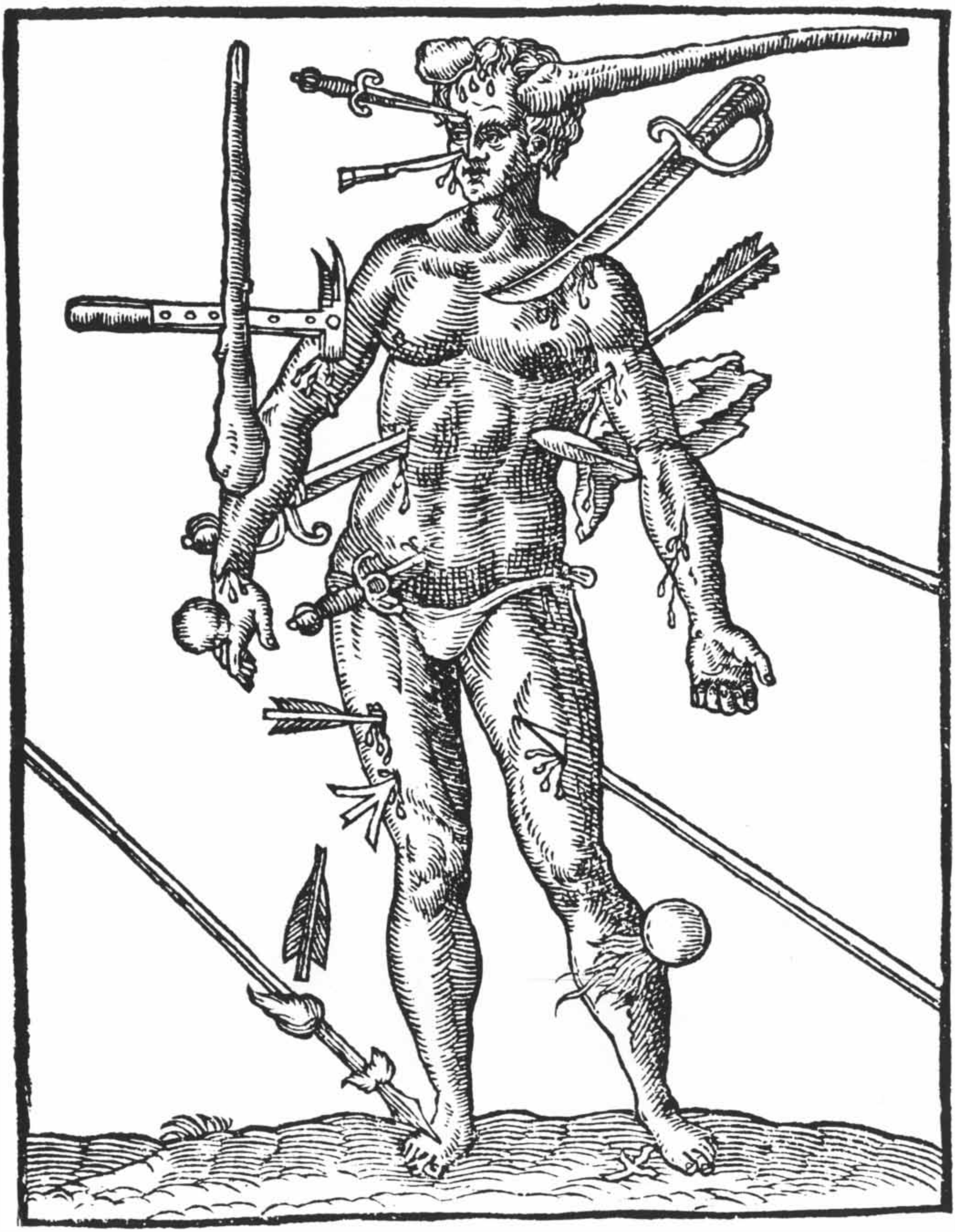
THIRTY-FIVE HOURS IN THE LIFE of two gasoline refining catalysts, tested at 1500° F under 1 atmosphere of steam, are charted above. The graph shows the greater thermal and steam stability of Cyanamid's new Hi PV* Catalysts (upper curve) over a catalyst in current use (lower curve). By increasing pore volume, in careful balance with pore diameter and specific surface, Cyanamid has given AEROCAT® Fluid Cracking Catalysts activity that stays high longer under conditions of refinery operation. Activity maintenance means high efficiency in gasoline production. Extensive experience with Hi PV Catalyst in refining units has demonstrated commercially these performance characteristics. (Industrial Chemicals Division, Dept. A)

*Trade-mark

GOOD PLASTICITY IS ACHIEVED in natural rubber with PEPTON® 65 Plasticizer, which permits mastication at low temperature. This newest addition to Cyanamid's extensive line of rubber chemicals allows a reduction of as much as 30% in the milling cycle while still imparting the desired plasticity. And where the milling cycle is held constant, the viscosity of the rubber is substantially reduced—an important performance feature in processing soft rubber for products such as blown sponge. (Organic Chemicals Division)

Building for the Future Through Chemistry

Additional information may be obtained regarding these products by writing on your business letterhead to the Division of American Cyanamid Company, 30 Rockefeller Plaza, New York 20, N.Y., indicated in the captions.



TORTURED HUMAN FIGURE appears in a 1617 English translation of Paré entitled *The Method of Curing Wounds made by Gunſhot. Alſo by Arrowes and Darts, with their Accidents.* The figure was used to describe various battle injuries discussed in the text.

Ambroise Paré

This 16th-century Frenchman was one of the founders of modern surgery. He spent most of his professional life on military campaigns, where he developed many of his humane skills in the treatment of gunshot wounds

by Sir Geoffrey Keynes

The extent to which an individual can influence the course of history has often been questioned, and it may be that in world affairs it is apt to be exaggerated. But in narrower spheres the importance of individuals is difficult to deny. In the history of surgery it is possible to point to a number of pioneers who shaped events literally with their hands. Outstanding among these is the figure of the 16th-century Frenchman Ambroise Paré. In the century of giants such as Raphael and Titian, Luther and Erasmus, Paracelsus and Vesalius, Paré was equally famous as the foremost surgeon of his time. He was the surgeon of kings and an idol of the common people. He was also one of the founders of civilized surgery—an innovator who introduced many practices which are in common use today.

His career reads rather more like that of a soldier than of a man of medicine. Paré was a military surgeon, a participant in the many wars between the kings of France and the Holy Roman Empire of Charles V, and most of his inventions in surgery were made on the battlefield. But he took care to record his adventures and discoveries in a series of books, and so his work became a part of the history of medicine.

Paré rose from a humbler origin than most of the other great figures of the Renaissance. Born in 1510 in a village of northwestern France, he was the son of a valet and barber. Following the example of an older brother and a brother-in-law, young Ambroise decided to become a barber-surgeon. This was the lowest grade of the medical hierarchy in 16th-century France, but it was the despised barber-surgeons who performed nearly all surgery, for the higher ranks of "surgeons" and physicians thought it degrading to use their hands. Lacking Latin and Greek, Paré could not aspire to admission to the medical profession, that is, election to the Faculty of Physicians of Paris or the Surgeons of the College of St. Côme. He therefore went to work, at the age of 22 or 23, as apprentice to a barber-surgeon in Paris, learning bloodletting, cupping and operations for cataract, hernia and gallstones.

His common sense and remarkable powers of observation soon won him an appointment as resident surgeon at the only public hospital in Paris, the Hôtel-Dieu. After three years he somehow attracted the attention of the Mareschal de Montejan, a colonel general of the army. Although Paré was still only an apprentice, de Montejan made him his staff surgeon. In those days there was no organized army medical service, the only doctors in the field being those attached to the person of a leading officer.

It was de Montejan's luck or foresight to create an opening for a young man who was to become one of the greatest military surgeons of all time. Paré soon realized that the accepted methods of treating the wounded were inhuman and inefficient, and he proceeded to introduce his own improvements.

It was generally believed that gunshot wounds were poisoned or infected by the gunpowder, and doctors customarily cauterized the wounds with "oil of elders scalding hot, with a little treacle mixed therewith." Aside from being extremely painful, the hot oil must have caused the death of tissues, thus helping to bring on the very complications it sought to avoid. Paré at first used the conventional treatment. One day, running out of oil, he substituted an unheated dressing made up of "digestive of the yoke of an egg, oil of roses and turpentine." "That night," he later related, "I was unable to sleep in peace. I thought that for lack of cauterization I would find the wounded poisoned to death, which made me rise in the very early morning to visit them." To his delight, he found the patients in much better shape than those who had been treated with hot oil.

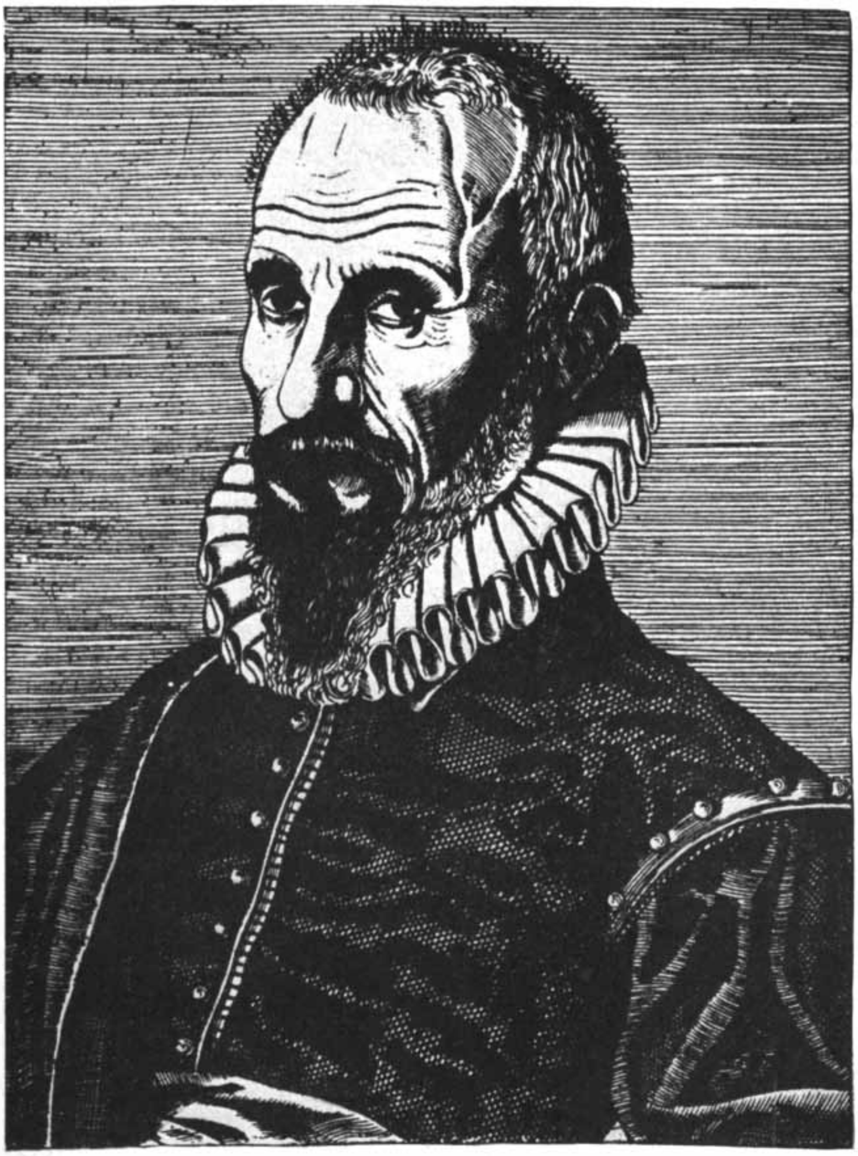
Paré's "digestive mixture" was clearly not antiseptic in the modern sense, but it at least formed a protective layer and led only to a mild formation of pus instead of the acute inflammation which followed the application of scalding oil. It was the beginning of the rational treatment of gunshot wounds. Paré experimented with other dressings and later described his discovery in his first book, *The Method of Curing Wounds Made by Gunshot.*

Paré's successful innovation, together with his humane attitude toward the sufferings of the soldiers, established his reputation as a military surgeon, and his services were in great demand. But when de Montejan died not long afterward, Paré was so overcome with grief at the loss of his commander that he left the army and returned to Paris. He resumed the study of anatomy so that he might at length pass the examination for admission as a qualified barber-surgeon. This he achieved in 1541, at the age of 31. He practiced surgery in Paris, married Jeanne Mazelin, a woman of the people, and acquired some property on the left bank of the Seine and in the country at Meudon.

Yet Paré did not stay settled in Paris. He shortly joined the Vicomte de Rohan in the siege of Perpignan, and for the next 30 years he pursued his career as a military surgeon, taking part in a series of campaigns which brought him ever increasing credit as a surgeon and a reputation for outstanding courage, common sense and honesty. During this time he was surgeon to four successive French kings—Henry II, Francis II, Charles IX and Henry III. Paré's adventures are recorded in a remarkably entertaining and historically valuable autobiography. He wrote it to reply to a jealous physician who had attacked his novel surgical methods; fortunately his enthusiasm so carried him away that the reply became a long account of his experiences, which he titled *Apology and Treatise Containing the Journeys to Diverse Places.*

At Perpignan Paré distinguished himself by removing from the shoulder of the Grand Master of Artillery a bullet which had baffled other surgeons. His method of locating the course of a bullet in the body was to place the limb in the exact position it had occupied at the time the victim was shot. It was during another campaign with the Vicomte de Rohan that Paré applied a history-making innovation in surgery which has ever since been associated with his name. To prevent bleeding after an amputation, surgeons usually applied a hot cautery to the cut ends of the main blood vessels, inducing the blood to clot. Any mild surface infection at the site of the wound, however, would loosen the clot, and many amputated patients bled to death from the reopened ends of the vessels. Paré adopted the simple device of tying off the ends of the vessels with linen thread—what is now known as a ligature.

Shortly after this campaign he was appointed a surgeon-in-ordinary to King Henry II. An appeal for his help soon came from the besieged city of Metz, where a French garrison was surrounded by a Spanish army. Nearly all the wounded in the city died, and it was thought that the medicaments being used to treat them might be poisoned. Paré made his way into the city through the Spanish lines with the help of a Spanish-speaking servant. After surveying the situation he concluded that the cause of the high mortality was the severity of the wounded's injuries, abetted by the extreme cold. He succeeded in saving many lives with skillful dressing of wounds and common-sense treatment.



ENGRAVED PORTRAIT shows Paré at 72. Born in 1510, he became a military surgeon in his twenties. In 1567 he was appointed *Premier Chirurgien du Roy* (first surgeon of the king).

The following year Paré was captured by the Spaniards at Hesdin in Picardy. He avoided being put to death on the battlefield by attaching himself, disguised as a servant, to a French nobleman who was considered an important prisoner by the Spaniards. The nobleman had suffered a bullet wound through the lungs. Paré knew that his patient was dying and feared that he would be blamed, so he was delighted when he was ordered to hand over the treatment of his charge to a Spanish charlatan. When the nobleman died, Paré was asked to embalm the body. He did this with such skill and so shrewd a display of anatomical knowledge that he was asked to enter the Spaniards' service under the Duke of Savoy. This he had the courage to refuse. Ultimately Paré regained his liberty by saving the life of another wounded nobleman.

During his service under Charles IX of France, Paré performed one of his less creditable experiments. A substance known as "bezoar stone"—a calcium growth which sometimes forms in the intestines of goats and other ruminant animals—was supposed at the time to be an almost magical antidote to all poisons. Paré, who refused to believe this, was challenged to prove that bezoar stone was ineffective. He accepted the challenge and chose as the subject of his experiment an unfortunate cook who was to be hanged for the theft of two silver plates. The cook was given corrosive sublimate, followed by the useless bezoar, and died in great agony. Paré performed a triumphant post-mortem examination which proved that the bezoar had failed to counteract the effects of corrosive sublimate.

Between military campaigns Paré pursued his studies of anatomy in Paris. For these he used the body of an executed criminal, of which he dissected only one side. He claimed to have kept this half-dissected corpse for more than 27 years, but gave no details of his method of preservation. Working with

SCIENCE AND ENGINEERING

AT LOCKHEED MISSILE SYSTEMS DIVISION

THE OPERATIONAL APPROACH TO RELIABILITY

Reliability is the root of operational effectiveness, seeking out and solving failure before it occurs. The end result of Reliability is a missile system able to perform its mission successfully at a time dictated by military necessity.

To achieve that high standard, scientists and engineers at Lockheed Missile Systems Division apply an operational approach to Reliability in all phases of missile systems research, development and operation.

Under the Lockheed philosophy of Reliability, scientists and engineers combine their talents to study:

Human factors; training; design and operational safety; ground support and maintenance systems; airborne systems reliability; statistical methods; components application, including electronic, electrical, electromechanical and mechanical systems and environmental conditions.

Those possessing a high order of ability applicable to these areas of endeavor are invited to write:

Dr. Richard R. Carhart, Carl D. Lindberg, Reliability Staff Dept. Engineer, and Dr. O. B. Moan evaluate the functional and operational reliability effects of proposed revisions in the electrical power supply of a missile.

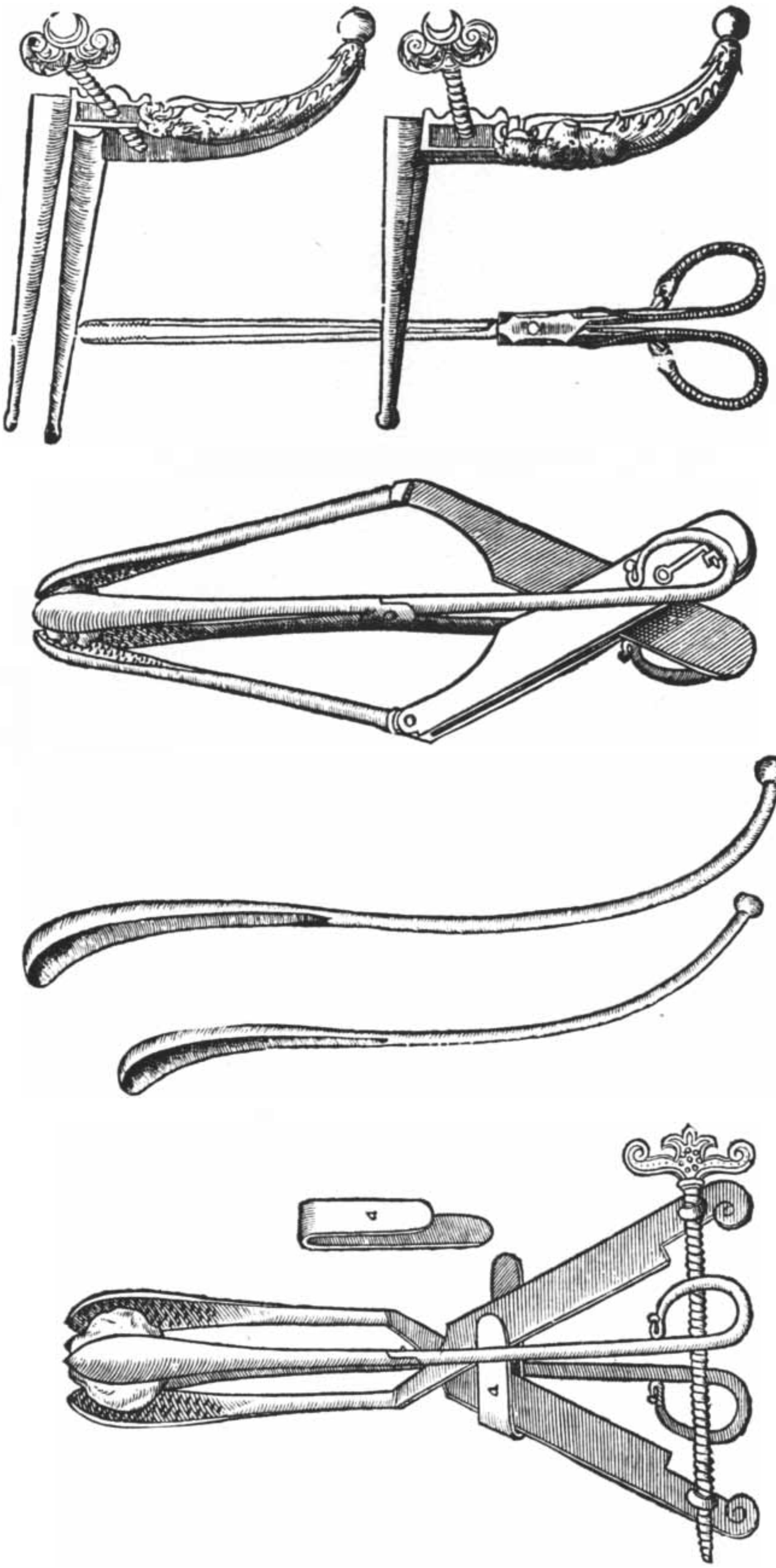
Lockheed

MISSILE SYSTEMS DIVISION

research and engineering staff

LOCKHEED AIRCRAFT CORPORATION

VAN NUYS, CALIFORNIA



SURGICAL INSTRUMENTS were depicted in Paré's many books. The long device at the top, called a "crane's beak," was used to remove bullets. Superimposed on it are two views of a "swan's beak," through which it was inserted. Second from the top and at bottom are tools for the removal of larger projectiles. Between them are curettes to scrape blood clots.

his friend, Thierry de Héry, Paré published a small treatise on anatomy in 1549, six years after his great contemporary Vesalius had published the famous *Fabrica*. Paré's treatise could not have owed much to the *Fabrica*, since the barber-surgeon was ignorant of Latin. The most important section of his book was an appendix on obstetrics and gynecology. It is plain to any medical reader of this section today that Paré must have based it on a great deal of firsthand experience and observation.

In the course of a chapter on surgical extraction of a child from the womb "whether dead or alive," Paré almost casually reported an obstetrical discovery of the first importance. He described a procedure for turning the fetus by drawing down the feet so that it can be extracted without injury to the mother. This maneuver, now known as "podalic version," is one of Paré's greatest contributions to medical practice.

Paré's reputation in Europe eventually became so outstanding that the physicians and surgeons of Paris elected him to their faculties without the usual examinations or fees, in spite of his lack of Latin and Greek. He went on publishing books, of which his most important was *Five Books of Surgery*, retired from military campaigns, and spent most of his time working in Paris, with the title of "premier surgeon of the King." Paré was encouraged by this title to attempt to gain personal control over all the surgeons working in France, but this met with defeat.

In 1573 Paré's wife died. She had borne him three children, only one of whom, a daughter, survived to adult years. Though now 64, Paré soon married again, and his second wife, Jacqueline Rousselet, bore him six more children. Two of them were boys, but both died in infancy.

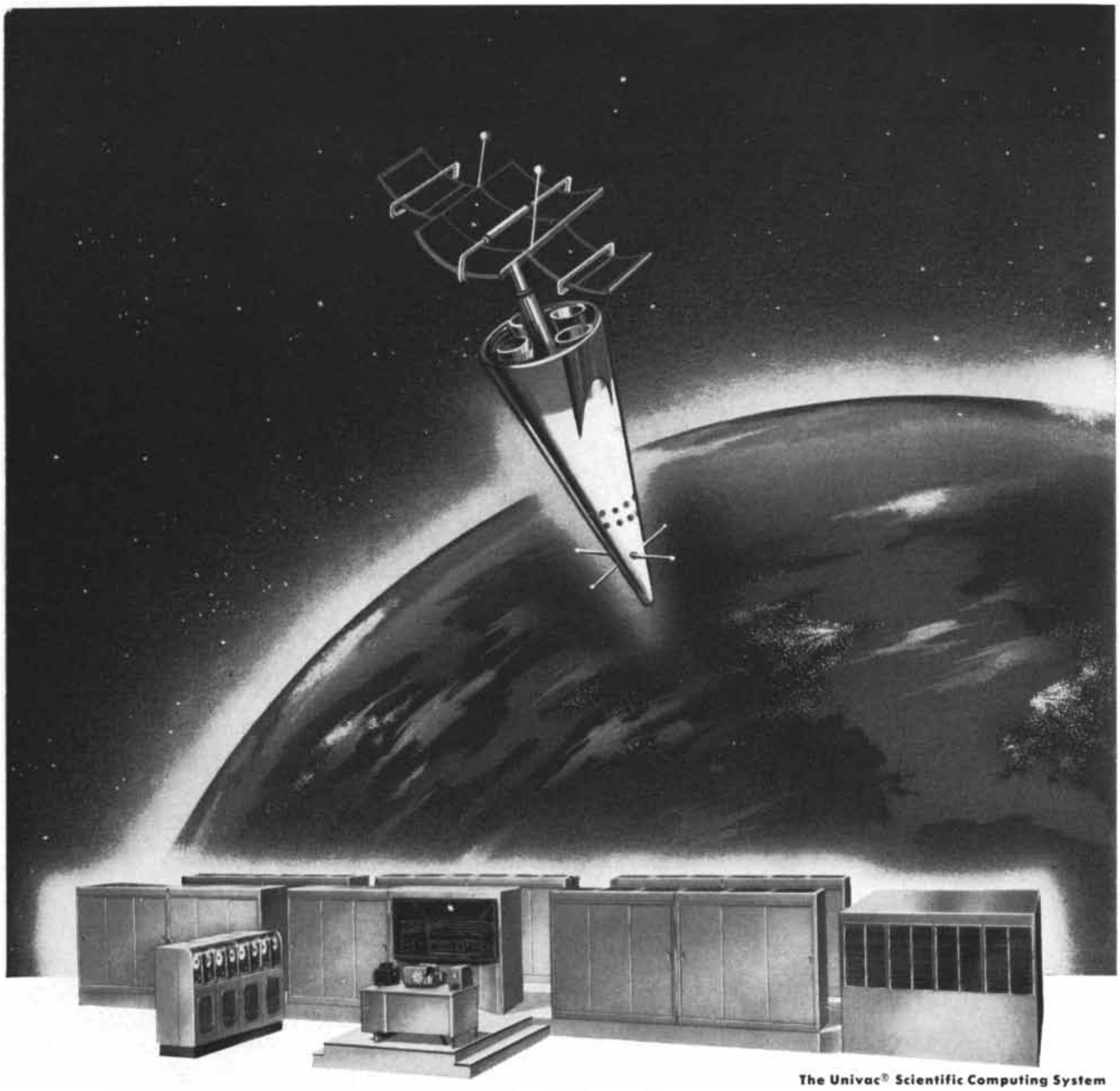
In 1575 he brought together all his writings and published them in a single volume, the *Collected Works*. The learned physicians and surgeons of Paris, still jealous of him though they had elected him to their company, saw an opportunity to attack in the fact that the *Oeuvres* were not written in Latin; Paré replied briefly in a published note that Hippocrates, the father of medicine, also had written in his own language. Not handicapped by false modesty, the great surgeon knew that his book was the most enlightened surgical work ever published up to that time. During his lifetime three more editions of his work were published, and it was translated into Dutch, German and Latin. His splendid book was so full of improve-

ments in the theory and practice of surgery that it remained the leading authority on the subject throughout Europe for many years.

Paré's contributions were not confined to surgery. He invented instruments for extracting bullets and arrowheads from wounds, for holding open the mouth of a person suffering from lockjaw so that he could be fed, for extracting teeth. He was the first to suggest the reimplantation of teeth knocked out of the jaws. He introduced the use of artificial limbs and popularized the use of trusses for hernia. He presented original medical descriptions of congenital "monsters," such as Siamese twins. He was even responsible for the first important work on medical jurisprudence.

Paré passed the last 15 years of his life living quietly in Paris. But at the age of 80 he emerged from seclusion for one final act on behalf of the common people from whom he had sprung. The city, in rebellion against the King of Navarre, was being besieged and its citizens were dying of famine. They wished to surrender, but the city's commander, the Archbishop of Lyons, answered their demands with bloodshed. Paré rose to protest against the commander's cruelty. Because of his great prestige, his plea for a peaceful settlement prevailed. Paré died soon afterward, on December 20, 1590, and he was buried in the Church of Saint André des Arts.

FETUS in the uterus was depicted by Paré. He devised a procedure, still in use today, by which the fetus could be turned and extracted without serious injury to the mother.



The Univac® Scientific Computing System

Launching Tomorrow's Satellite

When the first man-made satellite is launched on its orbit around the earth, it will owe its existence to the thousands of missiles which have preceded it, and to the careful analysis of their patterns of flight. The Univac Scientific of Remington Rand has speeded this effort immeasurably, handling flight analyses for the nation's guided missile program.

Each missile firing, each analysis, involves enormous amounts of in-flight data, with manual computations normally requiring from 250 to 500 hours. This staggering work load is accomplished by the Univac Scientific Electronic Computer in approximately *4 to 8 minutes*.

Because of its ability to reduce large volumes of data at tremendous speeds, the Univac Scientific System easily handles even the most difficult research problems. Its speed is matched by many other outstanding characteristics, including: superb operating efficiency, obtained through large storage capacity . . . great programming versatility . . . the ability to operate simultaneously with a wide variety of input-output devices . . . and far greater reliability than any computer of its type.

For more information about the Univac Scientific System or for information about how you might apply the system to your particular problems, write on your business letterhead to . . .

ROOM 1117, 315 FOURTH AVE., NEW YORK 10 **Remington Rand Univac**
DIVISION OF SPERRY RAND CORPORATION

The Sargasso Sea

It is commonly supposed that this area of the Atlantic is so thick with seaweed that ships cannot penetrate it. Although it is indeed strewn with floating Sargassum, it is actually a biological desert

by John H. Ryther

For more than four centuries the Sargasso Sea has been wrapped in a legend which has frightened mariners and still fascinates armchair travelers. The seaweed to which the sea owes its name has always given it an aura of uniqueness and mystery. Early voyagers in it pictured the sea as a vast, impenetrable mass of floating vegetation in which hapless ships might become imprisoned with no hope of ever escaping. The legend still lives. As recently as 1952 Alain Bombard, the French physician who crossed the Atlantic alone in a life raft, carefully plotted his course to avoid the Sargasso Sea, because, as he said: "The whole area has always been a major navigational hazard, a terrible trap, where plant filaments and seaweed grip vessels in an unbreakable net."

Ship captains who regularly cruise to Bermuda, which lies in the middle of this sea, must smile at such accounts. Yet the Sargasso Sea remains an intensely interesting body of water, in many ways more interesting than the romantic but mistaken legends about it. Generations of scientists have sailed forth to study it, and the Sea has rewarded them with many unexpected discoveries. Most unexpected of all is the paradox that the Sargasso's masses of seaweed hide a biological wasteland. Contrary to what the floating vegetation might suggest, the Sargasso Sea is not a jungle teeming with life but one of the great oceanic deserts of the earth.

Christopher Columbus noticed the unusual plant life of these western waters on his first voyage across the Atlantic in 1492. He began to encounter floating seaweed not far west of the Azores, and by the time he reached mid-ocean there was "such an abundance of weeds that the ocean seemed to be covered with them." When the ship was becalmed for three days, his men grew alarmed, for they feared that the masses of vegetation covered coastal waters with submerged rocks and reefs—little realizing that the ocean bottom lay nearly three miles below them.

Columbus described the weeds in some detail in his log, and later explorers brought back further tales of these strange waters. Portuguese sailors gave the sea its name: air bladders on the floating seaweed reminded them of small grapes at home which they knew as "salgazo." Through the centuries the legend grew, as ship captains traveling between the Old World and the New reported encounters with the greatest accumulations of weeds they had ever seen. The legend became so firmly established that in 1897 the Sargasso Sea was described by the *Chambers' Journal for Popular Literature, Science and Arts* in these terms: "It seems doubtful whether a sailing vessel would be able to cut her way into the thick network of weeds even with a strong wind behind her. With regard to a steamer, no prudent skipper is ever likely to make the attempt, for it certainly will not be long before the tangling weeds would altogether choke up his screw and render it useless."

When William Beebe sailed on the much-heralded expedition of the *Arcturus* in 1925, the reading public was keyed up by lurid predictions of sea monsters that would be found in the great weed beds of the Sargasso. The expedition was an unbelievable disappointment. Not only was there a total absence of sea monsters, but in all the area of the Sargasso Sea over which he voyaged Beebe could find no patches of seaweed larger than a man's head!

Beebe was unlucky. The Sargasso Sea is rarely as barren as he found it along his route. Nonetheless scientists have known for a century that its reputation is greatly exaggerated. It is doubtful that the Sargasso's weed masses are ever dense enough to impede the progress of even the smallest vessel. And indeed the floating *Sargassum*, though intriguing enough in its own right, is no more than a surface outcrop of a great oceanic phenomenon.

What exactly is the Sargasso Sea? The scientific study of this huge sea without shores began with attempts to define its borders by charting the extent of the seaweed. In 1881 the German scientist O. Krümmel analyzed the reports of German sea captains, who for many years had been required to record their observations of drifting weeds in the Atlantic. He concluded that the Sargasso Sea covered an area of some 1,720,000 square miles—an area elliptical in shape and extending from the mid-Atlantic to near the North American coast.

In 1923 a Danish botanist, O. Winge, made a second attempt at the same problem. He had the advantage of information on regular collections of seaweed made with net tows by Danish ships plying the Atlantic, which gave more systematic data than the estimates of the German sea captains. Winge decided that the Sargasso Sea was considerably bigger than Krümmel had pictured it. He placed its eastern boundary near the Azores (at exactly the point where Columbus had located the first weed masses) and its southern boundary somewhere near the West Indies. The western and northern borders of the weed area, he found, shifted considerably from season to season; this he attributed to changing weather conditions.

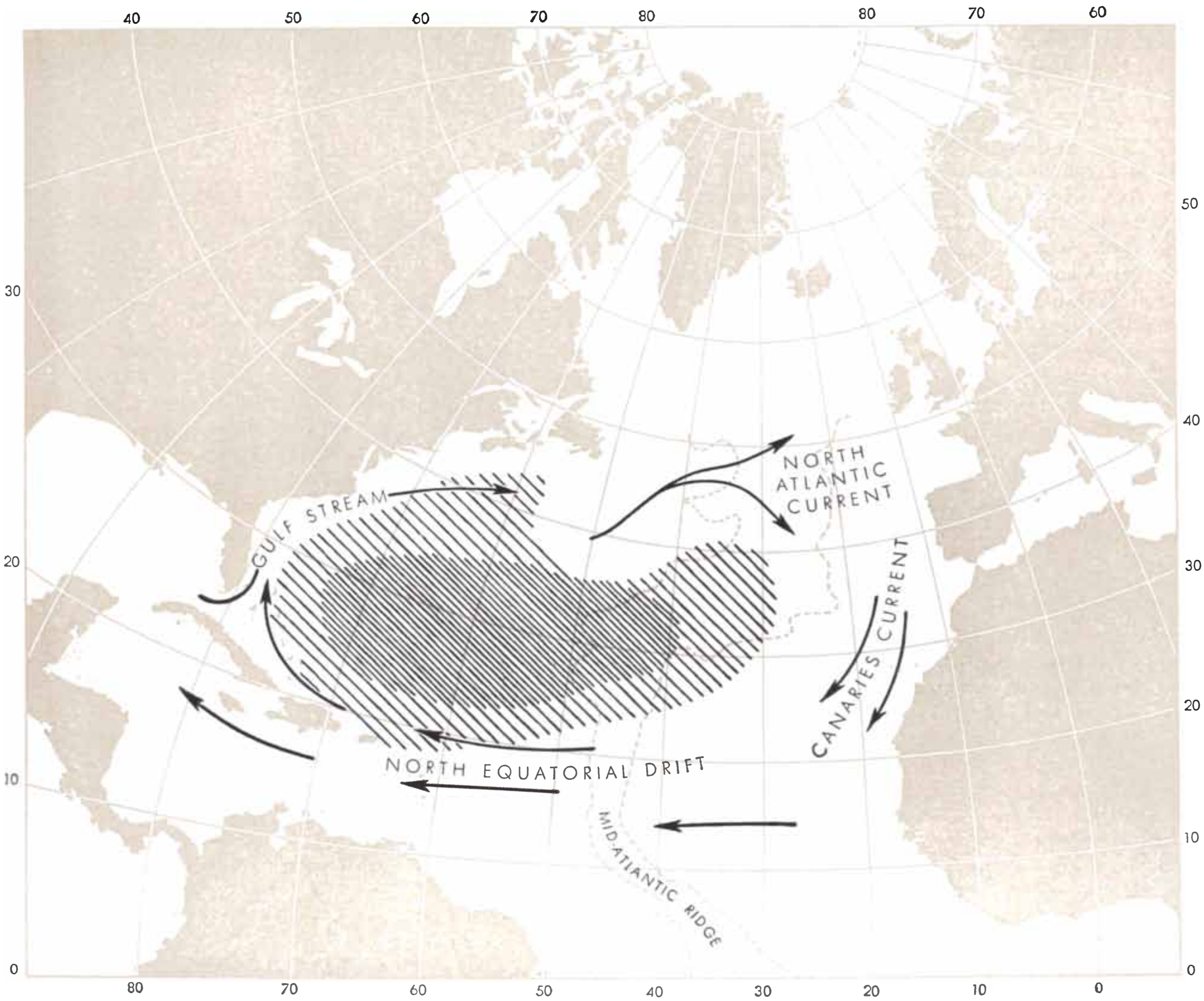
In the 1930s and 1940s oceanographers made an altogether different approach to defining the Sargasso Sea. Columbus O'Donnell Iselin, then director of the Woods Hole Oceanographic Institution, pointed out that the circular system of currents in the North Atlantic Ocean would outline the boundaries of the Sargasso Sea more definitely than drifting seaweed could. These currents are the Gulf Stream and North Atlantic Current on the western and northern sides, the Canaries Current on the eastern side, and on the south the slow movement of water parallel to the equator which is known as the North Equatorial Drift. This ring of currents encloses a great eddy, some two million square miles in area, which rotates slowly clockwise under the influence of the earth's rotation. Detailed studies have now made clear that this eddy of surface water is the Sargasso Sea.

Because of variations in the currents, the borders of the Sea are not constant or sharply defined. The Gulf Stream shifts and meanders, hence it is small wonder that Winge found the weed boundaries shifting in this region. On the south the equatorial drift also changes position from season to season. And on the east the Canaries Current is so weak and diffuse that it can barely be detected, much less provide a barrier to the movement of water or seaweed.

We must therefore look below the surface to get a clearer picture of the Sargasso Sea. When we do, we find that temperature measurements mark out a distinct, clearly defined body of water. The Sargasso Sea is a huge lens of warm water, separated from the colder layers below by a zone of sharply changing temperature.

It is lens-shaped because the rotation of the eddy piles up water at the center (where the sea surface is about two feet higher than at the outer edges). At its deepest the layer that defines the Sargasso Sea goes down no more than about 3,000 feet. In other words, the Sea proper is a shallow body of fairly homogeneous water lying upon an ocean whose total depth is roughly five times as great as this layer. Tracing the borders of the lens by temperature measurements, oceanographers find it is bounded on the west and north by the Gulf Stream and North Atlantic Current, on the south by the equatorial drift and on the east roughly by a line which runs along the submerged mountain ridge in the middle Atlantic. The Sargasso's seaweed drifts almost 1,000 miles farther east, but from a hydrographic point of view the lens of water that defines the Sea ends here.

What makes the Sea's weeds collect in masses? Most commonly they lie in long parallel bands, sometimes stretching as far as the eye can see. Some of these formations undoubtedly are due to the major current systems, piling



CIRCULAR SYSTEM of currents in the North Atlantic outline the Sargasso Sea. The darker shading represents the Sea as charted by O. Krümmel on the distribution of *Sargassum*. The lighter shading indicates a similar attempt made by the botanist O. Winge.

bands of weeds along the lines where water masses of different densities converge. But winds also can produce them. Winge reasoned that such bands might grow by accumulation as weeds sailed before the wind, picking up more and more weeds in their wake. However, the physicist Irving Langmuir, on a voyage across the Atlantic in 1927, noticed that when the wind veered about at right angles to its former direction, the seaweed bands re-formed in the new direction within 20 minutes. Since mere cohesion could not explain this rapid reorientation of weed streamers, Langmuir suggested that shifts in the flow of water, rather than the wind itself, must be responsible for the formation of the bands. He later demonstrated experimentally that the action of wind over open fetches of water produces counter-rotating eddies, and that between such eddies there are bands of sinking water where floating weeds would collect.

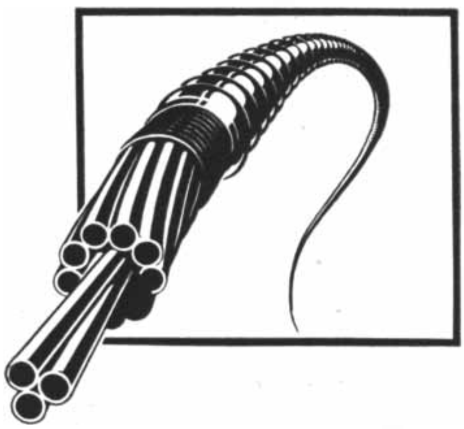
The Sargasso weeds themselves raise many interesting questions. The most intensive study of them was carried out between 1932 and 1935 by Albert E. Parr, then director of the Bingham

SARGASSUM FLUITANS, one of perhaps eight species of the weed, was collected in the Sargasso Sea by Albert E. Parr, then at the Bingham Oceanographic Laboratory at Yale University and now director of the American Museum of Natural History.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Copper tube is used for hot and cold water lines, radiant panel heating, drainage lines, and to carry fuel or lubricants in automobiles and machine tools. Those are some of the conventional applications. However, during the last few years a new market has developed for this tube. You might like to hear about it. It is in pneumatic or hydraulic recording and control systems. One end of the tube is located at the point where temperature or pressure must be observed, and the other end is connected with a dial, a recording device, or an automatic controller. The tube may be filled with air, an inert gas such as nitrogen, or a fluid. The tube has the great advantage that it carries no electricity, and thus can be installed in places where a spark might cause an explosion, as in a plant handling combustible gases or chemicals.



Originally the idea of using copper tube for this purpose was carried out by running separate lengths of bare tube from the originating points to the panel board. This meant considerable care in installation, and it was also necessary to run the tube where it would not be subject to mechanical damage, or to protect it otherwise. Then a new development appeared: cabled tube. A way was found to put as many as 19 quarter-inch copper tubes in a single armored cable, so that instead of rigging 19 separate runs of tube, just one cable is run, the tubes being fanned out at each end as required. Installation time is cut markedly, and the armor provides self-protection. Cable runs as long as 1,000 feet are possible without joints. The tubes are color-coded.

Just to give you an idea of the usefulness of tubes in cables, here are a few of the applications in the plant of just one public utility: boiler temperatures, main and reheat steam pressure, boiler feed and condensate pump pressure, condensate temperature, fuel oil and gas pressures, liquid levels, tide level, boiler drum water level, control of fuel feed, draft dampers, and numerous other controls.

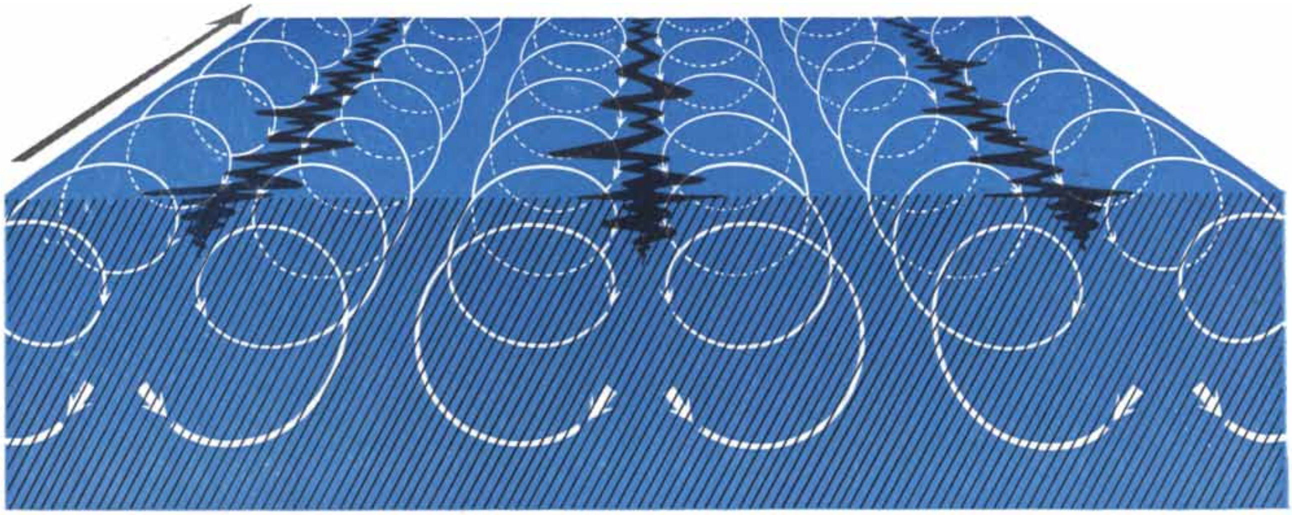
This is a fast-growing use for copper tube, and while it will not match the demand for tube in commercial structures and private homes, nevertheless it is an important subject for industry and instrumentation engineers. In fact, a couple of years ago we thought that cabled tube had enough news interest to justify running an advertisement about it. Revere does not make cabled tube, but a Revere customer does, so we reported the matter as a service to industry. Mail began to arrive immediately, asking for further information. It is still pouring in, as the result of a second advertisement on the subject, appearing less than a year ago. American business certainly watches the advertisements for news it can use.

This is an example of imagination applied to a product that literally is as old as the pyramids. We have said in the past that "copper is the metal of invention," because it is so adaptable to man's genius. But there are many other materials, not merely metals, but such substances as glass, wood, plastics, fabrics and fibres, that also respond to an inspired touch. Why not get in touch with your suppliers, and let them know your problems? Perhaps they can arrive at a new way to use an old product, or even develop something new to solve an old problem. Just let it be known what you need, and watch people respond!

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

***Executive Offices:* 230 Park Avenue, New York 17, N. Y.**

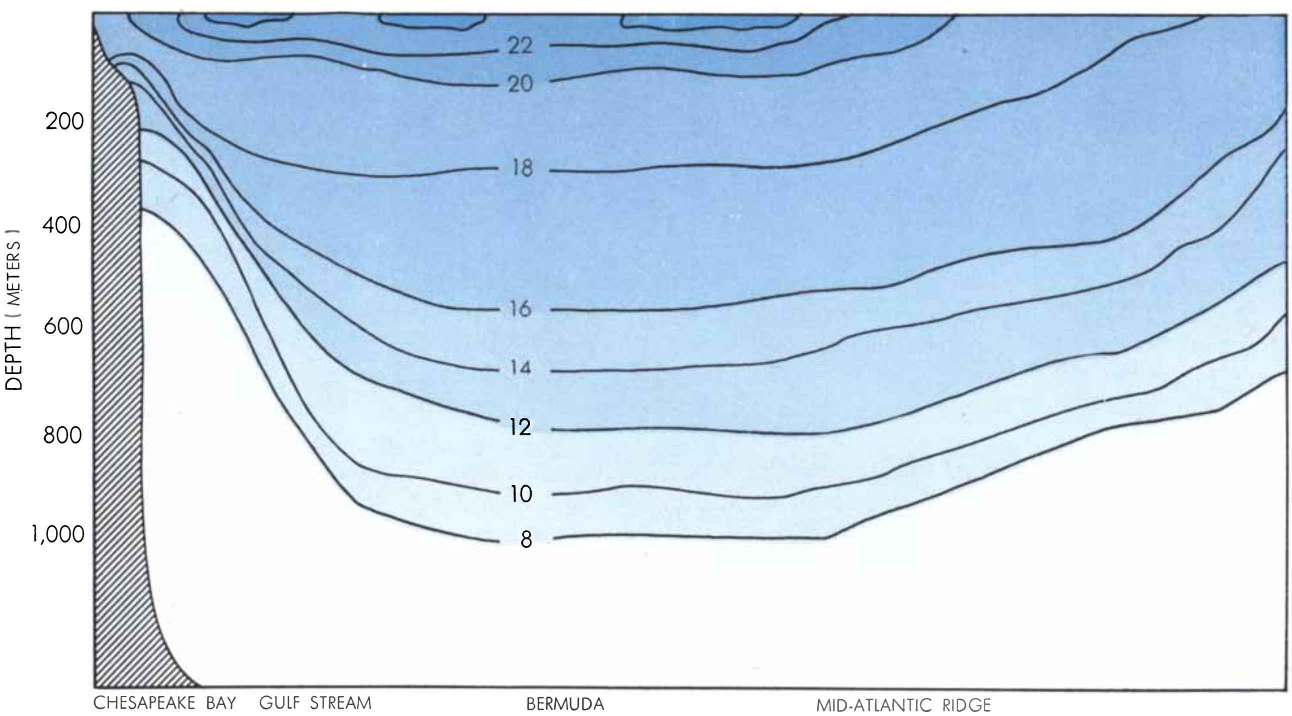


LANES OF SARGASSUM (*dark gray bands*) are believed to form as shown in this diagram. The drag of the wind (*arrow at upper left*) on the surface of the water sets up counter-rotating horizontal eddies (*white arrows*). The weed collects where the water sinks.

Oceanographic Laboratory at Yale University. In three cruises on the Woods Hole research ship *Atlantis*, covering 7,000 miles, he collected nearly 5,000 pounds of drifting Sargassum. More than 90 per cent of the weeds by bulk were of two floating species which are never found attached to the ocean bottom and lack organs for sexual reproduction. The question therefore arises: Where do the weeds come from, and how do they grow and reproduce?

Columbus theorized that the drifting weeds were torn loose from great submerged beds of plants near the Azores, and his theory was later shared by Alexander von Humboldt and other naturalists. But no such beds have ever been found, either near the Azores or Bermuda. Some botanists consequently have proposed that the weeds come from banks in the West Indies or the Gulf of Mexico. This theory too has been proved unlikely. From his sampling of the Sargasso Sea, Parr estimated that the Sea has an average standing crop of some seven million tons of weeds. No more than a small fraction of this crop could be supplied by all the available sites for beds along the entire Caribbean and Atlantic Coasts, even assuming that such beds exist. Moreover, it would probably take several years for weeds torn loose from the West Indies to drift far enough to span the whole Sargasso Sea, and weeds uprooted from their beds could not live more than a few months.

The floating Sargassum gives every evidence of growing, reproducing and



TEMPERATURE of the Atlantic is analyzed in this cross section along a line running due east from Chesapeake Bay. The contours, in degrees centigrade, indicate that the Sargasso Sea is a lens-shaped body of warm water. The vertical dimension is greatly exaggerated.

Hughes-equipped T-29 "flying laboratory" for systems evaluation.

Flight evaluation of advanced interceptor electronic system uses unique approach.

T-29 "INTERCEPTOR"

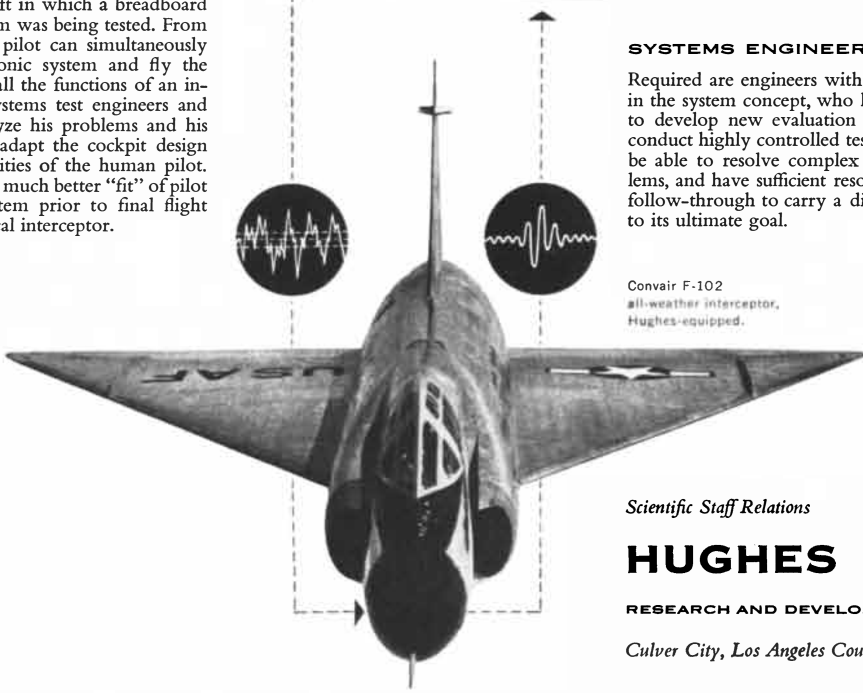
THE DEVELOPMENT OF AIRBORNE ELECTRONIC SYSTEMS REQUIRES THOROUGH FLIGHT EVALUATION OF BREADBOARD AND PROTOTYPE EQUIPMENT PRIOR TO FINAL DESIGN. AT HUGHES, SYSTEMS FOR INTERCEPTORS ARE FIRST TESTED IN "FLYING LABORATORIES" IN WHICH THE EQUIPMENT IS READILY ACCESSIBLE TO SYSTEMS TEST ENGINEERS.

One interesting problem recently confronting Hughes engineers was that of evaluating the requirements imposed upon the pilot of a high-speed one-man interceptor. This arose in the development of a new integrated electronic system to control several phases of an all-weather interceptor's flight. Because of the great importance of providing the pilot with the optimum design and arrangement of displays and controls, it became necessary to determine accurately the pilot's work load during flight, and the human factors that affect his ability to carry out his task.

The solution was to install a complete mock-up of the actual interceptor cockpit in a large T-29 aircraft in which a breadboard model of the system was being tested. From this cockpit a test pilot can simultaneously operate the electronic system and fly the T-29, performing all the functions of an interceptor pilot. Systems test engineers and psychologists analyze his problems and his performance, and adapt the cockpit design to the natural abilities of the human pilot. The result will be a much better "fit" of pilot and electronic system prior to final flight testing in the tactical interceptor.

SYSTEMS ENGINEERS

Required are engineers with a basic interest in the system concept, who have the ability to develop new evaluation techniques and conduct highly controlled tests. They should be able to resolve complex circuitry problems, and have sufficient resourcefulness and follow-through to carry a difficult program to its ultimate goal.



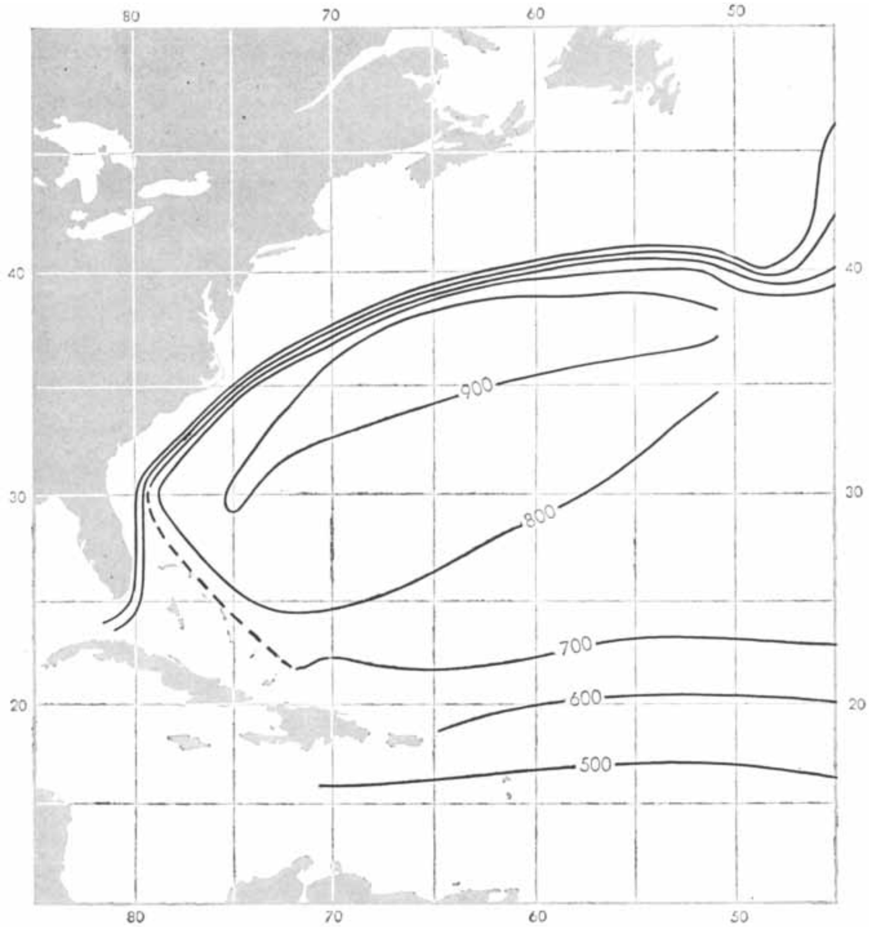
Convair F-102 all-weather interceptor, Hughes-equipped.

Scientific Staff Relations

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California



PLAN VIEW of the same Atlantic temperature structure again outlines the Sargasso Sea. Here the contours represent the depth in meters at which 10 degrees C. is encountered.

living an independent life in the Sea where it is found. It has a healthy color and shows new leaves and vigorous young shoots. For this reason and because of the absence of sexual fruiting bodies in the prevailing species, many oceanographers now favor the theory that the great bulk of the seaweed in the Sargasso Sea is native to the Sea itself. Its forebears may originally have come from beds on the bottom, but it has now evolved the ability to live a free, floating existence on the surface of the Sea. It can reproduce vegetatively—that is to say, by putting forth shoots which eventually break off as new plants.

Seaweed is not the only plant life in the Sargasso Sea. Like other seas it contains a subsurface floating population of the microscopic plants known as plankton. This material bulks much larger than the seaweed: estimates of the plankton production in the Sargasso range from 10 million to 100 million tons per day. Such a figure may seem huge, but it is small when one considers the vastness of the Sargasso. It amounts to something of the order of five hundredths of a gram of organic carbon per day for each square yard of the Sea's surface.

The Danish botanist Einer Steemann Nielsen, during a recent cruise of the research ship *Galathea*, made sample measurements of the plankton production in all the major oceans of the world. He found that the Sargasso Sea had the poorest production rate of all—only about one third of the average.

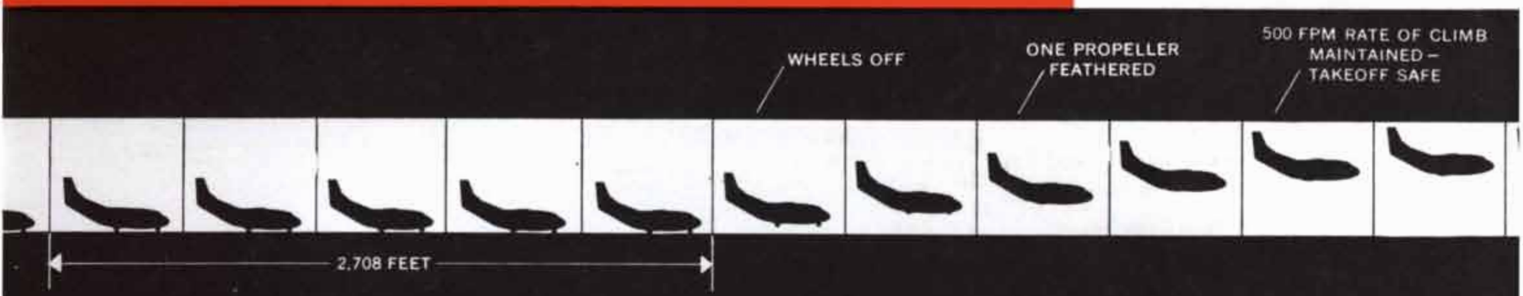
Here is the odd paradox. In spite of its show of life on the surface, the Sargasso Sea is in reality the most barren of waters. Alain Bombard was not far wrong when he wrote of the Sargasso as "a great dead expanse." The best evidence of its low biological content is the extreme clarity of its dark-blue waters.

There is a possibility that below the top 100 feet these clear waters, where sunlight can penetrate for an unusual distance, may contain more plant life than appears near the surface. But even allowing for this possibility, there can be no doubt that volume for volume the Sargasso Sea is the clearest, purest and biologically poorest ocean water ever studied.

C-123 TURBOJET COMBINATION PROVES OUTSTANDING

MISSION: Combat Test Problem
WEIGHT: 13,000 lbs. Overload
TAKEOFF CONDITION: Power Failure
RESULTS: Successful

NUMBER 7 OF A SERIES



In a recent test for the U. S. Air Force, the Fairchild C-123 proved the value of thrust assist in meeting emergency single engine conditions!

A C-123 was equipped with two Fairchild J-44 jet engines and loaded to achieve gross weight of 66,742 pounds – *13,000 pounds overload.*

During takeoff and climb, both jets were operated to provide 2,000 pounds continuous thrust in addition to the two piston engines. At 2,708 feet, wheels were off the ground, and a moment later at a speed of 122 knots, one propeller was feathered!

From this takeoff position, the C-123 climbed out at 500 feet per minute – proving again its *big job capability and assault versatility,* heightened by jet augmentation to give extra power and extra safety in any emergency.

A Division of Fairchild Engine and Airplane Corporation

WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN, MARYLAND

A colorful need . . . a colorful

plastic

When the need is for color — any conceivable color — you'll always find Tenite plastics among the first materials considered.

For example, Tenite Butyrate is used for the new color telephones being made by Western Electric Company for the Bell Telephone System.

This Eastman plastic offers all the properties needed. In Tenite, an unlimited range of colors is available — durable colors that won't chip, peel or wear off. And tough Tenite Butyrate more than meets the mechanical requirements for strength, impact resistance and dimensional stability.

One of the lightest of plastics, Tenite Butyrate means a telephone that is almost featherweight, while its low heat conductivity makes it pleasantly warm to the touch.

Tenite Butyrate stands up well in use, too. It is practically unbreakable and does not corrode.

Use of this Tenite plastic also means important production economies. These telephones are molded at exceptionally fast speeds. The Tenite Butyrate parts come from the molds with smooth, hard surfaces and natural high luster.

Does this use of Tenite Butyrate suggest a solution to one of your own material selection problems? We will be glad to help you or your molder evaluate Tenite Acetate, Tenite Butyrate or Tenite Polyethylene. These versatile, colorful Eastman plastics may improve the appearance, the performance, or the life of some product you make, while cutting its cost. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE

ACETATE · BUTYRATE · POLYETHYLENE

plastics by Eastman

The Library of Science

Invites You To Receive As a Membership Gift Any One of These Extraordinary Two-Volume Sets

Because these sets may be so important to the work and thinking of readers of *Scientific American*, the LIBRARY OF SCIENCE will send you as a gift the set you choose, as a concrete demonstration of the benefits of membership. The LIBRARY OF SCIENCE is playing an increasingly valuable role in the work of many of your colleagues who receive, at substantial savings, the books of enduring value reflecting the unity of all the sciences. Members need take as few as 3 more Selections in the next 24 months—out of approximately 30 fine volumes available. Reduced member's prices and free books of your choice with every fourth Selection taken effect savings up to forty per cent.

You are invited to enroll in the LIBRARY OF SCIENCE and choose your first Selection below. With it you receive entirely free the two-volume set of your choice—as much as $16.00 worth of books for as little as $3.95. You may discontinue membership at any time after taking your first four selections.

The monumental new two-volume

INTERNATIONAL ENCYCLOPEDIA OF UNIFIED SCIENCE

Thirteen of the most distinguished scientific figures of our time demonstrate the logical structure common to all the sciences and integrate scientific knowledge and methodology. Among the contributors: Niels Bohr, Bertrand Russell, Rudolf Carnap, Ernest Nagel, Philipp Frank, Egon Brunswik, Felix Mainx.

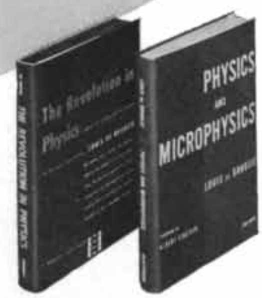
PUBLISHED AT $11.00

George Polya's two-volume set

MATHEMATICS AND PLAUSIBLE REASONING

The latest work of one of the world's foremost research mathematicians, analyzing the methods of mathematical problem-solving, showing their application to other fields of scientific inquiry, developing a logic of plausibility, examining the strengths and weaknesses of scientific evidence.

PUBLISHED AT $9.00



Two volumes by Louis de Broglie

PHYSICS AND MICROPHYSICS THE REVOLUTION IN PHYSICS

A comprehensive survey and interpretation of the development of physical theory, from classical mechanics to the latest advances in molecular physics. Contents include: Theory of Relativity; Wave Mechanics; Quantum Mechanics; Probability Interpretation; Radioelectricity; etc.

PUBLISHED AT $9.00

Choose your first Membership Selection from these outstanding volumes in the LIBRARY OF SCIENCE

TWO MAJOR WORKS

*by J. Robert Oppenheimer**

The Open Mind (just published) and *Science and the Common Understanding* —embodying Oppenheimer's view of the educational, social and ethical problems posed by the rapid advances in atomic physics and atomic armaments.

List price $5.50, **Member's price $4.50**

*Two volumes count as one Selection

LIBRARY OF SCIENCE 379

59 Fourth Avenue, New York 3, N. Y.

Please enroll me as a member and send the books indicated below, one without charge as my free GIFT BOOK and the other as my initial Selection to be billed at the special Member's Price plus a few cents charge for postage. I agree to take as few as 3 more Selections in the next 24 months, and may cancel membership any time after taking my first 4 Selections.

FREE BOOK ______________

FIRST SELECTION ______________

NAME ______________

ADDRESS ______________

CITY ______ ZONE ____ STATE ______

A HISTORY OF SCIENCE

by George Sarton

The panorama of ancient science from the beginnings of writing to the flowering of Greek mathematics, astronomy, medicine, biology, geography, engineering. "Remarkably readable . . . a work of the greatest scholarship." *Yale Review*

List price $10.00, **Member's price $6.95**

SCIENTIFIC AMERICAN READER

By the editors of Scientific American

The frontiers of scientific exploration today, by over 50 noted scientists. Links the latest research in atomic energy, biochemistry, astrophysics, genetics, sensation and perception, virology, zoology, geology, animal behavior.

List price $6.00, **Member's price $4.95**

PATTERNS OF SEXUAL BEHAVIOR

By Clellan S. Ford & Frank A. Beach

An anthropologist and a psychologist present the most complete study available of sexual behavior in humans and animals. "I know of no other place in which so much or so accurate information on sexual behavior has been brought together." *Ralph Linton*

List price $5.00, **Member's price $4.25**

FRONTIERS OF ASTRONOMY

by Fred Hoyle

"New ideas about the structure of the earth, cause of the ice ages, formation of the moon's craters, the origins of the planets (and) directions in which thought is leading on the frontiers of astronomy."

—The London Times

List price $5,00, **Member's price $3.95**

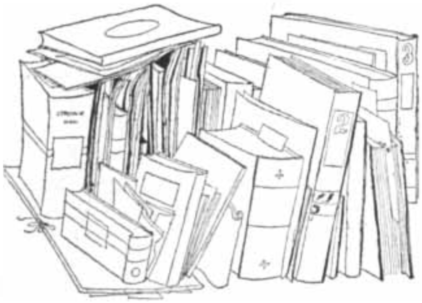
READINGS IN THE PHILOSOPHY OF SCIENCE

Edited by Feigl and Brodbeck

The structure and meaning of science is analyzed by 33 leading thinkers, who show the method of concept-formation basic to all sciences. H. Poincaire, M. Schlick, A. Einstein, H. Reichenbach, K. W. Spence, G. Bergmann, others.

List price $6.00, **Member's price $4.95**

THE LIBRARY OF SCIENCE, 59 Fourth Ave., N. Y. 3, N. Y.



BOOKS

About the analogy between the social organization of cells and of animals

by Clifford Grobstein

CELLS AND SOCIETIES, by John Tyler Bonner. Princeton University Press ($4.50).

John Bonner's pleasant little account of the living world takes as its text the common denominators that characterize all organisms. Every living system—single-celled or many-celled, solitary or social—takes in energy, reproduces and shows coordination and integration of behavior. Bonner's is a simple text, comfortable as an old shoe to most biologists, but he gives it a twist and a charm which make an enjoyable winter's evening even for the jaded professional.

Bonner does not deal with his subject in abstraction. Having laid out the basic skeleton, he quickly reclothes the bare bones by turning to the description and analysis of living organisms in their native habitat. We begin near the end, and close to human interest, with mammalian societies. These opening chapters are among the best in the book—the product of an analytical eye coupled with the pen of a naturalist and impressionist. If the description of what transpires among the beasts below man sometimes seems too loud and redolent for your maiden aunt, it is, nonetheless, good biology. And it suffers no whit in the telling by a narrator who unabashedly admits that, when he spends an afternoon at the zoo watching the scandalous goings-on among the baboons, he sees "my own emotions, my own desires and aversions." Our author, besides being a naturalist and an impressionist, is a curious kind of romantic.

He takes us to the deep forest of Barro Colorado Island in Panama, where at dawn "the sodden stillness of the air is broken by a long low guttural roaring wail way off in the jungle"—the sign and sound of bands of howling monkeys beginning their day. We clamber over the cold Pribilof Islands in the Bering Sea, "exposed and harsh and nude" to man, but for the fur seals "a friendly gathering place" to which they return year after year to court, to breed and to raise their young. In northwest Scotland we stalk the red deer—a delicate enterprise, for we may be scented while a half-mile away, must be garmented in Harris tweeds lest our clothes be heard scraping on the rocks and must keep our eyes motionless when deer are within 70 yards because they may be frightened off by the flashing whites of our eyes. In North America we visit the notoriously shy beavers and watch them busily changing their environment to suit their way of life—a propensity they share with man.

In this visiting about in several kinds of mammalian society we not only satisfy our natural curiosity about how others really live but begin to feel something of the fabric of livingness. The evolutionary advantages of community life are displayed. Interactions between individuals emerge as significant both in satisfying the needs of the individual and in promoting the survival and propagation of the group. Food-gathering, sexual reproduction, communication are seen as group processes—and yet penetrating down into individuals in the form of perception, neuro-muscular activity, digestion, excretion and metabolism. We see how the scope of biology ranges from the chemistry of the cell through rudimentary language and mother-infant relations to the behavior of full-scale animal societies. In these days of specialization it is good to be reminded frequently of this broader fabric.

From the mammals Bonner takes us to the social insects. (He skips—reluctantly, I am sure—the rich material provided by the birds; you can fill that gap if you wish by reading Niko Tinbergen's *The Herring Gull's World.*) With the insects, interestingly enough, we seem to enter a more familiar world, thanks to the wide circulation of the writings of naturalists like William Morton Wheeler, Jean Henri Fabre and Karl von Frisch. Here are the rigidly patterned but astonishingly resourceful societies of the ant, the termite and the bee. Bonner gives us some insight into the limitations and accomplishments of the short-range tactile and chemical mechanisms by which these societies are integrated. As Theodore C. Schneirla's studies of the army ant have shown, the cyclic reproductive behavior of one individual—the queen—shapes the behavior of the whole colony, with communication depending largely upon recognition of odor and the chemical sense. The termites, it is postulated, may have a system of "social hormones": the breeding "king" and "queen" apparently secrete substances which inhibit all other members of the colony from becoming breeders, for if the king and queen are removed, "secondary reproductives" appear among the workers at the next molt. Thus the regulation of caste within a colony of insects may involve mechanisms—and possibly even substances—similar to those that regulate the differentiation of cells and tissues into "castes" in an individual animal.

Pessimists have suggested that insect societies are the prototypes of "1984"—that dismal time when human beings may be encased in social restraints as the insects are encased in their exoskeletons. Fortunately mammalian societies differ from insect societies in many fundamental ways. For one thing, individuals in mammalian societies are biologically equivalent to one another (except for the dichotomy hailed in *Vive la difference!*), while in insect societies they are sharply differentiated and specialized. Worker ants and termite soldiers cannot breed, and the male gallants that breed can neither work nor fight. The so-called queen is a monstrosity—a complete travesty on romantic notions of royalty. She is "but one huge egg factory": a fat, kept creature needing little more than mouth, gut, ovary and her special aroma. Individuals in an insect society, though physically separated, are not independent units: they cannot cope with the general environment alone. They are dependent parts of an organization in which otherwise incompetent males and females are the propagators and keepers of genetic continuity while nonbreeding vegetators bear the brunt of selection and the wear and tear of daily living. Clearly the situation has similarities with multicellular organisms, in which the sexual cells are shut off from direct contact with the environment and selective processes operate primarily through the body.

Bonner next considers the animals known technically as the coelenterates—collections of cells which are united by a single digestive system. There is no more fascinating group in the animal kingdom than this assemblage, embracing the giant polyps, the diaphanous jellyfish, the corals, the Portuguese man-of-war and the inconspicuous hydra of elementary textbook fame. This is the group which first, among animals, realized the full potential of multicellularity.

In a succinct chapter Bonner gives the essence of the story. Center stage is the polyp: a tube of tissue closed at one end and perforated at the other. The perforation, surrounded by tentacles, serves for both intake and output—a situation which has caused the polyp to be toasted for its versatility in limericks composed by generations of biologists. Hydra is a polyp which lives as a solitary individual. Though obviously a fairly early design, it has mastered most of the fundamental engineering of multicellularity. It may reproduce sexually or by budding like a plant. When it buds, the product separates off, giving rise to a new individual which takes up independent existence. There are forms closely related to the hydra, however, in which the products of budding fail to separate; they remain joined together by a common stem like multiple Siamese twins. This aggregation of individuals (polyps) usually is referred to as a colony. In some species the individuals become specialized and biologically incomplete. In the case of the Portuguese man-of-war, the differentiation and specialization have gone so far that the animal as a whole appears to be a single individual, although it is composed of a mass of polyps. For example, the air bladder that supports it at the surface of the water is a specialized polyp, as are the wicked stinging tentacles that dangle below.

Is the Portuguese man-of-war a collection of individuals, a colony, a society or an individual? This is an unhappy question which I can never resist putting to myself, and to which I react with the same discomfort engendered by an ambiguous geometrical figure. No matter how I strain to see it and hold it in one interpretation or the other, I end up by concluding that *it* is *they*.

We are not through with the embarrassment. Bonner now takes us down to colonies of cells, where multicellularity is assumed to have begun. We are introduced to the ciliates, flagellates, amoebae and bacteria. Most of these are content to live in isolation, but look, for example, at that group of algae with euphonious names: Gonium, Pandorina, Eudorina and Volvox. These are packets of flagellate-like individuals. Each successive member of the series is composed of a greater number of units with more interdependence and specialization. Again we must ask: At what point does a colony become an organism?

Or take the slime molds [see "The Social Amoebae," by John Tyler Bonner; SCIENTIFIC AMERICAN, June, 1949]. Here are perfectly respectable individual amoebae, feeding, dividing, leading well-adjusted solitary lives. But when cell density becomes high and food supply low, they suddenly develop a yen for community life, stream together into masses and form an integrated body or plasmodium. This moves about in all respects like an organism, and eventually produces an amazing fruiting structure in which various amoebae (cells?) specialize in different directions in precise and coordinated fashion. Then out of the fruiting body come spores which in good time give rise again to individual, free-living amoebae. In other words, the life cycle of the creatures regularly alternates between single-celled and multicelled phases.

It has been known for many years that the lowly sponges can be made to behave in a manner very like slime molds. Forced through a sieve, they emerge as a thick suspension of individual cells and small cell clusters. The units thus liberated have little taste, however, for solitary life. They quickly reaggregate to make larger and larger masses, and from these grow brand-new sponges complete in every detail.

What happens to the individual cells if they are prevented from reaggregating? They apparently will not survive in ordinary sea water, but are there conditions under which they could survive? Maurice Sussman of Northwestern University has recently discovered a hereditary variant of the slime-mold amoeba which loses interest in social contact and remains bravely individual. Would long-isolated sponge cells develop the same tendency?

These problems are not limited to the forms at the bottom of the evolutionary tree. The complex architecture and functions of higher animals rest upon capacities of cells sometimes to aggregate and sometimes to separate and stay apart. Confusion between these two tendencies may have serious consequences, as when

Let us send you—without charge—these two 33⅓ rpm high fidelity recordings of

The most sublime music ever composed!

Ludwig van Beethoven

Superbly performed in full symphonic high fidelity— plus a majestic chorus of glorious voices!

BEETHOVEN'S
SUPREME ACHIEVEMENT — THE IMMORTAL
9th SYMPHONY

The Gramophone says: "The best LP version available. Musically and technically excellent. This is also a 'human' interpretation played by the Philharmonic Orchestra under Abendroth. Some of the finest soloists — Edith Laux, Diana Eustratie, Ludwig Suthaus, and Karl Paul — give their very best."

The mighty 9th Symphony

Towering high even among Beethoven's majestic accomplishments, the Ninth Symphony is literally the Mt. Everest of music. Its astounding length encompasses every emotion . . . the stark reality of the opening movement . . . the rollicking humor of the *scherzo* . . . the haunting melody of the *adagio* giving way finally to the glorious last movement, affirming Beethoven's passionate love of democracy and the brotherhood of man. So exalted is Beethoven's vision that the orchestra can no longer contain it: above the instruments we hear a chorus of human voices singing Schiller's *Ode to Joy*, concluding a magnificent tribute to the glory of Man unapproached by any other composer.

COMPLETE ON TWO LONG-PLAYING 33⅓ rpm HIGH-FIDELITY RECORDS

yours **FREE**

WITH THIS MONTH'S RECORD—ON 7 DAYS FREE TRIAL

An Exciting Way to Own the Best-Loved Symphonies, Concertos, Musical Comedies—AT AN UNUSUALLY LOW COST!

A Few of the More Than 100 Works You Will be Offered During the Coming Year

BEETHOVEN: "Emperor" Concerto
SCHUBERT: "Unfinished" Symphony
STRAUSS, Johann: Artist's Life; Blue Danube; Wine, Women and Song
SAINT-SAENS: Danse Macabre
BIZET: L'Arlesienne Suite
TCHAIKOVSKY: "Pathetique" Symph.
TCHAIKOVSKY: Nutcracker Suite
RAVEL: Bolero
MOZART: Symphony No. 40 in G Minor
HAYDN: "Surprise"/Symphony No. 94
RIMSKY-KORSAKOV: Scheherazade
BACH: Brandenburg Concertos
SIBELIUS: Finlandia
BRAHMS: Hungarian Dances
GRIEG: Peer Gynt Suites No. 1 and 2
DEBUSSY: Afternoon of a Faun
STRAUSS, Richard: Tyl Eulenspiegel
MENDELSSOHN: A Midsummer Night's Dream
DVORAK: "New World" Symphony
SMETANA: Bartered Bride Overture
DEBUSSY: La Mer
GRIEG: Piano Concerto
CHOPIN: Les Sylphides
RACHMANINOFF: Piano Concerto
WAGNER: Overtures
PROKOFIEFF: Love For Three Oranges
RICHARD RODGERS: South Pacific, Oklahoma, etc.
JEROME KERN: Showboat
VICTOR HERBERT: Symphonic Suite
SCHUMANN: "Rhenish" Symphony

MAIL the coupon now and you will receive FREE—Beethoven's 9th Symphony complete on two pure vinyl, long-playing high-fidelity records.

Under this planned program called MUSIC TREASURES OF THE WORLD you can now enjoy in your own home a complete library of the world's great music . . . beautifully recorded on the latest high-fidelity electronic equipment, with the full range of sound the human ear is capable of hearing (30-15,000 cycles per second)! Because assured distribution to members eliminates the usual expense of unsold records—and because of the development of mass production high-fidelity record pressing equipment—we can offer our members 12" long-playing high-fidelity records, most containing at least two complete works — for only $2.98!

WHAT DOES THIS MUSIC PROGRAM INCLUDE?

All over the world — in Paris, Vienna, New York, Berlin, Milan — the engineers are recording and mastering the best-loved works of all the greatest composers, both serious and light. And these selections are all thrilling brand-new performances played by world-famous symphony orchestras under such eminent conductors as Walter Hendl, Herman Abendroth, Hans Swarowsky, Max Schoenherr, Kurt Graunke, Richard Kempe, Felix Prohaska, William Strickland, George Sebastian.

FREE — MUSIC APPRECIATION COURSE

By accepting this offer now you will also be enrolled in our home study Music Appreciation Course — FREE. With each Music Treasures selection you accept you will receive, free, a new issue of our course. Prepared by Joseph Machlis, Assoc. Prof. of Music, Queens College of N.Y.C. — this course enables you to understand the fine points of music and listen to it as do the critics and composers themselves!

HOW THIS UNIQUE MUSIC PROGRAM WORKS

Your acceptance of the Beethoven 9th Symphony does not obligate you to buy additional Music Treasures records—ever! However, we will extend to you the courtesy of an Associate Membership . . . and each month, you will be offered a new 12" long-playing record at the special member's price of only $2.98 (plus a few cents for U.S. tax and shipping). If you do not wish to purchase any particular record, you merely return the form provided for that purpose.

This great work is too long to be recorded properly on one 12" Hi-Fi record, (more than an hour of listening pleasure). It has therefore been specially transcribed on TWO 10" records. The current selection which will accompany the gift records, and all future records, will be recorded on 12" discs — and sold exclusively to members for only $2.98 plus a few cents U.S. tax and shipping. This current selection is on approval; because we want to demonstrate the great value only members of Music Treasures enjoy. Mail the coupon NOW.

MUSIC TREASURES OF THE WORLD, Dept. 295 SA-1
100 Sixth Ave., New York 13, N. Y.

YOURS—FREE
Beethoven: 9th Symphony

Please enroll me as a Trial Member and send me FREE, Beethoven's immortal 9th Symphony on two 10" long-playing, High Fidelity records, together with your current record selection. I am not obligated to take any specific number of records, and I am to receive an advance description of your future releases. I will receive a free section of your Music Appreciation Course with every record I accept. Also I may reject any record before or after I receive it and I may cancel my membership whenever I wish.
For each of your regular 12" monthly selections I decide to purchase, I will send you only $2.98 plus a few cents tax and shipping.

Membership limited to one person over 21 in any household

Name.. (please print)

Address..

City.................... Zone........ State..................

IN CANADA: 1184 Castlefield Ave., Toronto 10, Ont.

MUSIC TREASURES OF THE WORLD
100 Sixth Ave., New York 13, N.Y.

blood cells clump and plug a vessel, or when cancerous tissues fragment and seed the body with metastases.

The second half of Bonner's little volume is a quick survey of the structure and functioning of plants and animals. His treatment of these subjects is orthodox, and it fails to provide a culmination for the thesis so beautifully introduced in the first half of the book. But there are several understandable reasons. One lies in the fact that the book is not a treatise on organization but arose out of experimentation with a course in general biology given by Bonner at Princeton University. No one who has had any experience with elementary biology courses—as producer or consumer—can fail to concur in the need for experimentation. However, Bonner himself has related elsewhere an anecdote which is apropos. After he had completed lectures on the social mammals and insects, he turned to the polyps. At the end of the lecture a student came up and complained about the shift, saying bitterly: "After all, sir, who gives a damn about a polyp?" The student was wrong; he certainly missed the point. But I would have stood shoulder to shoulder with him several lectures later if he had come up and said: "After all, sir, after treating us to the fascination of interrelations among cells, individuals and societies, who gives a damn about excretion?"

The fact is, of course, that the subject of biological organization itself has remained in an introductory stage. It has long been a favorite theme for speeches on ceremonial occasions and has evoked a good deal of fuzzy-minded and sometimes socially dangerous thinking. It has been given serious thought only by a few theoretically oriented biologists; experimental study of the subject has been limited and factual knowledge fragmentary. Fortunately the gaps in knowledge are now beginning to be filled. It may not be too long before there are enough answers to specific questions to indicate some common denominators in the aggregation and interaction of living units —denominators possibly as fundamental in biology as mass and energy are in physics.

Short Reviews

Great Experiments in Biology, edited by Mordecai L. Gabriel and Seymour Fogel. Prentice-Hall, Inc. ($3.75). This is an unusually interesting collection of some of the classics of biological literature. They are the original memoirs of biologists, some famous and some not so famous, announcing major discoveries in cell theory, general physiology, microbiology, plant physiology, embryology, genetics and evolution. Among the selections are Robert Hooke's account "Of the Schematisme or Texture of Cork, and of the Cells and Pores of Some other such Frothy Bodies;" Antoine Lavoisier's and Pierre Simon de Laplace's celebrated memoir on animal heat; Claude Bernard's paper on the mechanism of formation of sugar in the liver; Louis Pasteur's brilliantly clear, polemical memoir on spontaneous generation; a letter of Gregor Mendel summarizing much of his epochal work on peas; G. H. Hardy's beautifully simple communication to *Science* suggesting an elementary algebraic formulation of the principle of genetic equilibrium.

Concepts of Space, by Max Jammer. Harvard University Press ($3.75). Dr. Jammer, lecturer on physics and the history of science at the Hebrew University in Jerusalem, traces the evolution of the concept of space from ancient times through the field theories of modern physics. The path of this evolution, as Jammer shows, is a strange and somewhat circular affair. In Greek philosophy and science, mainly under Aristotle's influence, space was conceived as finite, not uniform in all directions and carved out, so to speak, by matter. All elemental substances had a "natural tendency to move toward their own special places," and space itself consisted of the sum total of all "places" formed by the inner boundaries of material bodies. It took a long time before Aristotle's conception was discarded. After presenting in some detail Judeo-Christian ideas of space and the wonderful metaphysical and theological gymnastics of the Middle Ages, the author describes Newton's concept of absolute space and time, of inertia and motion and of space as the "container of all material objects." Even during the reign of classical physics not all philosophers accepted Newton's views; Leibnitz, for example, held that space is merely a system of relations dependent on the position of bodies; that it possesses no independent reality or existence. The field physics ushered in by the work of Faraday and Maxwell, and climaxed by Einstein's theories, may be said to have reinstated certain of Aristotle's curious notions and to have vindicated Leibnitz' profound intuition. For now the concept of absolute space is once more in disfavor, and in place of the inertial system and gross material objects, the whole of physical reality is envisaged "as a field whose components depend on four space-time parameters."

Thus there is no empty space, nor is space uniform or continuous. Matter itself has vanished, or at least has been dissolved into the field, and in Einstein's words, "that which constitutes the spatial character of reality is simply the four-dimensionality of the field." Jammer has written an absorbing study.

THE SANE SOCIETY, by Erich Fromm. Rinehart and Company, Inc. ($5.00). Dr. Fromm is esteemed as one of the most thoughtful and original students of psychiatry, psychoanalysis and social psychology today. His writings, which have attracted a wide audience, have been concerned mainly with the effects of social forces on behavior. His *Escape From Freedom* examined the circumstances that lead men to flee what they profess most to cherish—freedom—and to embrace what they profess most to abhor—authoritarianism. His new book elaborates this theme. Its central argument is that society—the U. S. being a prime example—conflicts with and thwarts the fulfillment of man's basic needs: to express his individuality, to exercise creative imagination and reason, to develop feelings of human solidarity and "relatedness," to love and be loved. Instead of providing man with the opportunity to use his human gifts and unfold his powers, society has turned means and ends topsy-turvy. Man is taught to strive for things and causes rather than for his own growth; he is subordinated to economic and political activities instead of controlling them as instruments for his advantage. In short, society clamps him in a press. If he tries to break out, he is considered a misfit and must suffer the consequences; if he submits, he is more apt to emerge a stamping than a human being. Fromm draws a distressing picture of a sick society which produces "a socially patterned defect" common to all its members. It is not easy, however, to put a society on the couch. The therapy Fromm offers is scarcely more than a sermon on the benefits of love, self-respect and cooperation. While the world undoubtedly could use a great deal more of each, philosophers and religious leaders have been advocating the same panacea for centuries. If Fromm's book does not tell us how to get out of the mess we are in, he at least makes us see many things which may hitherto have escaped our notice.

MONOGRAPHS ON TOPICS OF MODERN MATHEMATICS, edited by J. W. A. Young. Dover Publications, Inc. ($3.95). One of the most stimulating approaches to mathematics is the reexamination of elementary topics from an advanced standpoint. When precise and powerful methods are brought to bear on what were long considered settled matters, they often become unsettled, new insights are gained and creative thought is quickened. The best known modern reappraisal in this vein is Felix Klein's famous book *Elementary Mathematics from an Advanced Standpoint.* Young's volume, first published in 1911 and now reprinted, is a similar undertaking, also of high merit. It consists of nine monographs by leading mathematicians. Oswald Veblen presents a modern axiomatization of Euclidean geometry; Thomas Holgate shows how the latter can be extended by "purely geometric or synthetic methods as opposed to the algebraic methods of Descartes and Fermat;" Frederick S. Woods describes the revolutionary development of non-Euclidean geometry; Edward V. Huntington discusses the logical basis of the real and complex number systems, proffering a set of axioms from which all the theorems of algebra and analysis can be derived. Other articles deal with the evolution of the algebraic equation, the function concept and the fundamental notions of the calculus; the theory of numbers; the 2,500-year-old problems of squaring the circle, duplicating the cube and trisecting the angle, and the history of the most celebrated of all numbers, π, whose true nature was not established until the end of the 19th century. Morris Kline has written an interesting new introduction reviewing the literature that has appeared since the first publication of the book.

EVEREST IS CLIMBED, by Wilfrid Noyce and Richard Taylor. Penguin Books Ltd. (50 cents). Among the many accounts of the ascent of Everest this Puffin Picture Book holds a high and special place. The simple, clear text by Noyce, a member of the victorious expedition, gives a brief historical resumé of earlier attempts and an unusually vivid description of all major phases of the Hunt undertaking from preliminaries to the final triumph. Taylor provides brilliant pictures which far surpass the illustrations in Hunt's own book. Some are in color; there are admirable relief maps, scenes of the great crevasse, the icefall and the various camps, diagrammatic charts, sketches of the equipment used.

ALL THE SEXES, by George W. Henry. Rinehart and Company, Inc. ($7.50). Dr. Henry, a leading psychiatrist, reports his findings and conclusions on sexual variations, based upon extensive study of problems of psychosexual adjustment and many years of clinical observation. The author considers the role of constitutional deficiencies and the influence of family patterns and other environmental factors on sexual development, supporting his opinions by many verbatim excerpts from patient interviews and other firsthand data. A number of statistical tables on the occupational distribution of sex variants add to the value of this enlightened treatment of a problem which is a conspicuous victim of sensationalism and ignorance.

MATHEMATICS IN ACTION, by O. G. Sutton. G. Bell and Sons, Ltd. (16 shillings). Of the mathematician's endless fancies only a few are immediately applicable to what G. H. Hardy called this "stupidly constructed" universe in which we live. Yet somehow, by the formal juggling of symbols of our own creation according to rules we ourselves have invented, an enormous amount is learned about the physical world and even how to control it. In this unpretentious, attractively written book a leading British mathematical physicist explains how the abstract concepts of mathematics are turned into tools for extending the observations of the physicist and other experimental workers. He illustrates the process by examples from ballistics, meteorology, aerodynamics, electromagnetic theory, nuclear physics, statistics, astronomy. Sutton gives a rapid review of fundamentals—complex numbers, the calculus, differential equations—so that anyone who has had even a smattering of advanced mathematics can refresh himself sufficiently to follow other parts of the account. There are many simple, helpful diagrams. At an intermediate level this is one of the clearest and best surveys of its kind published in many years; indeed one must turn back half a century to Mellor's classic *Higher Mathematics for Students of Physics and Chemistry* to find a work of comparable lucidity.

Notes

MICROWAVE SPECTROSCOPY, by C. H. Townes and A. L. Schawlow. McGraw-Hill Book Company, Inc. ($12.50). An advanced monograph. It is concerned primarily with the "furiously active" field of microwave spectroscopy of gases.

HANDBOOK OF FOOD AND AGRICULTURE, edited by Fred C. Blanck. Reinhold Publishing Corp. ($12.50). A 1,000-page manual on the applications of science and technology to aspects from fertilizers to food packaging.

PRINCIPLES OF NUCLEAR REACTOR ENGINEERING, by Samuel Glasstone. D. Van Nostrand Company, Inc. ($7.95). By a consultant to the Atomic Energy Commission with the assistance of 10 staff members of the Oak Ridge National Laboratory.

STRATIGRAPHICAL PALAEONTOLOGY, by E. Neaverson. Oxford University Press ($16.80). Second edition of a technical monograph on the habitats of ancient animals.

THE OPEN MIND, by J. Robert Oppenheimer. Simon and Schuster ($2.75). A collection of eight addresses, four on the social aspects of atomic energy and four on science and scientists in the contemporary world.

RADIOCARBON DATING, by Willard F. Libby. University of Chicago Press ($4.50). A second edition, describing improvements in measurement technique and hundreds of additional dates determined in Libby's laboratory.

HIGHER MATHEMATICS FOR STUDENTS OF CHEMISTRY AND PHYSICS, by J. W. Mellor. Dover Publications, Inc. ($3.95). A clearly written review of differential equations, probability theory, infinite series, the calculus of variations and related topics.

LOGIC AND NATURE, by Marie Collins Swabey. New York University Press ($3.75). A defense of logic as the most dependable apparatus for interpreting the world, and a protest against "the betrayal of reason to conventionalism and pragmatic empiricism." Revised edition.

MOSQUITOES OF NORTH AMERICA, by Stanley J. Carpenter and Walter J. La Casse. University of California Press ($10.00). This handsome, richly illustrated monograph presents the results of 18 years of research. A worthy tribute to a formidable pest.

FUNDAMENTAL FORMULAS OF PHYSICS, edited by Donald H. Menzel. Prentice-Hall, Inc. ($13.50). A cooperative compilation of mathematical formulas in many fields of physics.

DIELECTRIC BEHAVIOR AND STRUCTURE, by Charles Phelps Smyth. McGraw-Hill Book Company, Inc. ($9.00). On dielectric constants and losses, dipole moments and their relations to molecular structure, induced polarization, methods of measurement, dielectric properties of glasses, high polymers and ferro-electrics, and related topics.

STOCHASTIC MODELS FOR LEARNING, by Robert R. Bush and Frederick Mosteller. John Wiley and Sons, Inc. ($9.00). For experimental psychologists who remember their calculus and statistics and are not averse to learning a little matrix algebra and set theory. The authors promulgate the theory that learning is probabilistic or stochastic—"that events change the probabilities of the various responses."

QUANTUM THEORY OF SOLIDS, by R. E. Peierls. Oxford University Press ($4.80). The electron theory of metals, the dynamics of crystals and other fundamental aspects of the subject.

BASIC PROCESSES OF GASEOUS ELECTRONICS, by Leonard B. Loeb. University of California Press ($13.50). This is a major elaboration and reworking of part of Professor Loeb's well-known book *Fundamental Processes of Electrical Discharge in Gases.*

SOUTHERN AFRICA: A GEOGRAPHICAL STUDY, VOL. II, by John H. Wellington. Cambridge University Press ($6.50). The second volume of Professor Wellington's large-scale study investigates the economic and human geography of South Africa. Illustrations and maps.

RAILROADING AROUND THE WORLD, by S. Kip Farrington, Jr. Coward-McCann, Inc. ($10.00). This author's seventh book on railroads is a scrappy and disorganized affair so far as the text is concerned, but the main thing is the numerous photographs of trains and tracks all over the world, many of which are first rate.

A HISTORY OF FLYING, by C. H. Gibbs-Smith. Frederick A. Praeger ($4.95). A well-written, attractively illustrated account of the history of flying from the earliest times to 1918, with a brief postscript carrying the chronicle to the present day.

ELEMENTARY MATHEMATICS FROM AN ADVANCED STANDPOINT, by Felix Klein. Dover Publications, Inc. ($3.25). A reissue in English of the noted lectures Felix Klein gave almost half a century ago to German secondary-school teachers of mathematics. His purpose was to spur independent thought and enliven their methods of instruction by tracing the historical development of concepts.

1955 — **OVER 600 EXPERIENCED ENGINEERS AND SCIENTISTS* CHOSE RCA SYSTEMS, DESIGN OR DEVELOPMENT CAREERS**

1956 — **NEW SYSTEMS, DESIGN AND DEVELOPMENT POSITIONS AT RCA OPEN HIGH-LEVEL OPPORTUNITY FOR YOU!**

**Plus hundreds of field service, recent graduates and other engineers.*

FIELDS OF ENGINEERING ACTIVITY	MANAGERS	Electrical Engineers 1-2	Electrical Engineers 2-3	Electrical Engineers 4-15	Mechanical Engineers 1-2	Mechanical Engineers 2-3	Mechanical Engineers 4-15	Physical Science 1-2	Physical Science 2-3	Physical Science 4-15	Chemistry Ceramics Glass Technology Metallurgy 1-2	Chemistry Ceramics Glass Technology Metallurgy 2-3	Chemistry Ceramics Glass Technology Metallurgy 4-15
SYSTEMS *(Integration of theory, equipments and environment to create and optimize major electronic concepts.)*													
AIRBORNE FIRE CONTROL				W M			M			W M			
DIGITAL DATA HANDLING DEVICES	M C			C			C			C			
MISSILE ELECTRONICS • RADAR	M			M X			M			M			
INERTIAL NAVIGATION	M			M			M			M			
COMMUNICATIONS				C I						C I			
DESIGN • DEVELOPMENT													
KINESCOPES (B & W and COLOR), OSCILLOSCOPES—Electron Optics—Instrumental Analysis—Solid States (Phosphors, High Temperature Phenomena, Photosensitive Materials and Glass to Metal Sealing)		L	L	L	L	L	L	L	L	L	L	L	L
RECEIVING TUBES—Tube Design—Test and Application Engineering—Chemical and Physical Development—Methods and Process Engineering—Advanced Development		H	H	H		H	H		H	H		H	H
SEMI-CONDUCTORS—Transistors—Semi-Conductor Devices—Materials		H	H	H	H	H	H	H	H	H	H	H	H
MICROWAVE TUBES—Tube Development and Manufacture (Traveling Wave—Backward Wave)	H		H	H		H	H		H	H		H	H
GAS, POWER AND PHOTO TUBES—Photosensitive Devices—Glass to Metal Sealing		L	L	L	L	L	L	L	L	L	L	L	L
AVIATION ELECTRONICS—Radar—Computers—Servo Mechanisms—Shock and Vibration—Circuitry—Remote Control—Heat Transfer—Sub-Miniaturization—Automatic Flight—Design for Automation—Transistorization	M C	M C X	M C X	M C X	M C	M C X	M C X	M C X	M C X	M C X			
COMPUTERS—Systems—Advanced Development—Circuitry—Assembly Design—Mechanisms—Programming		C	C X	M C X	C	C X	M C X	C	C	M C			
RADAR—Circuitry—Antenna Design—Servo Systems—Gear Trains—Intricate Mechanisms—Fire Control	M C	M C X	M C X	M C X	M C X	M C X	M C X	M C X	M C X	M C X			
COMMUNICATIONS — Microwave — Aviation — Specialized Military Systems		C	C	C		C	C		C	C			
RADIO SYSTEMS—HF-VHF—Microwave—Propagation Analysis—Telephone, Telegraph Terminal Equipment		I	I	I									
MISSILE ELECTRONICS—Systems Planning and Design—Radar—Fire Control—Shock Problems—Servo Mechanisms	M	M	M	M	M	M	M	M	M	M			
COMPONENTS—Transformers—Coils—TV Deflection Yokes (Color or Monochrome)—Resistors		C	Z C	Z C	C	Z C	Z C	C	C	C		Z	Z
MACHINE DESIGN Mechanical and Electrical—Automatic or Semi-Automatic Machines			L	L		L H	C L H		L	L			

Locations: **C**—Camden, N.J. **H**—Harrison, N.J. **I**—International Div. **L**—Lancaster, Pa. **M**—Moorestown, N.J. **W**—Waltham, Mass. **X**—Los Angeles, Calif. **Z**—Findlay, Ohio

Modern benefits program . . . Liberal relocation assistance.

Please send resume of education and experience, with location preferred, to:

Mr. John R. Weld, Employment Manager
Dept. A-1A, Radio Corporation of America
30 Rockefeller Plaza, New York 20, N. Y.

RADIO CORPORATION of AMERICA

THE AMATEUR SCIENTIST

About experiments with sound for the high-fidelity enthusiast

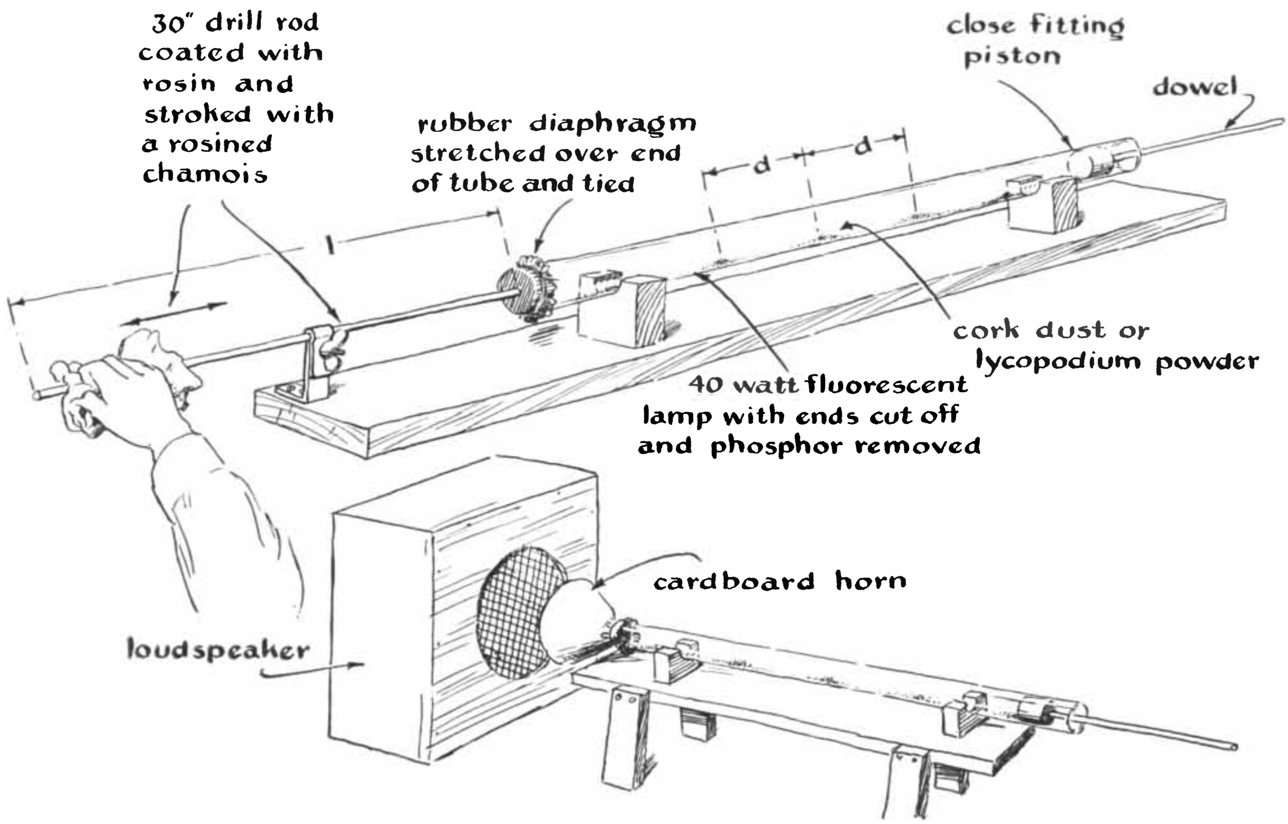
Besides bringing good music to the home, the high-fidelity reproduction of sound has introduced some devotees to a new hobby. In installing a hi-fi system, you must adjust and tinker to bring the system to its best performance, and during this process it is easy to develop an interest in the machinery as well as the music it reproduces. In the course of adjusting the tone controls, finding the best location in the room for the speaker, damping the speaker with rock wool, modifying the amplifiers, regulating the needle pressure, looking into volume expanders and so on, you are likely to discover the fascinating science of acoustics. Pursuing this further, you may find that you can use your sound system as an acoustic telescope, a microscope, a kind of X-ray machine and a general utility instrument.

A sound system does not have to be particularly "hi-fi" to serve for investigating the sound a fly makes when it walks upside down. You need a fairly sensitive system, however, to hear termites munching inside a wooden beam. Only the best equipment, carefully groomed for the job, will enable you to hear the so-called "dawn chorus," the mysterious "tweeks," "bonks" and "swishes" that appear to come from the ionosphere at sunrise [*see article on page 34*].

Many aspects of sound can be studied without any amplifying system at all. A simple apparatus built from common materials will serve to measure the speed of sound, study the pure tones that make up complex sounds, observe harmonic vibrations and perform many other experiments in what, until recently, was a long-neglected branch of science.

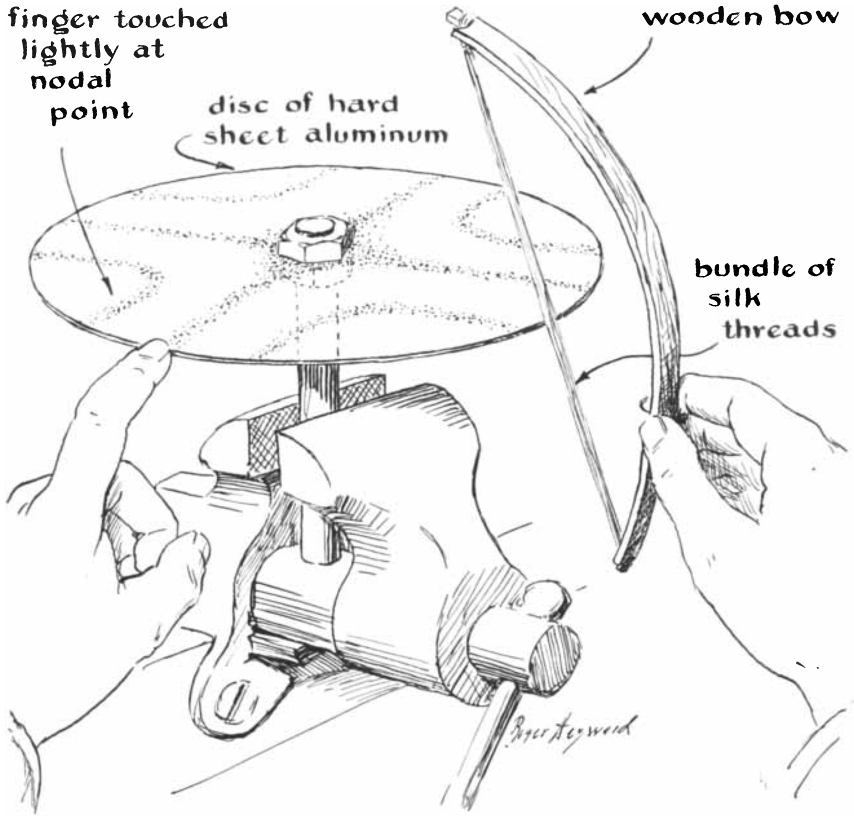
It seems strange that acoustics has so long played the role of Cinderella among the physical sciences. Many people who know a good deal about the work of the pioneers in optics, mechanics, heat, electricity, magnetism and nuclear physics cannot even name their counterparts in acoustics. Yet the science has had a number of gifted workers. As a matter of fact, the wave nature of sound was explained long before an equally solid theoretical footing was established for the study of optics.

The first important name in acoustics was Marcus Vitruvius Pollio—who is also revered by architects. In his remarkable treatise *De architectura*, which ap-



Kundt apparatus for measuring the velocity of sound peared during the reign of the Roman emperor Augustus Caesar, Vitruvius wrote: "Now the sound of the voice is transmitted by a progressive motion in the air which can be perceived by the sense of hearing. It is propagated in the form of a countless series of concentric circles, as when a stone is thrown into standing water. Innumerable circular waves form and grow as they recede from the center of the disturbance until they reach some obstruction. When opposed, the first waves recoil and interfere with succeeding waves." After discoursing upon reverberation and wave interference, Vitruvius concluded: "Accordingly, the ancient architects constructed tiers of steps in theatres in harmony with clues they found by studying the facts about the voice."

After Vitruvius the study of facts about acoustics was pursued only spasmodically over the centuries. It has begun to come into its own only during the past quarter century, with the advent of electronics and especially under the stimulus of World War II. Today acoustical research is being applied in such fields as architecture, sound reinforcement, noise abatement and ultrasonics, which is rapidly making a place for itself in industry.



Chladni apparatus for demonstrating modes of vibration

A hi-fi addict who wishes to explore the scientific aspects of sound can make a good start with the classic Chladni plate, invented by the 18th-century German physicist Ernst Chladni to study the nature of harmonic vibrations. Chladni's plate behaves much like the paper cone in a loud-speaker. Here is his account of the apparatus:

"As an amateur in music, the rudiments of which I had begun to study at the rather late age of 19, I noted that the theory of sound was more neglected than several other branches of physics. In 1785 I had observed that a plate of glass or metal, if clamped at the center, gave different sounds when struck at different places. But I found nowhere any account of these different modes of vibration. The journals had given at that time some notices about a musical instrument made in Italy by Abbé Mazzochi, consisting of bells to which he applied violin bows. When I applied a bow to a round plate of brass fixed at its center, it emitted different tones, but the nature of the motions to which these sounds corresponded was still unknown to me. The experiments on electric figures that form on a resin plate dusted with powder led me to surmise that the different vibratory motions of a sonorous plate might also present a different appearance if I sprinkled on the surface a little sand.

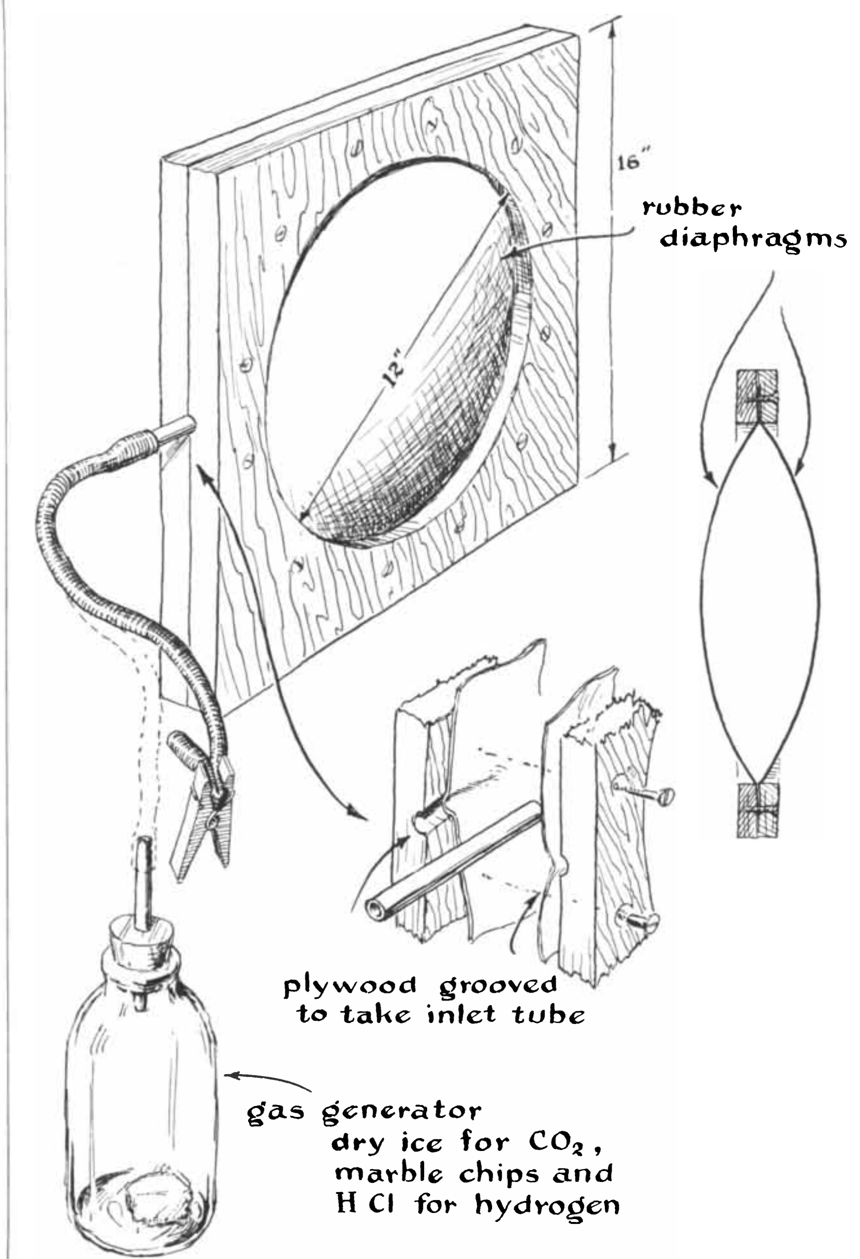
"Upon applying this device, the first figure that presented itself to my eyes on the round plate resembled a star with 12 points. Just imagine my astonishment and delight upon beholding this sight which no one had ever seen before!"

A version of Chladni's plate is shown in the drawing above. It is made of hard aluminum sheet, but any good "bell" material will work. An old violin bow will spare you the labor of making the one shown. You sprinkle a layer of white sand evenly on the plate and then draw the bow over the edge. The sand grains collect in bands in the zones of least motion, and you can see the whole vibrating system. It is interesting to experiment with plates of various shapes: square, triangular, elliptical and so on. The edge of the plate should be free of grease, and the bowing action will be improved if you rub the strings with rosin. While bowing one point on the edge, touch your finger lightly to other points. You will get various interesting sand patterns, each corresponding to a different arrangement of standing waves in the plate and to a different tone.

The cone of a loud-speaker will show similar patterns if you coat it with a thin layer of powdered sulfur, lycopodium or similar material, using a small camel's-hair brush to apply the powder. The ideal speaker cone would vibrate as a whole at every frequency instead of separating into zones, but paper cones rarely approach the ideal. As the frequency increases, movement is confined more and more to the central portion of the cone, although rays of vibration occasionally extend to the edge. The pattern depends on the thickness and composition of the material and the method of suspension at the center and the edge. Hi-fi students who make this experiment may be astonished to learn that many speakers assumed to have an effective diameter of 12 or 15 inches do a lot of their work within an acoustical diameter of less than three inches, with the remaining zones performing a bewildering series of gyrations which have little to do with the "facts of the voice."

Another simple and beautiful experiment, devised in 1876 by August Kundt of Germany, measures the velocity of sound. Kundt used a common wooden whistle as his source of sound, but in a modern laboratory version of his apparatus a vibrating steel rod is substituted for the whistle. The apparatus is illustrated on the opposite page. The glass tube shown is a 40-watt fluorescent lamp with its ends cut off. (In cleaning out the tube be careful not to breathe in any of the material that comes out, because the phosphors and gas used in some of these lamps are poisonous.) You place inside the tube a small amount of lycopodium powder, powdered cork or precipitated silica, which will serve as the vibration indicator. One end of the tube is stopped with a movable piston, which will regulate the tube length. You cover the other end with a thin, stretched rubber or cellophane diaphragm, and against this diaphragm, making light contact with it, you place the end of a steel rod. The rod is supported and clamped at its mid-point as shown.

Now you stroke the outer end of the rod with a rosined chamois, making it vibrate. With a little practice you can make the rod "sing" in a strong monotone. The vibration of the rod against the diaphragm causes the powder inside the glass tube to fly around. You slowly move the piston at the other end of the tube until the length of the air column in the tube is tuned to "resonance" with the rod tone; that is, until standing waves are formed in the tube. You will recognize this event by a sudden increase in loudness of the sound. Now the flying powder inside the tube will settle and collect in little piles at "nodal" points where the air is not vibrating. There will be one node at the piston, one near the diaphragm and perhaps others between. The distance from one node to



Construction details of an acoustic lens of the gas type

what helps a scientist grow?

Here are four factors given by distinguished Avco scientists. They reflect both the thinking and opportunity at Avco Advanced Development Division.

"Top-level associates"

says Dr. Arthur Kantrowitz, noted authority in gas dynamics, member of Avco Advanced Development, and professor, Cornell University.

"A scientist's effectiveness depends on mental stimulation provided by able associates. It's important at all levels and it is essential to a young scientist."

"Technical sophistication"

says Dr. E. R. Piore, former chief Scientist and Deputy Chief of the Office of Naval Research, now Avco V.P. and Chairman of its Committee on Advanced Research.

"The more advanced, more challenging, the more technically sophisticated his work—the better a talented scientist will respond."

"An atmosphere of inquiry"

says Eaton H. Draper, noted nuclear weapons systems expert and Engineering Manager of Avco Advanced Development Division.

"Provide a climate which encourages a healthy questioning of the known, as well as the unknown, and a scientist or engineer will perform at his peak . . . and even beyond."

"Freedom from routine"

says Dr. Mac C. Adams, noted aerodynamicist, author of papers on aerodynamics and gas dynamics, and Director of the Avco Research Laboratory.

"A scientist is most effective when he is free to direct his full energy against major problems. Adequate technical assistance releases him from time-consuming routine."

Helping talented scientists and engineers—at all levels—become more effective is the best way we, at Avco Advanced Development, know of helping our own growth. For that reason, we offer them assignments worthy of their abilities, stimulating associates, and the fullest technical support possible. Add to these factors the unique combination of small-company flexibility and large-company stability—and you have an environment ideally suited to growth. For outstanding men, Avco's long-range expansion—in missiles and in all the physical sciences—offers unprecedented opportunity.

Write Dr. E. R. Piore, Vice-President in Charge of Research, Room 405, Avco Advanced Development Division, Stratford, Conn., or Phone Bridgeport, Conn., DRexel 8-0431.

WANTED:

Leaders in the exploitation of new areas of Science

Physical Scientists

Advanced degree preferred — in Physics • Aerodynamics • Electronics • Metallurgy • Physical Chemistry • Mathematics

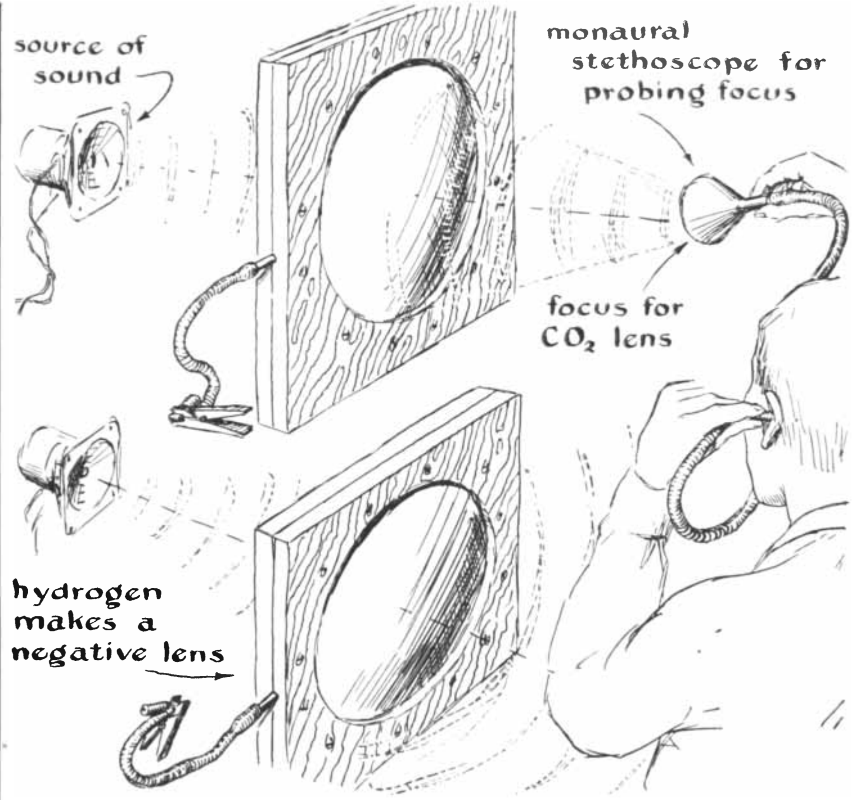
Engineers

Electronic • Mechanical • Aeronautical • Chemical

avco MFG. CORP. **advanced development division**

avco defense and industrial products

combine the scientific skills, and production facilities of 3 great Avco divisions of Avco Manufacturing Corp.: Avco Advanced Development; Crosley; Lycoming which currently produce power plants, electronics, air-frame components, and precision parts.



An experiment employing acoustic lenses

the next is half the wavelength of the sound tone, and so you can measure the wavelength with a ruler.

The wavelength times the frequency of the wave gives the velocity of the sound in the tube. To determine the velocity, therefore, you need to know the frequency. You could arrange this simply by feeding a tone of known frequency into the tube, using, instead of a steel rod, a small horn [*see lower part of illustration*] hooked to a recording of a pure tone—the Westminster DRB hi-fi demonstration record is a good one for the purpose. But you can measure the frequency of the steel-rod vibrations yourself by matching it with a home-made siren. Take a 10-inch disk, perforate a series of quarter-inch holes around it near its rim at regularly spaced intervals, spin the disk with a direct-current motor and blow at the spinning holes with a soda straw. Each passage of air through a hole is a sound-making vibration, and blowing through the succession of holes will produce a typical siren tone, whose frequency is measured by the number of revolutions of the disk per second multiplied by the number of holes. Now you adjust the speed of the motor until the siren tone matches the tone from your steel rod in the Kundt apparatus. The calculation just described (assisted by a revolution counter to measure the speed of the motor) gives you the frequency of this tone.

With the Kundt tube you can measure the velocity of sound in gases other than air. If the gas in the tube is carbon dioxide, the nodes will fall closer together; in other words, in this gas a tone of a given frequency produces vibrations of shorter wavelength. This means that the velocity of sound in carbon dioxide is less than in air. In hydrogen, on the other hand, sound will travel faster than in air.

You can also measure the speed of sound in the steel rod. The distance from the point at which the rod is clamped (not vibrating) to the end of the rod (where it vibrates most strongly) is half the distance between nodes, or one quarter of a wavelength. The ratio between the wavelength of sound in the rod to its wavelength in the air of the tube measures the ratio of the speed of sound in steel to the speed in air. Consequently, having determined the wavelength in the tube, you can easily calculate the velocity of sound in the rod.

The fact that the speed of sound varies with the material through which it travels implies that a beam of sound waves will be refracted when passing from one material to another. It should be possible, therefore, to make "lenses" or "prisms" which will have the same ef-

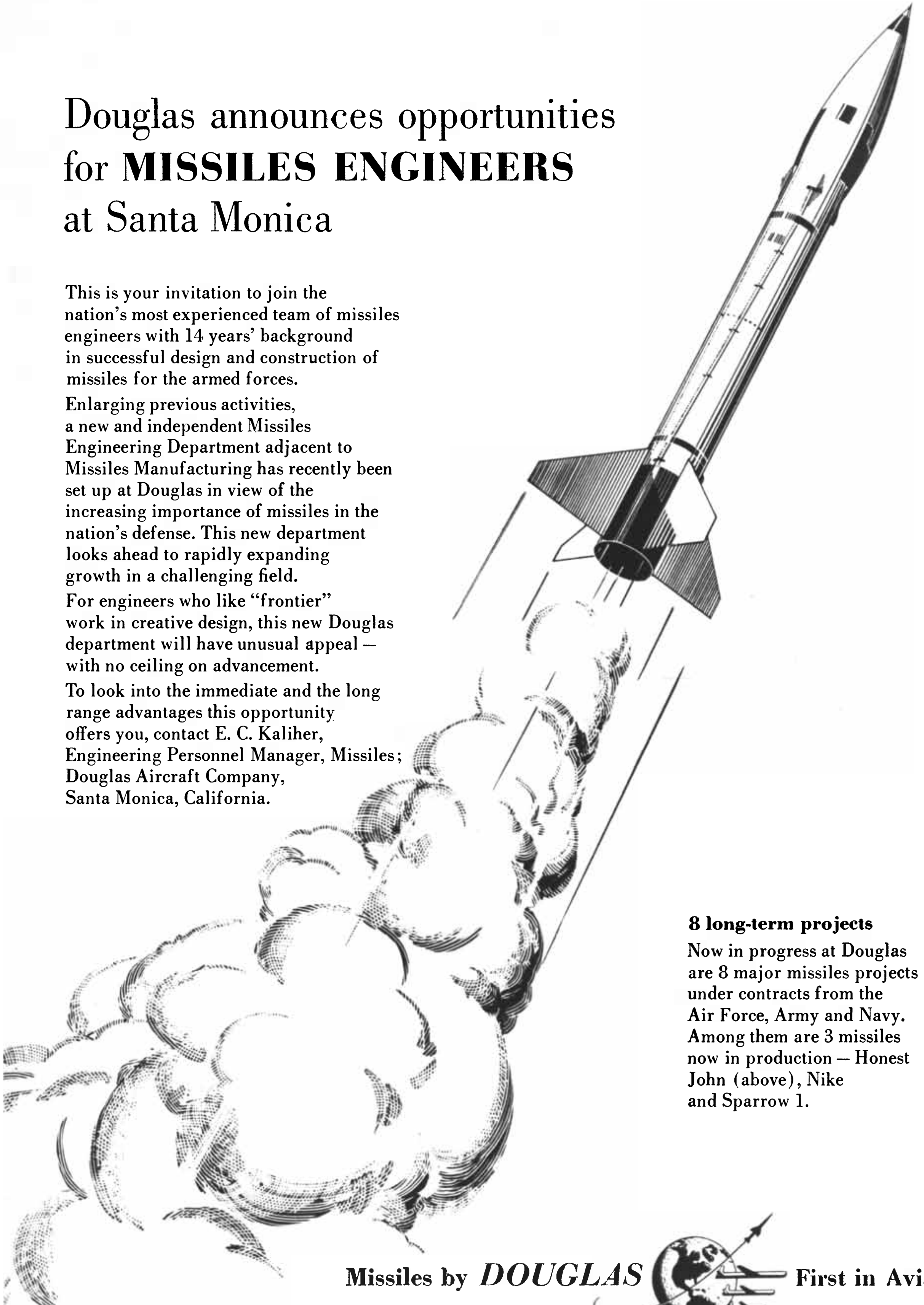
Douglas announces opportunities for **MISSILES ENGINEERS** at Santa Monica

This is your invitation to join the nation's most experienced team of missiles engineers with 14 years' background in successful design and construction of missiles for the armed forces.

Enlarging previous activities, a new and independent Missiles Engineering Department adjacent to Missiles Manufacturing has recently been set up at Douglas in view of the increasing importance of missiles in the nation's defense. This new department looks ahead to rapidly expanding growth in a challenging field.

For engineers who like "frontier" work in creative design, this new Douglas department will have unusual appeal – with no ceiling on advancement.

To look into the immediate and the long range advantages this opportunity offers you, contact E. C. Kaliher, Engineering Personnel Manager, Missiles; Douglas Aircraft Company, Santa Monica, California.



8 long-term projects

Now in progress at Douglas are 8 major missiles projects under contracts from the Air Force, Army and Navy. Among them are 3 missiles now in production – Honest John (above), Nike and Sparrow 1.

Missiles by *DOUGLAS* **First in Aviation**

fect on sound as a glass lens has on light. Physicists at the Bell Telephone Laboratories have designed various such devices. One of them is illustrated on page 122. The lens consists of carbon dioxide gas in a lens-shaped volume enclosed by two rubber diaphragms. The dimensions are not critical. Care should be taken to make a tight joint at the edge of the rubber sheeting and at the point where the inlet tube enters the lens. It helps if you are generous with rubber cement. The so-called "rubber dam" sheeting carried by dealers in dental supplies is convenient to use and works well.

As in optics, the dimensions of an acoustic lens must be substantially greater than the wavelength of the sound if it is to bend the waves into sharp focus. For long sound waves in the lower range of hearing the lens would have to be much too large. But a fairly high-pitched sound such as one of 8,600 cycles per second, whose waves are about an inch and a half long, can be focused to a sharp "image" with a gas lens 12 inches in diameter inflated with carbon dioxide to a thickness of five inches. You can pick up the "image" with a stethoscope [*see drawing on page 124*].

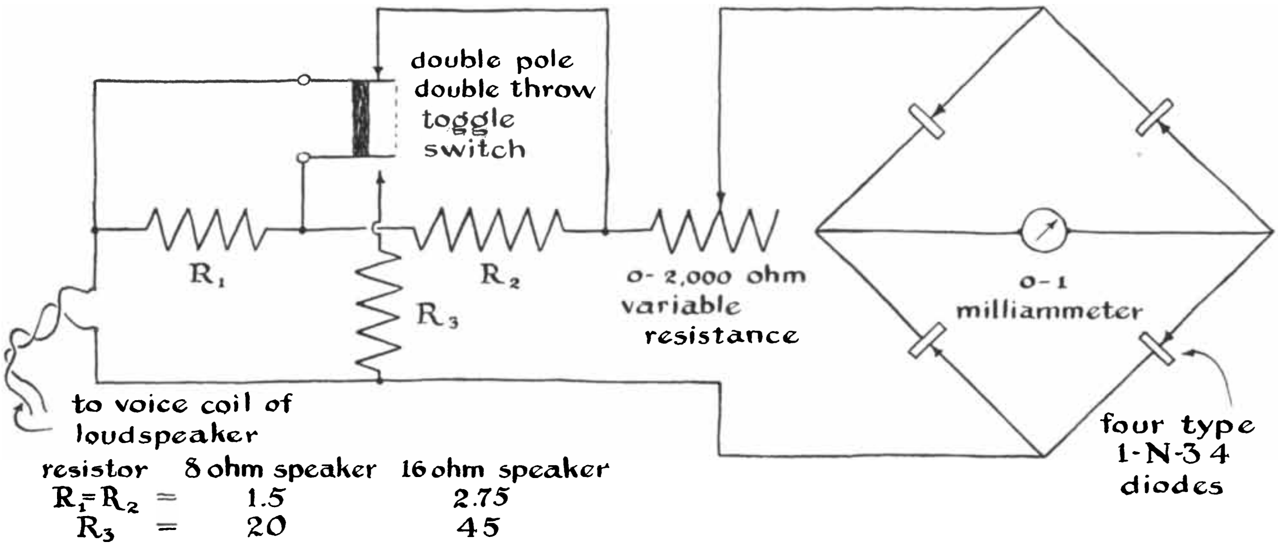
An acoustical lens of this type has one great advantage over its optical counterparts: its focal length can be varied simply by inflating or deflating it. Indeed, you can even focus sound rays with a toy balloon. Blow up a balloon (preferably with carbon dioxide) and put your ear close to one side while holding your wrist watch close to the other. The ticks will come through much louder than you can hear them with the unaided ear.

A more useful form of the acoustical lens is shown in the drawing on page 128. Here a barrier of slats refracts the sound waves, in effect, by increasing the length of their path to the place where they are heard. The amount of refraction varies directly with the width of the slats and inversely with the spacing between them. The structure must be large in proportion to the wavelength and the spacing of the slats small. The lens illustrated here is of the dispersing or "negative" type: it is designed to spread the beam of a loud-speaker into the fan-shaped pattern desired for good listening in all parts of a living room. Its two-inch spacing limits this lens to frequencies below 8,000 cycles; for higher frequencies the spacing must be reduced and more slats added.

You do not need lenses to take up acoustic microscopy. A microphone which is not too noisy will pick up sounds far below the threshold of human hearing. You simply hook it to the input circuit of the sound system where the phone pickup is normally connected, and turn up the volume for as much acoustic magnification as you need. In making these experiments, be careful not to let sounds from the loud-speaker reach the microphone, for the resulting feedback may produce "sing" loud enough to wreck the speaker. It is safer to do your listening with headphones.

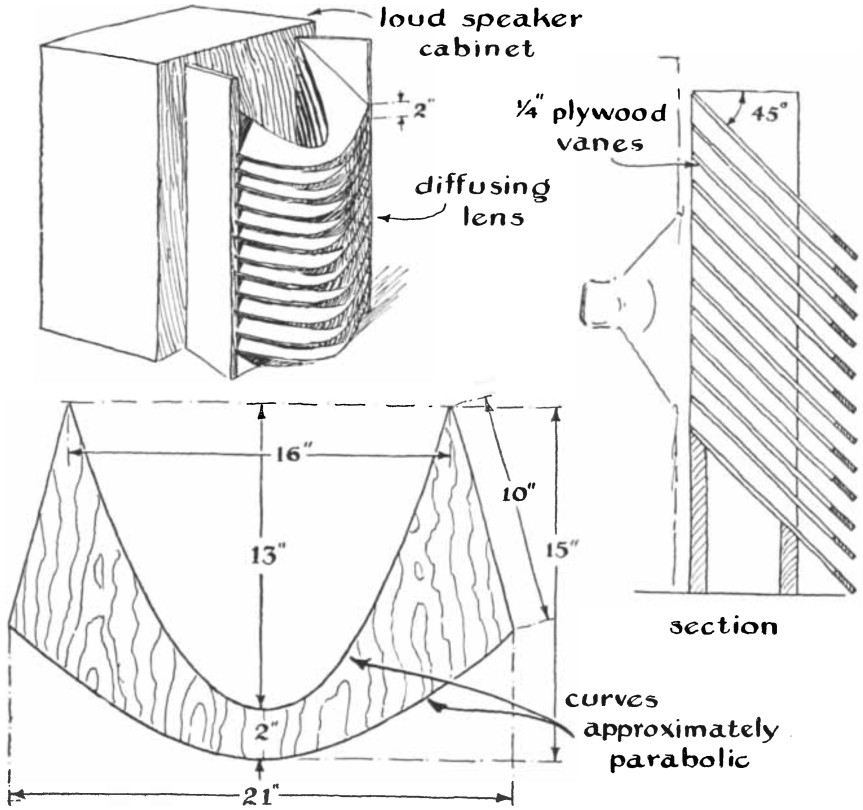
Microphones of the condenser type work well in experiments of this kind. They are costly, but for a few cents you can make a crude one which will pick up the footsteps of insects. Sandwich a sheet of cleansing tissue about four inches square between two sheets of aluminum foil. The cleansing tissue acts as a springy insulator. The weight of an insect walking across one of the foil sheets compresses the tissue, changing the distance between the plates and hence altering their capacity to hold electrical charge. If the condenser is charged, the variations in capacity will produce alternating currents which can be picked up and made audible by your amplifier. Use a 180-volt battery to supply the charge, connecting it in series with a 30-megohm resistor. The resistor in turn should be connected across the phono-input of the sound system through a tenth-microfarad capacitor. The capacitor is inserted in the ungrounded lead of the phono-input. The capacitor insulates the battery from the amplifier. To prevent unwanted noises from entering the system, put the insect, the microphone, battery, resistor and capacitor in a closed wooden box wrapped in a one-inch-thick blanket of rock wool and then pack the whole business into a metal box which will serve as an electrical shield. Connect the microphone assembly to the amplifier with a length of coaxial cable, grounding the outer conductor to the metal box and the chassis of the amplifier. The completed "microscope" is sensitive enough to make the hopping of a flea sound like a cannonade!

If you enjoy weird sounds of this sort, you will not want to miss the "dawn chorus." You can listen to it most easily by picking up a copy of the remarkable recording *Out Of This World,* prepared by the Cook Laboratories of Stamford, Conn. To hear it directly, you hook a 300-foot length of wire to the ungrounded terminal of your amplifier's phono-input. You must also install a filter which discriminates against 60 and 120 cycles plus all odd harmonics through



resistor	8 ohm speaker	16 ohm speaker
$R_1 = R_2$ =	1.5	2.75
R_3 =	20	45

Circuit details of an output meter for sound systems



Construction details of an acoustic lens of the slat type

the 13th, and another to keep out frequencies of 19 kilocycles and above. Millett G. Morgan of the Thayer School of Engineering at Dartmouth College, who has made extensive observations of ionospheric sounds, recommends that the antenna slant upward, with the outer end supported as high as possible. He also suggests that the experiment be made in the country as far as possible from power lines and that you use batteries for power—in short, minimize electrical noise as much as possible. In effect your audio amplifier is substituted for a radio set.

Hi-fi fans who are interested mainly in the reproduction of music may enjoy constructing the simple instrument shown on page 126. It is a power output meter. With it—and a recording of the frequencies between 40 and 15,000 cycles—you can measure and chart the electrical response of your entire system, from pickup to loud-speaker. In addition, you can calibrate the volume control of the amplifier and make quantitative records of the level at which each recording sounds best.

To check the electrical characteristics of the system, you connect the input terminals of the meter across the voice coil of the loud-speaker, start the recording and, when the first frequency comes on, adjust the 2,000-ohm variable resistor until the pointer of the milliammeter registers close to the mid-point of the scale. If the response of the system is "flat," subsequent frequencies will produce identical meter readings. If your system is properly adjusted, however, the response will not be flat. It should conform with one of the standard curves adopted by the recording companies.

Operating the toggle switch will cut in the network of resistors and drop the meter reading three decibels. This loss can be compensated by increasing the volume control of the amplifier. The interval through which the control must be turned represents a three-decibel step. This can be marked on the dial. The attenuating network is then switched out of the circuit and the sensitivity of the meter lowered by adjusting the 2,000-ohm resistor until the pointer is again centered. This cycle is repeated until the volume control is fully calibrated. The load represented by the loud-speaker varies with frequency, depending upon the speaker's characteristics, and will influence the accuracy of the calibration. You can eliminate this variable by substituting a "dummy" load for the speaker—a fixed resistor of the same resistance value and power-dissipating capacity as the speaker.

INDEX OF ADVERTISERS

JANUARY, 1956

BIBLIOGRAPHY

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

TRANSLATION BY MACHINE

Machine Translation of Languages. Edited by William N. Locke and A. Donald Booth. John Wiley & Sons, Inc., 1955.

WHISTLERS

An Investigation of Whistling Atmospherics. L. R. O. Storey in *Philosophical Transactions of the Royal Society of London*, Series A, Vol. 246, No. 908, pages 113-141; July 9, 1953.

Musical Atmospherics. T. S. Eckersley in *Nature*, Vol. 135, No. 3403, pages 104-105; January 19, 1935.

Whistling Tones from the Earth. H. Barkhausen in *Proceedings of the Institute of Radio Engineers*, Vol. 18, No. 7, pages 1155-1159; July, 1930.

EARLY ENVIRONMENT

Effects of Early Experience upon the Behavior of Animals. Frank A. Beach and Julian Jaynes in *Psychological Bulletin*, Vol. 51, No. 3, pages 239-263; May, 1954.

The Effects of Early Restriction on Activity in Dogs. W. R. Thompson and W. Heron in *Journal of Comparative and Physiological Psychology*, Vol. 47, No. 1, pages 77-82; February, 1954.

The Genesis of Emotional Behavior: An Experimental Study of the Dog. R. Melzack in *Journal of Comparative and Physiological Psychology*, Vol. 47, No. 2, pages 166-168; April, 1954.

THE NEUTRINO

Detection of the Free Neutrino. F. Reines and C. L. Cowan, Jr., in *The Physical Review*, Vol. 92, No. 3, pages 830-831; November 1, 1953.

Introductory Nuclear Physics. David Halliday. John Wiley & Sons, Inc., 1955.

THIRST

Physiology of Man in the Desert. E. F. Adolph and others. Interscience Publishers, Inc., 1947.

Shipwreck Survivors: A Medical

He brought snow to New Guinea

DECEMBER 24, 1944. The captured, rebuilt airstrips bake under a blazing sun. No breeze stirs the kunai grass. The dim, weather-stained notice clinging to the mail-room door tells you Jap subs sank the ship carrying Christmas packages.

If you punch two buttons on the walkie-talkie at the same time, you can tune in the Jungle Network. The song you hear is a favorite all over the Pacific. It seems to bring you home.

"I'm dreaming of a white Christmas . . ."*

The man who wrote that song is an expert at cheering up troops. In 1918, Private Irving Berlin wrote his first all-soldier show, in 1942 his second: "This Is The Army," with which he toured almost every theater of war.

Berlin is also an expert at coming up the hard way. Immigrant to America at 5, on his own at 19, his first song earned just thirty-three cents. But Berlin kept trying; never lost faith in himself or his opportunities.

His hard-working, confident drive is a trait Americans set great store by. And Americans have a lot of it. Which helps account for the fact that our country's Savings Bonds are one of the finest investments in the world.

For the drive of 165 million Americans stands behind these Bonds.

That's why it's such a sound idea for every American—for you—to invest regularly in United States Series E Savings Bonds, and hold on to them.

**Copyright 1942, Irving Berlin.*

★ ★ ★

It's actually easy to save money—when you buy Series E Savings Bonds through the automatic Payroll Savings Plan where you work! You just sign an application at your pay office; after that your saving is done *for* you. The Bonds you receive will pay you interest at the rate of 3% per year, compounded semiannually, when held to maturity. And *after* maturity they go on earning 10 years *more*. Join the Plan today. Or invest in Bonds regularly where you bank.

Safe as America—U.S. Savings Bonds

STUDY. Macdonald Critchley. J. A. Churchill, Ltd., 1943.

THE URINARY FUNCTION OF THE KIDNEY. A. V. Wolf. Grune & Stratton, Inc., 1950.

THE VOYAGE OF THE HÉRÉTIQUE. Alain Bombard. Simon & Schuster, Inc., 1954.

CAROTENOIDS

ANIMAL BIOCHROMES AND STRUCTURAL COLOURS. D. L. Fox. Cambridge University Press, 1953.

CAROTENOIDS. P. Karrer and E. Jucker. Elsevier Press, Inc., 1950.

THE COMPARATIVE BIOCHEMISTRY OF THE CAROTENOIDS. T. W. Goodwin. Chapman & Hall, Ltd., 1952.

THE PHOTORECEPTOR FUNCTION OF THE CAROTENOIDS AND VITAMIN A. George Wald in *Vitamins and Hormones*, Vol. 1, pages 195-225; 1943.

AMBROISE PARE

AMBROISE PARÉ AND HIS TIMES, 1510-1590. Stephen Paget. G. P. Putnam's Sons, 1897.

THE APOLOGIE AND TREATISE OF AMBROISE PARÉ. Edited by Geoffrey Keynes. University of Chicago Press, 1952.

LIFE AND TIMES OF AMBROISE PARÉ. Francis R. Packard. P. B. Hoeber, 1921.

SELECTIONS FROM THE WORKS OF AMBROISE PARÉ. Edited by D. W. Singer. J. Bale Sons & Danielson, Ltd., 1924.

THE SARGASSO SEA

THE SARGASSO SEA. G. E. R. Deacon in *The Geographical Journal*, Vol. 99, No. 1, pages 16-28; January, 1942.

SARGASSO SEA MERRY-GO-ROUND. Myron Gordon in *The Scientific Monthly*, Vol. 53, No. 6, pages 542-549; December, 1941.

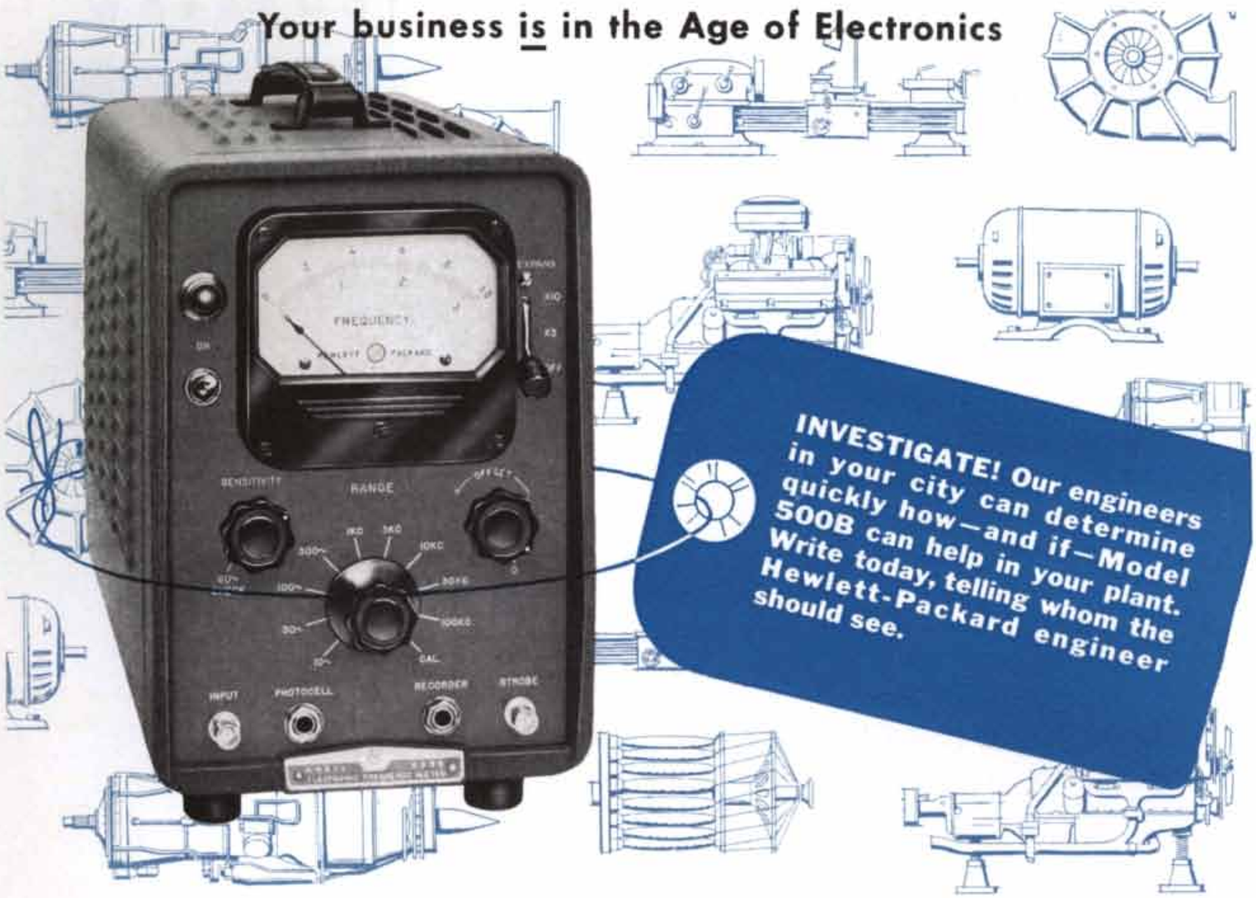
A STUDY OF THE CIRCULATION OF THE WESTERN NORTH ATLANTIC. C. O'D. Iselin. *Papers in Physical Oceanography and Meteorology published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution*; Vol. 4, No. 4; 1936.

THE AMATEUR SCIENTIST

ELEMENTS OF ACOUSTICAL ENGINEERING. Harry F. Olson. D. Van Nostrand Company, Inc., 1947.

HIGH FIDELITY TECHNIQUES. John H. Newitt. Rinehart Books, Inc., 1953.

PHYSICS. N. C. Little. D. C. Heath & Company, 1953.



This new instrument is a low cost solution to industrial control and overspeed problems

Automatic speed control is a vital part of modern manufacturing. The ingenious new Hewlett-Packard 500B Frequency Meter provides a sure, simple electronic way to control machinery speed, guard against overspeed or underspeed, and facilitate speed recording. The instrument will also count or control many other quantities such as random events, temperature, pressure and weight, which can be converted to electrical impulses. Operation does not require technical training.

Model 500B, priced at $285, is one of over 250 major precision instruments Hewlett-Packard manufactures for science, the military, and industry.

hp

WORLD LEADER IN ELECTRONIC MEASURING EQUIPMENT

Engineers in principal areas throughout the U. S. and Free World

HEWLETT-PACKARD COMPANY

275 PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAvenport 5-4451