

SCIENTIFIC AMERICAN



WHY LEAVES FALL

FIFTY CENTS

November 1955



Apart, they're liquid... together, they're solid

—and this strange reaction helps make parts for your car

... your television set ... and even your tableware

BY THEMSELVES, these two liquids flow as freely as water. Yet when poured together they quickly turn into a solid—harder than many metals.

THESE AMAZING LIQUIDS which become a solid, without applying heat or pressure, are man-made chemicals—one called a resin, the other a curing agent. The chemists have coined the name, *epoxy*, for the resulting plastic.

FROM YOUR KITCHEN to the automobile plant, you will find epoxies now at work. In the latest tableware, they seal knife blades in their handles, keeping them everlastingly tight.

Epoxies are being used to make huge dies to stamp out automobile parts, airplane wing sections, and other varied shapes. These dies can be made in little more than half the time it takes to make all-metal dies, and at substantial savings, too.

DELICATE PARTS for television, radio, and other electronic equipment are embedded in epoxies to protect them from moisture and vibration.

MANY INDUSTRIES now are looking to epoxies for help in making better things for you. Developing and producing epoxies—as well as long-familiar plastics—is one of the many important jobs of the people of Union Carbide.

FREE: Learn how *ALLOYS, CARBONS, GASES, CHEMICALS, and PLASTICS* improve many things that you use. Ask for "Products and Processes" booklet F.

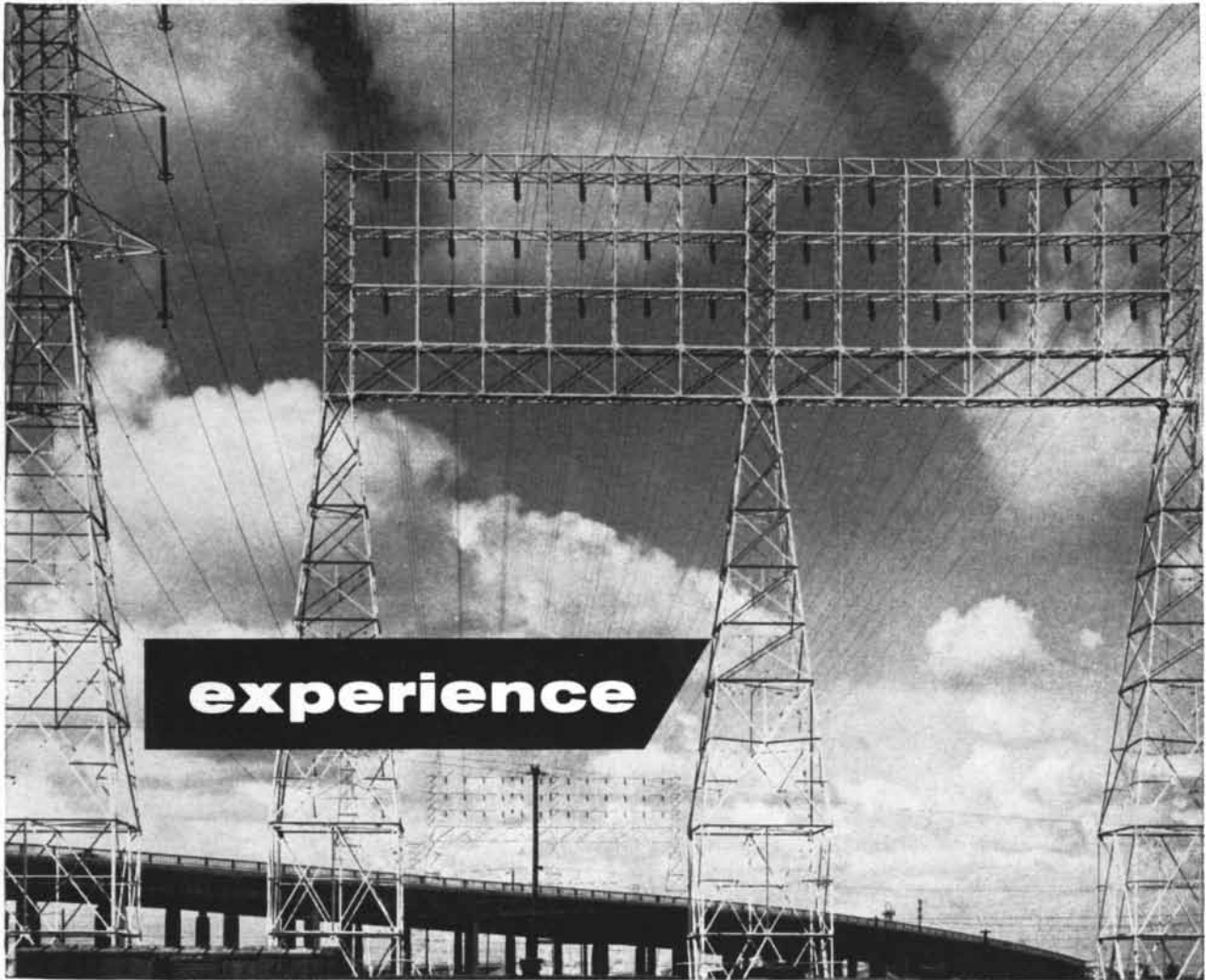
UNION CARBIDE
AND CARBON CORPORATION

30 EAST 42ND STREET  NEW YORK 17, N. Y.

In Canada: UNION CARBIDE CANADA LIMITED

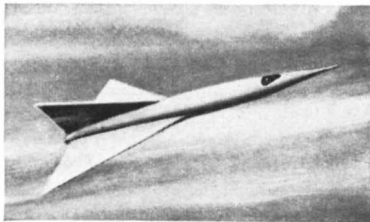
UCC's Trade-marked Products include

BAKELITE, VINYLITE, and KRENE Plastics	PYROFAX Gas	PREST-O-LITE Acetylene	EVEREADY Flashlights and Batteries
SYNTHETIC ORGANIC CHEMICALS	LINDE Silicones	PRESTONE Anti-Freeze	LINDE Oxygen
Dynel Textile Fibers	ELECTROMET Alloys and Metals	HAYNES STELLITE Alloys	ACHESON Electrodes
			NATIONAL Carbons



experience

plays a vital role in every success



Pressure actuated switches for every requirement from zero absolute to 12,000 psi. Meletron switches are used by every major aircraft manufacturer.

Bringing electric power across miles of terrain requires a vast amount of knowledge, plus experience with the behavior characteristics of many metals.

In the precision instrument field, experience also plays an important part. To design and build a few pressure switches that exceed specifications, is relatively easy. But to produce more than a million consistently reliable instruments requires techniques and controls gained only through *experience*.

MELETRON[®]
CORPORATION

950 N. HIGHLAND AVE.
LOS ANGELES 38,
CALIFORNIA

J. M. WALTHER CO., Boeing Field, Seattle 8, Washington; ROUSSEAU CONTROLS Ltd., 2215 Beaconfield Avenue, Montreal 28, Canada; JOSEPH C. SORAGHAN & ASSOCIATES, 1612 Eye Street, N. E., Washington 6, D. C.; J. N. FAUVER CO., Inc., 5562 Montgomery Road, Cincinnati 12, Ohio; and Waterville, Ohio; GEORGE E. HARRIS & CO., Inc., 3241 E. Douglas Ave., Wichita 8, Kan.

LETTERS

Sirs:

I submit the enclosed open letter to George Gamow, whose article, "Information Transfer in the Living Cell," published in your October issue, gave an erroneous value for π : 3.14158 . . . instead of the correct 3.14159 . . .

Professor Gamow,
Fie!
You've undervalued π
(on page LXXV-
III, column 3)

A hundred thousandth. Why
Is π so oddly shy?
Was even 8 preferred
Since, 9 \acute{e} d, π 's a surd?

Absurd! For π , with 8,
Still's incommensurate.
Oh, naught can justify
Redeucing valued π ;

Buffon, that honest Count,
To reckon π 's amount,
Cast needles down on lines,
But did not cast out 9s.

The eye is slower than
The hand; perhaps you can
Not only cheat your π
But halve it too, but I

(Imaginary i)

Scientific American, November, 1955; Vol. 193, No. 5. Published monthly by Scientific American, Inc., 2 West 45th Street, New York 36, N. Y.; Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer. Entered at the New York, N. Y., Post Office as second-class matter June 28, 1879, under act of March 3, 1879. Additional entry at Greenwich, Conn.

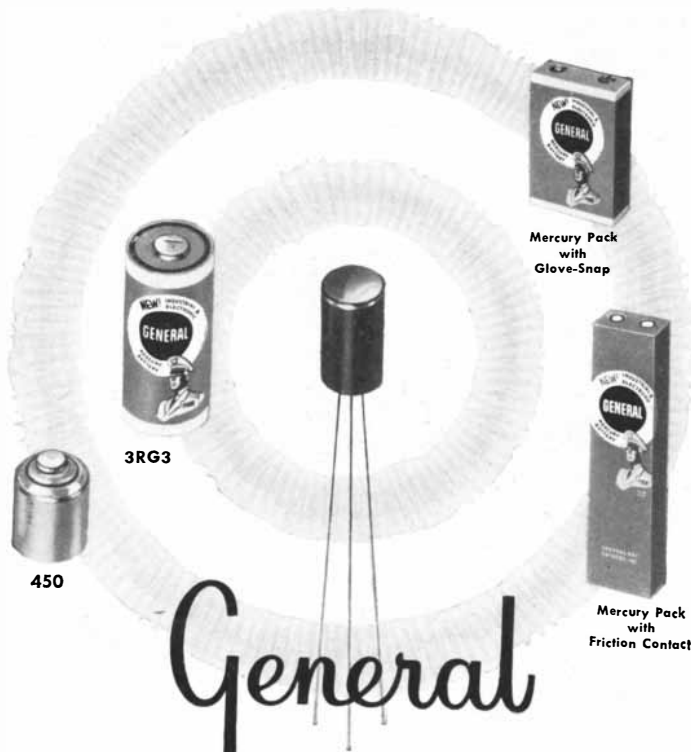
Editorial correspondence should be addressed to The Editors, SCIENTIFIC AMERICAN, 2 West 45th Street, New York 36, N. Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

Advertising correspondence should be addressed to 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.



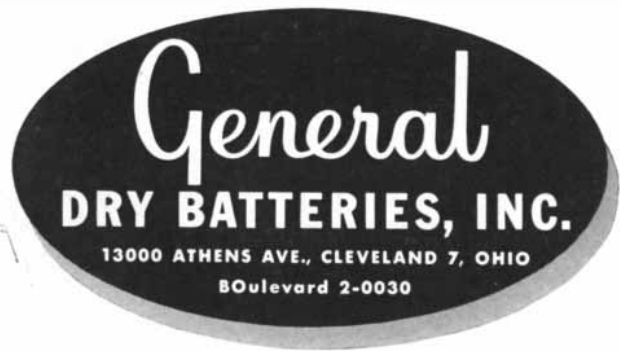
mercury batteries can add extra dependability to your products

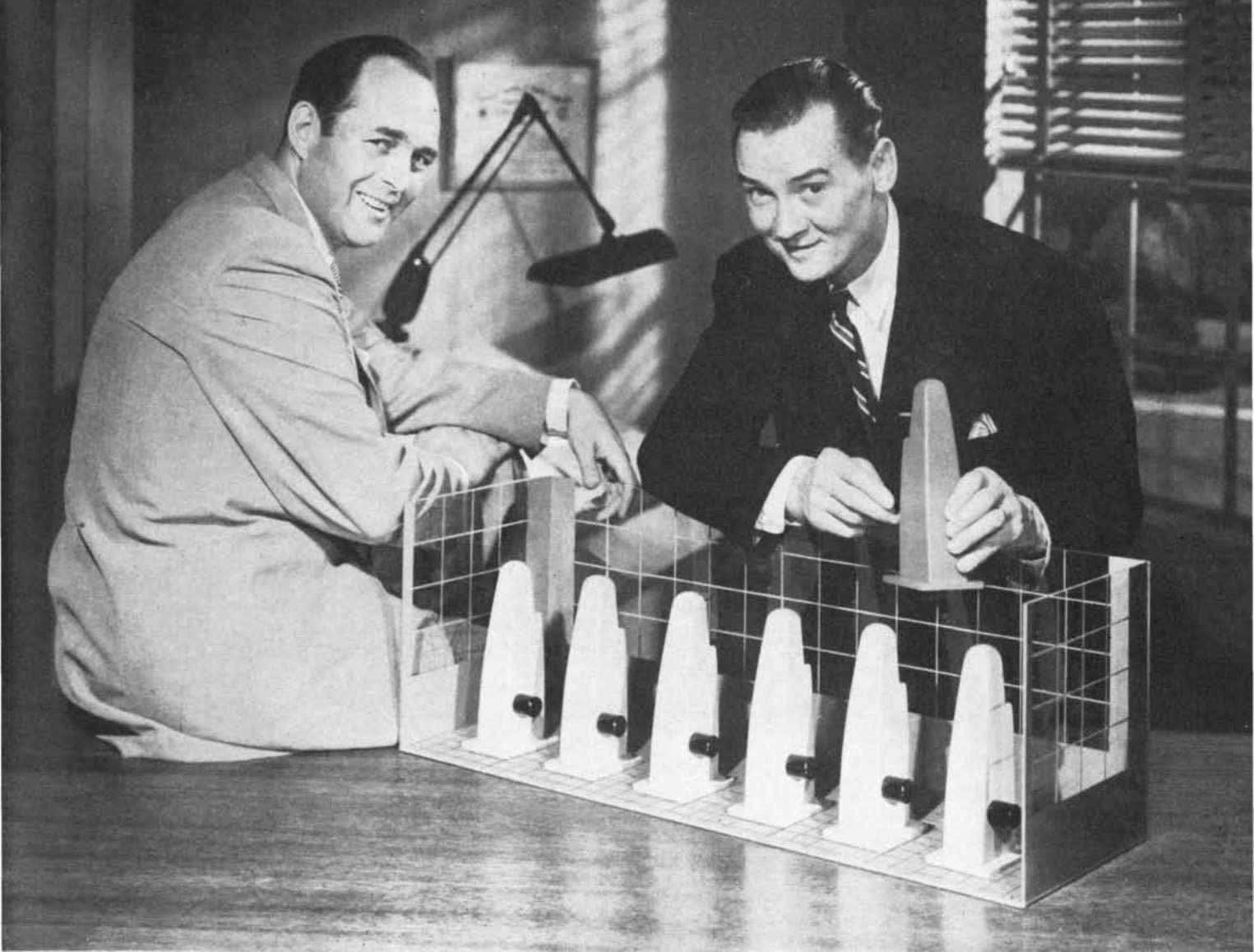
TODAY, many products are providing greater dependability, thanks to the unique qualities offered by General Mercury Batteries.

General Mercury Batteries have excellent shelf and operating life, have a high ratio of energy to size and they provide a constant source of voltage till exhausted. A nickel-plated steel can makes them resistant to the effects of humidity and corrosive atmospheres. General Mercury Batteries are available in "power packs" in an unlimited number of series, parallel or series-parallel combinations. These packs are made up of individual cells joined together by General's exclusive surge-weld process. This method assures a safe, sound, lifetime connection.

These qualities are being used in many products with transistor or electronic circuits like Geiger counters, tachometers, guided missiles, pocket radios, hearing aids, and numerous test devices.

If you need dependable power in small space, you might find that our experience in developing mercury cells and "power packs" can be of valuable assistance. It's at your disposal. Just write and tell us how we can help. We will be glad to send you free data.





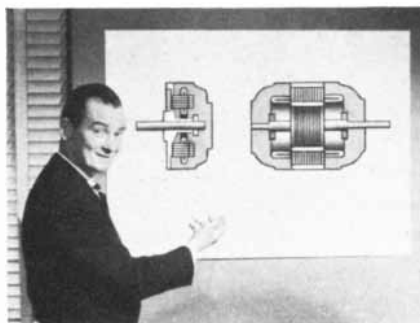
They wanted to add another machine on the line

Fairbanks-Morse Design Engineers wanted to see how *you* could get more production out of every square foot of premium production line space.

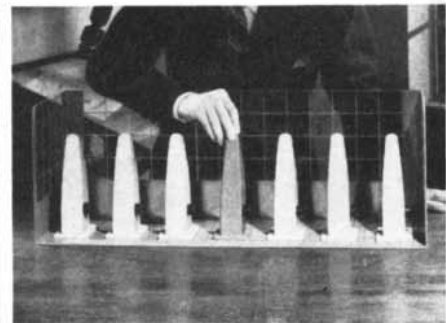
They designed the now-famous Fairbanks-Morse Axial Air Gap Motor that is much shorter than conventional type motors. That saved "motor space" can become "production space" by the addition of one or more machines to every production line.

It is this kind of design approach that typifies the product bearing the Fairbanks-Morse Seal of Quality. When next you look for an electric motor... a scale... a pump... a diesel engine, look for the F-M Seal and see the difference that quality makes.

Fairbanks, Morse & Co., Chicago 5, Ill.



The Secret... is that the air gap in this motor is perpendicular to the shaft, rather than parallel as in a conventional motor... without sacrifice in performance.



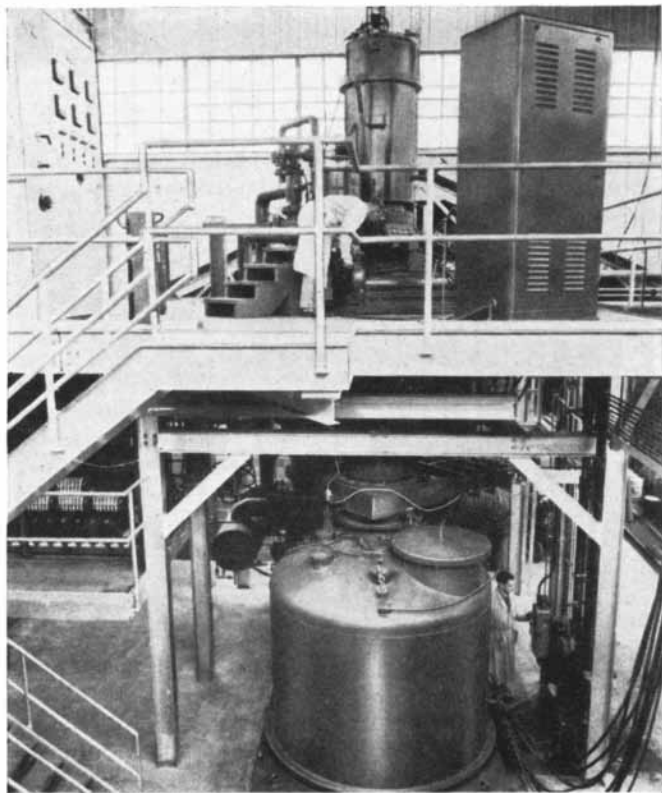
The Result... is that by replacing conventional motors with F-M Axial Air Gap Motors, enough space has been saved to add one or more machines to the line.



FAIRBANKS-MORSE

a name worth remembering when you want the best

ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS



Unique new vacuum furnace yields 60 tons of high-purity alloys a month

Until recently vacuum metallurgists had to open a vacuum furnace after each production cycle to remove the processed metal and insert a new charge and molds. This slowed production to the point where these metallurgists measured their yield in *pounds*.

A new CVC furnace, recently installed at General Electric's Carboly Department, breaks through this bottleneck, by means of a system of airtight valve interlocks.

The metallurgist can lower pressure in the new furnace to less than 1 micron Hg, insert a 1,000-pound charge, melt it, cast it, remove the cast molds, and insert a new charge and new molds—all without breaking vacuum.

Carboly engineers repeat this cycle indefinitely and they measure their yield in tons—60 tons of high-purity alloys a month.

The furnace has other interesting features: the world's fastest high-vacuum pump (evacuates at the rate of 1,000,000 micron-liters a second); modular design which permits remarkable flexibility in capacity and production techniques.

Perhaps your high-vacuum problem is not metallurgical. Well, let us hear about it anyway. CVC has solved high-vacuum problems in electronics, dehydration, metal and plastic finishing, nuclear energy, hermetic sealing, and other fields. We will welcome a chance to work with you.



Headquarters
For High Vacuum

Consolidated Vacuum Corporation Rochester 3, N. Y.

a subsidiary of CONSOLIDATED ENGINEERING CORPORATION, Pasadena, California

CVC sales now handled through Consolidated Engineering Corporation with offices located in: Albuquerque • Atlanta • Boston • Buffalo • Chicago • Dallas • Detroit • New York • Palo Alto • Pasadena • Philadelphia • Seattle • Washington, D. C.

Will not stand idly by
While any constant k
Is idly chipped away.

Where'd logarithms be
If you diminished e ?
Or relativity,
If one could vary c ?

If π were any less
Than what we now profess,
The universe would then
Expand some more again.

(The red shift—is it due
To tamperers like you?)
Go pick on S_0
There's plenty there to cull!

But please, Professor G.,
Leave π alone, for me.
(It's bad enough my T
 $\rightarrow O$.) Be

As generous with "stet"
As with ideas; let
 π be, while life endures,
Itself, as I am,
Yours,

THEODORE MELNECHUK

Linde Air Products Company
New York, N. Y.

P. S. "Redeucing" in verse three is sic; " S_0 " in verse nine is Cantor's "aleph null."

T. M.

Sirs:

Two weeks ago I received the results of 3,000 RNA "poker games" played with a random selection of card suits on MANIAC, the digital computer at the Los Alamos Scientific Laboratory. These results slightly change some conclusions in the article I wrote for your October issue. I refer to the chart on page 76 and to the third paragraph from the end of the article. I should now like to add the following correction (or rather extension) to the article.

At the beginning of the paragraph it was stated: "When the 'weighted' triplet rule is applied to the four different types of nucleotides, assumed to be randomly distributed in the RNA chain, the curve of the nucleotide combinations occurring agrees perfectly with the observed abundances of amino acids in proteins [see chart]." This statement, as well as the gray line in the chart, pertains to the random distribution of the four nucleotides, the relative amounts of

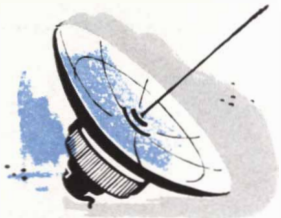
Farnsworth
In Defense and Industry

RESEARCH



Applied Physics, Circuit Research, Solid State Physics, Low Temperature Physics.

RADAR



Transmitters and Receivers, Computers, Microwave Components, Pulse-Coding and Circuitry.

ELECTRON TUBES



Photomultipliers, Storage Tubes, Image Tubes, Infrared Tubes.

MISSILE



Guidance and Control System, Test Equipment.

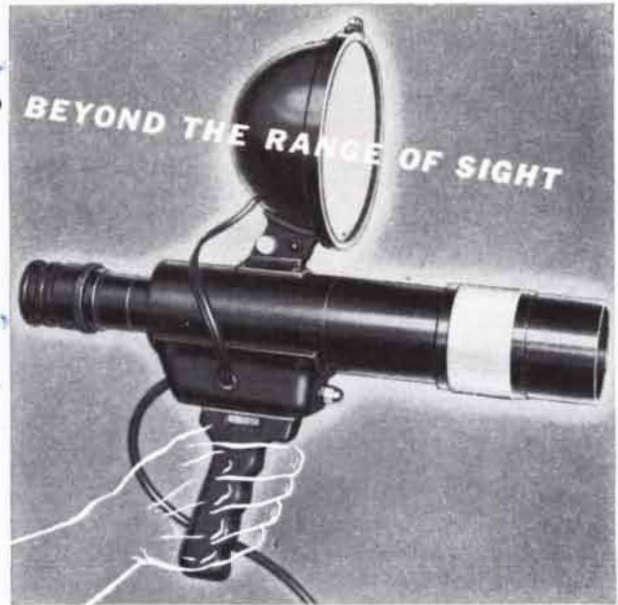
Farnsworth **DIVISION OF IT&T**

INFRARED VIEWER

Lets you see in the dark!

Another Farnsworth Achievement!

A natural by-product of Farnsworth's outstanding work in the field of infrared. Using techniques originally developed for the military, this handy Viewer has proved equally useful in civilian life, wherever there is a need to see in the dark. Farnsworth — pioneer in television and electronics — is dedicated in this as in its other activities, to the extension of man's vision beyond the range of sight.



Farnsworth

The name backed by more than a quarter century of development of television and the allied electronic arts. Pioneers in the production of special purpose tubes, in the guided missile field, in infrared, and many other electronic specialties.



MOBILE PATROL SURVEILLANCE



FILM PROCESSING INSPECTION



MEDICAL BIOLOGICAL RESEARCH



MILITARY LAND-SEA-AIR APPLICATIONS

For more information on the Infrared Viewer and other outstanding Farnsworth achievements write Dept. V-105.

FARNSWORTH ELECTRONICS COMPANY • FORT WAYNE, INDIANA
a division of International Telephone and Telegraph Corporation

SQUARE ROOT?

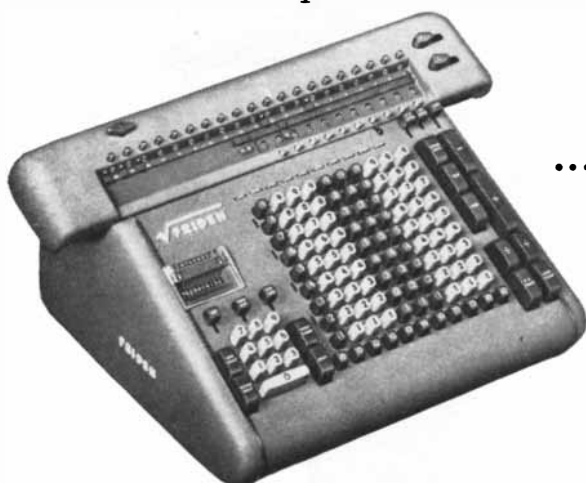
Nothing could be simpler
—thanks to Friden

Features and abilities of the fully automatic Friden Square Root Calculator (Model SRW) are described in detail by this Information Sheet. Write for your copy to FRIDEN CALCULATING MACHINE CO., INC., Dept. SA-11, San Leandro, Calif.



IN ADDITION to providing all basic features which enable the fully automatic Friden Calculator to perform more kinds of figure-work *without operator decisions* than any other calculating machine ever developed...

Friden Calculator model SRW
extracts square root automatically



at a touch
of one key
...for the first
time on any
desk
calculator

Can you afford
to be without this
remarkable **Friden**
THE THINKING MACHINE
OF AMERICAN BUSINESS

FRIDEN makes Automatic Calculators in a range of prices and sizes meeting all figuring needs; also the Natural Way Adding Machine, the Computyper and the Add-Punch Machine. Friden sales, instruction and service available throughout the U.S. and the world.

which were chosen in accordance with the chemical analysis of RNA. It seems, however, that the relative amounts of the four nucleotides in RNA molecules are not random. In fact, the results obtained by Giulio Fermi and N. Metropolis, who drew their 3,000 MANIAC hands on the assumption of random abundances of the four nucleotides, do not fit at all with the observed curve of the amino acid abundances. Thus one must conclude that, while the *placement* of nucleotides in the RNA molecule is at random, the *selection* of nucleotides to be used is subject to some restrictions. The details will be soon published by the author and Martinus Yčas in *Proceedings of the National Academy of Sciences*.

GEORGE GAMOW

George Washington University
Washington, D. C.

Sirs:

As a geologist I am fascinated by the two-page oblique aerial photograph reproduced on pages 110-111 of your September issue. One of the most remarkable features shown, not mentioned in the description, is the clearly expressed, straight trace of the San Andreas Fault, which passes between the two southernmost of the snow-clad peaks, and on the northwest just this side of the most distant snow-covered peak.

R. F. YERKES

Brea, Calif.

Sirs:

I have just finished reading Jotham Johnson's article "The Changing American Language" [SCIENTIFIC AMERICAN, August] and thought he would like a tidbit to add to his collection.

I have heard an excellent example of vowel inversion ("turmoil—toimerl") in this country. The North Country folk (Lancashire, notably) have a very different pronunciation of the "u" and "o" from the southerners. A friend of mine is named Cutbush, which I normally pronounce with the short "u" for "cut" and an "oo" sound for "bush." In Lancashire he is called "Cootbush," with an exact inversion of the vowel sounds!

G. PARR

Chapman & Hall, Ltd.
London, England

in design and precision

there's nothing like a LEICA

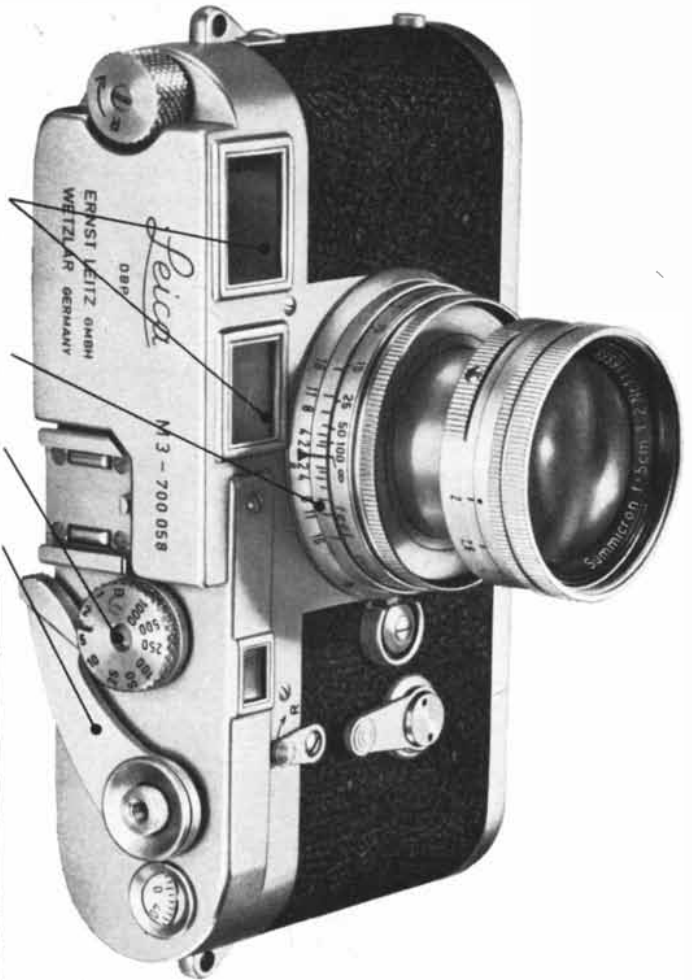


Bright-line frame outlines exact field of view. Frame changes automatically with insertion of different lenses. Automatic parallax correction for all lenses.

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 **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

Life on the Chemical Newsfront



CYANAMID HAS RECENTLY RESEARCHED two new color-stable types of Phthalocyanine blue pigments to solve the problem of color drift in automotive finishes. The new red shade Cyan Blue Toner BNF 55-3750 and the green shade Cyan Blue Toner GT-NF 55-3450 have the unique physical properties of being both flocculation-resistant and crystal-stable in automotive finishes. So now, regardless of application techniques, uniform color and depth are easily obtained on both original and refinishing coatings. (Pigments Division)



UNDERWEIGHT INFANTS now may have their appetites stimulated and rate of growth increased by a new preparation known as INCREMIN® Lysine-Vitamin Drops. Developed by the Lederle Laboratories Division of Cyanamid, INCREMIN is a combination of a vital growth-stimulating amino acid and the necessary vitamins. Based on extensive research in human nutrition, INCREMIN is prepared as a cherry-flavored liquid and packaged in an unbreakable "squeeze" bottle for easy dispensing. Effective for infants, INCREMIN also may be used for elderly persons who do not have sufficient zest for their food. (Lederle Laboratories Division)

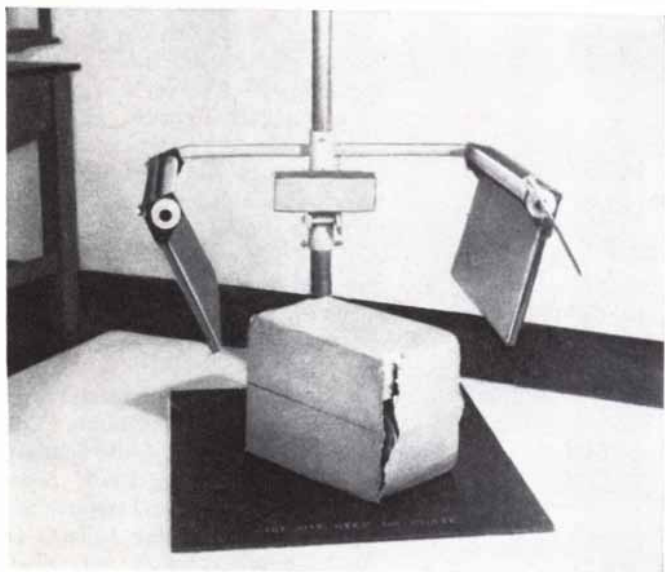


PACKAGED MEAT, FISH AND FROZEN FOODS keep fresher longer when the cellophane wrap is coated with ACCOBOND® 3900 Resin before waterproofing treatment. The cationic nature of ACCOBOND 3900 helps to produce strong adsorption to cellophane and exceptionally high bond strength between cellophane and the nitrocellulose waterproofing coating. A new and simple test method, developed by Cyanamid research, gives rapid evaluation of bond strength and better control of the cellophane coating process. For details of the new test write on your letterhead. (Industrial Chemicals Division, Department A)

News Briefs



A NEW LOOK now can be given thermosetting plastic products with colored decorations molded into the top surfaces. The dinnerware pictured above is molded of Cyanamid's Melamine Molding Compound No. 1077. The decorative paper overlay is impregnated with Cyanamid's Melamine Resin No. 405. Known as a "foil," the overlay can be printed with special inks in any number of colors. It is inserted in the mold during the breathing or de-gassing phase of the molding cycle. Heat and pressure fuse the impregnated foil and the molding compound into a homogeneous mass. Many other possible applications can be envisioned: decorative door knobs, gift boxes, closures, wall tiles and cosmetic containers. (Plastics and Resins Division)



NEW PERFORMANCE RECORDS for paper packaging materials such as the carton shown in the "drop-test" above, may be established by fortification with Polyacrylamide of the conventional adhesives used in carton construction. The addition of small amounts of Polyacrylamide increases the strength and durability of the adhesive bond. It also provides high initial tack and unusual spreadability. As a result, packages are stronger and more resistant to the wear and tear they encounter in transit. Polyacrylamide is a white, odorless powder, readily soluble in cold water, and it does not decrease in solubility with increase in temperature. The remarkable properties of Polyacrylamide make it suitable for a wide range of industrial applications. (New Product Development Department)

IMPROVED PERFORMANCE IN COLORED PAPERS

is made possible with CALCOTONE® Pigment Pastes. Full color value is developed with CALCOTONE Pigment Pastes because their fine particle size and compatibility with paper additives assure excellent dispersion of the color in the beater. The CALCOTONE Pigment Pastes also have outstanding light-fastness and chemical stability. Better color results are obtained on all grades of paper ranging from tissues to heavyweight board. (Organic Chemicals Division)

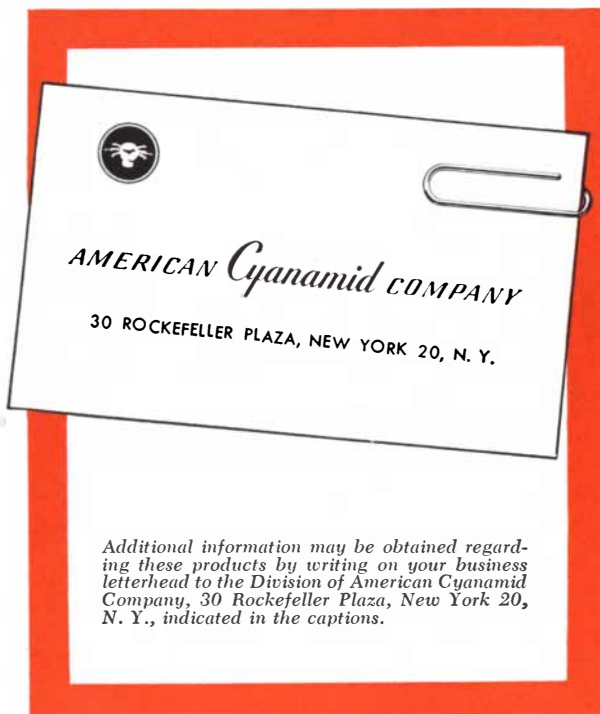
MORE EFFICIENT PURIFICATION OF MUNICIPAL WATER

has been obtained by replacement of dry alum with special liquid alum. The use of liquid alum reduces labor costs in handling and storage. Also, liquid alum can be fed continuously to the raw water at an accurate rate by metering devices, thus eliminating operation and maintenance of the dry feed machine. With the new liquid alum, savings of almost 10% have been reported in large-scale municipal water purification operations. (Industrial Chemicals Division, Department A)

ACCONOX* FEED SUPPLEMENT

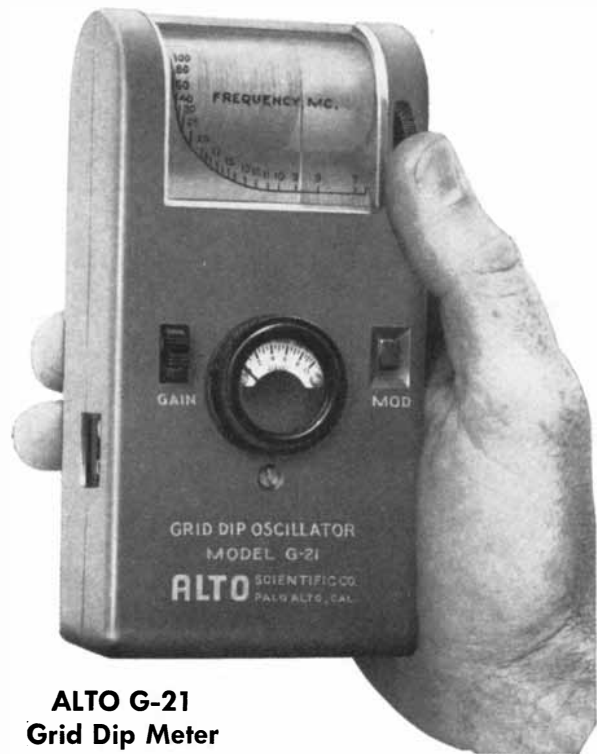
, the first antioxidant premix offered to feed manufacturers, keeps feeds appetizing longer by deterring rancidity which develops in feeds during storage. It eliminates the unpleasant smell and taste in feed by retarding oxidation. Also, it conserves vitamins A and E, thus helping to prevent deficiency diseases. Acconox 25 is a special blend of butylated hydroxyl toluene. It does not dust, cake, or cling to mixing equipment, thereby assuring even distribution in the mixing operation. (Fine Chemicals Division)

*Trade-mark



LOOK!

**A 120 MC Grid Dip Oscillator
You Hold in Your Hand!**



**ALTO G-21
Grid Dip Meter
\$150⁰⁰**

**New! 7 to 120 MC! ±5% accuracy! Transistorized!
Printed Circuits! Direct reading! No plug-in coils!
Rugged, battery driven, weighs 18 oz.!**

Cradle this unbelievable, feather-weight new Grid Dip Oscillator in your hand—and make transmitter, receiver or system frequency measurements with convenience never known before! Operate all controls with one hand—with your fingertips. Obtain 1 KC modulation with a flick of modulator switch (audible signal in headphones). Increase gain for good “dip” indication on front panel meter. Open the rugged, shock proof alkyd resin case; study the radical yet proven new circuitry that makes this possible.

The price? \$150—much less than a large, ac powered laboratory instrument would cost you.

Why not check the brief specifications, then write today for complete details!

SPECIFICATIONS

- Frequency Range 7 to 120 MC
- Modulator Frequency . . . 1 KC nominal
- Accuracy ± 5% below 100 MC
- Battery Life 30 hrs. (continuous)
- Size 1½" x 3" x 5¾"
- Weight 18 oz., complete
- Price \$150.00 f.o.b. factory

Data subject to change without notice

Write Today for Complete Details

ALTO SCIENTIFIC COMPANY

855 COMMERCIAL ST. • PALO ALTO, CALIFORNIA, U. S. A.
DAVENPORT 4-4733



**50 AND 100
YEARS AGO**



NOVEMBER, 1905: “The latest of the aeronautic experiments of Israel Ludlow, of New York City, occurred on Sunday, October 22, when the aeroplane carrying Charles K. Hamilton, a professional aeronaut, was successfully launched into the air from the east bank of the Hudson River, and after a flight of some minutes’ duration, settled gradually into the water near midstream. The experiment was intended thoroughly to test the flying, or more properly the gliding, properties of the machine, and for this purpose the motive power at the end of the rope, or ‘kite string,’ was a powerful tugboat, an arrangement permitting the use as a course of the unbroken sweep above the river. After a number of unsuccessful starts—the slack not being completely taken up before the drag acted on the machine—the aeroplane was at length flung into the air in the teeth of a strong wind. Until a height of approximately 500 feet was attained the rise was rather erratic; Hamilton, however, with great coolness, managed to keep the giant white-winged kite on an even keel by shifting his weight from one point to another as the occasion required, and when more than 600 feet of rope had been let out from the tugboat, the machine settled down and followed steadily in the wake of the vessel.”

“In an article in the last annual report of the Smithsonian Institution Col. W. C. Gorgas, U. S. A., Chief Sanitary Officer of the Isthmian Canal Zone, shows that yellow fever and malaria, the two great scourges of the Isthmus of Panama, can be successfully controlled. Briefly stated, the sanitary problem is to protect the fifteen thousand men that are likely to be employed on the canal. At present yellow fever is endemic nowhere in the Canal Zone except the city of Panama, and the immediate object is to get rid of the infected *Stegomyia* mosquitoes present in the city. An even more important problem is the control of malaria. Four times out of five, if the female *Anopheles* mosquito bites a na-

A GIANT FOR ITS SIZE!



Telephone science produces an important new rectifier

At Bell Laboratories one line of research is often fruitful in many fields. Latest example is the silicon power rectifier shown above.

Product of original work with semiconductors—which earlier created the transistor and the Bell Solar Battery—the new rectifier greatly reduces the size of equipment needed to produce large direct currents. It is much smaller than a tube rectifier of equal performance and it does not require

the bulky cooling equipment of other metallic rectifiers.

In the Bell System the new rectifier will supply direct current more economically for telephone calls. It can also be adapted to important uses in television, computers, industrial machines, and military equipment. Thus, Bell Telephone Laboratories research continues to improve telephony—while it helps other fields vital to the nation.

BELL TELEPHONE LABORATORIES



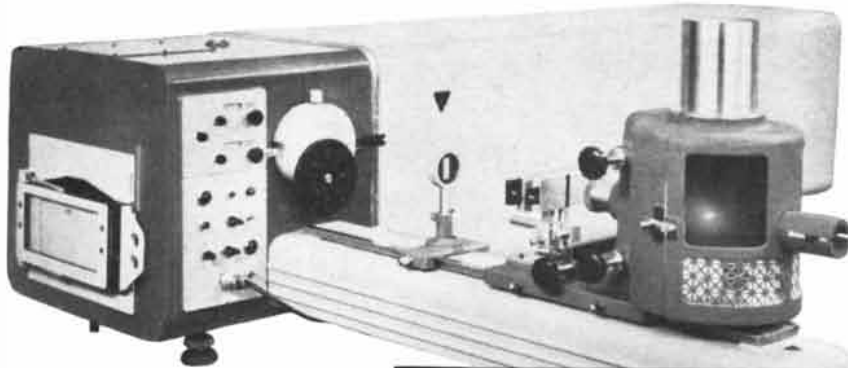
IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES
CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS



Above, new rectifier (held in pliers) is contrasted with comparable tube rectifier and its filament transformer, rear. Mounted on a cooling plate, lower center, the new rectifier can easily supply 10 amperes of direct current at 100 volts, that is 1000 watts—enough to power 350 telephones.

NEW!

TWO spectrographs in ONE... photographs two spectra at once!



**FASTER, EASIER! DOUBLE DATA!
MORE DEPENDABLE DETERMINATIONS!
LOWER OPERATING COST!**

- 100% use of 20" spectra; ample resolution for critical edge-to-edge study.
- Unique flexibility! Photographs two different spectral regions in one exposure on 4" x 10" plate or two 2" x 10" plates. Two independent gratings provide 2000A and 1000A coverage. First order ranges: 1850A-24000A and 1850A-12000A.
- Certified-Precision Replica Gratings—equal or superior to original; can be realuminized. Ample dispersion for critical study. Grating A: 8A/mm, first order; 4A/mm, second order. Grating B: 4A/mm, first order; 2A/mm, second order.
- Exclusive Step-Variable Slit provides instant choice of four different slit apertures, all reproducible to $\pm .5$ micron!
- Compact—only 2' x 7'...less than half the size of any other spectrograph of similar dispersion and resolution.
- Attractive modern styling...smooth 2-tone baked enamel finish...enhances laboratory appearance.

SEE SAMPLE SPECTROGRAMS IN NEW DATA BOOKLET!

Find out how easily and efficiently you can handle the widest range of wet and dry analyses with the B&L DUAL Grating Spectrograph...newest addition to the most complete, the world's finest spectrographic line.



NEW! FREE!

ANALYTICAL PLANNING SERVICE



Whether you now use spectrography or not, let us survey your present and future analytical problems...both wet and dry. We'll recommend efficient spectrographic methods and equipment to assure you best results for today *and* tomorrow!

WRITE TODAY for your copy of DUAL Grating Data Booklet D-272. Free ANALYTICAL PLANNING SERVICE, too, is yours on request... Bausch & Lomb Optical Co., 78147 St. Paul St., Rochester 2, New York.



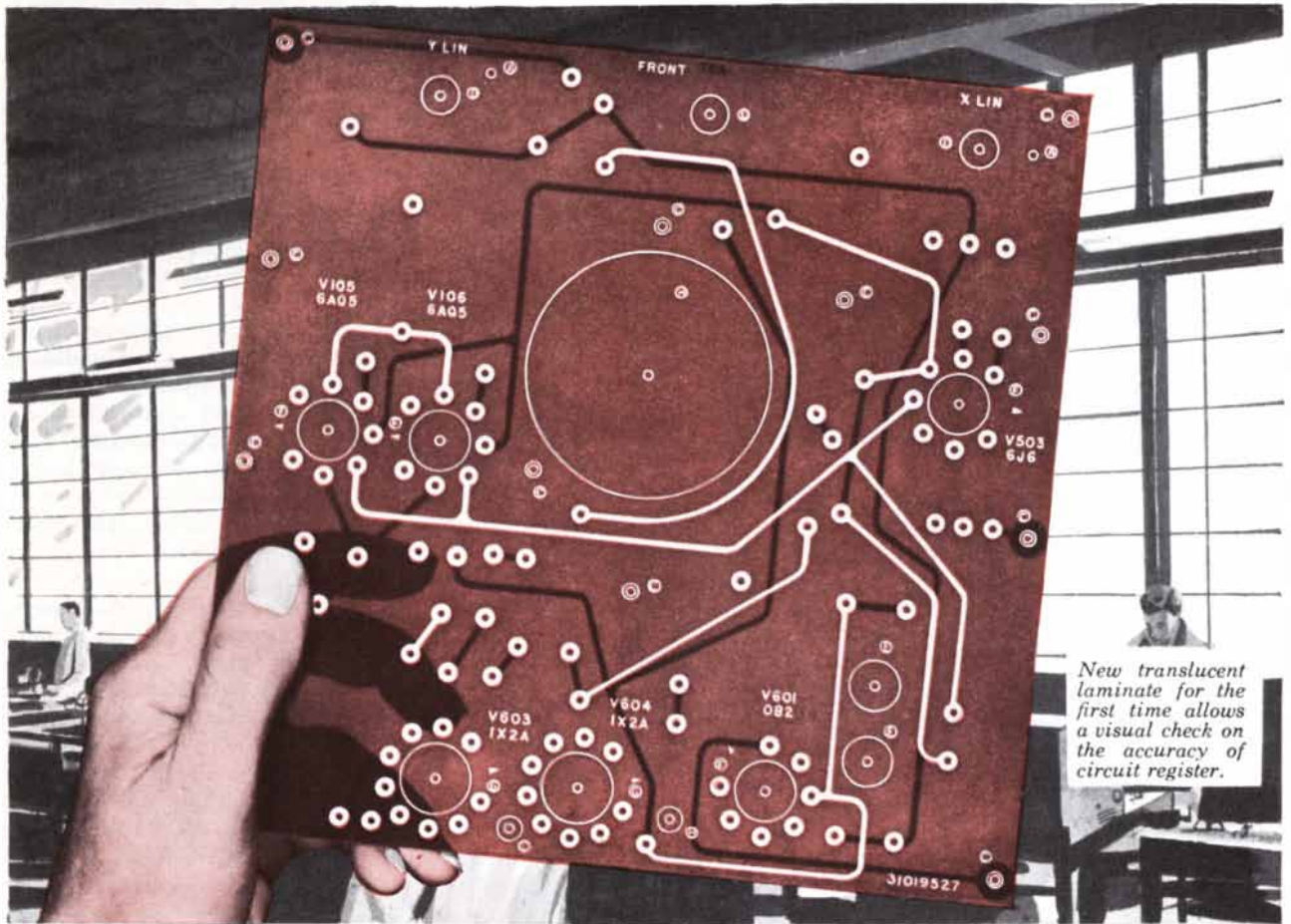
America's only complete optical source...
from glass to finished product.

tive it becomes infected, and when it bites one of our nearby laborers, he in turn becomes infected. Hence, if our laboring force is not to be completely used up, as was that of the French government, preventive sanitary measures must be taken. Most of the effective tropical sanitarians have achieved a great success by inducing as large a proportion of the population as possible to take regularly small quantities of quinine. The disease may also successfully be attacked from the mosquito's side, and the *Anopheles* may be exterminated by covering up water containers, preserving roads so there will be no puddles, instituting a regular system for the collection of garbage, and by the use of oil."

"In a lecture given in Paris July 8, 1904, and reprinted in the Smithsonian Institution's Annual Report, Elie Metchnikoff of the Pasteur Institute discusses the problem of old age. He notes that in the cells of certain senile organs the general and essential phenomena consist in the destruction of parts useful to the organism by wandering cells that present some traits in common with each other. They are voracious cells belonging to the category of elements designated under the generic name of macrophages. Certain macrophages remove the pigment of the hair, certain others destroy the osseous lamellae, others still devour the contractile substance of muscles. It is easy to prove that this activity or rather superactivity of the macrophages is observed in the most diverse organs of the aged. After having destroyed the noble elements of the aging organism, such as the nervous, renal and hepatic cells, the macrophages become fixed in place and are transformed into connective tissue without ever being able to supply the place of the precious elements that have disappeared. It is in this way that there is set up in the aged that main factor of our premature decay, sclerosis of the organs."



NOVEMBER, 1855: "At a recent meeting of the New York Academy of Medicine, Dr. Stowe, a distinguished surgeon of New Orleans, was introduced, who gave some valuable information respecting the yellow fever. In his opinion yellow fever is a specific disease, the same everywhere. Its epidemic character is almost undisputed. When the



Formica Research perfects sensational new cold punching laminate

Brings 1,000,000 megohms resistance value, precision and translucency to printed circuitry

Research, an important part of the exclusive new Formica 4-point service, has just perfected a new cold punching paper base laminate offering 1,000,000 megohms insulation resistance and valuable new translucent properties.

Known as XXXP-36, the new grade brings greater accuracy to printed circuitry. Because of its cold punching qualities, XXXP-36 requires no heat cycle. Therefore, the base laminate is not subject to dimensional

change as in grades which must be heated before punching. This means that with Formica XXXP-36, you can now produce printed circuits with new and higher standards of accuracy.

XXXP-36 translucency can be doubly useful. Make this simple test: hold it to the light. You can see (1) the smooth, homogenous structure, the total absence of resin pockets, voids and imperfections that dissipate the insulating properties of ordinary paper base

laminates . . . and (2) how perfectly the circuit on one side registers with that on the other. New XXXP-36 is ideal for terminal boards and tv insulators requiring high I. R. Formica's engineering skill can help you find new materials for new products and processes. For complete information on the new XXXP-36, or on the new "Formica-4" service, use coupon below. The Formica Co., 4593 Spring Grove Ave., Cincinnati 32, Ohio.



FORMICA®—the most famous name in laminated plastics—Engineered for industry, Beauty Bonded for the home.

Make the Formica Translucency Test. Send for a sample XXXP-36 printed circuit. Fill out and mail coupon today.



Gentlemen:

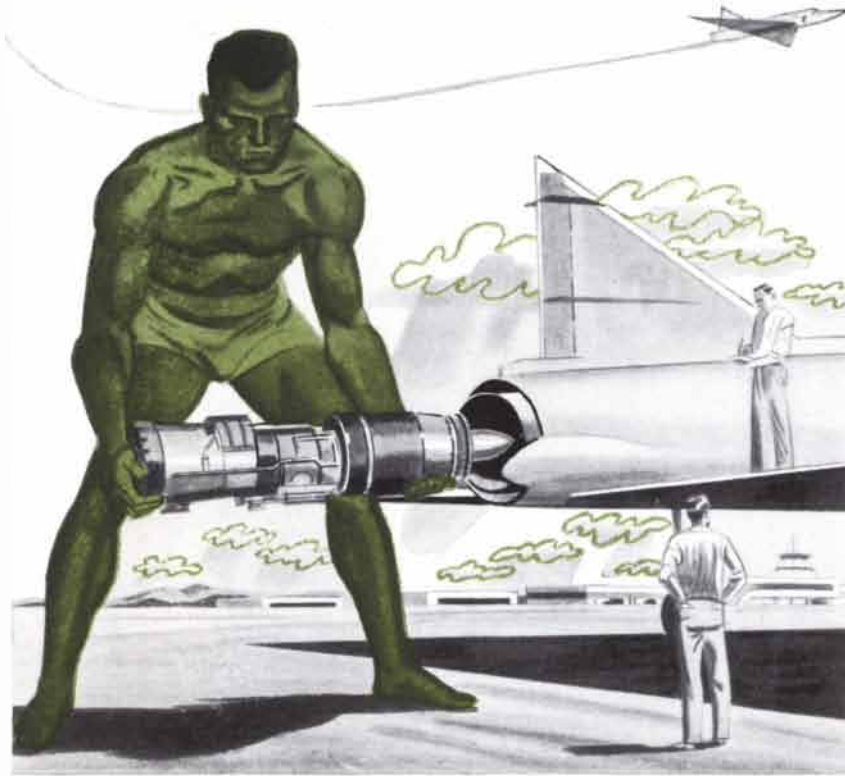
- I'd like a sample XXXP-36 printed circuit and complete information on this new grade.
- Send bulletin showing how I can take advantage of the new "Formica-4" laminated plastics service.

Name _____

Company _____ Title _____

Address _____

City _____ Zone _____ State _____



BABY TENDER for 4 tons of THUNDERBOLTS

The "baby" in this case is a jet engine for an Air Force fighter—8,000 pounds of super-precise, highly adjusted mechanism that must be lifted from the ground and carefully "threaded" into the needle's eye of the fighter fuselage.

Or the baby may be an x-thousand-pound super bomb that is lifted, transported, then hoisted into the bay of an interglobal bomber.

For jobs like these, Cleveland Pneumatic is designing, engineering, and building a variety of special ground-handling equipment. The experience we have in hydraulics, pneumatics, and actuating mechanisms is being used successfully on all this giant equipment.

If you have problems that involve moving, hoisting and juggling unusual sizes and shapes, and if ordinary methods haven't solved them, let our Special Devices Division work on them.

Because each of these problems requires its own custom-design solution, no literature is available. But we'll welcome your inquiries.

Cleveland Pneumatic

Tool Company CLEVELAND 5, OHIO

Department D-1155

3781 East 77th Street • Cleveland 5, Ohio

BALL-SCREW MECHANISMS • AIR-OIL IMPACT ABSORBERS
AIRCRAFT GROUND HANDLING EQUIPMENT

WORLD'S LARGEST MANUFACTURER OF AIRCRAFT LANDING GEARS

fever is epidemic anything which disturbs the system develops it; at such seasons it is impossible to have any other disease. Any excitement at such times is sufficient to create or develop it. This disease has literally no anatomical character—it is a blood poison. It is a self-limited disease; it is not to be treated—it is to be managed. All that is to be done is to keep the patient alive for a certain time, and he will get well."

"The London *Athenaeum* contains an account of the rumored recent discovery of a large sea in Africa, which occupies the vast space between the Equator and lat. 10 south, and between lon. 23 and 30 east—or about 7,000 miles long and 450 broad, and therefore twice as large as the Black Sea. It is not stated whether it is a fresh or salt sea."

"Our London correspondent sends us the following particulars in regard to the mammoth steamship *Great Eastern*: 'On my visit to the mammoth steamer now building at Blackwall on the Thames, I was fortunate enough to procure from the engineers and others the following information. Much has been said, although little is known respecting her, especially in the United States. The vessel is not yet named, though it is rumored she is to be called the *Great Eastern*. She is being built by J. K. Brunel, Esq., the well-known engineer for the Eastern Steam Navigation Company, who have a capital of six million of dollars; their vessels are all designed for the India and Australia trade, and will be four in number, the first being the *Great Eastern*. She will be the largest and most powerful steamship in the world, as will be seen by the following statement of her dimensions: length, 680 feet; breadth 83 feet; number of decks, 4; length of saloons, 400 feet; capacity, 27,000 tons. She is to have both screw and paddle engines, whose total nominal horse power will be 2,600. The paddle wheels have been fixed at sixty feet diameter. She is to carry six hundred first-class passengers and eighteen hundred second-class. If used as a transport, she will carry an army of 10,000 men, with all their field equipments. The masts are five in number—ship rigged. The vessel will have ten boilers and five smoke pipes. In her external appearance—drawing inference from the working model—I should think the *Great Eastern* would be a splendid ship. Her speed should average fourteen miles an hour. At the present time over five hundred men are at work upon the ship in all departments."

The Howard Hughes Fellowships

IN SCIENCE AND ENGINEERING

Eligible for these Fellowships are those who have completed one year of graduate study in physics or engineering. Successful candidates must qualify for graduate standing at the California Institute of Technology for study toward the degree of Doctor of Philosophy or post-doctoral work. Fellows may pursue graduate research in the fields of physics or engineering. During summers they will work full time in the Hughes Laboratories in association with scientists and engineers in their fields.

Each appointment is for twelve months and provides a cash award of not less than \$2,000, a salary of not less than \$2,500, and \$1,500 for tuition and research expenses. A suitable adjustment is made when financial responsibilities of the Fellow might otherwise preclude participation in the program. For those coming from outside the Southern California area provision is made for moving and transportation expenses.

FOR APPLICATION FORMS AND COMPLETE INFORMATION, ADDRESS CORRESPONDENCE TO THE HOWARD HUGHES FELLOWSHIP COMMITTEE, OFFICE OF SCIENTIFIC STAFF RELATIONS.

Hughes

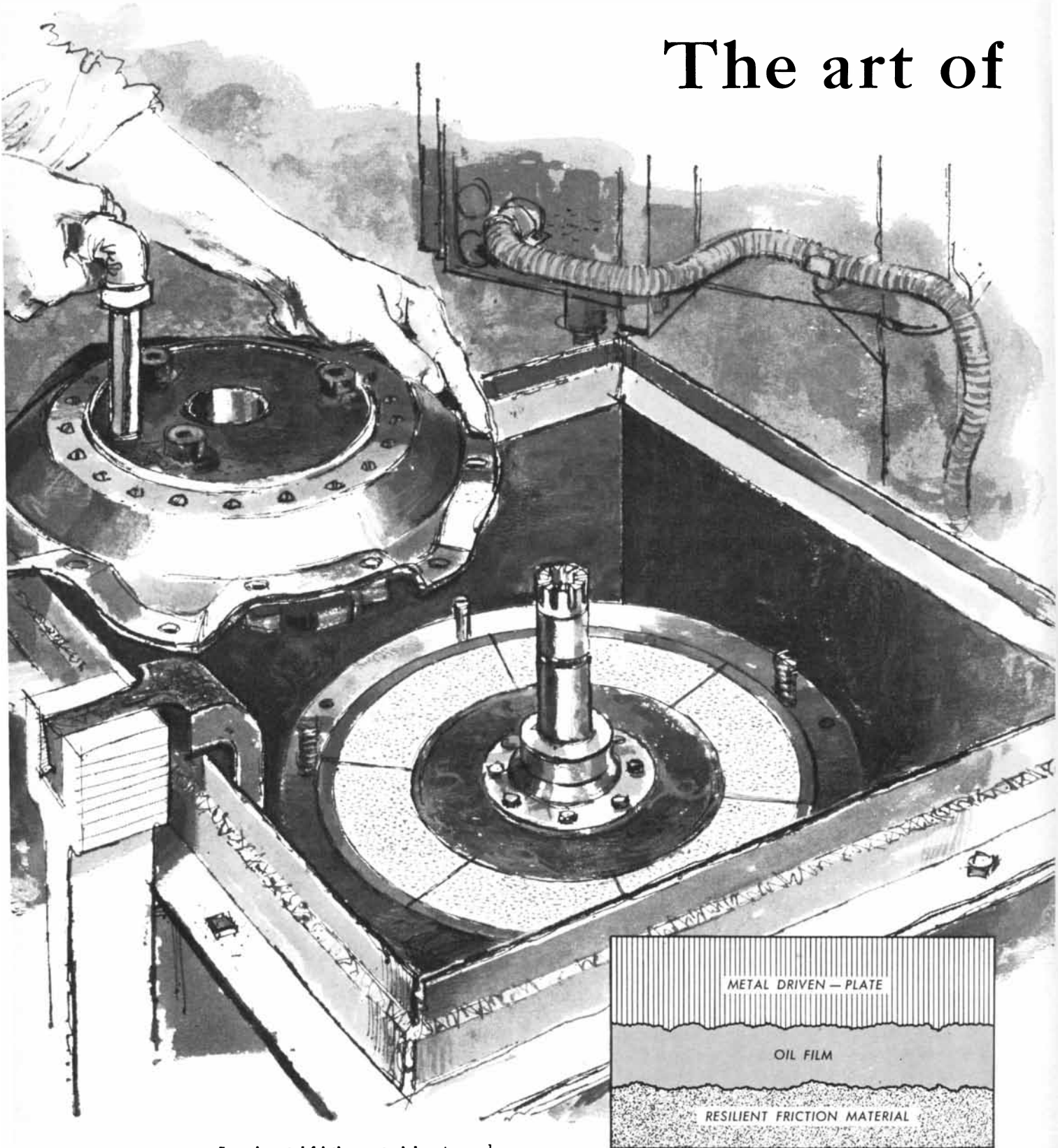
RESEARCH AND DEVELOPMENT
LABORATORIES

Culver City, Los Angeles County, California

Dr. Lee A. DuBridge, President, California Institute of Technology (center), welcomes several recipients of the Howard Hughes Fellowships. Dr. A. V. Haeff, Vice-President, Director, Hughes Research Laboratories (standing), is Chairman of the Fellowship Committee.



The art of



Experimental friction materials get a work-out in this test clutch at the Armstrong Research and Development Center. All conditions—temperature, pressure, and speed—are precisely controlled. Automatic recorders chart the operating characteristics of facings during each engagement cycle.

In wet clutches, the driving and driven surfaces are separated by an oil film when disengaged. The film thins as engagement pressure forces the surfaces into contact. After a brief period of slip, the surfaces grip and the clutch becomes fully engaged as relative movement ends.

making friction behave

*How research men control the grip of friction materials
to help cars, appliances run smoother*

Shifting gears automatically in an automobile . . . changing from "rinse" to "spin-dry" in a washer . . . rapid-fire starting and stopping of an industrial sewing machine — all depend on how well a thin sheet of friction material in a clutch does its work.

Although the job of the clutch — to engage and disengage the driving force — is nearly always the same, the way it engages may vary considerably.

With an industrial sewing machine, for example, the operator runs a seam at high speed, stops on a stroke of the needle, turns the fabric, and races down another seam. Here, research men found that a cork clutch facing material, operated "dry," will take hold fast enough to take the machine from a dead stop to full speed in a fraction of a second.

But the same kind of fast-acting dry clutch in an automobile would produce too much shock for both car and rider. And if to avoid this shock the clutch plates were allowed to slip during engagement, the heat generated might burn up the facing material.

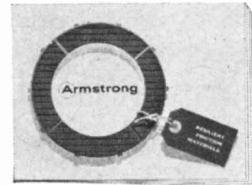
Smooth, gradual engagements are commonplace, however, in the clutches of automatic transmissions. Here cork facings are operated "wet," that is, immersed in oil. Surprisingly, cork keeps much of its high friction even when flooded with the same oil that lubricates the transmission. In fact, oil makes gradual engagements practical by carrying off much of the heat that's generated.

Changing the shape of the plates in a wet clutch produces different kinds of engagement, too. A flat plate with radial slots, for example, engages faster than a plain flat plate. On the other hand, a "waved" plate engages more slowly.

Although there are many such mechanical techniques, the art of making friction behave also depends a great deal on the compounding of the friction material itself. The research worker faces almost limitless possible combinations of cork, rubber, resins, and fibers. Even small changes in these ingredients or their proportions may make significant differences in clutch performance.

As a result, developing a new material with specific frictional properties is a job that takes a large measure of resourcefulness and imagination. The only criterion for success, however, is found in the very practical question, "Does it work?"

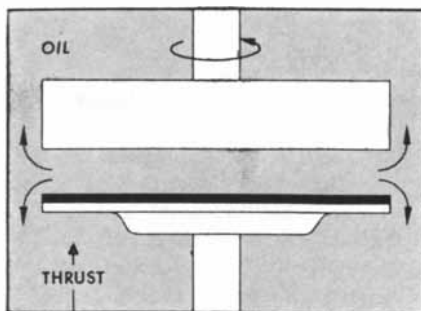
If you make or design clutches for automobiles, appliances, machine tools, business machines, or the like, send us the details. We may be able to suggest ways for you to lower costs or improve performance with Armstrong resilient friction materials. And for data on designing with cork facings, write for the booklet, "Armstrong Resilient Friction Materials." Armstrong Cork Company, Industrial Division, 8211 Inland Road, Lancaster, Pa.



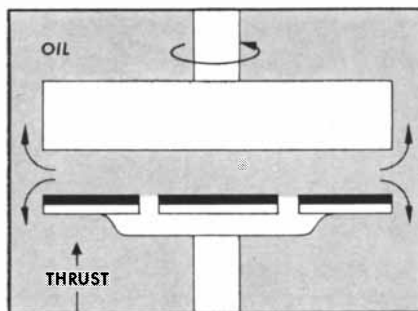
Armstrong INDUSTRIAL PRODUCTS

... USED WHEREVER PERFORMANCE COUNTS

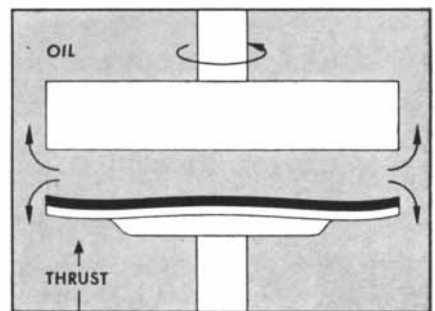
adhesives . . . cork compositions . . . cork-and-rubber . . . felt papers . . . friction materials



Changes in clutch plate design permit designers to manipulate the oil film and control the engagement period. It takes a flat plate, for example, a relatively long time to squeeze away the oil film and become fully engaged.



Radial slots in a flat clutch plate tend to create short engagement periods, even with low engagement pressures. The slots apparently set up a "squeegee" action that wipes away the film of oil, hastening full contact.



A "waved" plate maintains the oil film much longer during engaging period when the pressure is being applied. When full pressure is finally developed, the plate flattens to make full contact, and engagement is completed.

THE AUTHORS

 **check
this
list**

*if you have any of the
following filtration problems:*

- | | |
|---|---|
| <input type="checkbox"/> Lack of clarity | <input type="checkbox"/> Pollution and disposal
of filter cake |
| <input type="checkbox"/> Need for "sparkle" | <input type="checkbox"/> Unstable pre-coat |
| <input type="checkbox"/> Uneconomical volume
of clarified filtrate | <input type="checkbox"/> Loss of cake due to
pressure drop |
| <input type="checkbox"/> "Bleeding" of filter aid | <input type="checkbox"/> Too much retention of
filtrate in filter cake |
| <input type="checkbox"/> Abrasion of pumps,
valves, etc. | |

SOLKA-FLOC as a filter aid
can help you solve them.

Mail this check list to Dept. FN-11, our Boston
office, for samples and complete information.

BROWN  **COMPANY**
Berlin, New Hampshire

General Sales Office: 150 Causeway Street, Boston 14, Mass.

SOLKA PULPS • SOLKA-FLOC • NIBROC PAPERS • NIBROC TOWELS • NIBROC
KOWTOWLS • NIBROC TOILET TISSUE • BERMICO SEWER PIPE AND CONDUIT
ONCO INSOLES • CHEMICALS

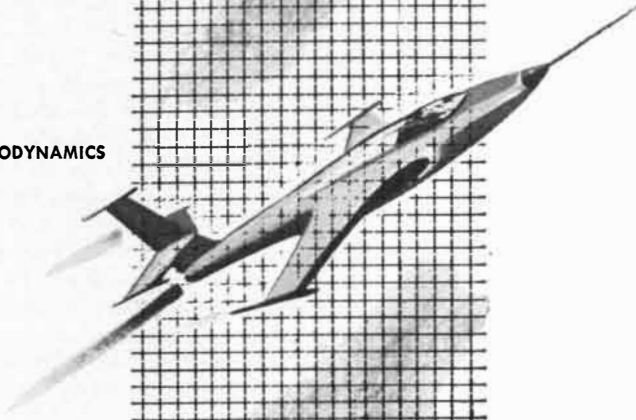
SOLOMON E. ASCH ("Opinions and Social Pressure") is professor of psychology at Swarthmore College. He was born in Warsaw in 1907, came to the U. S. in his youth and graduated from the College of the City of New York in 1928. After taking his M.A. and Ph.D. at Columbia University, he taught at Brooklyn College and the New School for Social Research before joining the Swarthmore faculty in 1947. This year he is giving a course on the psychological foundations of social behavior at Harvard University and participating in the Laboratory of Social Relations.

ROBERT L. FISHER and ROGER REVELLE ("The Trenches of the Pacific") are members of the University of California's Scripps Institution of Oceanography. Revelle, who has been at Scripps since 1931, is now its director. After graduating from Pomona College in 1929, he went to Scripps as a research assistant, taking his Ph.D. there in 1936. He was a Navy oceanographer during World War II, and was head of the oceanographic section of the task force which conducted the atomic bomb test at Bikini in 1946. He addressed the recent Geneva Atoms for Peace Conference on disposal of radioactive wastes in the ocean. Fisher is a marine geologist. He did his undergraduate work at the California Institute of Technology and his graduate work at Northwestern University and at Scripps. "My interest in oceanography," he writes, "dates from a not-particularly-distinguished naval career in the western Pacific in World War II, augmenting early reading of Melville, Maugham and Pierre Loti." For the past four years he has been engaged in field studies of several Pacific trenches. He acted as scientific leader of the 1953 and 1954 Scripps expeditions to the west coasts of Mexico and Central America.

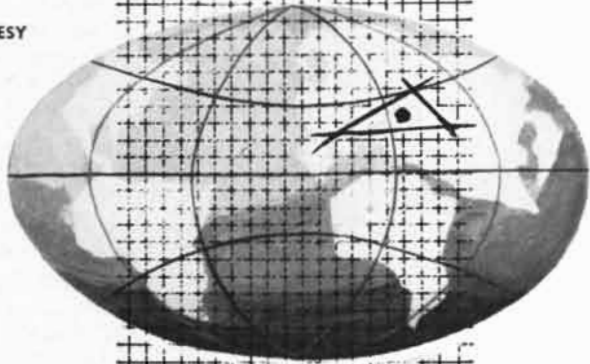
P. W. BRIDGMAN ("Synthetic Diamonds"), after a long career devoted to the physics of high pressure and the philosophy of science, retired last year as University Professor at Harvard University. He was born in Cambridge in 1882 and did his graduate and undergraduate work at Harvard, taking a Ph.D. in physics in 1908. He has taught at Harvard ever since, from 1926 to 1950 as Hollis Professor of mathematics and natural philosophy. He was named University Professor in 1951. From an early

Extra Core Storage for IBM 704

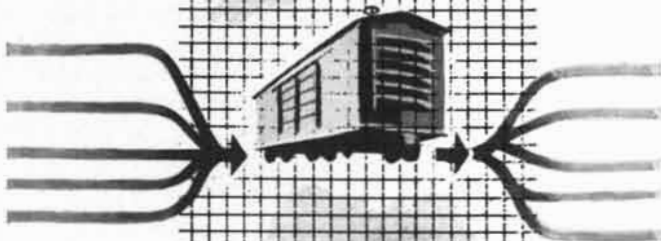
AERODYNAMICS



GEODESY



TRANSPORTATION
SCHEDULING



- increases IBM 704 capacity to the binary equivalent of 327,680 decimal digits!
- gives high-speed random access to any memory address!

NOW . . . with this *expandable* memory system, mathematical models can be expanded to include phenomena heretofore beyond the capacity of any computer!

NOW . . . researchers can have random access to all elements of a matrix of order greater than 175 in only 12 microseconds!

NOW . . . for matrix problems in Operations Research, aerodynamics; geodesy; transportation scheduling and similar areas which involve systems of equations where $AX=B$ (when A has 178 rows and 178 columns; X has 178 rows and 1 column; and B has 178 rows and 1 column) can be solved within this *new* capacity of 327,680 decimal digits of storage.

NOW . . . an arbitrary matrix of order greater than 125—with every element expressed to a precision greater than that obtained by using 20 decimal digits—can be inverted without aid of auxiliary storage.

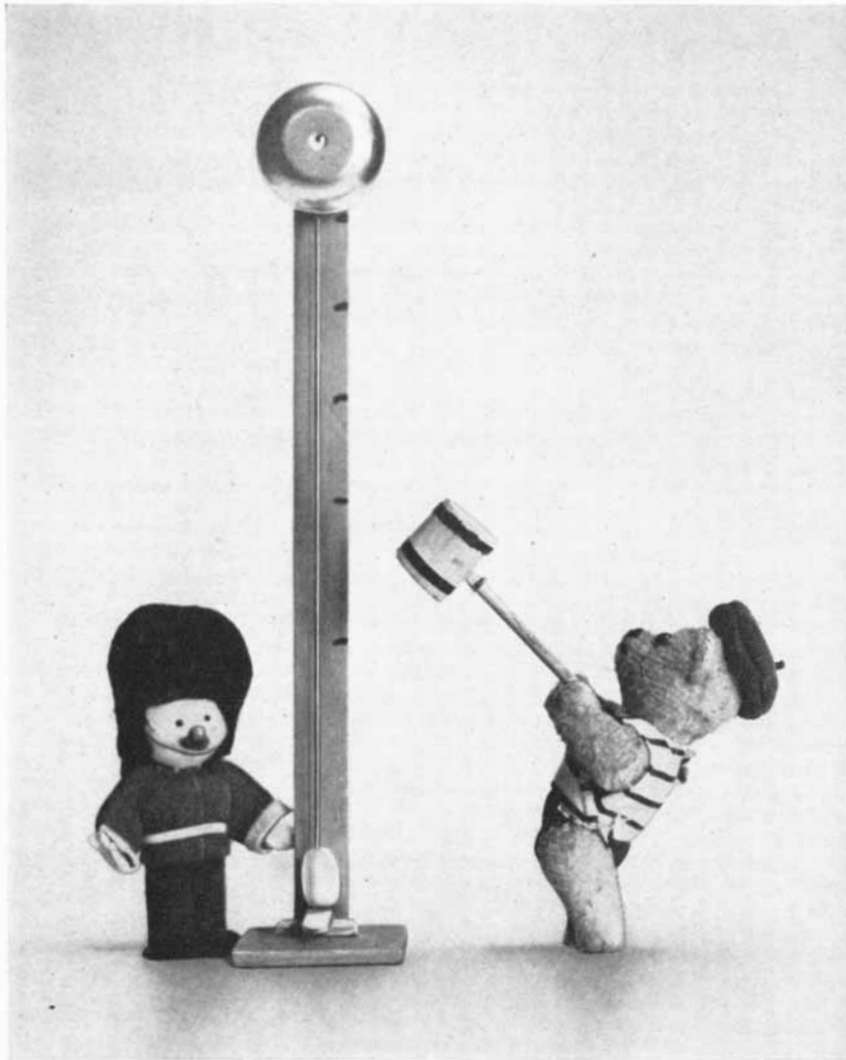
This new *expandable* memory system can be considered as three modular units. Models I and II of the familiar IBM 737 Memory store respectively 4,096 and 8,192 ten-digit words. The IBM 738, with its 32,768 ten-digit words of random access core storage, replaces the other two units.

This is but one of IBM's solutions to large-scale scientific and business problems. For *every* data processing job there is a down-to-earth IBM answer that can help you work better and faster . . . at less cost. For detailed assistance on your particular data processing problem, call your local IBM representative.

IBM

**DATA
PROCESSING**

International Business Machines Corporation
590 Madison Avenue, New York 22, N. Y.



about testing . . .

...AND FORD INSTRUMENT COMPANY

When an instrument is built for military use, it must be able to withstand the rigors of battle conditions. That is why the design and manufacture of each computer or control for the armed forces at Ford Instrument Company is a matter of great precision and ruggedness. It must be able to withstand the temperature extremes of arctic or tropical use; it must, if shipborne, be safe from salt spray damage; if airborne, be capable of withstanding high altitudes. In all cases it must be shockproof. Rigorous environmental tests are given each instrument.

In many cases, because of the uniqueness of the computers designed, special test instruments must be designed and built to allow the equipment

to be tested and adjusted in the field. This is but another facet of the engineering skills which, since 1915, Ford Instrument Company has brought to bear on automatic control problems. If you have a problem in this field, it would pay you to talk to the engineers of Ford. Write for more complete information.



**FORD INSTRUMENT
COMPANY**

DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Ave., Long Island City 1, N. Y.
Beverly Hills, Cal. · Dayton, Ohio

81

ENGINEERS:

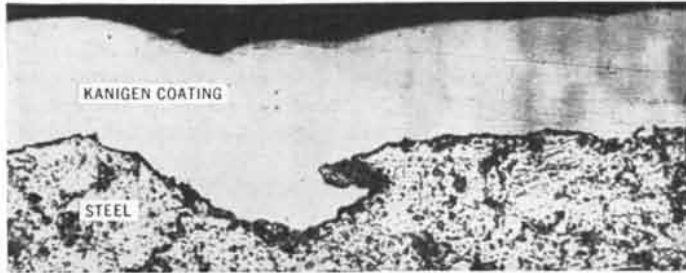
FORD IS CONSTANTLY ADDING TO ITS STAFF OF ENGINEERS. IF YOU CAN QUALIFY, THERE MAY BE A POSITION FOR YOU.

date he devoted himself to the physics of high pressure, ultimately finding ways to increase available laboratory pressures almost 100 times, Bridgman has managed to produce pressures of six million pounds per square inch, and most of his recent work has been in the range of 500,000 to 1,500,000 pounds per square inch. He has also been active outside the laboratory—in the more general and social concerns of science. In 1927, with *The Logic of Modern Physics*, he launched a new interpretation of the values of science, which he called “operationalism.” He proposed that physical entities have no significance except in terms of the human operations through which they can be observed, and that ideas which cannot be tested by such operations are without meaning. For the high-pressure apparatus he invented and for the states of matter he discovered with it, Bridgman was awarded the Nobel prize in physics for 1946.

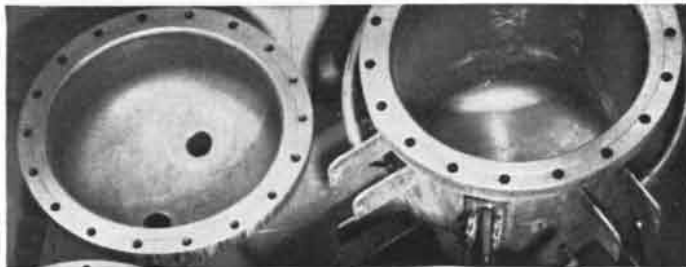
H. J. MULLER (“Radiation and Human Mutation”), professor of genetics at Indiana University, is the man who found that mutations could be accelerated by X-rays. This discovery, which he made in 1927, won him the Nobel prize in physiology and medicine for 1946. Muller was born in New York City in 1890 and was educated at Columbia University, where he took a Ph.D. in zoology in 1916. From 1915 to 1936 he taught zoology, first at the Rice Institute, then at the University of Texas. In 1933 to 1937 he worked at the Institute of Genetics in Moscow as senior geneticist, but he later became a fierce foe of the Soviet system. After spending some years at the University of Edinburgh and at Amherst College, he joined Indiana University in 1945.

H. C. VAN DE HULST (“Empty Space”) is an astrophysicist at the Observatory in Leiden, the Netherlands. He took up theoretical astronomy during World War II, when the University, at which he was a student, was closed. Van de Hulst was the first to suggest, in 1944, that the hydrogen in interstellar space probably emitted radio vibrations at the 21-centimeter wavelength. He has recently been following up the clues these signals give to the content of interstellar space.

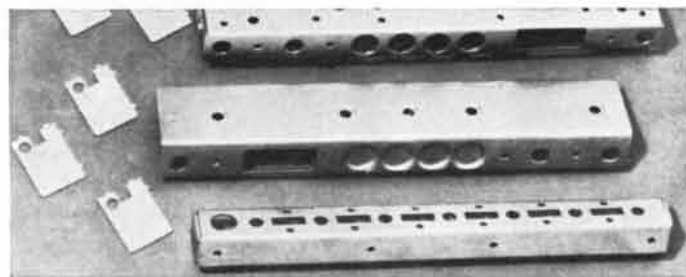
WILLIAM P. JACOBS (“What Makes Leaves Fall?”) is an associate professor of biology at Princeton University. Born in Boston, he graduated from Harvard College in 1942, then studied at the California Institute of Tech-



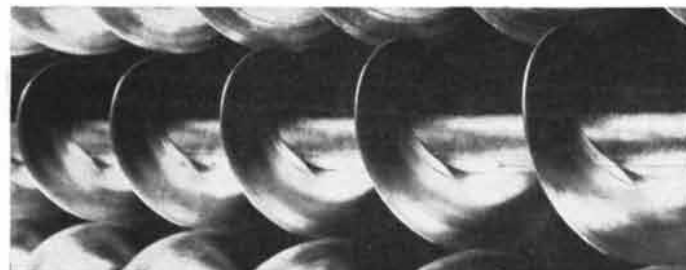
photomicrograph showing uniformity of Kanigen coating over steel (250X)



Kanigen-coated pressure vessels



Kanigen-coated aluminum electronic assembly ready for soldering



Kanigen-coated screw conveyor: 9" diameter; 10' length

Could you use Kanigen* coating to prevent iron pick-up? To form an alkali-resistant surface? To apply a coating of virtually non-porous nickel-phosphorus to many metallic and non-metallic materials . . . without the use of electricity?

Can your product benefit from the hardness of Kanigen coating? Would coating aluminum to increase surface hardness and permit solderability give your product an advantage?

Is uniformity of coating, even on complex shapes, important? Could you lower your costs with a uniform coating of Kanigen that offers a service life comparable to that offered by costly clad or solid materials?

Does coating on plastics (printed circuits, for example) seem worth investigating? There is nothing like Kanigen. Metallurgically unique—not just a substitute for electroplate—it has many unexplored uses. It is available only from General American and our licensees.

**"where can you use this
metallurgically-unique
material—Kanigen?"**

It pays to plan with General American

**KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION**
General Offices: 135 South LaSalle Street • Chicago 90, Illinois
West Coast Plant: 12222 W. Olympic Blvd., Los Angeles 64, Calif.
Phone Bradshaw 2-2143



**"KANIGEN" is a mark identifying chemical deposition of a high-nickel, low-phosphorus alloy by General American Transportation Corporation and its licensees, and the coating resulting therefrom.



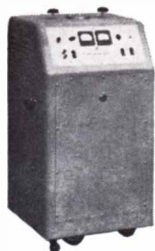
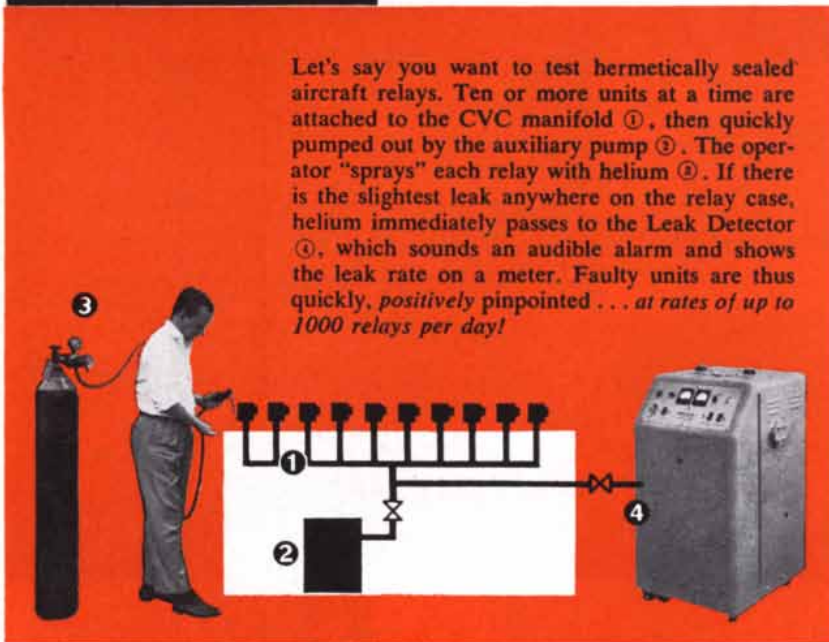
**POSITIVE
LEAK
TESTING...
CEC's
Leak
Detector
makes it
practical**

If your product needs positive protection against the ravages of moisture, dust, high altitude, corrosion, and arcing, there's one *sure* protection against them all... hermetic sealing and testing with a CEC Leak Detector and a Consolidated Vacuum manifold system. Proven and practical, engineered to work together, they locate leaks *undetectable by any other method.*

Fast, simple, sure...

Here's how CEC leak detection works

Let's say you want to test hermetically sealed aircraft relays. Ten or more units at a time are attached to the CVC manifold ①, then quickly pumped out by the auxiliary pump ②. The operator "sprays" each relay with helium ③. If there is the slightest leak anywhere on the relay case, helium immediately passes to the Leak Detector ④, which sounds an audible alarm and shows the leak rate on a meter. Faulty units are thus quickly, *positively* pinpointed... *at rates of up to 1000 relays per day!*



Now, two CEC leak detectors

The standard Type 24-101A detects one part of helium in 200,000 parts of air... measures leak rates to 10^{-9} std cc/sec. The new ultra-sensitive Type 24-110 detects one part of helium in 2,000,000 parts of air! It is valuable, for example, in atomic-reactor equipment and in the production of "reliable-type" electron tubes. Send for Bulletin CEC 1801D-X12.

Consolidated Engineering Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT & CONTROL
300 North Sierra Madre Villa, Pasadena 15, California

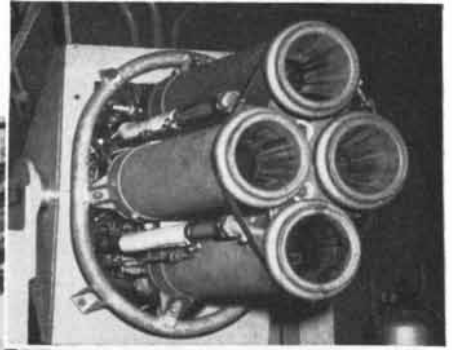
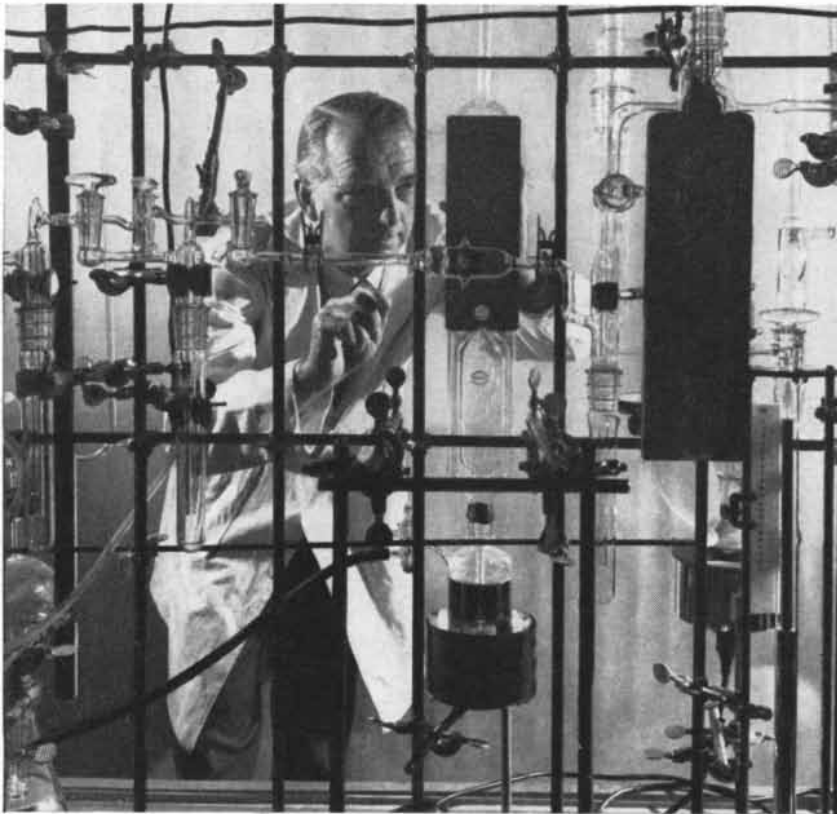
Sales and Service Offices Located in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

nology on a Sheldon traveling fellowship from Harvard, returned to Harvard as a Fellow and took a Ph.D. in biology in 1946. He has been at Princeton since 1948. About the choice of his line of work he writes: "Under the influence of Professor Ralph H. Wetmore of Harvard and Professor Frits Went of California Institute of Technology, I decided to concentrate on trying to discover what internal factors *normally* control the growth and differentiation of plants. The control of leaf fall was picked as a 'warm-up' problem, preparatory to applying similar quantitative methods to the more difficult problems of what is going on inside the plant in terms of cell differentiation."

ALDO NEPPI MODONA ("Etruscan Metallurgy") is professor of ancient Greek and Roman civilization at the University of Florence. He was born in Florence, which lies near the northern limit of the ancient Etruscan territory, and has specialized in Etruscan studies, doing his doctoral thesis on the Etruscan findings at Cortona. In 1928 a scholarship took him to the island of Rhodes; while on that trip he did much research on the neighboring island of Cos and there met his wife. Neppi Modona is secretary of the Florence Institute for Etruscan Studies and director of the Permanent Committee for Etruscan Research.

A. STARKER LEOPOLD ("Too Many Deer") is associate professor of zoology at the University of California, where he teaches wildlife conservation and management. He graduated from the University of Wisconsin in 1936 with a major in soils and agronomy, then trained in forestry at Yale University. From 1939 to 1944 he was a field biologist for the Missouri Conservation Commission, working on problems of managing deer and wild turkeys in the Ozarks. He took a Ph.D. in zoology at the University of California in 1944. After conducting a survey of wildlife resources in Mexico for two years, he returned to the University of California. He is currently on sabbatical leave, writing a book on Mexican wildlife, of which he has kept track intermittently in recent years. Leopold's part in the California deer surveys started in 1947, when the California Fish and Game Commission contracted with the University of California for an extensive study of deer in the state. The project lasted three years. One of the five members of Leopold's field crew, Thane Riney, later became chief of Big Game Research in New Zealand.

new team impetus...



In the field of fuels research, Olin Mathieson and Reaction Motors are developing new liquid and solid propellants as well as additives to improve current propellants. Reaction Motors and Marquardt Aircraft establish specifications for these new rocket and ramjet fuels and test and evaluate their capabilities for meeting tomorrow's needs.



developing super fuels for supersonic propulsion

Applying the modern "weapons system" concept to the problems of supersonic propulsion, Olin Mathieson, Reaction Motors, and Marquardt Aircraft are combining their unique skills and experience in the development and production of rockets, ramjets, and special

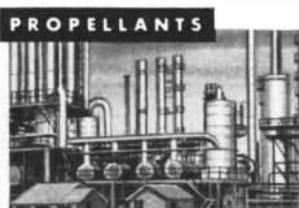
fuels. Coordinated by the OMAR Joint Technical Committee comprised of representatives of the three companies, this applied research program is dedicated to the practical advancement of supersonic aircraft and missile propulsion.

3519



RAMJETS

Marquardt Aircraft Company



PROPELLANTS

Olin Mathieson Chemical Corporation



ROCKETS

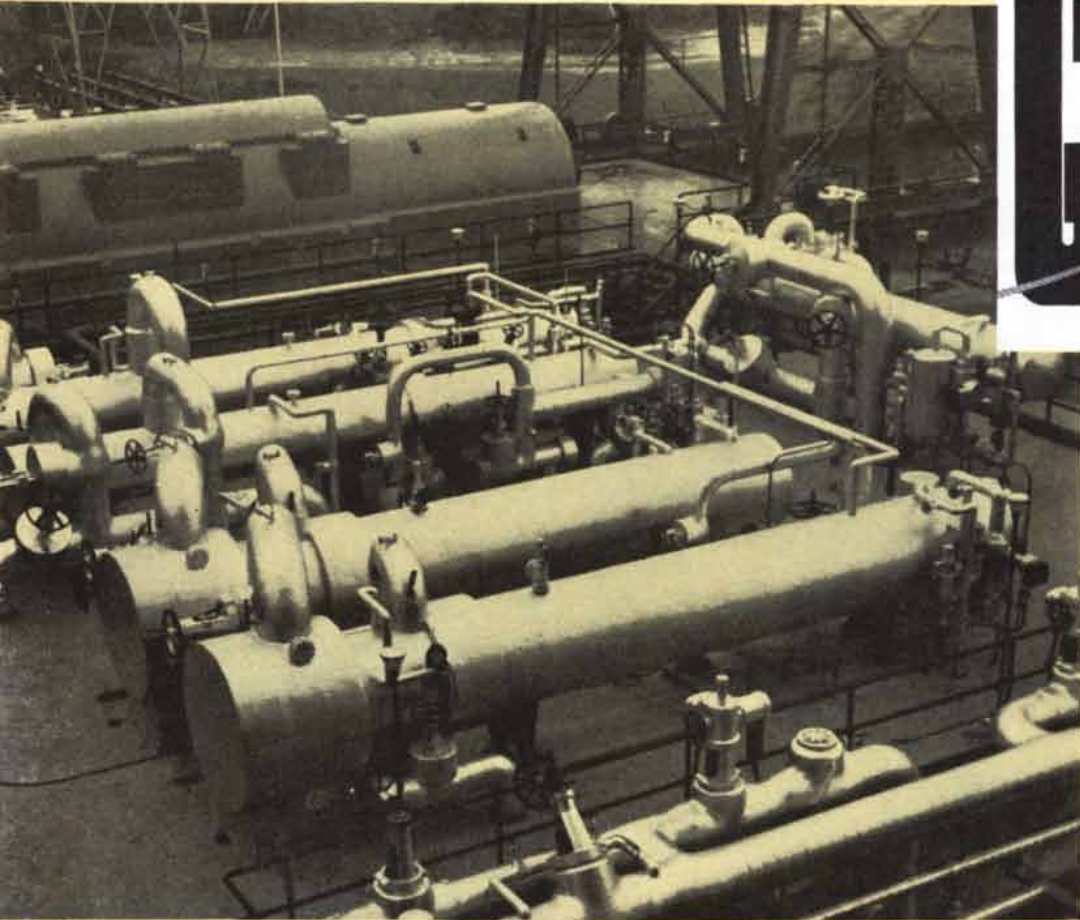
Reaction Motors, Inc.



MARQUARDT AIRCRAFT
OLIN MATHIESON CHEMICAL
REACTION MOTORS

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

GPE



◀ Grisco-Russell feed water heaters in a 125,000 KW public-utility power station; save nearly 100 tons of coal per day. Heaters handle flow of water exceeding 2000 G.P.M. at 2500 pounds pressure and steam extracted from the turbine at five different points; "train" of five units pre-heats water fed to boilers from 90° F. to 441° F.



◀ Askania multiple fuel boiler control panel in large steel plant; maintains metered proportion between combustion air and fuels—coke oven gas and fuel oil—for most economical combustion; holds steam pressure constant through all load changes and keeps furnace pressure at a safe and predetermined value.



General Precision Laboratory's Industrial TV Camera, the "Bullet"; portable, easily operated; used to monitor and improve manufacturing processes and to view hazardous industrial operations.

The highly advanced technological products designed and manufactured by the eighteen producing companies of General Precision Equipment Corporation serve more than a dozen major industries. Products of six of these GPE Companies—Griscom-Russell, Askania, Librascope, Link, Kearfott and General Precision Laboratory—have widespread application in the processing and power industries.

Industrial Processing...and Power

The Griscom-Russell Company is one of the country's largest producers in the fields of heat exchange and water distillation. It is the pioneer in heat exchanger equipment—the key to the whole complex of modern industrial processing and power. For over seventy years, G-R equipment has been responsible for greatly increased efficiency and lowered operating costs in industry.

Askania Regulator Company for a quarter of a century has been a leading developer in the field of regulators and controls, including components and systems. Its products are widely used by the power, steel, gas and coke, mining, chemical, petroleum, glass and paper industries—wherever great reliability and accuracy are essential.

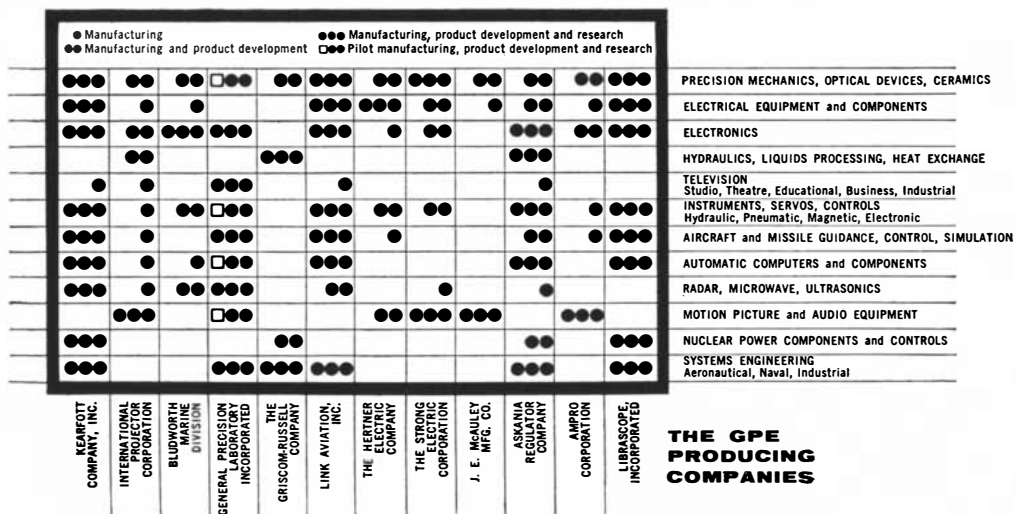
Kearfott Company, Inc.; Librascope, Incorporated; and Link Aviation, Inc. produce a wide variety of precision instruments, computers, servos and other control components for equipment and systems used throughout the power and the processing industries. Industrial television equipment manufactured by General Precision Laboratory Incorporated, the sixth GPE Company active in these fields, is playing increasingly important roles in "seeing eye" monitoring operations in these industries.

Each company in the GPE Group works in specific, highly specialized technical areas, as indicated in the

chart below. Each of these companies, in addition to specializing in its particular products and fields of technical competence, has at its command, as required, the facilities and specialized techniques of the other GPE Companies in their respective fields. Interrelation is achieved through GPE's basic operating policy, Coordinated Precision Technology.

In the fields of research and development, GPE Coordinated Precision Technology permits a high degree of specialization in particular areas of competence and supplements such specialization by the application of techniques in other fields, as desirable. In the field of production, it makes possible a highly flexible application of facilities. This policy has been responsible for a diversified line of precision equipment of superior design and performance, covering a wide range of both standard and special uses.

Perhaps the most conspicuous advantage of GPE Coordinated Precision Technology is that the concept and development of equipment, and of solutions to the underlying technical problems, are not restricted or distorted by traditional allegiance to specialization in a particular field. GPE coordination permits the engineers and technical personnel of each GPE Company to seek the optimum solution for the customer within the total capacities of the GPE Companies as a group.



A brochure relative to GPE Coordinated Precision Technology and the work of the GPE Companies is available. Address your request, or inquiries on specific problems, to:

General Precision Equipment Corporation

92 GOLD STREET, NEW YORK 38, NEW YORK

**new precision
in extended range
vibration testing:**

CALIDYNE'S

"HI-FI"

**SHAKER
SYSTEM**



Precisely controlled vibration testing — over the 5 to 5000 cps frequency range at full rated output — is now a reality with Calidyne's new Series 8000 Shaker System.

The Shaker itself incorporates an extremely rigid armature structure, designed to eliminate all secondary structural resonance in the operating frequency range. Actual frequency response values obtained by test are ± 1 db, 7 to 2000 cps; $\pm 3\frac{1}{2}$ db, 5 to 5000 cps (bare table). Full $\frac{1}{2}$ " peak-to-peak displacement or 600 pounds force output is maintained at all frequencies, *without* power factor correction or use of changeable impedance matching taps.

A control console incorporates all operating controls, and associated monitoring and cycling equipment. Switch selected inputs consist of single frequency, sweep cycling or complex waveform signals. Special features include a dual beam 'scope for comparing input and Shaker table acceleration signals, and five adjustable circuits to compensate for decrease in transfer function (g output/volts input) as frequency increases.

Complete Engineering Data and Specifications on Request



THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

SALES REPRESENTATIVES:

- | | | | |
|---|--|--|---|
| WALTHAM, MASS.
Robert A. Waters, Inc.
Waltham 5-6900 | CLEVELAND, OHIO
M. P. Odell Co.
Prospect 1-6171 | CHICAGO, ILLINOIS
Hugh Marsland & Co.
Ambassador 2-1555 | SAN FRANCISCO, CALIF.
G. B. Miller Co.
Lytell 3-3438 |
| NEW HAVEN, CONN.
Robert A. Waters, Inc.
Fulton 7-6760 | DAYTON, OHIO
M. P. Odell Co.
Oregon 4441 | INDIANAPOLIS, INDIANA
Hugh Marsland & Co.
Glendale 3803 | ALBUQUERQUE, NEW MEXICO
G. B. Miller Co.
Albuquerque 5-8606 |
| NEW YORK CITY AREA
G. C. Engel & Associates
Rector 2-0091 | DETROIT, MICHIGAN
M. P. Odell Co.
Superior 8-5114 | MINNEAPOLIS, MINN.
Hugh Marsland & Co.
Colfax 7949 | SEATTLE, WASH.
G. B. Miller Co.
Lander 3320 |
| RIDGEWOOD, NEW JERSEY
G. C. Engel & Associates
Gilbert 4-0878 | WASHINGTON, D. C.
F. R. Jodon, Inc.
Hobart 2-4300 | DALLAS, TEXAS
John A. Green Co.
Fleetwood 7-7385 | CANADA
Measurement Engineering Ltd.
Arnprior, Ont., Phone 400
Toronto, Ont., Mayfair 8860 |
| PHILADELPHIA, PA.
G. C. Engel
Chestnut Hill 8-0892 | SOUTHEAST
W. A. Brown & Assoc.
Alexandria, Va.
Overlook 3-6100 | HOLLYWOOD, CALIFORNIA
G. B. Miller Co.
Hollywood 2-1195 | EXPORT
Rocke International Corp.
13 East 40th St., N.Y. 16, N.Y.
Murray Hill 9-0200 |
| NORTHERN NEW YORK
Technical Instruments, Inc.
Waltham, Mass.
Waltham 5-8445 | | | |



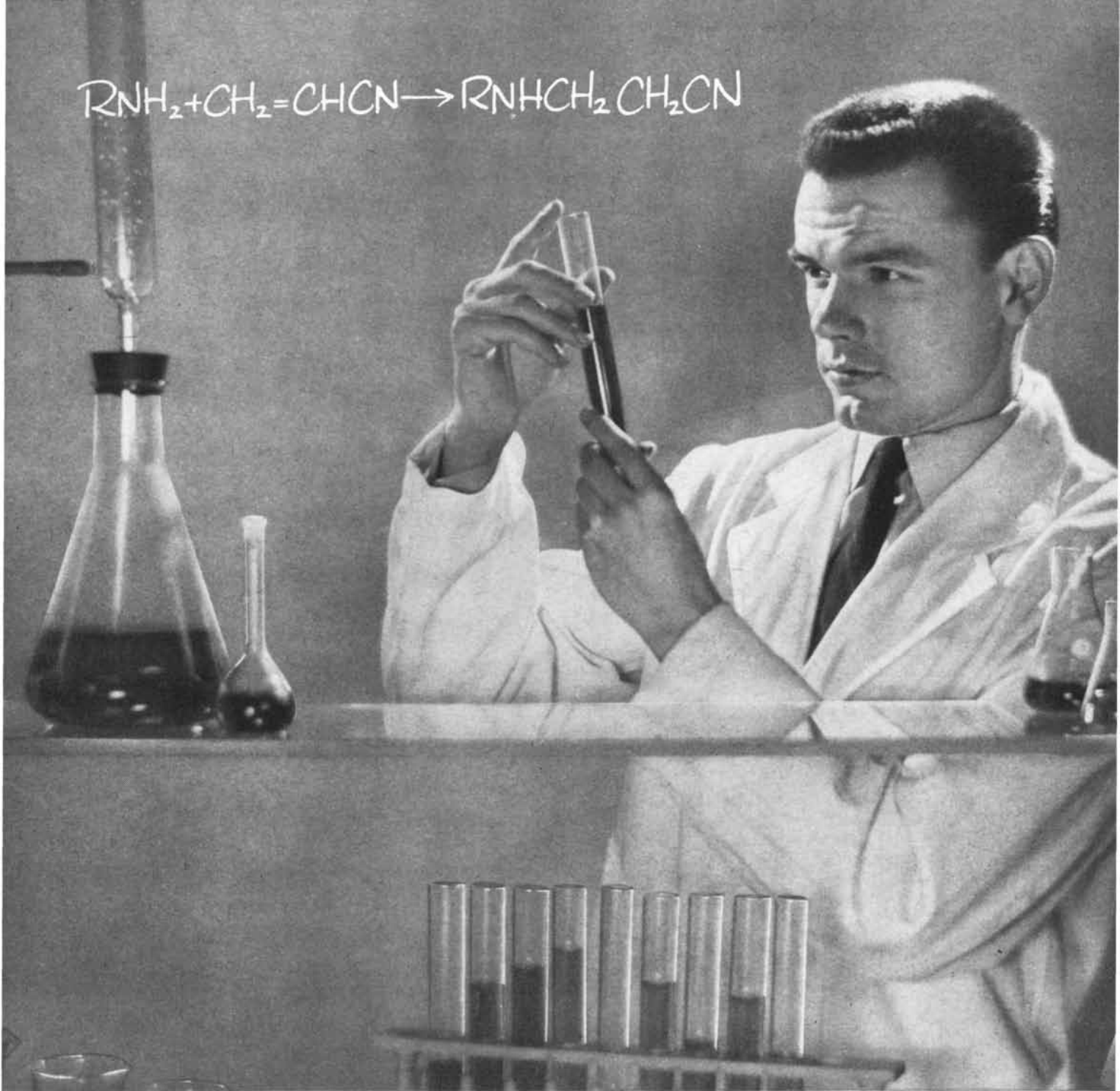
THE COVER

The painting on the cover shows a leaf falling from the branch of an oak tree. The fundamental process that causes leaves to fall is discussed in the article beginning on page 82. Until recently it was thought that leaves fell when their production of the plant hormone auxin tapered off. New experiments with the plant *Coleus* indicate, however, that auxin produced by young leaves plays an important role in the process.

THE ILLUSTRATIONS

Cover painting by Bernard Perlin

Page	Source
31	William Vandivert
32	Sara Love
33	William Vandivert
35	Sara Love
36-37	Bunji Tagawa
39	Scripps Institution of Oceanography
40-41	Bunji Tagawa
42-43	Paul Weller
44-45	General Electric Research Laboratory
46	Sara Love
59	T. C. Hsu
60-66	Irving Geis
72-74	National Geographic Society-Palomar Observatory Sky Survey
76-78	Bunji Tagawa
82-83	Eric Mose
84	Eric Mose (<i>top</i>), W. P. Jacobs (<i>bottom</i>)
86-89	Eric Mose
90	Etruscan Museum of Florence
91	Metropolitan Museum of Art
92	Etruscan Museum of Florence
94	John Langley Howard
101	Pennsylvania Game Commission
102	J. Dixon
104	H. H. Biswell (<i>top</i>), Sara Love (<i>bottom</i>)
106-107	J. Dixon
125-132	Roger Hayward



TODAY'S CHEMISTS are destined to open countless unexplored fields with a chemical that shows endless possibilities in many areas of research.

Acrylonitrile will react with virtually any organic or inorganic compound containing a labile hydrogen atom. That fact is known. But no one yet can guess what all the chemical transformations may be.

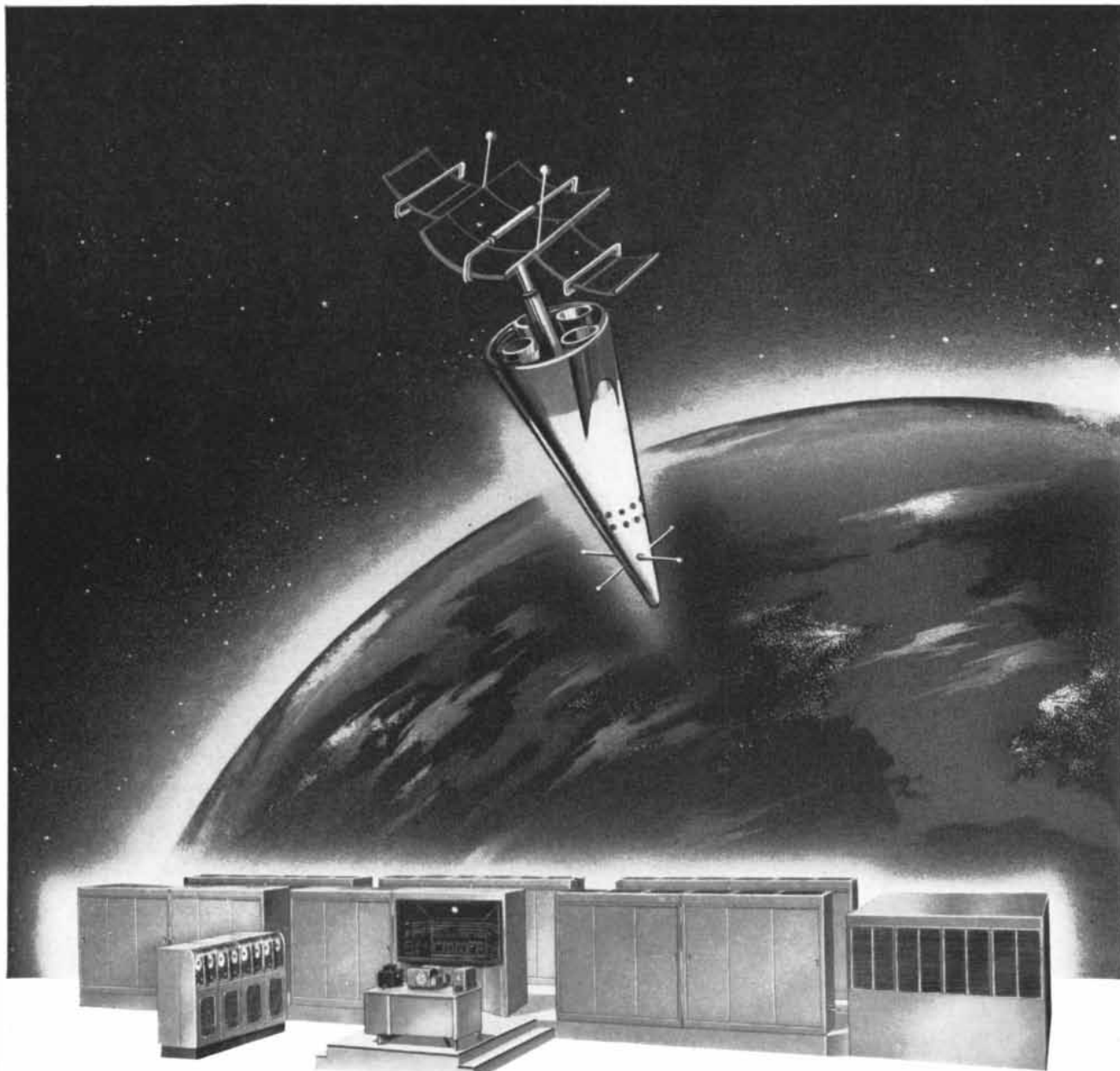
The possibilities are challenging. For example, by reacting acrylonitrile with starch, all or part of the original hydroxyl hydrogens can be replaced with the group- CH_2CH_2CN . This cyanoethylated starch is non-ferment-

ing. Will a non-fermenting starch be useful in your product? Will the reaction of acrylonitrile with certain amines create other interesting products? Creative chemists are hard at work searching for the answers.

If your company would like to experiment with acrylonitrile, you are invited to write Monsanto, the Monomer Headquarters of America, for laboratory-size samples. Address *Monsanto Chemical Company, Plastics Division, Dept. SA11, Springfield 2, Massachusetts.*



Nothing contained herein shall be construed as a recommendation to produce or use any product in conflict with existing patents.



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 . . .

ELECTRONIC COMPUTER DEPARTMENT **Remington Rand** ROOM 2116, 315 FOURTH AVE., NEW YORK 10
DIVISION OF SPERRY RAND CORPORATION

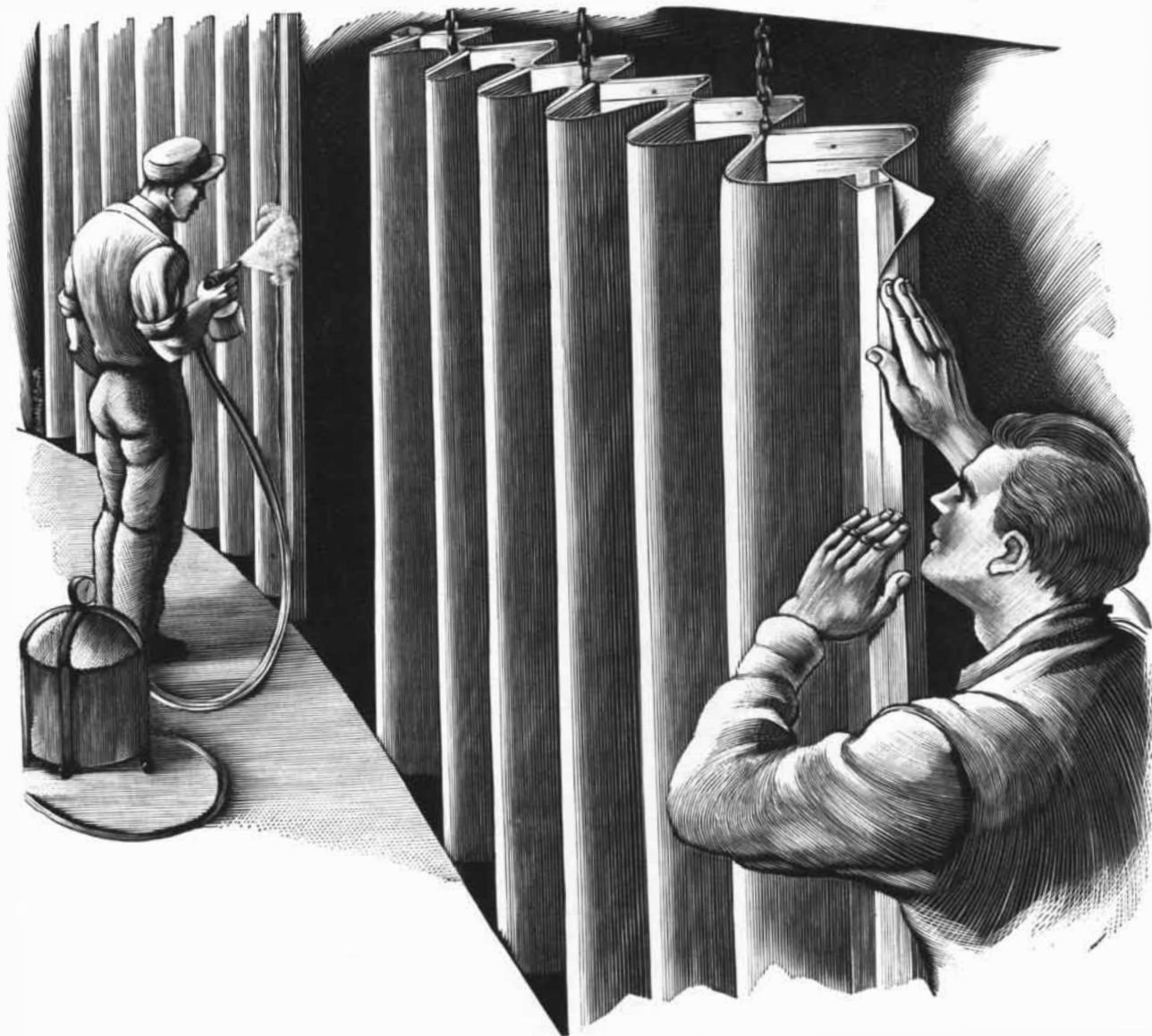
ARTICLES

- OPINIONS AND SOCIAL PRESSURE** by Solomon E. Asch
A psychologist reports a disturbing study indicating that to have the courage of one's convictions is a rather rare quality. In the face of apparent group pressure many people will disbelieve their own senses. 31
- THE TRENCHES OF THE PACIFIC** by Robert L. Fisher and Roger Revelle
Soundings of the Pacific floor have revealed that a series of monstrously deep chasms run around its periphery. The attempt to reconstruct their geologic history may shed some light on the formation of the continents. 36
- SYNTHETIC DIAMONDS** by P. W. Bridgman
The glitter of diamonds has long called forth an answering gleam in the eyes of experimenters who hoped to produce the gems artificially. Where avarice and wishful thinking failed, science has at last succeeded. 42
- RADIATION AND HUMAN MUTATION** by H. J. Muller
Through careless use of military, medical and industrial radiation over the last half-century men have been recklessly attacking their own genetic future. A geneticist assays the damage and sounds a warning. 58
- "EMPTY" SPACE** by H. C. van de Hulst
As long as their instruments failed to react to anything in interstellar space, astronomers felt free to ignore it. But now, with new techniques, they find it contains almost as much matter as comprises the stars. 72
- WHAT MAKES LEAVES FALL?** by William P. Jacobs
Without the conspicuous display that attends their autumn shedding, plants quietly drop their leaves through the year. The mechanism has been traced to their sensitive use of auxin, their growth hormone. 82
- ETRUSCAN METALLURGY** by Aldo Neppi Modona
After long honoring their Etruscan predecessors for their art and metalcraft, Italians have now come upon the wellspring of Etruscan power and achievement in the remains of its remarkable metallurgical industry. 90
- TOO MANY DEER** by A. Starker Leopold
These charming creatures, which bound across so many U. S. highways, tend to outgrow their food supply. From a study of their population balance the author concludes that we should permit more hunting. 101

DEPARTMENTS

LETTERS	2
50 AND 100 YEARS AGO	10
THE AUTHORS	18
SCIENCE AND THE CITIZEN	48
BOOKS	111
THE AMATEUR SCIENTIST	125
BIBLIOGRAPHY	138

Board of Editors: GERARD PIEL (*Publisher*), DENNIS FLANAGAN (*Editor*), LEON SVIRSKY (*Managing Editor*),
GEORGE A. W. BOEHM, ROBERT EMMETT GINNA, JEAN LE CORBEILLER, JAMES R. NEWMAN, E. P. ROSENBAUM
Art Director: JAMES GRUNBAUM
General Manager: DONALD H. MILLER, JR.
Advertising Manager: MARTIN M. DAVIDSON



Bond vinyl fabrics quickly, easily with these versatile adhesives

Whether you're bonding vinyl to metal, wood, rubber, glass, or to vinyl itself, an Armstrong adhesive will do the job with assembly-line speed and economy. Application is easy with spray gun, roller coater, or brush.

The Armstrong vinyl-bonding adhesives offer a range of strength, tack, open time, and bond flexibility that suits them to any production requirement. For example, if you want to apply vinyl around radii where clamping is impracticable—as on the end posts of folding doors—you can get an Armstrong adhesive with the high immediate strength you'll need.

You can also get Armstrong adhesives with open-time ranges to suit all practical produc-

tion procedures. And if you're bonding reverse-printed vinyls—where staining or discoloration may be a problem—an Armstrong non-staining adhesive will do the job neatly.

For more information on these and other adhesives, send for a copy of our 1955 catalog. It's free to industrial users. Write Armstrong Cork Company, Industrial Division, 8011 Inland Road, Lancaster, Penna. In Canada, 6911 Decarie Boulevard, Montreal.

Armstrong

ADHESIVES • COATINGS • SEALERS
... used wherever performance counts

Opinions and Social Pressure

*Exactly what is the effect of the opinions of others on our own?
In other words, how strong is the urge toward social conformity?
The question is approached by means of some unusual experiments*

by Solomon E. Asch

That social influences shape every person's practices, judgments and beliefs is a truism to which anyone will readily assent. A child masters his "native" dialect down to the finest nuances; a member of a tribe of cannibals accepts cannibalism as altogether fitting and proper. All the social sciences take their departure from the observation of the profound effects that groups exert on their members. For psychologists, group pressure upon the minds of individuals raises a host of questions they would like to investigate in detail.

How, and to what extent, do social forces constrain people's opinions and attitudes? This question is especially pertinent in our day. The same epoch that has witnessed the unprecedented technical extension of communication

has also brought into existence the deliberate manipulation of opinion and the "engineering of consent." There are many good reasons why, as citizens and as scientists, we should be concerned with studying the ways in which human beings form their opinions and the role that social conditions play.

Studies of these questions began with the interest in hypnosis aroused by the French physician Jean Martin Charcot (a teacher of Sigmund Freud) toward the end of the 19th century. Charcot believed that only hysterical patients could be fully hypnotized, but this view was soon challenged by two other physicians, Hyppolyte Bernheim and A. A. Liébault, who demonstrated that they could put most people under the hypnotic spell. Bernheim proposed that hyp-

nosis was but an extreme form of a normal psychological process which became known as "suggestibility." It was shown that monotonous reiteration of instructions could induce in normal persons in the waking state involuntary bodily changes such as swaying or rigidity of the arms, and sensations such as warmth and odor.

It was not long before social thinkers seized upon these discoveries as a basis for explaining numerous social phenomena, from the spread of opinion to the formation of crowds and the following of leaders. The sociologist Gabriel Tarde summed it all up in the aphorism: "Social man is a somnambulist."

When the new discipline of social psychology was born at the beginning of this century, its first experiments were



EXPERIMENT IS REPEATED in the Laboratory of Social Relations at Harvard University. Seven student subjects are asked by the experimenter (*right*) to compare the length of lines (see *diagram*

on the next page). Six of the subjects have been coached beforehand to give unanimously wrong answers. The seventh (*sixth from the left*) has merely been told that it is an experiment in perception.

essentially adaptations of the suggestion demonstration. The technique generally followed a simple plan. The subjects, usually college students, were asked to give their opinions or preferences concerning various matters; some time later they were again asked to state their choices, but now they were also informed of the opinions held by authorities or large groups of their peers on the same matters. (Often the alleged consensus was fictitious.) Most of these studies had substantially the same result: confronted with opinions contrary to their own, many subjects apparently shifted their judgments in the direction of the views of the majorities or the experts. The late psychologist Edward L. Thorndike reported that he had succeeded in modifying the esthetic preferences of adults by this procedure. Other psychologists reported that people's evaluations of the merit of a literary passage could be raised or lowered by ascribing the passage to different authors. Apparently the sheer weight of numbers or authority sufficed to change opinions, even when no arguments for the opinions themselves were provided.

Now the very ease of success in these experiments arouses suspicion. Did the subjects actually change their opinions, or were the experimental victories scored only on paper? On grounds of common sense, one must question whether opinions are generally as watery as these studies indicate. There is some reason to wonder whether it was not the investigators who, in their enthusiasm for a theory, were suggestible, and whether the ostensibly gullible subjects were not providing answers which they thought good subjects were expected to give.

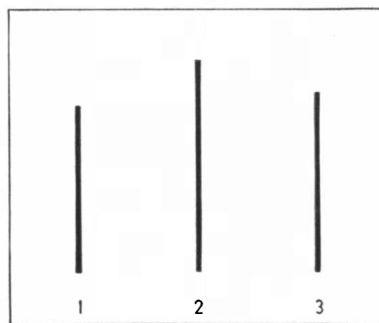
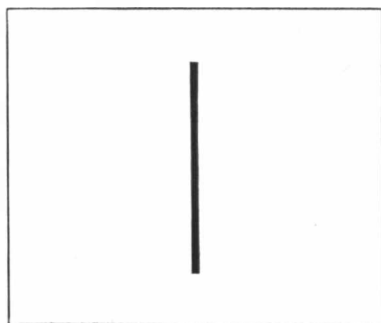
The investigations were guided by certain underlying assumptions, which today are common currency and account for much that is thought and said about the operations of propaganda and public opinion. The assumptions are that peo-

ple submit uncritically and painlessly to external manipulation by suggestion or prestige, and that any given idea or value can be "sold" or "unsold" without reference to its merits. We should be skeptical, however, of the supposition that the power of social pressure necessarily implies uncritical submission to it: independence and the capacity to rise above group passion are also open to human beings. Further, one may question on psychological grounds whether it is possible as a rule to change a person's judgment of a situation or an object without first changing his knowledge or assumptions about it.

In what follows I shall describe some experiments in an investigation of the effects of group pressure which was carried out recently with the help of a number of my associates. The tests not only demonstrate the operations of group pressure upon individuals but also illustrate a new kind of attack on the problem and some of the more subtle questions that it raises.

A group of seven to nine young men, all college students, are assembled in a classroom for a "psychological experiment" in visual judgment. The experimenter informs them that they will be comparing the lengths of lines. He shows two large white cards. On one is a single vertical black line—the standard whose length is to be matched. On the other card are three vertical lines of various lengths. The subjects are to choose the one that is of the same length as the line on the other card. One of the three actually is of the same length; the other two are substantially different, the difference ranging from three quarters of an inch to an inch and three quarters.

The experiment opens uneventfully. The subjects announce their answers in the order in which they have been seated in the room, and on the first round every person chooses the same matching line.



SUBJECTS WERE SHOWN two cards. One bore a standard line. The other bore three lines, one of which was the same length as the standard. The subjects were asked to choose this line.

Then a second set of cards is exposed; again the group is unanimous. The members appear ready to endure politely another boring experiment. On the third trial there is an unexpected disturbance. One person near the end of the group disagrees with all the others in his selection of the matching line. He looks surprised, indeed incredulous, about the disagreement. On the following trial he disagrees again, while the others remain unanimous in their choice. The dissenter becomes more and more worried and hesitant as the disagreement continues in succeeding trials; he may pause before announcing his answer and speak in a low voice, or he may smile in an embarrassed way.

What the dissenter does not know is that all the other members of the group were instructed by the experimenter beforehand to give incorrect answers in unanimity at certain points. The single individual who is not a party to this prearrangement is the focal subject of our experiment. He is placed in a position in which, while he is actually giving the correct answers, he finds himself unexpectedly in a minority of one, opposed by a unanimous and arbitrary majority with respect to a clear and simple fact. Upon him we have brought to bear two opposed forces: the evidence of his senses and the unanimous opinion of a group of his peers. Also, he must declare his judgments in public, before a majority which has also stated its position publicly.

The instructed majority occasionally reports correctly in order to reduce the possibility that the naive subject will suspect collusion against him. (In only a few cases did the subject actually show suspicion; when this happened, the experiment was stopped and the results were not counted.) There are 18 trials in each series, and on 12 of these the majority responds erroneously.

How do people respond to group pressure in this situation? I shall report first the statistical results of a series in which a total of 123 subjects from three institutions of higher learning (not including my own, Swarthmore College) were placed in the minority situation described above.

Two alternatives were open to the subject: he could act independently, repudiating the majority, or he could go along with the majority, repudiating the evidence of his senses. Of the 123 put to the test, a considerable percentage yielded to the majority. Whereas in ordinary circumstances individuals matching the lines will make mistakes less than 1

per cent of the time, under group pressure the minority subjects swung to acceptance of the misleading majority's wrong judgments in 36.8 per cent of the selections.

Of course individuals differed in response. At one extreme, about one quarter of the subjects were completely independent and never agreed with the erroneous judgments of the majority. At the other extreme, some individuals went with the majority nearly all the time. The performances of individuals in this experiment tend to be highly consistent. Those who strike out on the path of independence do not, as a rule, succumb to the majority even over an extended series of trials, while those who choose the path of compliance are unable to free themselves as the ordeal is prolonged.

The reasons for the startling individual differences have not yet been investigated in detail. At this point we can only report some tentative generalizations from talks with the subjects, each of whom was interviewed at the end of the experiment. Among the independent individuals were many who held fast because of staunch confidence in their own judgment. The most significant fact about them was not absence of responsiveness to the majority but a capacity to recover from doubt and to re-establish their equilibrium. Others who acted independently came to believe that the majority was correct in its answers, but they continued their dissent on the simple ground that it was their obligation to call the play as they saw it.

Among the extremely yielding persons we found a group who quickly reached the conclusion: "I am wrong, they are right." Others yielded in order "not to spoil your results." Many of the individuals who went along suspected that the majority were "sheep" following the first responder, or that the majority were victims of an optical illusion; nevertheless, these suspicions failed to free them at the moment of decision. More disquieting were the reactions of subjects who construed their difference from the majority as a sign of some general deficiency in themselves, which at all costs they must hide. On this basis they desperately tried to merge with the majority, not realizing the longer-range consequences to themselves. All the yielding subjects underestimated the frequency with which they conformed.

Which aspect of the influence of a majority is more important—the size of the majority or its unanimity? The experiment was modified to examine this



EXPERIMENT PROCEEDS as follows. In the top picture the subject (*center*) hears rules of experiment for the first time. In the second picture he makes his first judgment of a pair of cards, disagreeing with the unanimous judgment of the others. In the third he leans forward to look at another pair of cards. In the fourth he shows the strain of repeatedly disagreeing with the majority. In the fifth, after 12 pairs of cards have been shown, he explains that "he has to call them as he sees them." This subject disagreed with the majority on all 12 trials. Seventy-five per cent of experimental subjects agree with the majority in varying degrees.

question. In one series the size of the opposition was varied from one to 15 persons. The results showed a clear trend. When a subject was confronted with only a single individual who contradicted his answers, he was swayed little: he continued to answer independently and correctly in nearly all trials. When the opposition was increased to two, the pressure became substantial: minority subjects now accepted the wrong answer 13.6 per cent of the time. Under the pressure of a majority of three, the subjects' errors jumped to 31.8 per cent. But further increases in the size of the majority apparently did not increase the weight of the pressure substantially. Clearly the size of the opposition is important only up to a point.

Disturbance of the majority's unanimity had a striking effect. In this experiment the subject was given the support of a truthful partner—either another individual who did not know of the prearranged agreement among the rest of the group, or a person who was instructed to give correct answers throughout.

The presence of a supporting partner depleted the majority of much of its power. Its pressure on the dissenting individual was reduced to one fourth: that is, subjects answered incorrectly only one fourth as often as under the pressure of a unanimous majority [see chart at lower left on the opposite page]. The weakest persons did not yield as readily. Most interesting were the reactions to the partner. Generally the feeling toward him was one of warmth and closeness; he was credited with inspiring confidence. However, the subjects repudiated the suggestion that the partner decided them to be independent.

Was the partner's effect a consequence of his dissent, or was it related to his accuracy? We now introduced into the experimental group a person who was instructed to dissent from the majority but also to disagree with the subject. In some experiments the majority was always to choose the worst of the comparison lines and the instructed dissenter to pick the line that was closer to the length of the standard one; in others the majority was consistently intermediate and the dissenter most in error. In this manner we were able to study the relative influence of "compromising" and "extremist" dissenters.

Again the results are clear. When a moderate dissenter is present, the effect of the majority on the subject decreases by approximately one third, and extremes of yielding disappear. Moreover, most of the errors the subjects do make

are moderate, rather than flagrant. In short, the dissenter largely controls the choice of errors. To this extent the subjects broke away from the majority even while bending to it.

On the other hand, when the dissenter always chose the line that was more flagrantly different from the standard, the results were of quite a different kind. The extremist dissenter produced a remarkable freeing of the subjects; their errors dropped to only 9 per cent. Furthermore, all the errors were of the moderate variety. We were able to conclude that dissent *per se* increased independence and moderated the errors that occurred, and that the direction of dissent exerted consistent effects.

In all the foregoing experiments each subject was observed only in a single setting. We now turned to studying the effects upon a given individual of a change in the situation to which he was exposed. The first experiment examined the consequences of losing or gaining a partner. The instructed partner began by answering correctly on the first six trials. With his support the subject usually resisted pressure from the majority: 18 of 27 subjects were completely independent. But after six trials the partner joined the majority. As soon as he did so, there was an abrupt rise in the subjects' errors. Their submission to the majority was just about as frequent as when the minority subject was opposed by a unanimous majority throughout.

It was surprising to find that the experience of having had a partner and of having braved the majority opposition with him had failed to strengthen the individuals' independence. Questioning at the conclusion of the experiment suggested that we had overlooked an important circumstance; namely, the strong specific effect of "desertion" by the partner to the other side. We therefore changed the conditions so that the partner would simply leave the group at the proper point. (To allay suspicion it was announced in advance that he had an appointment with the dean.) In this form of the experiment, the partner's effect outlasted his presence. The errors increased after his departure, but less markedly than after a partner switched to the majority.

In a variant of this procedure the trials began with the majority unanimously giving correct answers. Then they gradually broke away until on the sixth trial the naive subject was alone and the group unanimously against him. As long as the subject had anyone on his side, he

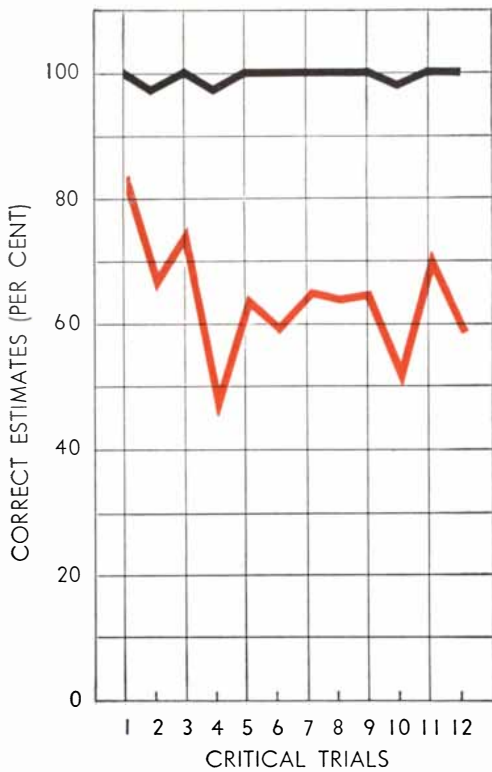
was almost invariably independent, but as soon as he found himself alone, the tendency to conform to the majority rose abruptly.

As might be expected, an individual's resistance to group pressure in these experiments depends to a considerable degree on how wrong the majority is. We varied the discrepancy between the standard line and the other lines systematically, with the hope of reaching a point where the error of the majority would be so glaring that every subject would repudiate it and choose independently. In this we regretfully did not succeed. Even when the difference between the lines was seven inches, there were still some who yielded to the error of the majority.

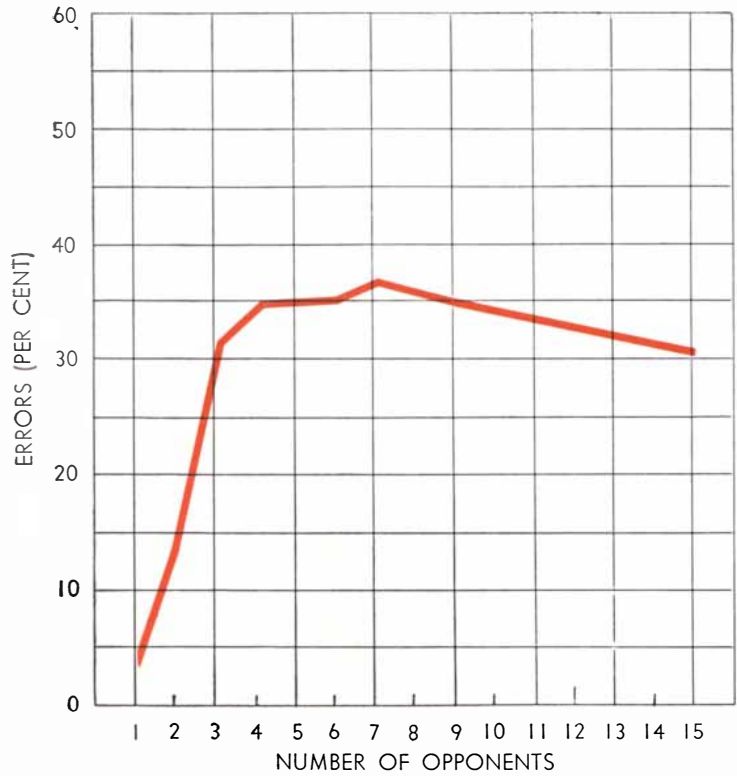
The study provides clear answers to a few relatively simple questions, and it raises many others that await investigation. We would like to know the degree of consistency of persons in situations which differ in content and structure. If consistency of independence or conformity in behavior is shown to be a fact, how is it functionally related to qualities of character and personality? In what ways is independence related to sociological or cultural conditions? Are leaders more independent than other people, or are they adept at following their followers? These and many other questions may perhaps be answerable by investigations of the type described here.

Life in society requires consensus as an indispensable condition. But consensus, to be productive, requires that each individual contribute independently out of his experience and insight. When consensus comes under the dominance of conformity, the social process is polluted and the individual at the same time surrenders the powers on which his functioning as a feeling and thinking being depends. That we have found the tendency to conformity in our society so strong that reasonably intelligent and well-meaning young people are willing to call white black is a matter of concern. It raises questions about our ways of education and about the values that guide our conduct.

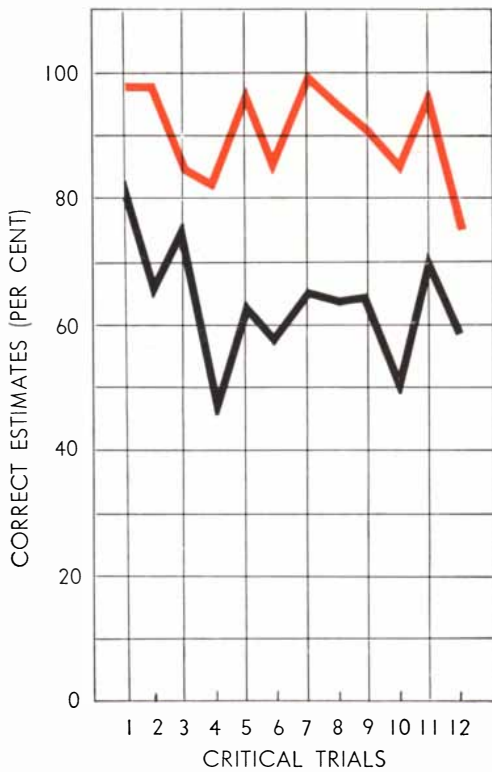
Yet anyone inclined to draw too pessimistic conclusions from this report would do well to remind himself that the capacities for independence are not to be underestimated. He may also draw some consolation from a further observation: those who participated in this challenging experiment agreed nearly without exception that independence was preferable to conformity.



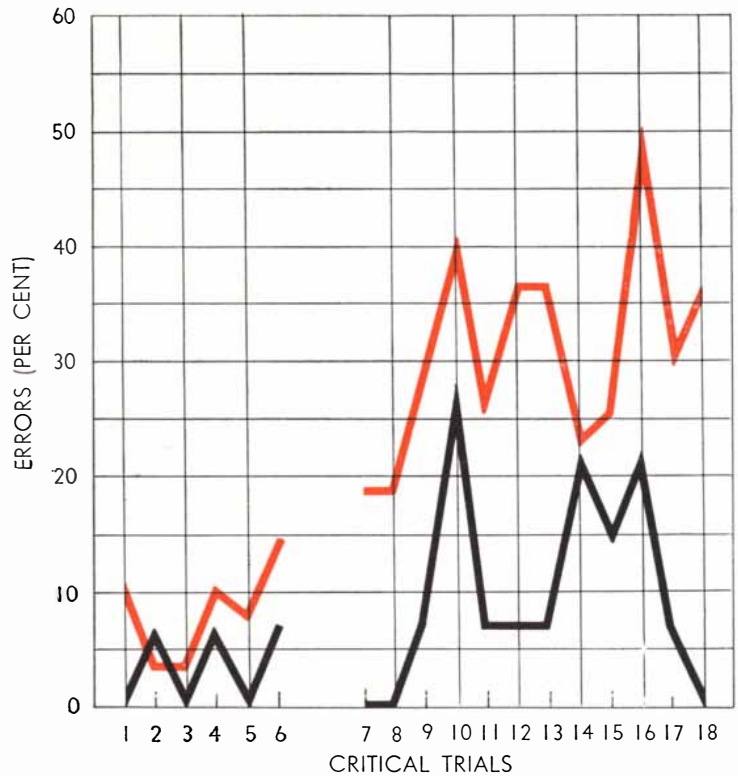
ERROR of 123 subjects, each of whom compared lines in the presence of six to eight opponents, is plotted in the colored curve. The accuracy of judgments not under pressure is indicated in black.



SIZE OF MAJORITY which opposed them had an effect on the subjects. With a single opponent the subject erred only 3.6 per cent of the time; with two opponents he erred 13.6 per cent; three, 31.8 per cent; four, 35.1 per cent; six, 35.2 per cent; seven, 37.1 per cent; nine, 35.1 per cent; 15, 31.2 per cent.



TWO SUBJECTS supporting each other against a majority made fewer errors (colored curve) than one subject did against a majority (black curve).



PARTNER LEFT SUBJECT after six trials in a single experiment. The colored curve shows the error of the subject when the partner "deserted" to the majority. Black curve shows error when partner merely left the room.

THE TRENCHES OF THE PACIFIC

The floor of the great ocean is incised with tremendous furrows. The bottoms of several are farther below sea level than Everest is above it. They are clues to the history of the earth's crust

by Robert L. Fisher and Roger Revelle

On April 28, 1789, Lieutenant William Bligh, commanding H.M.S. *Bounty*, had a memorable quarrel in the Pacific Ocean with his senior warrant officer, one Fletcher Christian, as a result of which they parted company and sailed off in opposite directions—Christian in the *Bounty* and Bligh in the ship's longboat. This historic mutiny took place near the great volcano of Tofua in the Friendly Islands, better known today as the Tonga Islands. Bligh and Christian were well acquainted with the fact that the oceanic topography around these islands was somewhat unusual—full of treacherous shoals and narrow interisland passages. But they could not know, for methods of deep-sea sounding had not yet been invented, how unusual it really was, nor that this place would one day yield one of the most remarkable discoveries in the history of ocean-going exploration.

Beneath the placid sea east of the Tonga Islands yawns a monstrous chasm nearly seven miles deep. A hundred years after the *Bounty* episode another British vessel first plumbed its depths. Surveying the ocean bottom around the islands, Pelham Aldrich, commanding H.M.S. *Egeria*, was surprised to find that on two occasions his sounding lead did not touch bottom until 24,000 feet of wire had been paid out. Aldrich's discovery prompted other nations to send out expeditions to explore the Tonga undersea abyss. Eventually they traced out a great trench running from the Tonga Islands south to the Kermadec Islands [see map on page 40]. The deepest sounding made recently by the research vessel *Horizon* of the Scripps Institution of Oceanography, is some 35,000 feet. The immense chasm plunges about 6,000 feet farther below sea level than Mount Everest rises above it!

The Tonga-Kermadec Trench is now known to be but one member in a vast chain of deep, narrow trenches which lie like moats around the central basin of the Pacific [see map]. All of them parallel island archipelagoes or mountain ranges on the coasts of continents. Along the coast of South America, the drop from the top of the Andes to the bottom of the offshore trench is more than 40,000 feet. And the length of the undersea troughs is no less remarkable than their depth: some are 2,000 miles long.

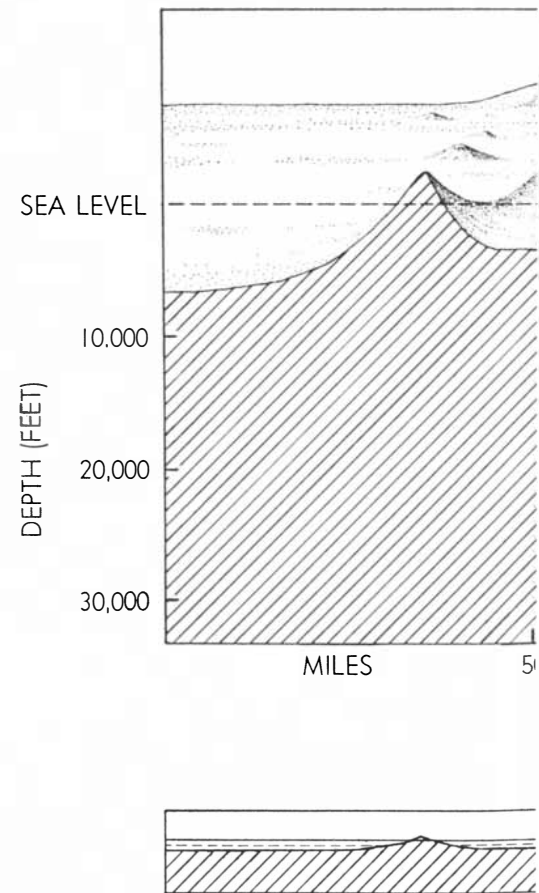
These great gashes in the sea floor are so unlike anything on land that they are difficult for us as land animals to visualize. It is hard to grasp the reality of a chasm so deep that seven Grand Canyons could be piled on one another in it, and so long that it would extend from New York to Kansas City. Yet these are the dimensions of the Tonga-Kermadec Trench.

The size and peculiar shape of the Pacific trenches stir our sense of wonder. What implacable forces could have caused such large-scale distortions of the sea floor? Why are they so narrow, so long and so deep? What has become of the displaced material? Are they young or old, and what is the significance of the fact that they lie along the Pacific "ring of fire"—the zone of active volcanoes and violent earthquakes that encircles the vast ocean?

Although the trenches are still only sketchily explored, some tentative answers to these questions can be gleaned from the information already obtained. We can take the Tonga-Kermadec Trench as a typical example.

The Trench lies on a long, nearly straight, north-south line east of the Tonga and Kermadec archipelagoes. At

its northern end it has a slight hook. It begins there as a gentle, spoon-shaped depression, runs southeasterly between Tonga and Samoa, then turns and deepens, strikes south for 1,200 miles and finally shoals and disappears at a point



TONGA TRENCH would appear as in the upper drawing if viewed northward from a point in the central Tonga Islands, and if vertical distances were exaggerated by a

north of New Zealand. In its deepest central portion the Trench is very narrow—no more than five miles wide. The chasm is V-shaped, but the arm of the V on the island side is considerably steeper than on the seaward side: on the landward western wall the slopes average from 16 to 30 per cent—*i.e.*, in places they are steeper than the 24-per-cent-average slope of the sides of the Grand Canyon at Bright Angel. In longitudinal section the Trench consists of deep depressions separated by saddles; it looks like beads on a string, or peaks and saddles on an upside-down mountain range.

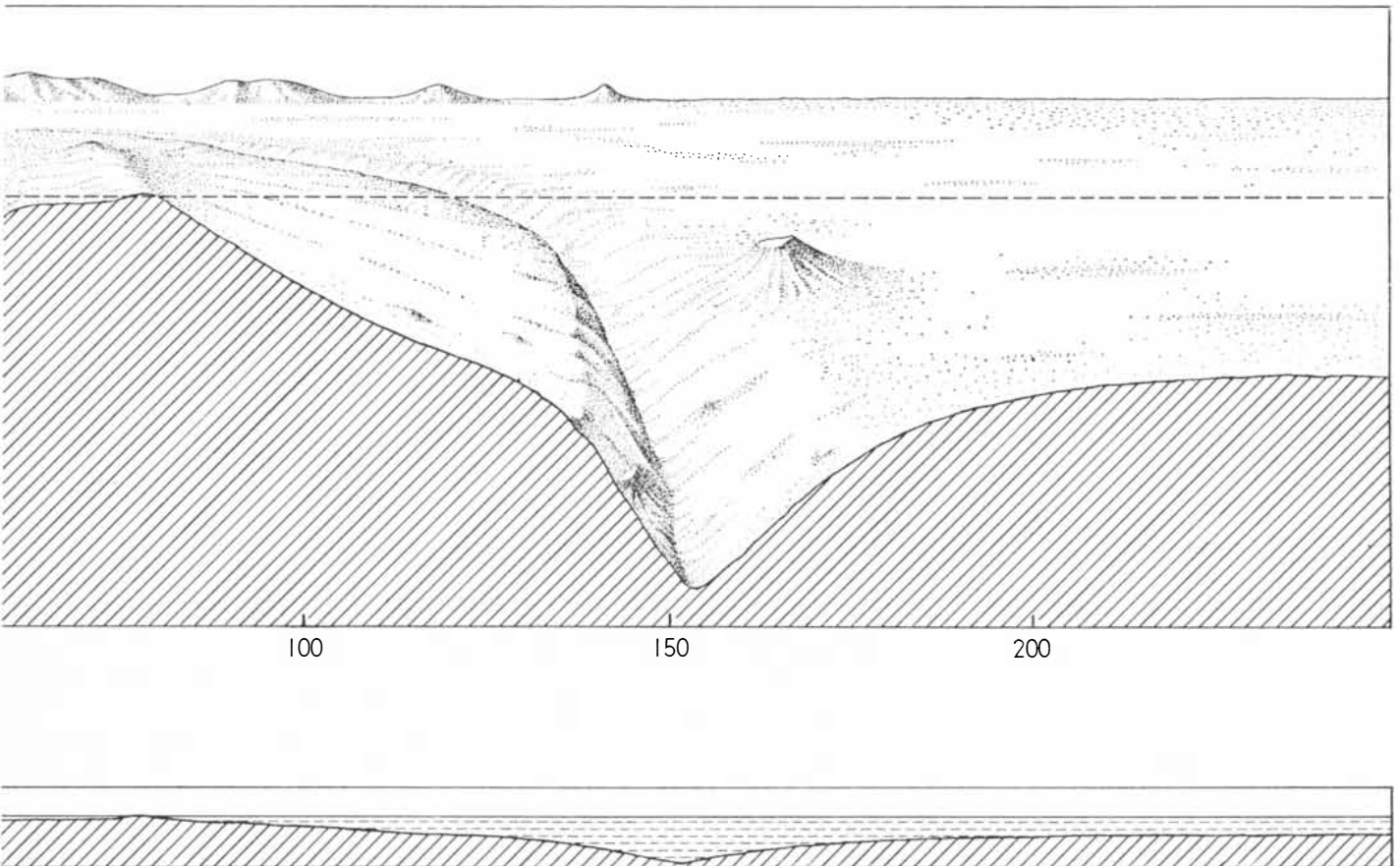
The islands on the western lip of the Trench appear to be part of the same crustal structure. They lie in two lines on a thousand-mile-long ridge atop the Trench's western slope. The islands of the Polynesian kingdom of Tonga are capped with limestones, laid down in shallow water during the last era of geologic time. These islands rest on broad

shelves of drowned coral, 180 to 360 feet deep, and they rise in a series of terraces to a few hundred feet above sea level. West of the limestone islands, separated from them by a shallow trough, is a chain of submarine volcanoes and high volcanic islands. The volcanoes are explosive, rather than of the quiet Hawaiian variety. They have contributed great quantities of ash and cinders to the surrounding sea floor. Five of the island volcanoes have erupted during the last hundred years, and the danger of further explosions has forced the government of Tonga to evacuate the inhabitants. There are also active volcanoes below the sea surface. One of them, Falcon Bank, rises several hundred feet above the sea during an eruption; indeed, this bank is commonly called Falcon Island. After each eruption waves quickly erode the erupted lava, and within a few years the volcano is submerged again.

The floor of the Tonga-Kermadec

Trench is rocky and seems to be nearly bare of sediments. During the Scripps Institution *Capricorn* expedition of 1952-1953, a core barrel with a heavy lead weight, which because of difficulties with the winch was dragged along the sea floor for several hours before it could be raised, came up badly battered by the bottom rocks. The heavy steel bail holding the instrument had been bent, and the lead weight looked as if it had been beaten with a hammer and chisel. Small fragments of black volcanic rock were embedded in the lead.

On the seaward slope of the Trench a single volcanic cone rises smoothly 27,000 feet, to within 1,200 feet of the sea surface. Just below its summit is a broad flat bench, tilted to the westward. Further study of this great cone, one of the highest mountains on earth, might tell us much about the history of the trench. Almost certainly the flat bench was cut by waves when the topmost part of the peak was above sea level. If



factor of 10 in comparison with horizontal. (In the lower drawing the cross section is shown without vertical exaggeration.) The exposed land mass in the left foreground is the island of Kao, a dormant volcano. In the distance are the Samoan Islands. The flat-

topped seamount on the eastern slope of the trench is one of the highest mountains in the world. Its summit, which is tilted down toward the west about one degree, was probably worn flat by wave action when trench was shallower and mountain above water.

shallow-water fossils could be recovered from the summit, we could fix the time when submergence occurred, and perhaps when the bench began to be tilted. This in turn might give us information about the rate of downward bending of the trench floor.

The Tonga Trench, as we have said, is typical of the great trenches in the Pacific. Some of the other giant furrows are the Aleutian, Kurile, Japan, Marianas, Philippine and Java Trenches on the northern and western sides and the Acapulco and Peru-Chile Trenches on the eastern side of the ocean. It is a remarkable and probably significant fact that the deepest trenches all have about the same maximum depth. The record sounding so far was one estimated to be somewhere between 35,290 and 35,640 feet, made in the trench southeast of the Mariana Islands. Appropriately enough this depth was measured by H.M.S. *Challenger*, the modern namesake of the famous ship whose voyage around the world in the 1870s marks the beginning of modern oceanography [see "The Voyage of the *Challenger*," by Herbert S. Bailey, JR.; SCIENTIFIC AMERICAN, May, 1953]. The original *Challenger* actually discovered the Marianas depression, and for many years it was known as the Challenger Deep.

All the deep trenches seem to be generally V-shaped in cross section, although some are slightly flattened at the very bottom; in the Japan and Philippine trenches this flat portion is two to 10 miles wide. Some shallower trenches and trenchlike depressions are U-shaped, with extremely flat bottoms over broad areas, as if they had been partly filled with sediments. If the V-shaped trenches contain any sediments, the layer cannot be more than a few hundred feet thick.

Direct exploration of the trenches is most difficult. Their great depth and extreme narrowness present formidable obstacles. To lower a dredge or other heavy sampling apparatus to the bottom of the deeper trenches, the ship needs a tapered wire rope of the strongest steel and a powerful, specially designed winch. Only three such winches exist today. One was built for the Swedish *Albatross* Expedition of 1948-49 and was later used on the Danish *Galathea* Expedition of 1950-52; another is installed on the Scripps Institution's research vessel *Spencer F. Baird*; the third is on the U.S.S.R. research ship *Vitiaz*. The winch drum on the *Baird* carries 40,000 feet of wire rope. When this wire was paid out in the Tonga Trench with

a heavy core barrel on the end, the strain at deck level was 12 tons.

A single lowering of a dredge or core barrel takes many hours. It is complicated by the problem of keeping a small ship in position in a rolling sea, often under the influence of strong and unpredictable currents and shifting winds. The hazards of fouling the wire or of machinery breakdown under the heavy strain are always present, with the possible loss of the precious cable. Such a loss would be crippling, and much of the investment in time and effort required to send a scientific ship to a remote part of the world would also be lost.

If sounding and sampling of the bottom are difficult, drilling to find what lies beneath the bottom of the trenches is quite impossible, with present techniques. For such explorations we must depend on indirect methods—studies of earthquake waves, measurements of gravity anomalies, the flow of heat through the crust and the magnetic properties of the buried rocks.

The zone of trenches is the scene of our planet's most intense earthquake activity. Nearly all the major earthquakes, especially those originating at great depths, occur in this zone. The deepest-focus earthquakes are associated with the deepest and steepest trenches. This strongly suggests that the seat of the trench-producing forces lies far below the earth's surface.

The earthquakes may, indeed, be responsible for the fact that a line of explosive volcanoes parallels the trenches. Some investigators have proposed that the heat produced near the focus of an earthquake melts the surrounding rocks, and that the melted material rises and is eventually ejected by the volcanoes.

Seismic refraction studies give us another clue to the nature of the crust under the trenches. These investigations have shown that beneath the trenches (Tonga and others) the outer crust is less than one third as thick as under the continents. We therefore arrive at the important conclusion that the crustal structure under the trenches is oceanic and not continental.

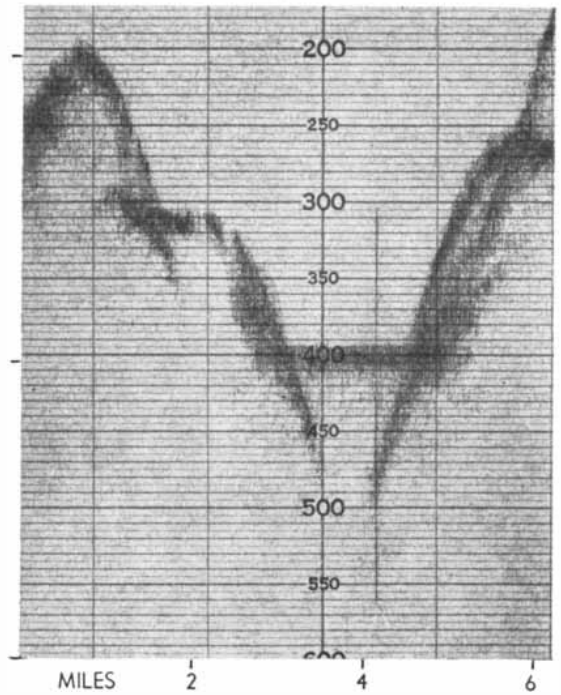
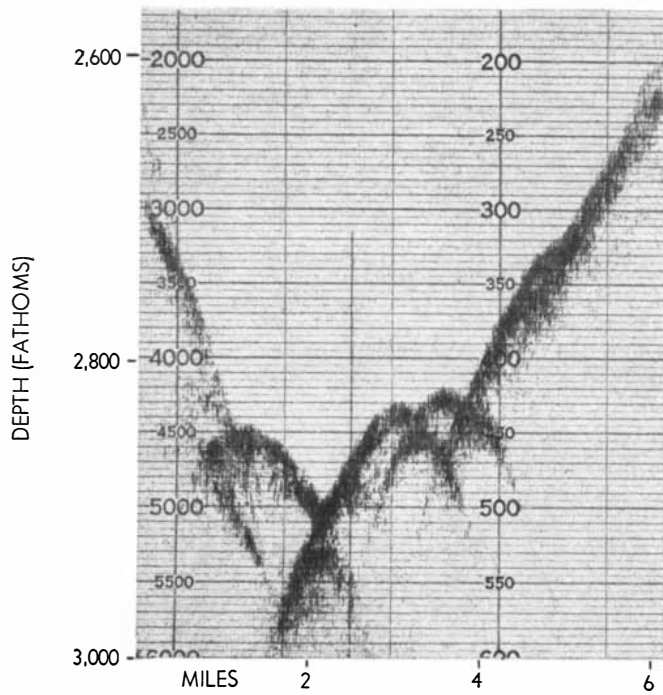
The most striking phenomenon associated with the trenches is a deficiency in gravity. The force of gravity depends on the mass of matter between the surface and some great depth in the earth. In general this force at any given latitude is about the same in ocean basins as in the continents, despite the fact that the volume of rock under a continental area is greater than under an equal area

of the ocean. Evidently the continents "float" high above the deep sea floor, like rafts of light material in a heavier medium. Within the continents themselves, there is usually little difference in gravity between high mountains and low plains, and it is commonly supposed that the mountains are underlain by a larger thickness of light material than the plains. This state of the earth's crust is called isostatic equilibrium.

Measurements of gravity near trenches show pronounced departures from the expected values. These gravity anomalies are among the largest found on earth. It is clear that isostatic equilibrium does not exist near the trenches. The trench-producing forces must be acting against the force of gravity to pull the crust under the trenches downward!

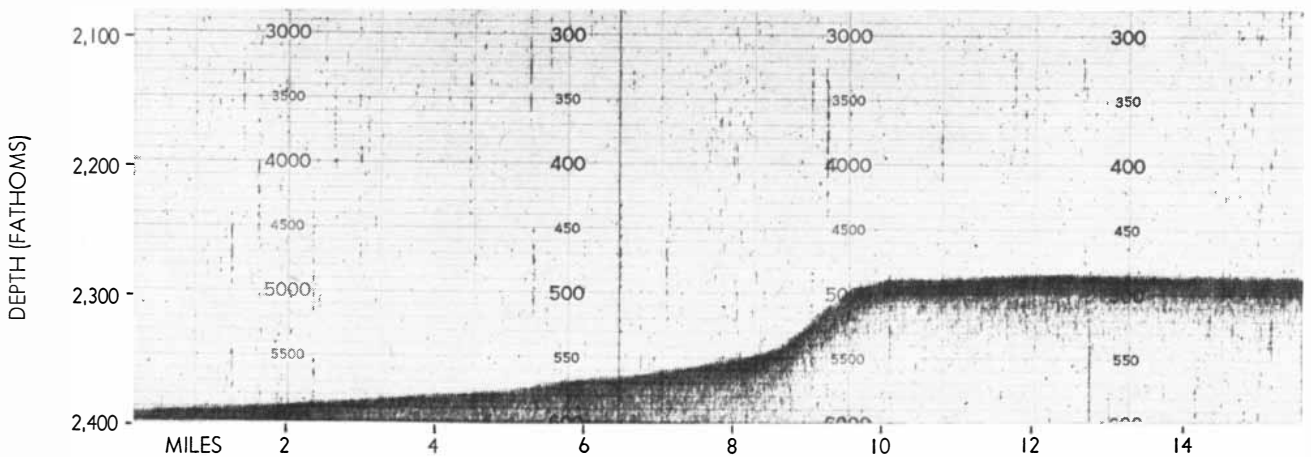
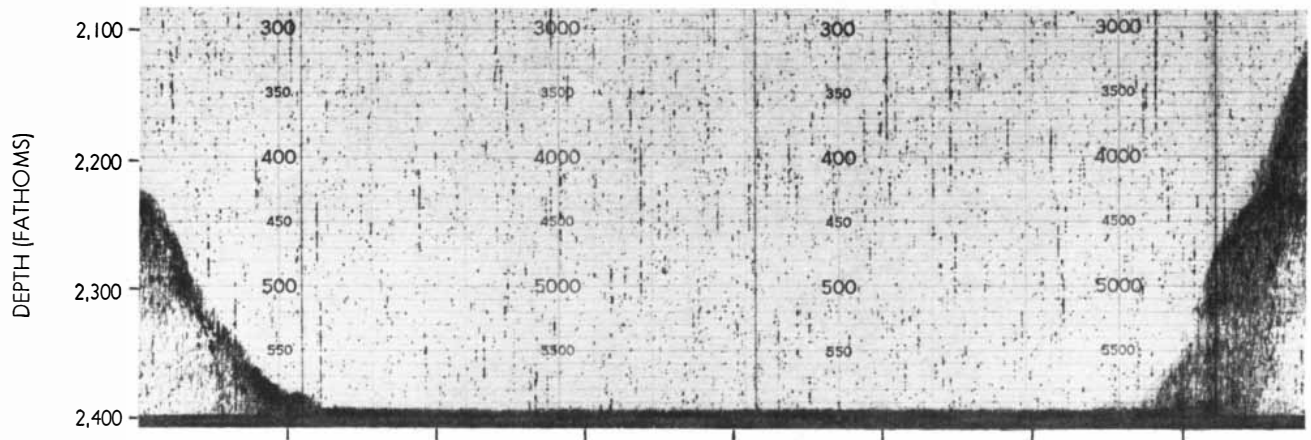
What may these forces be? Here studies of heat flow in the crust suggest a possible answer. It has long been known that there is a small, steady flow of heat from the earth's depths outward toward the surface. Most of this heat is generated by the disintegration of radioactive elements in the crust and the mantle just beneath the crust. Near the surface of the earth the heat is transported outward principally by conduction, but at greater depths there may be a slow upward movement of the hot rock itself, carrying heat toward the surface. If rock at these depths moves upward in some regions of the earth, there must be other regions where cold rock moves downward. This movement would reduce the outward flow of heat. Now measurements near the floor of the Acapulco Trench show that the flow of heat there is less than half the average for the earth's surface (the average being about 250 calories per year per square inch of surface). So it may be that relatively cool rocks are slowly moving downward under the trench. Such a downward flow would tend to drag the crust down with it and may well account for the formation of the trench. If this process is occurring, the earth's mantle should be cooler under the trench than elsewhere. Magnetic measurements suggest that this is in fact the case, but they are too few so far to be conclusive.

Speculating from what we know, we may imagine that a trench has the following life history. Forces deep within the earth cause a foundering of the sea floor, forming a V-shaped trench. The depth stabilizes at about 35,000 feet, but crustal material, including sediments, may continue to be dragged downward into the earth. This is suggested by the



ACAPULCO TRENCH is revealed in cross section by echo soundings. Near Acapulco (*left*), the bottom is V-shaped, with little sedi-

ment, and 2,930 fathoms deep. Near Manzanillo (*right*), it is flat at 2,795 fathoms. Numbers on the records do not represent fathoms.



CEDROS TROUGH, a short trench off the coast of Lower California, is traced in cross section by the upper echo-sounding and

longitudinally by the lower. The bottom is flat at 2,395 fathoms and measures 11 miles across at the point where measurement was made.

fact that the deepest trenches contain virtually no sediments, although they are natural sediment traps. During this stage in the trench's history there is violent volcanic and earthquake activity.

In a later stage the internal forces pulling or squeezing the crust downward under the trench become less active, and the trench begins to fill up with sediments. It acquires a flat bottom and a U shape as the accumulating sediments cover the topographic irregularities. The sediments may eventually pile up so high that the top of the pile rises above the sea, forming islands, when isostatic equilibrium is finally restored. The top-most sediments will be rock of the kind that is deposited in shallow water, like the limestones of Tonga and the Marianas.

Another process also may come into

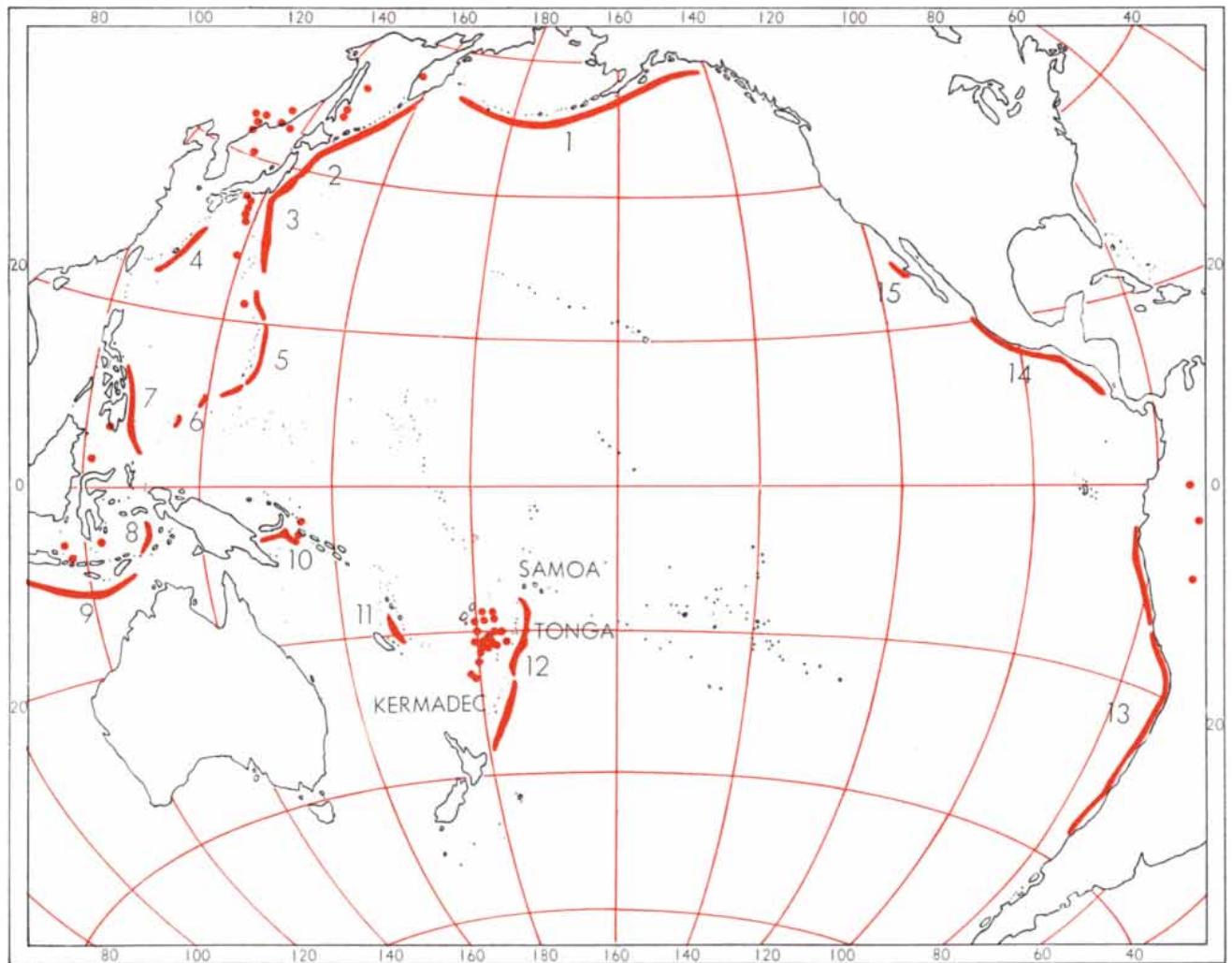
play if a thick layer of sediments accumulates. Because of their lower heat conductivity, the sediments would form an insulating blanket along the former trench. This would block the heat flow from the interior and cause a temperature rise which would partly melt the deep rocks. The melted material might then move upward and transform the heavy existing rock and the lower part of the sedimentary layer into light, granite-like rock. The thickness of the crust therefore should increase.

Some geophysicists have suggested that it was by such a sequence of events, occurring repeatedly during the geologic past, that the continents grew, at the expense of the ocean basins. The question then arises: Where on the continents are the ancient, filled-in trenches?

One naturally thinks at once of the

long, narrow structures, called geosynclines, where sediments piled up and mountain ranges developed by compression and folding. Were some geosynclines originally deep trenches such as now exist on the sea floor? It has usually been thought that this is not so, because most of the sediments in geosynclines appear to have been laid down in shallow water rather than in deep trenches. However, this appearance may in some cases be an illusion. Sediment samples collected from even the deepest trenches resemble in many ways deposits laid down in shallow water.

It is true that the sedimentary rocks in geosynclines contain no recognizable fossils of deep-sea animals. But trenches have little life that could leave a distinctive record. The depths of a trench are completely dark, except for the fee-



RING OF TRENCHES around the central basin of the Pacific is shown in color. The colored dots represent deep centers of earthquake activity. Numbered serially are: Aleutian Trench (1), Kurile Trench (2), Japan Trench (3), Nansei Shoto Trench (4), Marianas

Trench (5), Palau Trench (6), Philippine Trench (7), Weber Trench (8), Java Trench (9), New Britain Trench (10), New Hebrides Trench (11), Tonga-Kermadec Trench (12), Peru-Chile Trench (13), Acapulco-Guatemala Trench (14), Cedros Trough (15).

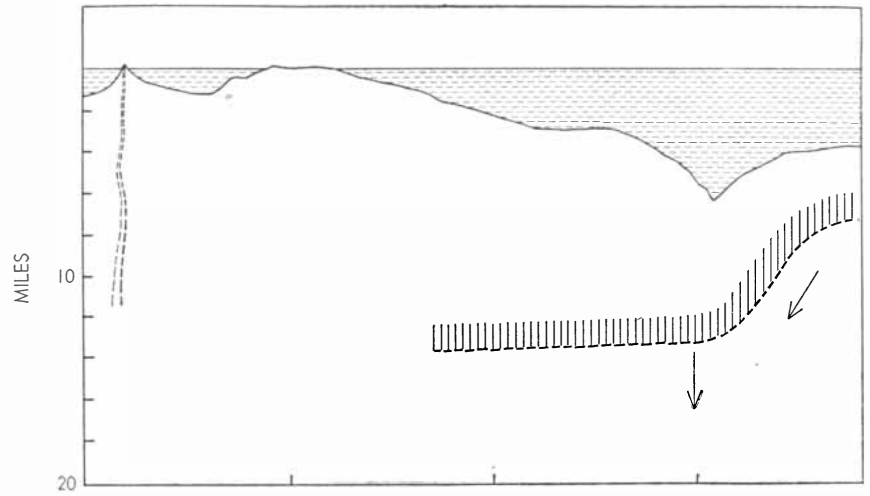
ble and flickering light produced by luminous organisms, and no plants can live there. The animals and bacteria of the abyss must gain their sparse food supply from plant and animal remains settling slowly from the upper layers of the sea. The waters are very cold: about 36.5 degrees Fahrenheit now, though they may have been some 20 degrees warmer in the geologic past. The pressure at the bottom of a trench is, of course, enormous—more than eight tons per square inch.

The Danish *Galathea* Expedition several years ago dredged up a few animals from the floors of trenches more than 30,000 feet deep. The principal animals recovered were sea cucumbers and a type of sea anemone, neither of which would be likely to leave distinctive fossils. Some worms, clams and crustaceans also were obtained, together with beautiful glass sponges.

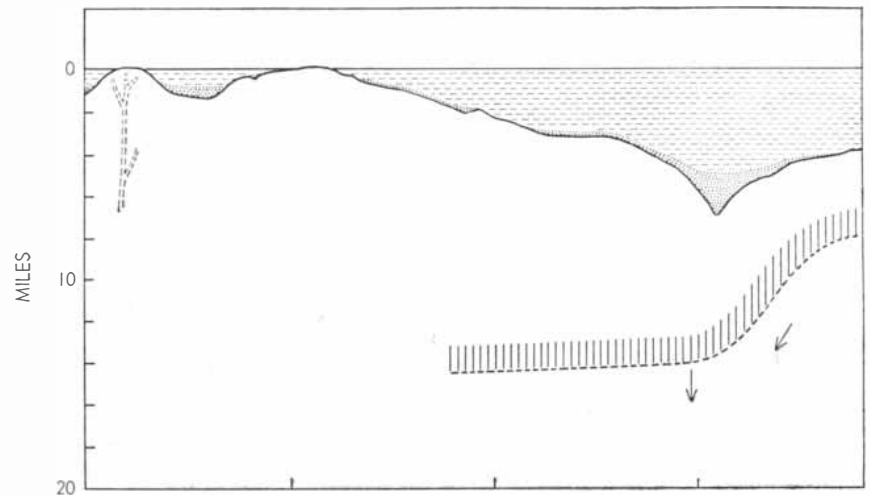
Materials which are usually supposed to be deposited only in shallow water have actually been found on the floor of some of the deep trenches. The *Galathea* recovered fine gray sand, pebbles, cobbles and land-plant debris from the floor of the Philippine Trench. The Lamont Geological Observatory of Columbia University found, in cores from the Puerto Rico Trough, the skeletons of plants and animals that live only at shallow depths. In the flat-bottomed northern part of the Acapulco Trench one core contained soft black mud, high in organic debris and stinking of hydrogen sulfide, while in other cores layers of gray, green and brownish sand and silt were interbedded with charred woody fragments and fine green mud.

However, it is clear that some geosynclines, notably those along what are now the Appalachian Mountains, could not have been deep sea trenches, for they contain deposits from marshes and flood plains interbedded with marine sediments, and therefore the deposits must have been laid down in shallow water.

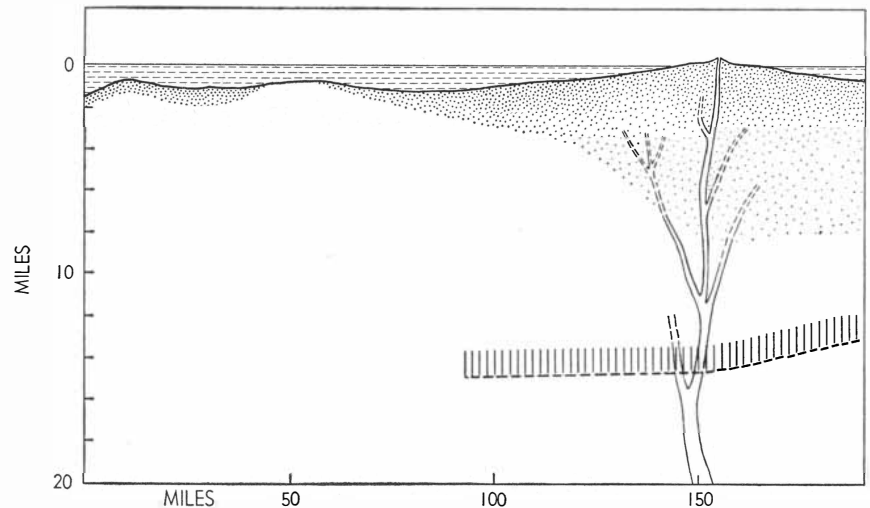
The question remains: Where are the trenches of yesteryear? Are we living in an exceptional geologic era; are the apparently young trenches of the present day unusual formations that have had no counterparts during most of geologic time? Such a speculation would be repugnant to many geologists, because it would be difficult to reconcile with the doctrine that the present is the key to the past. We must continue to search for ancient trenches—on the deep-sea floor, in the marginal shallow water areas and on the continents themselves.



POSSIBLE LIFE HISTORY of a trench is outlined in the three diagrams on this page. Here a force deep within the earth pulls down the floor of the ocean to form a V-shaped trench.



SEDIMENT COLLECTS in the bottom of the trench during the second stage, when the deep force weakens and relaxes its downward pull. Bottom is now flat and V changes to U.



SEDIMENT BUILDS UP and, with isostatic adjustment of the crust, rises above the surface of the sea. Deep molten rock rises through the sediment and is released by volcanoes.

Synthetic Diamonds

Their recent production was the culmination of a hundred years of attempts, some of which were claimed to be successful. An account of these efforts and the thermodynamic laws defining the problem

by P. W. Bridgman

Now that the problem of synthesizing diamond has at last been solved, it is perhaps of interest to survey some of the highlights of the history of this long endeavor. The attempts to solve this glittering problem have revealed the whole human spectrum: those engaged in it have ranged from first-rate scientists to downright muckers and charlatans. There has been no little wishful thinking and self-deception, not

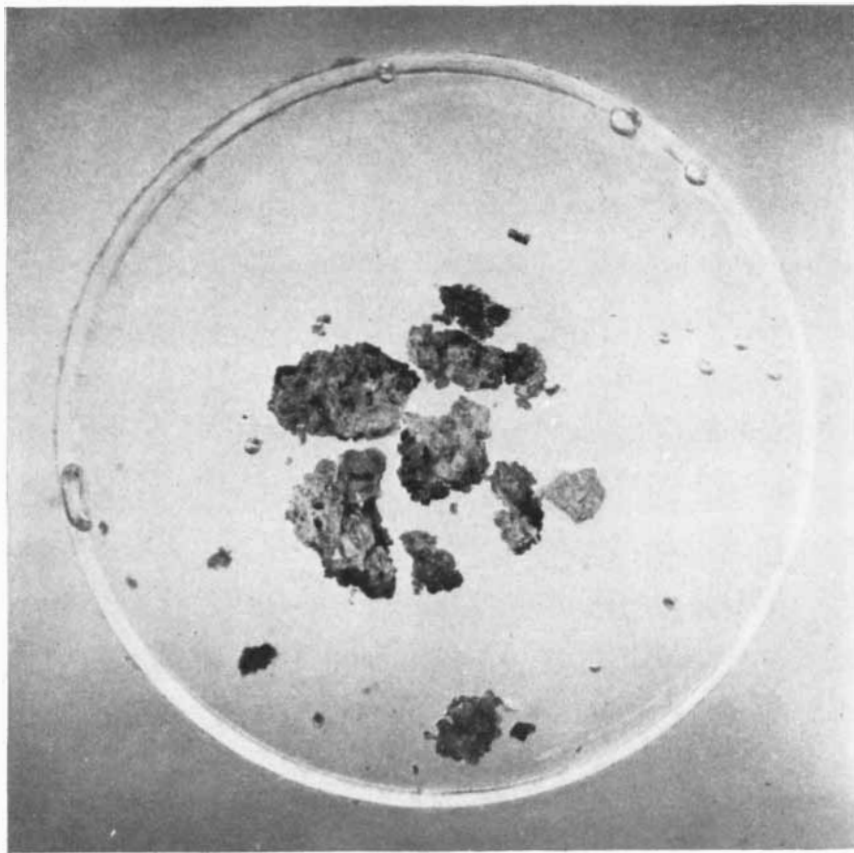
unmixed with avarice. The project has generated an extensive literature in technical journals and many accounts in the popular press, based on rumors later proved unsubstantial. Many amateurs have done their own unpublished thinking about the subject. I suppose that over the last 25 years an average of two or three people a year have come into my office, offering to share the secret and the profit of making diamonds in return

for my constructing the apparatus and reducing the idea to practice. The problem has got into the thriller literature, and I have often encountered the belief that the successful solver of this problem would be in danger of his life from the Diamond Syndicate.

The beginning of a foundation for scientific attack on the problem was laid in 1797 when the Englishman Smithson Tennant showed that diamond is a form of elementary carbon. This may be proved by burning a pure diamond in an atmosphere of pure oxygen: it burns to carbon dioxide without any residue. The common crystalline form of carbon, of course, is graphite. Diamond has a density of 3.51 against 2.25 for graphite. Modern X-ray analysis has disclosed the structural differences between them. Diamond crystallizes in a cubic system, with each atom symmetrically surrounded by four others, all at the same distance and arranged at the corners of a regular tetrahedron. Graphite crystallizes in the hexagonal system: the atoms are arranged in layers; within each layer the pattern is not greatly different from the arrangement in diamond, but the layers are separated by comparatively large intervals. It is to this that graphite owes its lubricating properties, for the layers can slip over one another under the action of weak mechanical forces.

Paradoxically, although diamond is very dense and is the hardest substance known, its atoms are not packed in the closest possible geometrical arrangement. It would be much denser if each atom were surrounded by 12 other equidistant atoms instead of only four.

Willard Gibbs's work in thermodynamics at the turn of the 19th century made it possible to say theoretically under what conditions carbon might



DIAMONDS made in the General Electric Research Laboratory are enlarged about seven diameters. They were grown by H. P. Bovenkerk in the press depicted on the opposite page.

take the form of diamond in preference to graphite. Gibbs's studies made clear that graphite could not turn into diamond unless the "thermodynamic potential" of diamond was less than that of graphite. The thermodynamic potential plays for chemical reactions a role closely analogous to the ordinary potential of mechanics. Just as a weight falls from a higher to a lower position because its potential is less near the earth, so a chemical reaction tends to run in the direction in which its thermodynamic potential becomes less—or, expressing the rule more rigorously, a chemical reaction *can* run only in the direction in which its thermodynamic potential decreases.

Gibbs showed how to calculate the thermodynamic potential in terms of the specific heat, the thermal expansion and other measurable properties of materials. It appeared probable at the time, and later it became a certainty, that the thermodynamic potential of graphite is lower than that of diamond—which is another way of saying that under ordinary conditions graphite is thermodynamically the more stable form. It follows that if any transformation is to take place at all at ordinary temperatures and pressures, it is from diamond to graphite.

But there is a catch when it comes to using these considerations to predict what will happen. For although we can tell when a transformation *may* run, we cannot tell when it *will* run. Although diamond has thermodynamic permission to transform itself into graphite under ordinary conditions, it has no mandate to do so. (Thermodynamic stability is not the same as mechanical stability.) Everyone knows that diamonds do not spontaneously change to graphite, and my wife has worn her engagement ring these many years with no solicitude on that score.

The mathematical expression for the thermodynamic potential showed that if the pressure could be raised high enough, graphite would receive thermodynamic permission to transform, even at ordinary temperatures, to diamond. This pressure was calculated to be about 20,000 atmospheres. But here again permission does not mean that the reaction will inevitably run.

Just as we cannot say that graphite will change to diamond if only it has thermodynamic permission, so also we cannot say that when a carbon compound decomposes, or when carbon is precipitated from a solution, the form of carbon that separates will be the form thermodynamically preferred. We know from the thermodynamic potential that

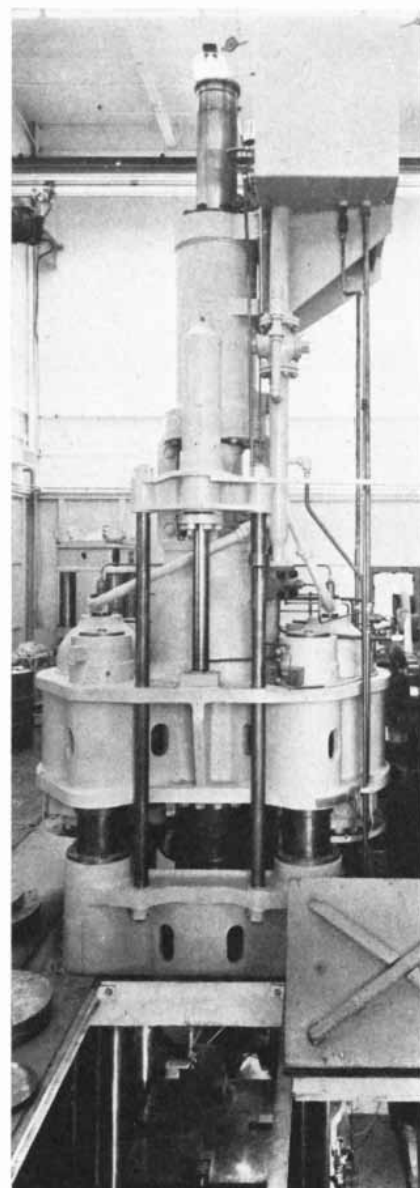
graphite is ordinarily the preferred form, but this does not enable us to say that the actual precipitate will be graphite and not diamond. As a matter of fact, there are many known instances in which an element's unstable form, corresponding to diamond, separates from a solidifying liquid or solution in preference to the more stable form.

The possibility that diamond may be formed as an unstable phase under conditions where "nascent" (uncombined) carbon is liberated makes it impossible to rule out the chance of an accidental success. Thus I could never say to the hopeful amateur who walked into my office: "Your process *certainly* will not work." I could only say this when he proposed to transform graphite directly into diamond under thermodynamically impossible conditions. The aforementioned possibility has been one of the bogeys in the whole situation. Many geologists and mineralogists have been of the opinion that diamond is formed in nature under unstable conditions, which would mean that it might be a matter of anybody's lucky guess to find the proper conditions.

None of the sophistications we have considered entered into the early attempts to make diamonds. Many of those who made the attempt were guided simply by the fact that diamond is more dense than graphite, which naturally suggested the possibility that it might be formed by subjecting carbon to great pressure. There were then no means of producing anything like the 20,000 atmospheres later calculated to be necessary, but claims of success were numerous nonetheless.

One of the earliest and still most discussed attempts was by a Scotsman, J. B. Hannay, in 1880. He mixed hydrocarbons, "bone oil" and lithium, sealed the mixture in a wrought-iron tube and heated it to redness in a forge. All but three of 80 tubes exploded. (The pressure in the tubes could not have been more than one or two thousand atmospheres.) In the residue of the unexploded tubes it was said that diamonds of density 3.5 were found. The claim was accepted at its face value and reported in the London *Times* by N. Story-Maskelyne. Subsequent attempts by a number of experimenters failed, however, to reproduce Hannay's results.

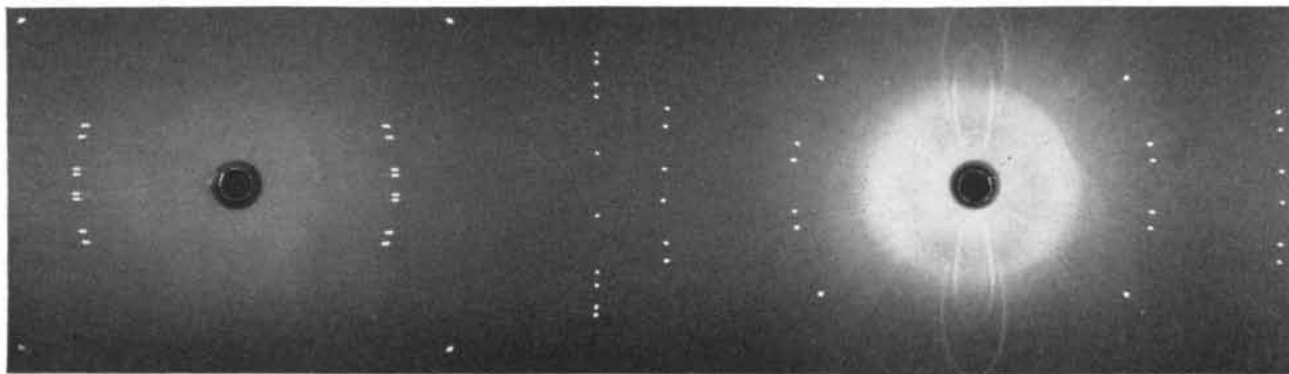
The matter was reopened in 1943 by the discovery in a forgotten corner of the British Museum of a small exhibit labeled "Hannay's Diamonds." These were analyzed with X-rays by F. A. Bannister



HYDRAULIC PRESS in which the diamonds were grown is capable of exerting a force of 1,000 tons. The pressure chambers are located below the floor level (*bottom*).

and Kathleen Lonsdale, and found to be certainly diamonds, and of a somewhat rare type at that. On the theory that it was unlikely that diamonds fraudulently inserted would be of this rare type, Bannister and Mrs. Lonsdale argued that Hannay's claim was probably genuine. But there was also contrary evidence, in particular, as pointed out by Lord Rayleigh, some known instances of bad faith on Hannay's part. It seems to be the present consensus that Hannay was a fraud. Mrs. Lonsdale recently told me that she now also inclines to that view.

Perhaps the best known experiments of all are those of the Frenchman Henri Moissan, made in the 1890s when he was



X-RAY DIFFRACTION PHOTOGRAPHS were the most conclusive evidence that the synthetic diamonds were identical with natu-

ral diamonds. On this page is the diffraction pattern of natural diamond; on the opposite page, the pattern of synthetic diamond.

perfecting the electric furnace. Cast iron is known to dissolve fairly large quantities of carbon. Moissan melted a mixture of iron and graphite in his electric furnace and plunged the white-hot crucible into water. The iron of course solidified first on the outside. The inner core, on solidifying later, was supposed to expand against the rigid outer shell, thus producing a tremendous internal pressure, and the pressure was further enhanced by the contraction of the external shell as it cooled. (It is now known that the pressure produced could not have been more than a few thousand atmospheres, because, in the first place, hot cast iron is not strong enough to withstand greater pressures, and, in the second place, cast iron actually contracts when it solidifies instead of expanding as was then erroneously supposed.) After the crucible was cooled to room temperature, its contents were dissolved in acids and given other appropriate chemical treatment. In the end there was a small residue which Moissan reported to be diamond.

His experiments have been repeated a number of times, and a number of times with announced positive results. One attempt that seemed particularly convincing was by O. Ruff of Germany. In 1917 he made an elaborate investigation, trying all the methods of synthesis that had been reported successful. All gave negative results except the method of Moissan: according to Ruff's report this method did yield some diamonds. Later, however, he changed his opinion, and in a communication published as a footnote in a paper by other authors he stated that he believed his own supposed diamonds were not genuine. It must be remembered that it is an extraordinarily difficult matter to establish the true nature of material obtained in such small quantities as has been the case in most

of the supposed synthetic diamonds.

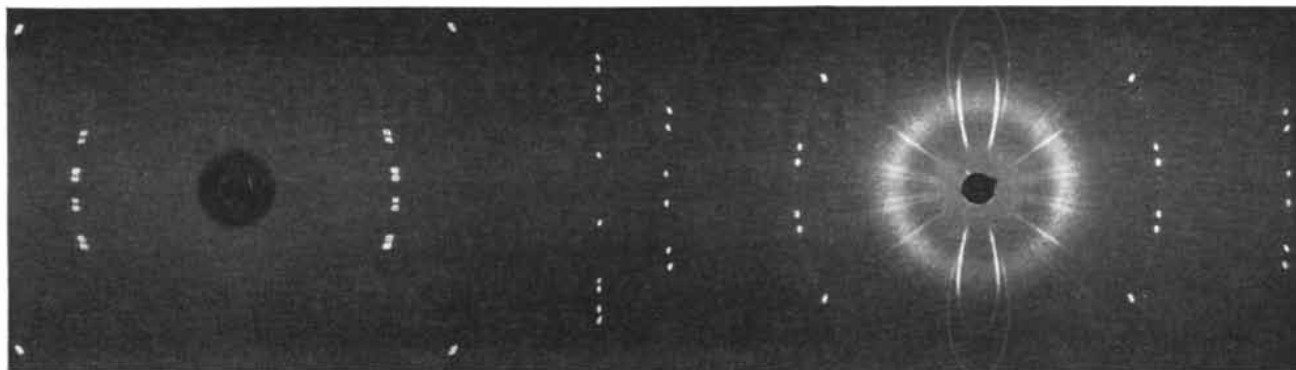
Another celebrated repetition of Moissan's work was by Sir Charles Parsons, the shipbuilder who invented the steam turbine. The problem of diamond synthesis was Parsons' hobby; on it he spent hundreds of thousands of pounds. He had at his command the enormous hydraulic presses of his shipbuilding establishment, and he tried nearly every conceivable method feasible at that time. He decomposed all sorts of carbonaceous materials and generated enormous momentary pressures by firing projectiles into tapering dead-end cavities. In his presses he was not able to obtain static pressures of more than 10,000 atmospheres. Parsons in his early work believed that he had duplicated Moissan's supposed success, but later more careful repetition convinced him that he had been deceived and had obtained only various spinels (hard, crystalline minerals) instead of diamonds. In 1924 Parsons informed me that Moissan's widow had told him Moissan had been the victim of fraud by one of his assistants, who had introduced diamond fragments into the cookery, in order to please the old man and to avoid the tedium of the long digestions.

In the U. S. successful use of Moissan's method was reported by the late J. W. Hershey, a professor of chemistry at McPherson College in Kansas. Hershey was accustomed to assign the project of making diamonds by a slightly modified Moissan procedure to his senior chemistry class. It is stated that 50 diamonds have been made altogether. The largest is said to be $2 \times 1.5 \times 1$ millimeters—a "record." A communication by Hershey in 1940, reporting his lack of success in attempts to make diamonds by another method, has been misquoted in a German paper as a repudiation by Hershey of his earlier claims, but so far as I

know that claim has never been withdrawn. There is still a militant local sentiment among at least some of the inhabitants of McPherson, Kan., to the effect that diamonds are an old story and that the General Electric Company is trying to put something over.

Another method that has had a considerable following is the solidification of molten graphite. A number of people have been convinced that if only graphite could be melted, it would solidify to diamond. The reason for this conviction is not easy to see—perhaps it is because graphite is so hard to melt. At atmospheric pressure graphite when heated passes directly from the solid to the gaseous phase without melting, just as solidified carbon dioxide does. However, frozen carbon dioxide can be melted to the liquid state under pressures above 30 atmospheres, and presumably something similar would be expected for graphite. James Basset of France has asserted that graphite has a triple point (where the solid, liquid and gaseous states can exist) in the neighborhood of 4,000 degrees centigrade and about 100 atmospheres. Above these temperatures and pressures the melting curve rises like that of a normal substance with rising temperature and pressure. Basset has made many attempts at the diamond problem along these lines, without success. Thirty years ago John M. Morehead of the Union Carbide and Carbon Corporation attacked the problem from the same angle. He claimed to have melted graphite under pressure. His results were never published. One can now say that if diamond does crystallize out of molten graphite, it must be as the thermodynamically unstable phase.

A number of experimenters have claimed success in making diamonds with the help of the electrical "singing arc," which when first developed was



The photographs were made by mounting photographic film around the inside of a cylinder, at the axis of which was mounted the dia-

mond. The beam of X-rays was directed through the side of the cylinder (*black holes in film*) while the diamond was rotated.

widely reported to be capable of melting graphite. In 1926 Professor M. La Rosa at the University of Palermo in Sicily showed me under the microscope a perfect little transparent octahedron which he said he thought was a diamond formed in his singing arc. It now appears almost certain that graphite could not have melted under these conditions, and that the appearance of melting was an effect of impurities, which doubtless were the origin of La Rosa's diamond.

In 1933 Hans Karabacek obtained a German patent for the formation of diamond by a complicated process involving the treatment of nascent carbon from carbon dioxide or monoxide with very high pressures attained by utilizing the thermal expansion attendant on cycles of heating and cooling. Karabacek was also an amateur fancier of minerals, of which he had accumulated a most remarkable collection. He put these on the market toward the end of his life, and Harvard University acquired a substantial part of them, along with some largish synthetic diamonds purportedly made according to his patent. For several years these diamonds were displayed in the Harvard Museum in a case labeled "Karabacek's synthetic diamonds." However, a member of the Harvard Society of Fellows, David Griggs, with the skepticism of youth, obtained permission to make a spectroscopic examination of one of them, and found all the characteristic impurities of the Cape diamonds. The label and the exhibit disappeared from the Museum thereafter.

Now let us shift the narrative to the more scientific attacks on the problem, made within the last 15 years, which have been based on the demands of thermodynamics, with the intention of attaining the conditions of thermodynamic stability. In 1938 F. D. Rossini

and R. S. Jessup at the National Bureau of Standards published data of sufficient accuracy to indicate with fair certainty the thermodynamic limits. The calculations indicate that the pressure at which diamond begins to become more stable than graphite is of the general order of 10,000 atmospheres at absolute zero temperature, rises to something of the order of 20,000 atmospheres at room temperature, and continues to rise with increasing temperature. Above 1,000 degrees C. the data needed for the calculation do not exist, so that one can only extrapolate estimates of the pressures required at higher temperatures.

It soon appeared that mere pressure would not transform graphite to diamond at ordinary temperatures. I had applied prolonged pressures of 425,000 atmospheres to graphite at room temperature and of 70,000 at red heat, but no transformation had occurred, in spite of the fact that it unquestionably had thermodynamic permission at these pressures. Evidently something would have to be done to overcome the reluctance of the transformation to run, and for this a further rise of temperature suggested itself. But how high would it be necessary to go?

It is known that at atmospheric pressure diamonds start to change spontaneously to graphite when heated to somewhere in the neighborhood of 1,500 degrees C. This suggested that the reverse transition might run at the same temperatures if only the pressure could be raised high enough. The chances seemed good enough to justify a gamble on success, and early in 1941, largely through the interest of Zay Jeffries of the General Electric Company, General Electric's Carboloy Department, the Carborundum Company and the Norton Company jointly entered into a five-year agreement with me to finance the con-

struction of apparatus and the conduct of experiments. The experiments were to combine high temperatures with pressures up to the 30,000 atmospheres or more which I was able to control in the laboratory. A 1,000-ton press was purchased and set up in the Harvard Geophysical Laboratory with the understanding that the apparatus could be used part time for experiments in geophysics. Very shortly, however, we were immersed in the war. Material became slow and difficult to procure, personnel was not available, and altogether the apparatus was used for less than two years of carbon experimenting instead of the five contemplated.

At first we attempted to get the requisite temperatures by heating graphite to 3,000 degrees C. outside the pressure vessel and then transferring it into the vessel and applying pressure as rapidly as possible. This attempt was given up because the graphite cooled too much before it could be put under pressure. A similar attempt at the impulsive application of pressure was made at about the same time in Germany by P. L. Guenther, P. Geselle and W. Rebentisch, also with negative results.

We next developed a method of heating the graphite within the pressure vessel by automatically setting off a stepped-up thermite type of reaction, which made it possible simultaneously to reach pressures of 30,000 atmospheres and temperatures of 3,000 degrees or more for a time of a few seconds. No diamonds were formed. The experiment did demonstrate for the first time, however, a pressure effect on the transition between graphite and diamond: at these pressures and temperatures the reverse transition from diamond to graphite was slowed down, and it stopped altogether at a pressure just on the edge of the maximum. The results encouraged the

hope that diamonds might be produced if pressures could be got above 30,000.

At this juncture the five years of the agreement were up, the agreement was not renewed and the apparatus was removed to the Norton Company plant in Worcester. The Norton Company continued experiments of their own for the next five years. The results have been published only in part. It is known that the Norton workers synthesized a number of minerals of interest to geologists, including a brand-new form of silica christened Coesite. There has been talk to the effect that occasionally diamonds were produced, but that the conditions of formation were obscure and could not be reproduced. It would appear from the outside that the probability is not high that these were genuine: the conditions of thermodynamic stability were doubtless not attained, and X-rays, the only certain method, were not used in the analysis. At any rate, at the end of five

years the Norton Company let it be known that they were through, and that if the problem was to be solved it would have to be by an organization with greater resources.

Then the Research Laboratory of the General Electric Company (distinct from the Carboloy Department) became interested. From a preliminary survey G.E. scientists concluded that the prospects were sufficiently promising to justify an all-out attack. By this time new theoretical light had been thrown on the problem by methods permitting estimates of the rates of transformation processes. Henry Eyring and F. W. Cagle, Jr., of the University of Utah demonstrated theoretically that the transformation rate would probably not change with temperature as simply as had been thought, so the estimate of the pressure required had to be revised materially upward. Even so, the prospects were such that a young official of the

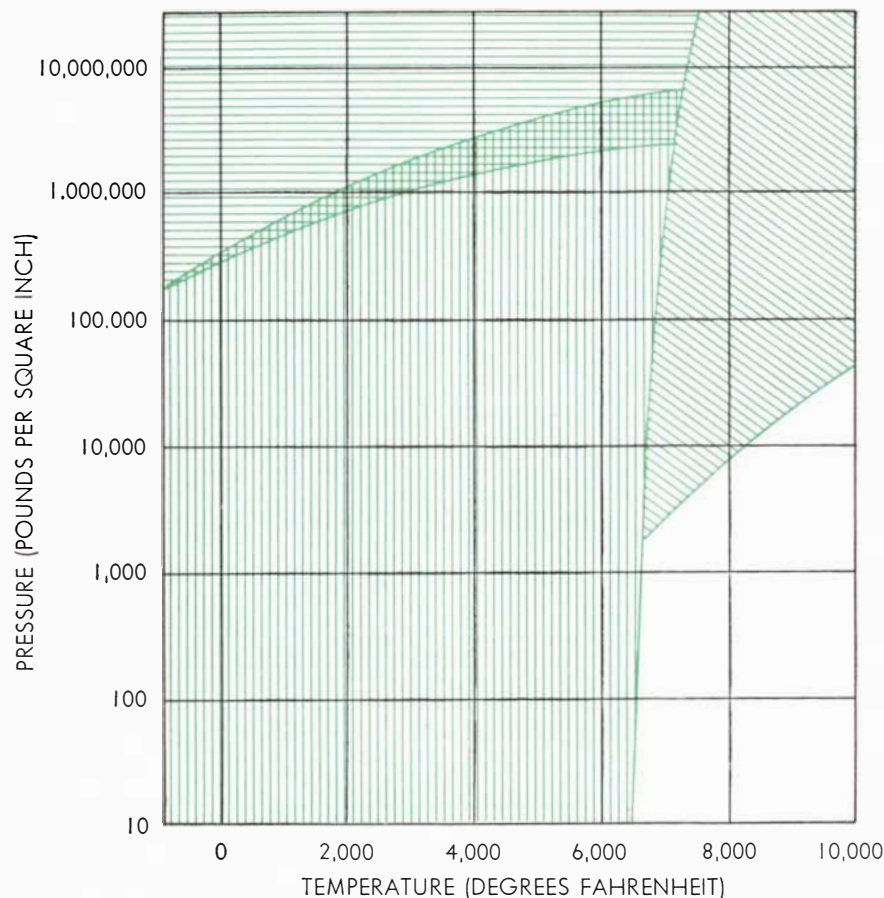
General Electric Company could say to me: "If G.E. goes into this, it is going to be successful."

Everyone now knows the results. Four years later a team of four G.E. physicists—F. P. Bundy, H. T. Hall, H. M. Strong and Robert Wentorf—could announce the successful conclusion of their labors. The stock of the de Beers Diamond Syndicate, which itself had been quietly trying to solve the synthetic diamond problem for its own purposes, dropped a few points on the announcement. But it recovered the next day, and no throats have been cut. The achievement is being taken in stride.

Full details of the process used by the G.E. group have not yet been announced. It is known that means have been found to maintain pressures of more than 100,000 atmospheres and temperatures of 2,500 degrees C. for hours at a time. The heating is electrical, and the pressures are attained by extending and improving methods which I had used. The diamond-synthesizing process is sure-fire: it works every time, and hundreds of batches have been made of diamonds which satisfy all the tests, including the conclusive X-ray test. The largest diamond so far is only one 16th of an inch long—but babies also are small in the beginning. The diamonds are produced under conditions of thermodynamic stability, which disposes of the old bogey that the problem might be solvable only by Edisonian methods of trying everything and waiting for luck to strike. In short, G.E. has solved this problem because it found out how to apply more pressure at a higher temperature and for a longer time than ever achieved before.

Doubtless the most important use for synthetic diamonds will be as an abrasive. Diamond abrasives are playing an increasingly indispensable role in modern machine-shop practice, so much so that the dependence of this country on foreign supply has become a matter of real concern to the Government.

The field of high temperatures and high pressures opened by the new techniques developed by the General Electric Company is a most inviting one for exploration. It is hard to put limits on what may legitimately be anticipated here in the way of new compounds or new alloys or new forms of old substances. Some day we may even be able to make the superdiamond that we would get if only the atoms of carbon could be compelled to assume a closer-packed arrangement than in our present diamonds.



-  VAPOR
-  LIQUID
-  GRAPHITE
-  DIAMOND

PHASES OF CARBON are plotted on this diagram. Each colored area represents the conditions of temperature and pressure at which one phase can exist (see key at left). Only parts of the diagram are accurately established by experimental measurement. The boundary between graphite and vapor at low pressure is well established. The boundaries at higher pressure between vapor, liquid, graphite and diamond are not fully accepted. The uncertainty of the boundary between graphite and diamond is the overlap of the two areas.

Kodak reports to laboratories on:

sponsored films for the kiddies . . . what you could have learned about our photoconductive cell . . . a product that's too good to eat

A gift horse's teeth

On the one hand, the educators, facing the oncoming hordes of kids by the unanticipated millions. With so pitifully few skillful and enthusiastic teachers to serve as infantry, reliance on the audio-visual artillery and cavalry must inevitably grow. Moreover, much of it is free, from public-spirited sources interested in the education of the young. Too bad that these gorgeously colored 16mm gift horses have to be looked so closely in the mouth to make sure they leave some more lasting kernel of truth than that Zilch's Flashlights pierce more gloom.

On the other hand, Zilch's advertising manager, no leering ogre but an intelligent, conscientious family man charged with much of the responsibility for keeping the people of the whole Zilchville Valley gainfully employed making dry cells. His is the task of explaining to young Zilch, the treasurer, how a film on basic principles of electrochemistry may possibly plant with the oncoming generation a seed of respect for the briefly seen Zilch trade-mark.

We're in the middle. We make projectors for the schools and film for Zilch's producer to use. We think both sides ought to be interested in the new booklet of the Association of National Advertisers, entitled "Criteria for Business-Sponsored Educational Films." (\$2, from A. N. A.'s headquarters, 285 Madison Avenue, New York 17, N. Y.)

PbS on a slip of glass

A little more than a year ago, in an advertisement that looked much like this one, there appeared an ecstatic announcement of a new type of photoconductive cell, y-clept *Kodak Ektron Detector*. No literature was offered—just the name of a man who could supply ordering information and transact business. If you had been one of those not repelled by such antediluvian merchandising technique, if, on the contrary, you had been sufficiently aroused to invest the price of an evening at a night club in a little

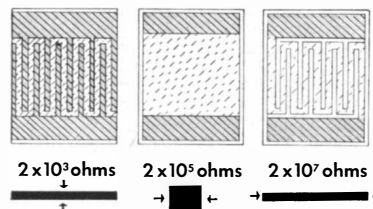
.030"-thick rectangle of glass coated with lead sulfide, you might have found out for yourself some of the following facts about it:

Response extends from a few Å in the x-ray region through the whole ultraviolet and the visible, all the way to 3.5μ in the infrared. Probably the reason response stops there is the infrared transparency of lead sulfide. It can't very well respond to radiation it can't stop.

The sensitive area can be in the shape of a square a quarter millimeter on a side, a rectangle as big as a playing card, an etching of moonrise over Fujiyama, or a draftsman's nightmare inspired by Boolean algebra. It's just a coating on a plate—no envelope, nothing to shake loose. Moreover, signal response is strangely independent of sensitive area size. (Almost. At a given point in the range where response is linear with bias voltage, the signal is roughly proportional to the 0.1 power of area.)

Sensitivity of the surface is so uniform that, in general, an 0.25 mm^2 spot scanning a 250 mm^2 cell surface produces signals varying no more than 50% from the mean. Much better, of course, with a bigger spot.

Signal-to-noise ratio with infrared radiation is high. Cooling to dry ice temperatures boosts signal response much more than noise. Also, cutting current density cuts noise. Just by pattern changes, a cell of given size can have a 10,000:1 range of impedance, viz.:



Time constant may be anywhere from 400 to 1000 $\mu\text{sec.}$ depending on the individual cell. At 60 C, frequency response is flat from 0 to

500 cycles; at 20 C, a drop is already noticeable at 120 cycles. When refrigerated for supersensitivity, drop in response with illumination chopping frequency is continuous. If the system can be operated at a sufficiently high frequency, response becomes virtually independent of temperature.

Now that a decent interval has elapsed for ambitious souls to pioneer with a new plaything, we have a booklet. It summarizes the properties of Kodak Ektron Detectors, compares them quantitatively with other photocells, and gives some basic circuits and optical arrangements for them. For a free copy, address Eastman Kodak Company, Special Products Sales Division, Rochester 4, N. Y.

Superior consommé

For photographic film and paper, we make and use a prodigious volume of gelatin; for that purpose it must be prepared even more carefully than for a journey through the alimentary canal. We make some that is purer still, having extremely low ash. When a laboratory needs a little of this superior consommé for some fussy purpose, such as the new technique for mounting microtome sections from undecalcified, plasticized bones to be autoradiographed (*Stain Technology*, 29, 225, where we are mistakenly called "Eastman Chemical Corporation"), we sell them one of two gelatins under the Eastman Organic Chemicals label. We don't bother our shy daughter, Eastman Gelatine Corporation of Peabody, Mass.

Gelatin (Purified, Pigskin) (*Eastman 5247*) and Gelatin (Purified, Calfskin) (*Eastman 1099*) go for \$4.85 a hundred grams. Prices on the rest of some 3500 Eastman Organic Chemicals are in our List No. 39, available from Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

Prices quoted are 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



THE DUAL ROLE OF

DUREZ IN INDUSTRY



make smooth tool housings



make more durable bench tops

BOTH could brighten
your business picture

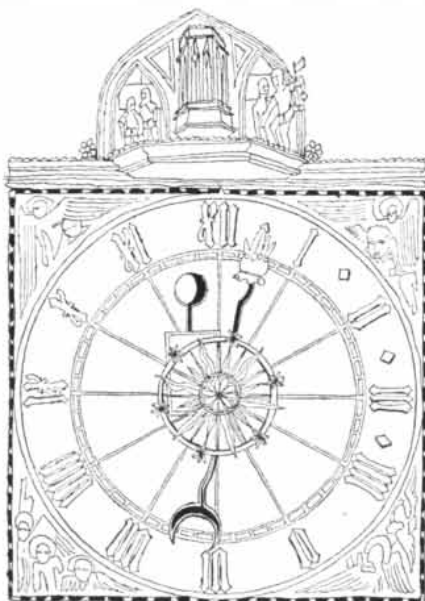
As *molding compounds*, Durez phenolics bring desired properties of strength, light weight, long wear, appearance, and safety to thousands of products, often simplify assembly and reduce costs. As *resins* in bonding, casting, coating, impregnating, and shell molding, to name a few functions, Durez phenolics serve to improve many processes and end products too. For profitable uses of these materials in your business, call on the experience of a leader in developing the phenolics, and their largest producer.

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY
811 Walck Road, North Tonawanda, N. Y.
Export Agents: Omni Products Corporation
464 Fourth Avenue, New York 16, N. Y.



"LEADERS IN PHENOLIC PLASTICS"



Eating, Exercise and Arteries

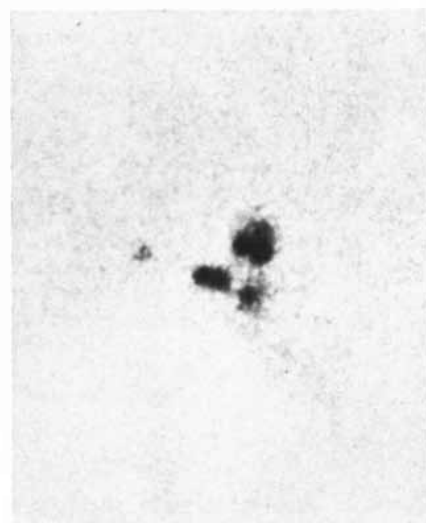
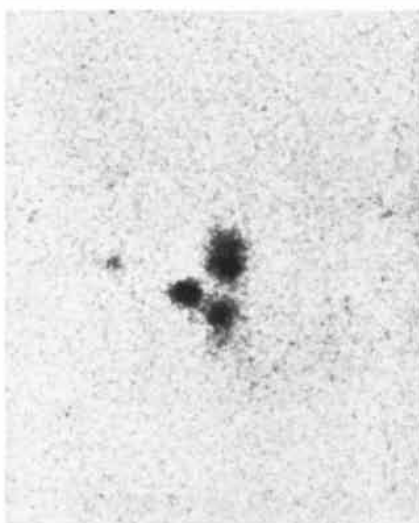
Atherosclerosis is a fatty degeneration of the artery walls which affects everyone, to some extent, as he grows older. If it becomes severe enough, it causes coronary thrombosis. Physicians suspect, although they have not yet proved, that high levels of cholesterol and certain other fat-containing molecules in the blood tend to hasten the process of atherosclerosis. They also suspect that such high levels can come from eating more food than the body needs.

Evidence in favor of this hypothesis was described recently in *The New England Journal of Medicine* by a group of

SCIENCE AND

nutrition researchers at Harvard University's School of Public Health. The group, headed by George V. Mann, experimented with three medical students, feeding them for many weeks a diet which contained twice their normal daily quota of calories but only the normal amount of fat. During the first half of the period the subjects kept their weight constant by vigorous daily exercise. The fat levels in their blood remained unchanged. Then they stopped exercising but continued to stuff themselves. They gained weight and their blood fat levels went up. Finally they were put on a reducing diet and their blood returned to normal.

At the beginning of the experiment the subjects had trouble getting all the extra food down, but after a few days of hard exercise they ate the food gladly and felt well. When the exercise was discontinued, the students lost their feeling of well-being but kept on gorging themselves quite willingly. The researchers suggest that their brief experiment is a capsule version of the average man's nutritional history. During his active early manhood he becomes accustomed to a high-calorie diet. Later he continues the high intake out of physiological habit long after his rate of energy expenditure has decreased. Thereby he builds up a high blood cholesterol level and, prob-



STAR CREATION may have been observed for the first time in these pictures. The photograph at the left, taken in 1947, shows a small section of the Orion Nebula which then contained three T Tauri stars. At right is the same area as photographed in 1954. Immediately to the left of each of the upper two original stars can be seen a new object. The two new bodies are actually separate from the older stars although they appear fused in this view.

ably, accelerates the degeneration of his arteries.

Stellar Birth?

About 1,600 years ago something unusual happened in the Orion Nebula. Light just now arriving on earth from that distant region indicates that two stars may have been born. If so, this is the first time astronomers have witnessed the birth of a star.

Evidence of the stellar birth was shown at the recent International Astronomical Union meeting in Dublin by George H. Herbig of Lick Observatory. He compared two photographs of a part of the Orion Nebula, one taken in 1947, the other in 1954. The 1947 picture shows three stars embedded in a dark cloud of dust and gas. Some time during the next seven years they were joined by two additional stars [see photographs on the opposite page].

Herbig was not wholly unprepared to find the two new stars. He and several other astronomers have been studying a peculiar type of star always found in the midst of dark interstellar clouds. They are called T Tauri stars because they are similar to the long-known variable star T Tauri. Much evidence indicates that this type of star is young and that it may be formed by condensation of a cloud.

The two new stars in Herbig's 1954 photograph may well be infant T Tauris. Herbig said cautiously: "Our understanding of what is taking place could hardly be more incomplete, but it may be that we have witnessed the opening phase of an episode in stellar evolution."

Chemical Society Meets

More than 6,500 chemists gathered in Minneapolis for the American Chemical Society's 128th national meeting, at which they read and discussed some 1,200 technical papers.

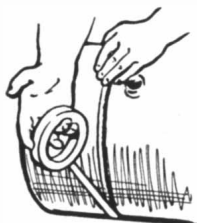
A group of St. Louis biochemists has taken apart and reassembled a virus without destroying its infectivity. This submicroscopic chemical surgery was announced by Barry Commoner of Washington University. The experimenters split tobacco mosaic viruses into protein particles and threads of ribonucleic acid, neither of which is infective by itself. When the pieces were mixed together,

DOW CORNING CORPORATION

SILICONE NEWS LETTER

Industry Reports New Production Economies

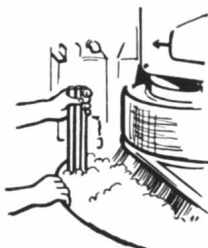
A quick look through industry finds manufacturers everywhere winning the battle for lower production costs with Dow Corning Silicones. Here are a few typical examples ranging from metal working to textile finishing. Use coupon below for additional information.



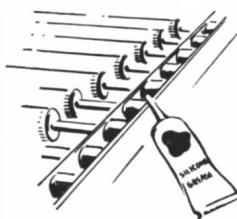
Silicone ADHESIVE "welds" steel skirts to hot water tanks. Imagine a tape that takes the place of welded joint; withstands 520 F; passes all AGA tests. White Products Corporation uses such a tape to replace the weld between tank and combustion chamber skirt of hot water heater . . . saves 7¢ per unit, doubles production in tank plant where welding was previously done. Mystik Co. makes the tape . . . a Dow Corning pressure sensitive silicone adhesive makes it work. **No. 1**



Silicone INSULATION Saves \$10,000 a year on one motor. Conveyor motor in Kaiser Gypsum plant burned out to the tune of \$10,000 per year, based on conservative estimate of lost production and rewinding costs. That was 6 years ago. At that time the 25 hp Class A motor was replaced with a silicone insulated 10 hp motor. No "burn-outs", no downtime since . . . just smooth production! **No. 2**



Silicone DEFOAMER kills foam that stole 25% of grinder production. Oil coolants used in heavy duty grinders at auto parts plant foamed so badly the grinders were down 15 minutes out of every hour while foam was removed. Enter—Dow Corning Antifoam A Emulsion. Exit—space-eating foam. Takes only ¾ cup of silicone defoamer to increase production 25% by killing foam in 300 gal. tank of coolant! **No. 3**



Silicones help deliver 2 extra miles of cloth per hour . . . by making it possible for National Drying Machinery Co. to produce a textile dryer which operates at temperatures and speeds that would quickly burn out bearings and char conventional rollers. Rollers in the new unit are molded of a silicone compound coated with Silastic*, Dow Corning's silicone rubber. Silicone grease lubricates bearings. Result—160 yds. per minute per strand vs previous average of 125 yds. per strand. **No. 4**

*TM REG. U. S. PAT. OFF.

Let Dow Corning Silicones increase your profit margin
mail coupon today!

Dow Corning Corporation, Dept. 9811, Midland, Michigan
Please send me: More information on: 1 2 3 4
 "What's a Silicone", 32 page illustrated booklet
 1955 reference guide to silicone products

Name _____
Company _____
Address _____

first in
silicones

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

ATLANTA CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

A water take-off in All American Engineering's hydro-lift airplane is accomplished easily as the aircraft picks up speed after a beach run of two or three times its own length, then turns into the water to become air-borne like any seaplane.



ENGINEERS

give your career a lift

The first airplane to be equipped with a retractable hydro-lift — a landing gear that permits a landplane to operate from any surface, including water, snow, mud, ice and runways — has now been successfully flight tested by All American Engineering.

This is typical of the kind of break-through project you will work on at All American Engineering.

Aero and Mechanical Engineers are needed now

All American offers a complete engineering and development service to the aviation industry and the military.

In this young and dynamic organization your personal contribution will receive full recognition. Our test facilities are among the finest in the country. In this stimulating atmosphere you will work on a variety of projects: tow target and air-sea rescue winches, in-flight refueling systems, ejection seat trainers, experimental impellers, many types of arresting gear and other problems of energy absorption.

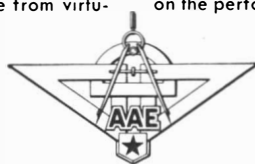
Investigate for yourself the opportunities at All American.



The hydro-lift landing gear developed by All American weighs less than 100 lbs., and permits a landplane to operate from virtually any surface.



In flight the gear is retracted to fit snugly under the wing where it will have little effect on the performance of the airplane.



RESEARCH • DESIGN • MANUFACTURE

All American Engineering Company

DUPONT AIRPORT • WILMINGTON, DELAWARE

they regained about 1 per cent of the infectivity of the starting material. Two months earlier a University of California group had successfully performed the same feat.

At a special symposium in the ACS meeting chemists agreed that it may become possible to make use of enzymes to synthesize proteins—a task too complicated for ordinary chemical methods. Basically the process would be similar to making plastics or synthetic rubber by polymerization.

The association between severe anemia and advanced cancer was explained by Vincent E. Price and Robert E. Greenfield of the National Cancer Institute. The anemia of cancer patients has commonly been ascribed to general debilitation of the patient. Price and Greenfield have found, however, that tumors actually deprive the blood of iron. "In rats with far advanced lymphosarcomas," they reported, "the tumor contained even more iron than the liver, which is the major iron-storage organ of the body. Studies using radioactive iron have shown that the tumor obtains much of this iron from hemoglobin, and also that iron can be rapidly taken up from the plasma."

Another form of iron shortage, the depletion of high-grade ores in the U. S., may be countered by a new process described by Robert J. Priestley of Stamford, Conn. The method converts low-grade ores into magnetite, which can be charged into blast furnaces with little further refining. The process, developed by 10 years' work, consists of bubbling a gas such as producer gas rapidly through low-grade powdered hematite ore, removing part of the oxygen and reducing hematite to magnetite.

Heavy sulfur may become a new tool for tracing geological history. H. G. Thode of Hamilton College, Ontario, noted that in the sulfate form sulfur is considerably richer in the heavy isotope S-34 than in the sulfide form. This peculiarity indicates that many of the world's large native sulfur deposits came from sulfates, presumably reduced by bacteria. Preliminary measurements show that all the petroleum in any given oil field contains about the same proportion of heavy sulfur. On the other hand, this proportion varies greatly from field to field. This suggests that petroleum may originate in various ways.

Geneva Postscript

Weeks after they had returned from the Geneva Conference on the Peaceful Uses of Atomic Energy, U. S.

scientists were still reliving the pleasure and excitement of that extraordinary meeting.

One of the chief thrills for physicists was the extremely close agreement between U. S. and U.S.S.R. scientists in their measurements of nuclear cross sections, although their work had been supersecret and completely independent. The physicists pointed out that cross-section experiments are so difficult that there had been considerable doubt about the accuracy of the results. Said one U. S. physicist, "If the Russian figures had been different from ours, we shouldn't have been surprised. And we should have been by no means certain that ours were right and theirs wrong."

The declassification of cross sections brought at least one immediate scientific dividend. Aage Bohr, a son of Niels Bohr and a member of the Institute for Theoretical Physics in Copenhagen, brought to Geneva an unannounced paper on an improved theory of nuclear fission. He had arrived at the theory only after receiving copies of the conference papers, which had been sent to all official participants a few weeks before the meeting. From the newly published figures on fission cross sections he derived a theory which explains why nuclei sometimes break into almost equal fragments and sometimes into unequal ones, and why the fragments sometimes fly off in certain preferred directions. It also sheds new light on the exact shapes of heavy nuclei, which are not spherical but elongated and in some cases apparently pear-shaped.

According to several U. S. delegates to the Conference, the Soviet papers showed impressive progress in physics. The U.S.S.R. investment in reactors, accelerators and the other heavy machinery of nuclear physics appears to be less than half as large as that of the U. S., but it was said to be well planned to give the maximum scientific return.

The most interesting aspect of Soviet physics was their high-energy work, both theoretical and experimental. Their 600-million-electron-volt synchrocyclotron is the only proton accelerator in the world working at this energy, an important one for a number of theoretical investigations. (In the U. S. there is no proton machine working in the range from 400 to 3,000 Mev, although a 600-Mev model will soon be ready at the University of California.) The Soviet scientists will also have a 10-billion-electron-volt synchrotron in a year or so.

Physicists are paid very well in the U.S.S.R., both in money and prestige. The salary of a young senior scientist at a

Jack Ammann



PHOTOGRAMMETRIC ENGINEERS
 BROADWAY AT TENTH • SAN ANTONIO 5, TEXAS
 Branch Offices: Denver, Colorado • Manhasset, New York

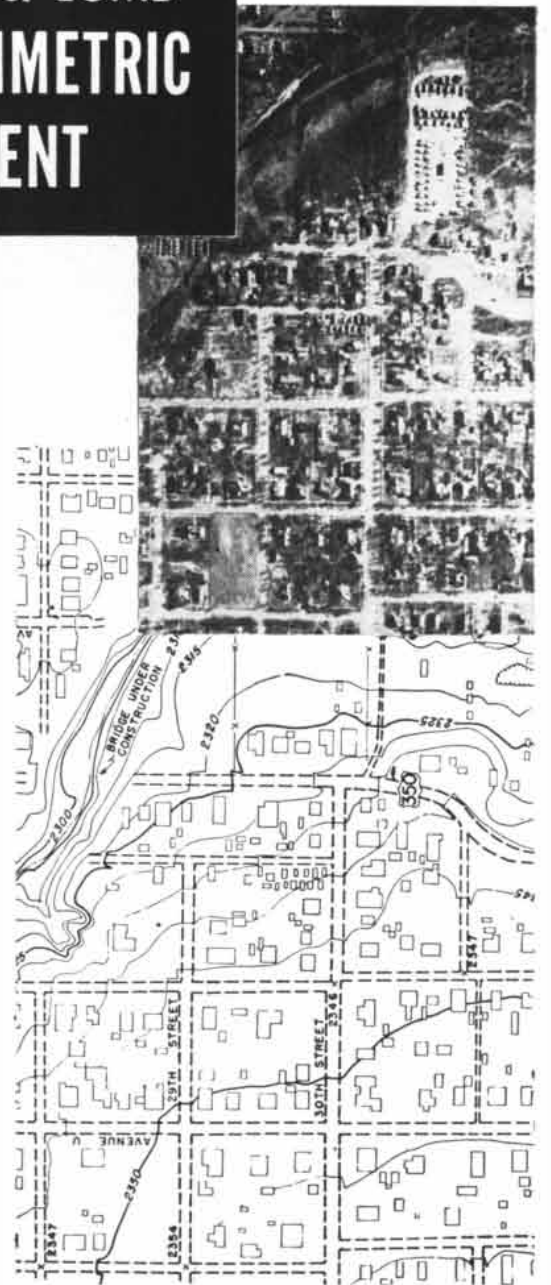
Saves 4 months in emergency re-design of boom town, ...with



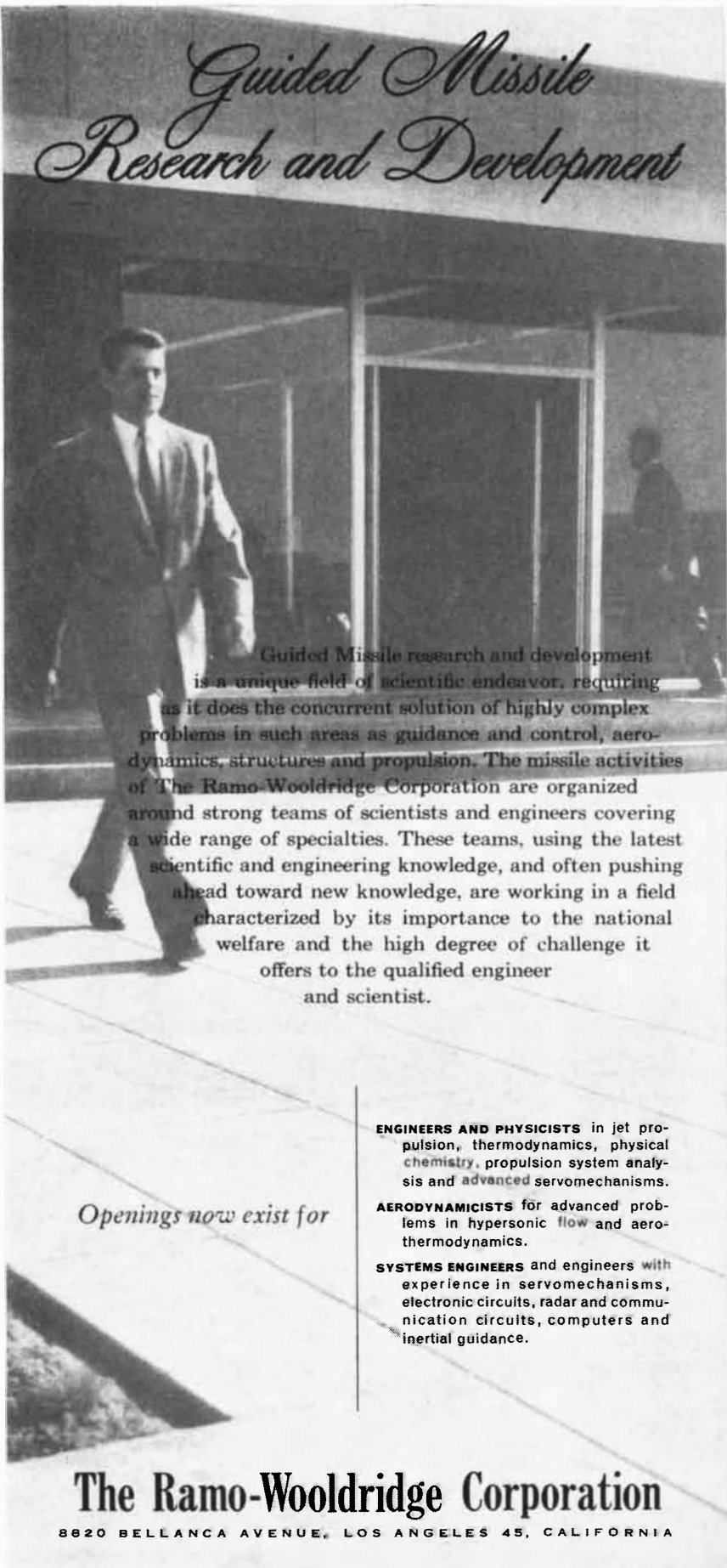
They struck oil near Snyder, Texas—and the rush was on. Almost overnight the town's population doubled. In a few days the water supply was depleted; sewers and disposal plants were hopelessly overloaded. Town and facilities had to be completely re-designed...and fast! Photogrammetry was the obvious answer.

Jack Ammann used B&L Multiplex Equipment to provide topographical data so detailed and so accurate that it permitted preparation of final contract plans—otherwise a 5-month job—in less than 30 days... at a saving of at least 30%!

WRITE for complete information on the world's finest photogrammetric equipment, including Multiplex, Auto-focus Rectifier, and Twinplex. Bausch & Lomb Optical Co., 69847 St. Paul St., Rochester 2, New York.



Guided Missile Research and Development



Guided Missile research and development is a unique field of scientific endeavor, requiring as it does the concurrent solution of highly complex problems in such areas as guidance and control, aerodynamics, structures and propulsion. The missile activities of The Ramo-Wooldridge Corporation are organized around strong teams of scientists and engineers covering a wide range of specialties. These teams, using the latest scientific and engineering knowledge, and often pushing ahead toward new knowledge, are working in a field characterized by its importance to the national welfare and the high degree of challenge it offers to the qualified engineer and scientist.

Openings now exist for

ENGINEERS AND PHYSICISTS in jet propulsion, thermodynamics, physical chemistry, propulsion system analysis and advanced servomechanisms.

AERODYNAMICISTS for advanced problems in hypersonic flow and aerothermodynamics.

SYSTEMS ENGINEERS and engineers with experience in servomechanisms, electronic circuits, radar and communication circuits, computers and inertial guidance.

The Ramo-Wooldridge Corporation

8820 BELLANCA AVENUE, LOS ANGELES 45, CALIFORNIA

government laboratory is equivalent in buying power to a U. S. income, after taxes, of about \$1,000 per month. One such physicist described his living conditions to his Western colleagues. He has a five-room apartment in Moscow (rent, about \$50 per month), runs two cars, employs a full-time maid and a nurse for his two children. His two months' paid vacation is spent at his own summer cottage or at the best hotels in popular resorts.

The Soviet attitude toward the scientific manpower problem is indicated by the pay scale for young scientists. A new Ph.D. can expect about \$400 a month. He has a choice of going into research or teaching, but gets a 20 per cent bonus if he chooses teaching. (The average industrial worker in the U.S.S.R. receives about \$100 per month.)

Sensitive Subject

Hermann J. Muller, the Indiana University geneticist, went to Europe this summer prepared to read a paper at the Geneva Atoms for Peace Conference. His topic was to be "How Radiation Changes the Genetic Constitution," essentially the subject for which he was given a Nobel prize in 1946. Three weeks before the conference opened, Muller received a letter from the Atomic Energy Commission informing him that his paper had been removed from the program.

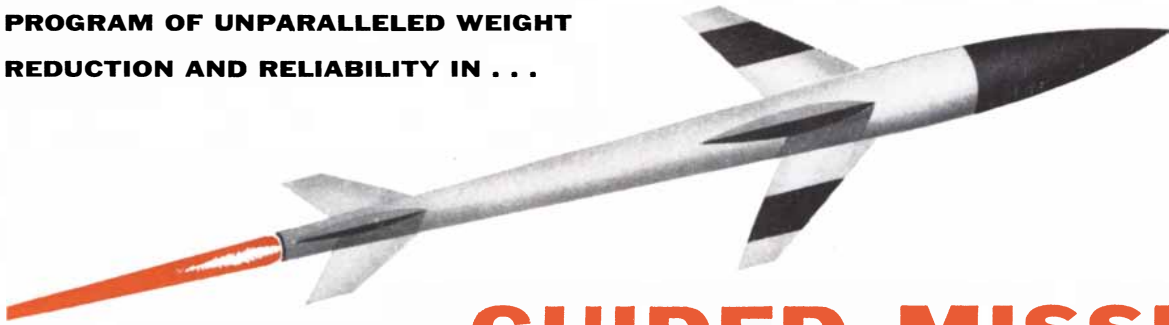
Last month the geneticist aired the incident in the press. The AEC explained that Muller's paper "was found to contain material referring to nonpeaceful uses of atomic energy, namely, the bombing of the Japanese city of Hiroshima." The Conference rules, it added, limited discussions to peaceful uses of the atom.

Muller insisted that "at a conference of this kind there should have been a full airing of the problem of the genetic damage produced by radiation." AEC Chairman Lewis L. Strauss later acknowledged at a press conference that the barring of Muller's presentation of his paper at Geneva was "a regrettable snafu." The paper will be published in the Conference Proceedings.

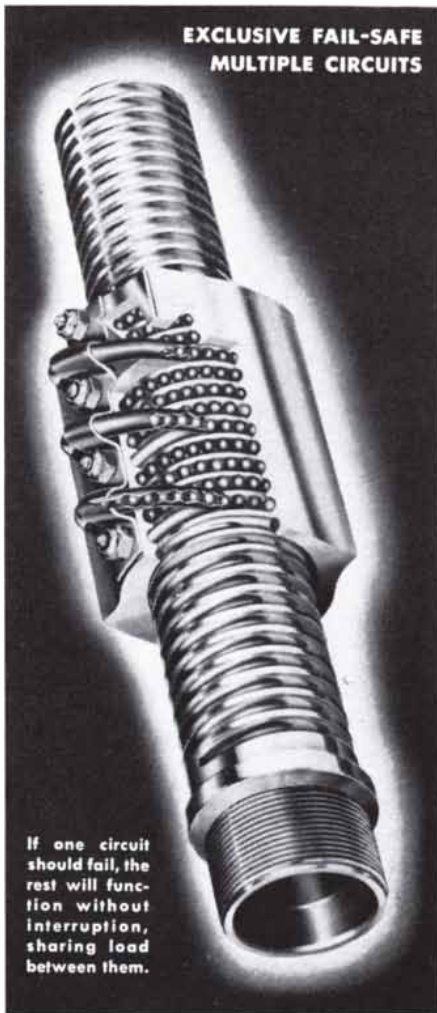
China Joins IGY

The Chinese Communist Government has indicated that it will participate in the program of the International Geophysical Year, according to a report last month from Brussels, where the special committee for the IGY was meeting. China will be the 41st nation to join,

NEW SAGINAW b/b SCREW LAUNCHES A PROGRAM OF UNPARALLELED WEIGHT REDUCTION AND RELIABILITY IN . . .



GUIDED MISSILE ACTUATION!



EXCLUSIVE FAIL-SAFE MULTIPLE CIRCUITS

If one circuit should fail, the rest will function without interruption, sharing load between them.

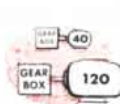
Two of the most critical problems facing R & D engineers are (1) peeling needless pounds off hardware and (2) achieving near-perfect reliability of guidance equipment. That's why they're placing more and more reliance on Saginaw's *Safety ball/bearing Screw* for vital actuation jobs. Free from the limitations of both inefficient Acme screws and bulky hydraulic systems,

the *Safety b/b Screw* will function dependably under "impossible" conditions.

Units have been built from 1½ inches to 39½ feet long. Each is individually engineered for its particular application, with the know-how that only Saginaw, the pioneer producer, can offer you. Our engineers are ready and eager to help solve your missile actuation problems—now!

WHY THE SAFETY b/b SCREW BELONGS IN YOUR MISSILES:

SPACE/WEIGHT SAVINGS INCREASE SPEED AND RANGE



Compared to either Acme screw or hydraulic actuators, the *Safety b/b Screw* saves significant weight and space by permitting the use of smaller motors and gear boxes; eliminating pumps, accumulators, piping, etc.

PERFECT PERFORMANCE AT EXTREME TEMPERATURES



Exhaustive laboratory tests prove that the *Safety b/b Screw* operates dependably at both extremely low and high temperatures, ranging from -90° F to +900° F—within limits of most interior missile environments.

POSITIVE POSITIONING AND SYNCHRONIZATION



Unlike some other types of actuators, the *Safety b/b Screw* permits precision control within thousandths of an inch, plus perfect synchronization of two or more movements—a tremendous boon to aircraft engineers.

FAR LESS DRAIN ON ELECTRICAL SYSTEM



By requiring only 1/3 as much torque as a conventional Acme screw for the same amount of lineal output, the *Safety b/b Screw* allows the use of much smaller motors, which save a substantial amount of power.

DEPENDABLE OPERATION DESPITE LACK OF LUBE



Because the *Safety b/b Screw* is inherently so friction-free (operating at 90% to 95% efficiency) it will function with only a small loss of efficiency even if lubrication fails or cannot originally be provided—a vital advantage.

GREATLY DECREASED COMBAT VULNERABILITY



By eliminating highly vulnerable hydraulic lines, accumulators, etc., the *Safety b/b Screw* makes guided missile actuation far more dependable. It also reduces maintenance due to its decreased sensitivity to dirt.

SEND TODAY FOR YOUR FREE ENGINEERING DATA BOOK

(or see our section in Sweet's Product Design File)

Saginaw Steering Gear Division
General Motors Corporation
Dept 10A, Saginaw, Michigan

Please send your Engineering Data Book to:

Name—Title _____

Firm _____

Address _____

City _____ Zone _____ State _____

Safety
ball bearing Screw by **Saginaw**

ideal
combination
for a
challenging
engineering
career!

* creative
ability

* *If you think
you have the first . . .*

* *And you know
you have the second . . .*

* practical
experience

* *We can provide
the third —especially for*
**aeronautical engineers
metallurgists
mechanical engineers
chemical engineers
engineering physicists**

* work on a
nuclear
project . . .

You may be qualified for our program to develop a nuclear aircraft engine if you have at least a B.S. degree from an accredited college and up to 5 years' professional experience. Previous related experience is desirable but not essential.

Please send a complete resume *immediately* to Mr. Paul Smith, Office 11, Employment Department.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

East Hartford 8, Connecticut

following a few months after the U.S.S.R. and several other Communist countries.

Fusion Power Project

The Atomic Energy Commission last month released the first information about U. S. efforts to achieve thermonuclear power. Chairman Lewis L. Strauss said a "major research effort" is under way. Its object is to extract useful energy from a fusion reaction, and the fusion fuel under study is deuterium (heavy hydrogen). Strauss made clear that no break-through idea for solving the problem had yet appeared, but he thought "a fair guess" as to how long it might take was 20 years.

The essential problems, he observed, are (1) to contain and control a reaction which must take place at temperatures of several hundred million degrees, and (2) to turn the energy released into electrical power. Strauss indicated that it might prove possible to obtain electrical energy directly, without the use of steam-driven generators. He thought fusion power might prove cheaper than that from fission, and pointed out that it would avoid the troublesome problem of disposing of radioactive fission products. He added that the oceans contain enough deuterium to supply the world with power for a billion years.

The U. S. research program on fusion power possibilities is called Project Sherwood. It is being carried out chiefly at Princeton University and at AEC laboratories operated by the University of California at Livermore, Calif., and at Los Alamos. Some studies are also being done at Oak Ridge National Laboratory and at New York University.

Lyman Spitzer, professor of astronomy at Princeton, is in charge of the research there. This work has been going on since 1951, when Spitzer suggested to the AEC an idea for containing and controlling thermonuclear reactions.

Other scientists taking part in the program include Edward Teller, associate director of the Livermore laboratory and head of the AEC's national steering committee on controlled thermonuclear reactions; Harold Grad, professor of mathematics at N.Y.U.; E. D. Shipley, John S. Luce and Albert Simon of the Oak Ridge National Laboratory.

Why Metals Slide

A vast deal of work has gone into efforts to develop smooth metals—for bearings, pistons, gear teeth and so on—but very little is known about what

Research by the payload



The Celanese research program has paid off big. It's based on finding the answer to one question:

How can a petrochemical be made a more productive industrial material?

Result: New processes and controls that produce Celanese* petrochemicals to speed up manufacturing cycles, up-grade products, and cut costs.

Formaldehyde, for example. This workhorse chemical is now available from Celanese in four forms—from a 37% solution to a completely anhydrous material—to give formaldehyde users new opportunities for efficiency and profit.

Many other profit-making chemicals are listed in the new Celanese product index. Why not write for a copy today?

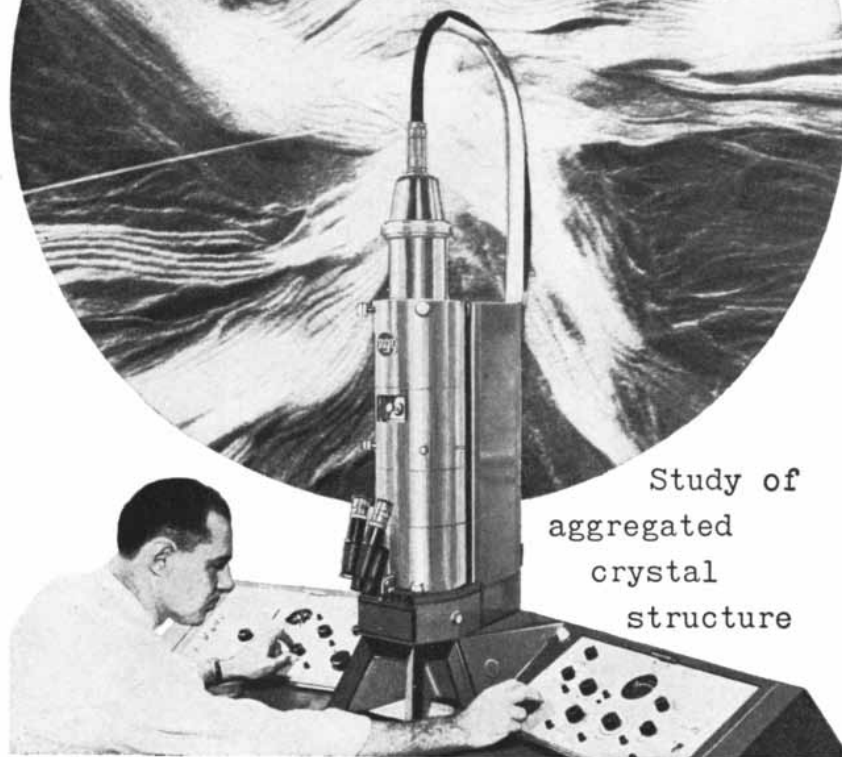
Celanese Corporation of America, Chemical Division, Dept. 582-K, 180 Madison Avenue, New York 16, N. Y.



BASIC REASONS FOR IMPROVED PRODUCTS

Acids	Glycols	Plasticizers	In textiles, plastics,
Alcohols	Hydraulic Fluids	Salts	agriculture, paper, surface
Aldehydes	Ketones	Solvents	coatings, electrical and
Anhydrides	Oxides	Synthetic Oils	building materials and
Esters	Polyols	Vinyl Monomers	equipment, pharmaceuticals.

POLYETHYLENE WEB



Mr. E. R. Walter shown at the controls of the new RCA EML-1 Microscope.

...facilitated with RCA ELECTRON MICROSCOPE

Until polyethylene was studied with the RCA Electron Microscope, its interesting properties were not fully determined. Recently, Mr. E. R. Walter of the Research and Development Department of Carbide and Carbon Chemicals Company, South Charleston, West Virginia, made the amazing electron micrograph shown. It reveals the complex aggregated crystal structure, produced by a tenuous webbing of submicroscopic filaments. A thin cast film of polyethylene was uranium shadowed and enlarged approximately 25,000 times.

Perhaps, you, too, have vital work that the RCA Electron Microscope alone can perform. The new EML-1 (shown above) and EMU-3 provide magnification higher than ever before possible.

National installation and service on all RCA Electron Microscopes are available from the RCA Service Company.

Informative new booklet on electron microscopy will be sent free of charge to those requesting it on their business letterhead. Write to Dept. Y-111, Building 15-1, Radio Corporation of America, Camden, N. J. In Canada: RCA VICTOR Company Limited, Montreal.



**RADIO CORPORATION
of AMERICA**

makes metals slide or stick. Now a comprehensive new theory has just been published in the *General Motors Engineering Journal*. It explains the performance of bearings in terms of the atomic size and crystalline structure of the two rubbing metals. Carl L. Goodzeit and the late Arvid E. Roach were the co-authors of the report.

They started by comparing the sliding of some 40 metallic chemical elements when rubbed against iron. Metals stick when atoms on the surface of one piece are pressed against surface atoms of the other piece and form strong interatomic chemical bonds. If the atoms of the other metal are about the size of iron atoms, there are many points of contact where bonds can form. Thus good bearing metals must have atomic diameters larger than 2.68 Angstrom units, about 15 per cent larger than iron atoms. Another factor is the type of chemical bond formed at the contact points. Some metallic atoms are joined to iron atoms by covalent bonds, in which the atoms share electrons. This sort of bond is weak and does not impede smooth sliding. So, according to the theory, the best bearing metals are those which have large atoms and form covalent compounds with iron.

Most of the well-known bearing materials, such as Babbitt, are alloys. They may be combinations of good and poor bearing metals. Such alloys will slide smoothly if the good bearing metal has a lower melting point; in that event the metal when melted by overheating smears a film over the bearing surface and insulates the journal from the poor bearing metal.

Does this theory apply to metals other than iron? Since preparing their report, the authors have tested the sliding of pure metals against both copper and silver. The unpublished results confirm that bearing quality depends entirely on atomic size and chemical bonding, no matter what two metals rub together.

Eagle Robs Lion's Nest

England, whose habit of impressing American seamen into the Royal Navy kicked up considerable fuss some years back, now appears to be getting her comeuppance technologically. Commenting on Britain's shortage of scientists and engineers, the magazine *Discovery* recently complained: "The position has been aggravated by the fact that American firms have taken to using this country as one of their hunting grounds, and the latest development is that American firms are flying British graduates over for interviews in the U. S.!"

Carboloy Trends and Developments for Design Engineers...

- How complex permanent-magnet assemblies are built to desired field patterns from simple magnet shapes

G-E Alnico magnets provide unlimited design flexibility

The fundamental problem in designing with permanent magnets is how to provide a specific magnetic flux in a desired field pattern.

In solving this problem, a designer can choose from seven General Electric Alnico grades, hundreds of styles, weights from a fraction of an ounce to a hundred pounds. He can use magnets with two poles—or many poles; with poles at the ends—or anywhere along the magnetic axis.

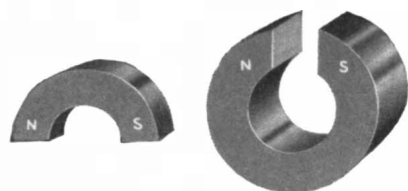
This all gives tremendous flexibility to the design of permanent magnets and magnet assemblies. But precisely because there are so many sizes, shapes, strengths, and other factors to be considered, this flexibility can make the designer's job far more complicated.

So, to help give a clearer understanding of what can and cannot be done with G-E Alnico permanent magnets, we have prepared this description of basic magnet shapes.

The simplest forms of a permanent magnet are the bar and rod. They are normally salient (i.e., the poles occur at the ends), and may be of any cross-sectional area.

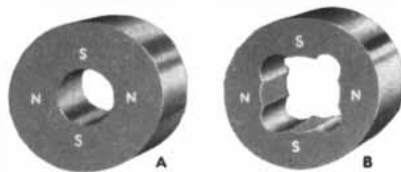


U- and C-shaped magnets are simply bars "bent" to bring both poles to the same plane.



Carry the bending process to its ultimate conclusion and you have the cylinder (see top of next column) with or without the hole. A cylindrical magnet can be magnetized with as many poles as desired on the outside diameter (A), or the inside diameter (B). Not only can the size

and shape of the hole be varied, but the magnet can be made salient (B), or nonsalient (A).

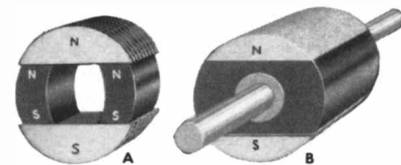


All other forms are merely variations on the original themes, even to such nonstandard shapes as these:



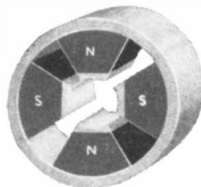
Use of pole pieces adds to design possibilities

One basic use of pole pieces is to provide a return path for the magnetic flux. Pole pieces may be solid (B), or laminated, like this generator magnet (A).



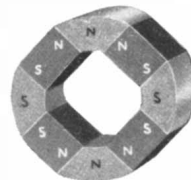
Designers can easily assemble pole pieces and properly shaped permanent magnets to obtain their required field patterns.

One version is this stator assembly, designed to provide inner poles. The

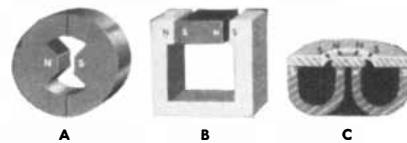


design can be altered in various ways, depending on mechanical, space, magnetic, or physical properties required.

For example, here is another 4-pole magnet using soft steel. It is also possible to construct an assembly with as many poles as required—by using a number of bar magnets or by using one 2-pole magnet.



Perhaps the most important consideration in the design of magnetic assemblies is the amount of flux across the air gap. These air gaps may be single (A), double (B), or annular (C).



Soft-steel pole pieces are often used to complete the magnetic circuit, allowing maximum flux density through the air gap, with a minimum amount of permanent-magnet material. However, there are a considerable number of variations possible, either with or without pole pieces.

Our G-E magnet engineers have broad knowledge and experience in the design and construction of permanent magnets, pole pieces, and air gaps. They will be more than happy to share their knowledge with you. There is no obligation, and all information is held in strictest confidence. A letter to us will get them to work on your problem immediately.

And keep in mind the Carboloy products that perform a myriad of important jobs throughout industry: *cemented carbides* for combating wear; *Thermistors* for detection, measurement, and control of minute temperature variations; *Hevimet* for high-density and radioactive-shielding applications; and *vacuum-melted metals and alloys*.

"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

CARBOLOY

DEPARTMENT OF GENERAL ELECTRIC COMPANY

11199 E. 8 Mile Road, Detroit 32, Michigan

CARBOLOY CREATED-METALS FOR INDUSTRIAL PROGRESS

RADIATION AND HUMAN MUTATION

In which the fundamental process of human evolution is discussed, with special reference to trends that may be caused by artificial radioactivity, medical X-rays and the preservation of harmful genes

by H. J. Muller

The revolutionary impact on men's minds brought about by the development of ways of manipulating nuclear energy, both for destructive and for constructive purposes, is causing a public awakening in many directions: physical, biological and social. Among the biological subjects attracting wide interest is the effect of radiation upon the hereditary constitution of mankind. This article will consider the part which may be played by radiation in altering man's biological nature, and also the no less important effects that may be produced on our descendants by certain other pertinent influences under modern civilization.

At the cost of being too elementary for readers who are already well informed on biological matters it must first be explained that each cell of the body contains a great collection—10,000 or more—of diverse hereditary units, called genes, which are strung together in a single-file arrangement to form the tiny threads, visible under the microscope, called chromosomes. It is by the interactions of the chemical products of these genes that the composition and structure of every living thing is determined. Before any cell divides, each of its genes reproduces itself exactly or, as we say, duplicates itself. Thus each chromosome thread becomes two, both structurally identical. Then when the cell divides, each of the two resulting cells has chromosomes exactly alike. In this way the descendant cells formed by successive divisions, and, finally, the individuals of subsequent generations derived from such cells, tend to inherit genes like those originally present.

However, the genes are subject to rare chemical accidents, called gene mutations. Mutation usually strikes but one gene at a time. A gene changed by mutation thereafter produces daughter genes having the mutant composition. Thus descendants arise that have some abnormal characteristic. Since each gene is capable of mutating in numerous more or less different ways, the mutant characteristics are of many thousands of diverse kinds, chemically at least.

Very rarely a mutant gene happens to have an advantageous effect. This allows the descendants who inherit it to multiply more than other individuals in the population, until finally individuals with that mutant gene become so numerous as to establish the new type as the normal type, replacing the old. This process, continued step after step, constitutes evolution.

But in more than 99 per cent of cases the mutation of a gene produces some kind of harmful effect, some disturbance of function. This disturbance is sometimes enough to kill with certainty any individual who has inherited a mutant gene of the same kind from both his parents. Such a mutant gene is called a lethal. More often the effect is not fully lethal but only somewhat detrimental, giving rise to some risk of premature death or failure to reproduce.

Now in the great majority of cases an individual who receives a mutant gene from one of his parents receives from the other parent a corresponding gene that is "normal." He is said to be heterozygous, in contrast to the homozygous individual who receives like genes from both parents. In a heterozygous indi-

vidual the normal gene is usually dominant, the mutant gene recessive. That is, the normal gene usually has much more influence than the mutant gene in determining the characteristics of the individual. However, exact studies show that the mutant gene is seldom completely recessive. It does usually have some slight detrimental effect on the heterozygous individual, subjecting him to some risk of premature death or failure to reproduce or, as we may term it, a risk of genetic extinction. This risk is commonly of the order of a few per cent, down to a fraction of 1 per cent.

If a mutant gene causes an average risk of extinction of, for instance, 5 per cent, that means there is one chance in 20 that an individual possessing it will die without passing on the same gene to offspring. Thus such a mutant gene will, on the average, pass down through about 20 generations before the line of descent containing it is extinguished. It is therefore said that the "persistence" of that particular gene is 20 generations. There is some reason to estimate that the average persistence of mutant genes in general may be something like 40 generations, although there are vast differences between genes in this respect.

The Human Store of Mutations

Observations on the frequency of certain mutant characteristics in man, supported by recent more exact observations on mice by W. L. Russell at Oak Ridge, indicate that, on the average, the chance of any given human gene or chromosome region undergoing a mutation of a given type is one in 50,000 to

100,000 per generation. Moreover, studies on the fruit fly *Drosophila* show that for every mutation of a given type there are at least 10,000 times as many other mutations occurring. Now since it is very likely that man is at least as complicated genetically as *Drosophila*, we must multiply our figure of 1/100,000, representing our more conservative estimate of the frequency of a given type of mutation, by at least 10,000 to obtain a minimum estimate of the total number of mutations arising in each generation among human germ cells. Thus we find that at least every tenth egg or sperm has a newly arisen mutant gene. Taking the less conservative estimate of 1/50,000 for the frequency of a given type of mutation, our figure would become two in 10.

Every person, however, arises from both an egg and a sperm and therefore contains twice as many newly arisen mutant genes as the mature germ cells do, so the figure becomes two to four in 10. When we say that the per capita frequency of newly arisen mutations is .2 to .4, we mean that there are, among every 10 of us, some two to four mutant genes which arose among the germ cells

of our parents. This is the frequency of so-called spontaneous mutation, which occurs even without exposure to radiation or other special treatment.

Far more frequent than the mutant genes that have newly arisen are those that have been handed down from earlier generations and have not yet been eliminated from the population by causing death or failure to reproduce. The average per capita frequency of all the mutant genes present, new and old, is calculated by multiplying the frequency of newly arisen mutations by the persistence figure.

The greatly simplified diagram on page 66, in which we suppose the frequency of new mutations in each generation to be .2 and the persistence to be only four generations, shows why this relation holds. We start with 10 individuals. Let us suppose that in this first generation eight persons contain no mutant genes while each of the other two has one newly arisen mutant gene. In the second generation these two mutant genes are passed along and two new ones are added to the group, making the total frequency 4/10. By the fourth gen-

eration the frequency is 8/10. After that the frequency remains constant because each mutant gene lasts only four generations and is assumed to be replaced by a normal gene.

Of course in any actual case neither the multiplication nor the distribution of mutant genes among individuals is as regular as in this simplified illustration, but the general principle holds. However, as previously mentioned, the persistence of mutant genes is of the order of 40 generations, instead of only four. Thus the equilibrium frequency becomes not 8/10 but 8. In other words, each person would on the average contain, by this reckoning, an accumulation of about eight detrimental mutant genes.

It happens that this very rough, "conservative" estimate, made by the present writer six years ago, agrees well with the estimate arrived at a few months ago by Herman Slatis, in a study carried out in Montreal by a more direct method. His method was based on the frequency with which homozygous abnormalities appeared among the children of marriages between cousins.

The eight mutations estimated above,



HUMAN CHROMOSOMES, which are much more difficult to photograph than those of fruit flies, are clearly revealed as dark bodies in this photomicrograph by T. C. Hsu of the M. D. Anderson Hospital and Tumor Institute in Houston, Tex. The chromosomes,

which are enlarged approximately 3,000 diameters, are in a human spleen cell. The cell was grown in a laboratory culture after spleen tissue had been removed from a four-month-old fetus. Human body cells normally contain 48 chromosomes; human germ cells, 24.

it should be understood, do not include most of the multitude of more or less superficial differences, sometimes conspicuous but very minor in the conduct of life, whereby, in the main, we recognize one another. The latter mutations probably arise relatively seldom yet become inordinately numerous because of their very high persistence. Thus the value that we arrive at for the frequency of mutant genes depends very much upon just where the line is drawn in excluding this mutational "froth." As yet

little attention has been given to this point. The number eight, at any rate, includes only mutant genes which when homozygous give rather definite abnormalities. In the great majority of cases these genes are only heterozygous and usually are but slightly expressed. Yet they do become enough expressed to cause, in each individual, his distinctive pattern of functional weaknesses, depending upon which of these mutant genes he contains and what his environment has been. The influence of environ-

ment on gene expression is often important.

Even the genes that give only a trace of detrimental effect, or are detrimental only when homozygous, play an important role, because of their high persistence and consequent high frequency. When conditions change, certain combinations of these genes may occasionally happen to be more advantageous than the type previously prevailing, and so tend to become established.

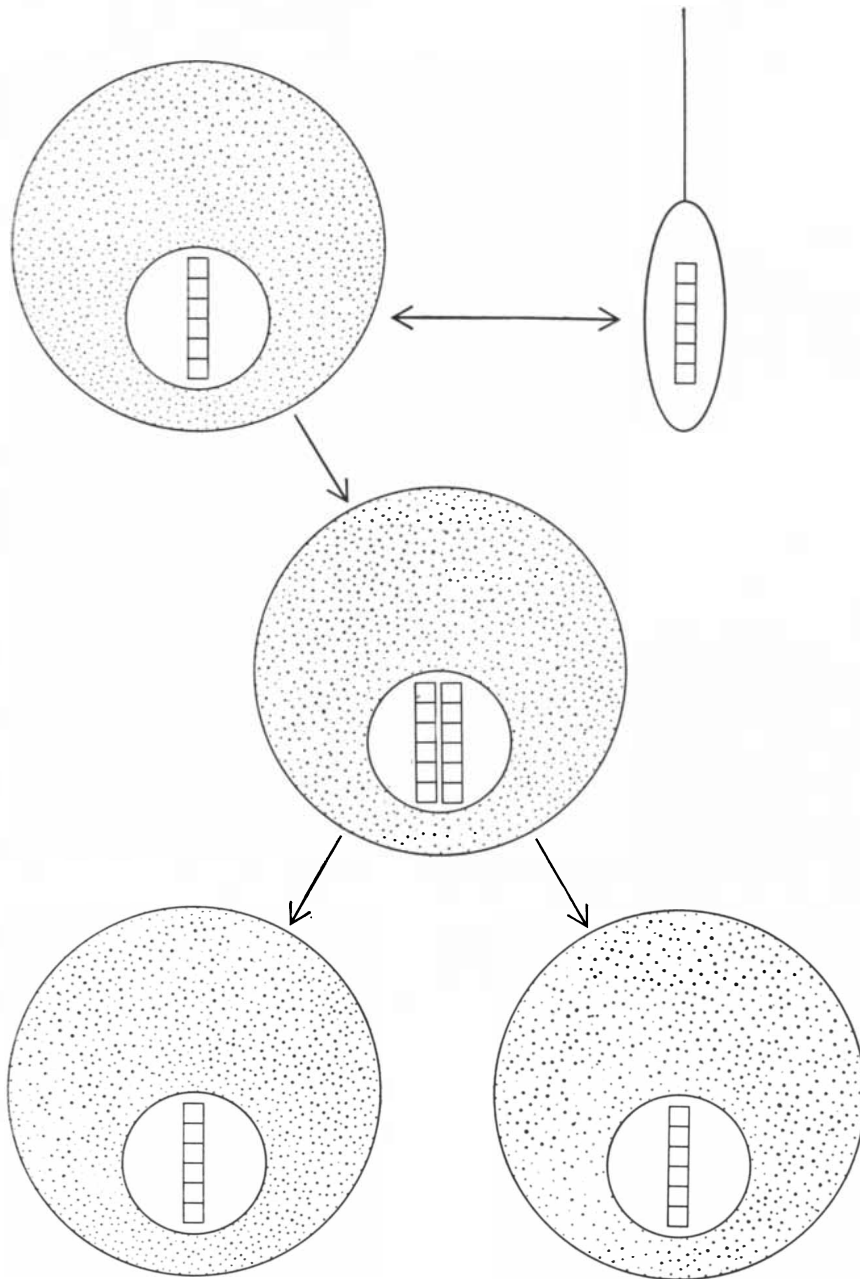
The Effects of Mutant Genes

In general each detrimental mutant gene gives rise to a succession of more or less slight impairments in the generations that carry it. Even if only slightly detrimental, it must finally result in extinction. Moreover, even though an individual suffers less from a slightly detrimental gene than from a markedly detrimental or lethal one, nevertheless the slightly detrimental gene, being passed down to a number of individuals which is inversely proportional to the amount of harm done to each individual, occasions a total amount of damage comparable to that produced by the very detrimental gene. Although each of us may be handicapped very little by any one of our detrimental genes, the sum of all of them causes a noticeable amount of disability, which is usually felt more as we grow older.

The frequency of mutant genes levels off at an equilibrium only when conditions for both mutation frequency and gene elimination have remained stable (or have at any rate fluctuated about a given average) for many generations. During such a period about as many mutations must be eliminated as are arising per generation. If, however, the mutation rate or the average persistence or both changed significantly because of increased radiation or a change in environmental conditions which made mutant genes more or less harmful than previously, then the frequency would move toward a new level. But it would be a long time before the new equilibrium was reached. If the average persistence of mutant genes was 40 generations, the new equilibrium would still be very incompletely attained after 1,000 years.

The Effects of Radiation

We may next consider how a given dose of ionizing radiation would affect the population. Such radiation, when absorbed by the germ cells of animals, usually induces mutations which are similar to the spontaneous ones. They are in-



FUNDAMENTAL PROCESS of heredity is depicted in highly schematic form. At the upper left is an egg cell; at the upper right, a sperm cell. Each contains a single chromosome bearing only six genes (*square segments of chromosome*). The chromosomes are paired in the fertilized egg (*center*), resulting in an organism with a complete set of genes from each parent. When the organism produces its own germ cells (*bottom*), the chromosomes are separated, leaving one set of genes to combine with those of a mate in the new generation.

duced at a frequency which is proportional to the total amount of the radiation received, regardless of the duration or time-distribution of the exposure. Russell's data on mice—the nearest experimental object to man that has been used in such studies—show that it would take about 40 roentgen units of radiation to produce mutations in them at a frequency equal to their spontaneous frequency. If the frequency of spontaneous mutations is two new mutations per generation among each 10 individuals, a dose of 40 roentgens, by adding two induced mutations to the two spontaneous ones, would result in a total mutation frequency of four new mutations per generation among 10 individuals. Now assuming the total mutant gene content is eight per individual to begin with, the radiation dose would raise this figure from 8 to 8.2, an increase of only 2.5 per cent. This effect on the population would ordinarily be too small to produce noticeable changes in important characteristics. One must also bear in mind that an actual mean change in a population may be masked by the great genetic differences among individuals and by differences in environment between two groups that are to be compared. These considerations explain why even Hiroshima survivors who had been relatively close to the blast, and who may have absorbed several hundred roentgens, showed no statistically significant increase in genetic defects among their children. However, offspring of U. S. radiologists who (judging by the incidence of leukemia) probably were exposed during their work over a long period to about as much radiation as these Hiroshima survivors, do show a statistically significant increase in congenital abnormalities, as compared with the offspring of other medical specialists. This was recently established in a study by Stanley Macht and Philip Lawrence.

The toll taken by mutant genes upon the descendants of exposed individuals is spread out over more than a thousand years—40 generations. It is too small to be demonstrable in any one generation of descendants. In the first generation of offspring of a population exposed to 40 roentgens, where the induced mutation rate is .2 per individual and the average risk of extinction for any given mutant gene is 1/40, the frequency of extinctions occasioned by these mutant genes would be .2/40 or 1/200. This would mean, for example, that in a total population of 100 million some 500,000 persons would die prematurely or fail to reproduce as a result of having mutant genes that had been induced in their parents by the ex-

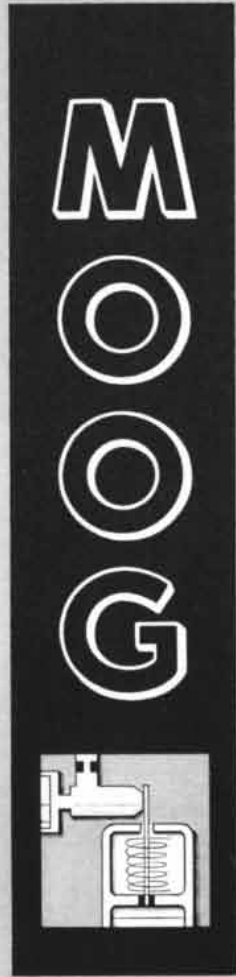
posure. Moreover, a much larger number would be damaged to a lesser extent. The total of induced extinctions in all generations subsequent to the exposure would be .2 times 100 million, or 20 million, and the disabilities short of extinction would be numbered in the hundreds of millions. And yet the amount of genetic deterioration in the population due to the exposure would be small in a relative sense, for the induced mutations would have added only 2.5 per cent to the load of mutant genes already accumulated by spontaneous mutation.

The situation would be very different if the doubling of the mutation frequency by irradiation in each generation were continued for many generations, say for 1,500 years. For after 1,500 years the mutant gene content would have been raised from eight to nearly 16 per individual. Along with this doubled frequency of detrimental genes there would of course be a corresponding increase in the amount of disability and in the frequency of genetically occasioned extinction of individuals.

It is possible that all this would be ruinous to a modern human population, even though in most kinds of animals it could probably be tolerated. For, in the first place, human beings multiply at a low rate which does not allow nearly as rapid replacement of mutant genes by normal ones as can occur in the great majority of species. Secondly, under modern conditions the rate of human multiplication is reduced much below its potential. Thirdly, the pressure of natural selection toward eliminating detrimental genes is greatly diminished, under present conditions at least, through the artificial saving of lives. Under these circumstances a long-continued doubling of the mutation frequency might eventually mean, if the situation persisted, total extinction of the population. However, we do not now have nearly enough knowledge of the strength of the various factors here involved to pass a quantitative judgment as to how high the critical mutation frequency would have to be, and how low the levels of multiplication and selection, to bring about this denouement. We can only see that danger lies in this direction, and call for further study of the whole matter.

Bomb Effects

In the light of the facts reviewed, we are prepared to come to some conclusions concerning the problem of the genetic effects of nuclear explosions. Let us start with the test explosions. J. Rotblat of London has estimated that the

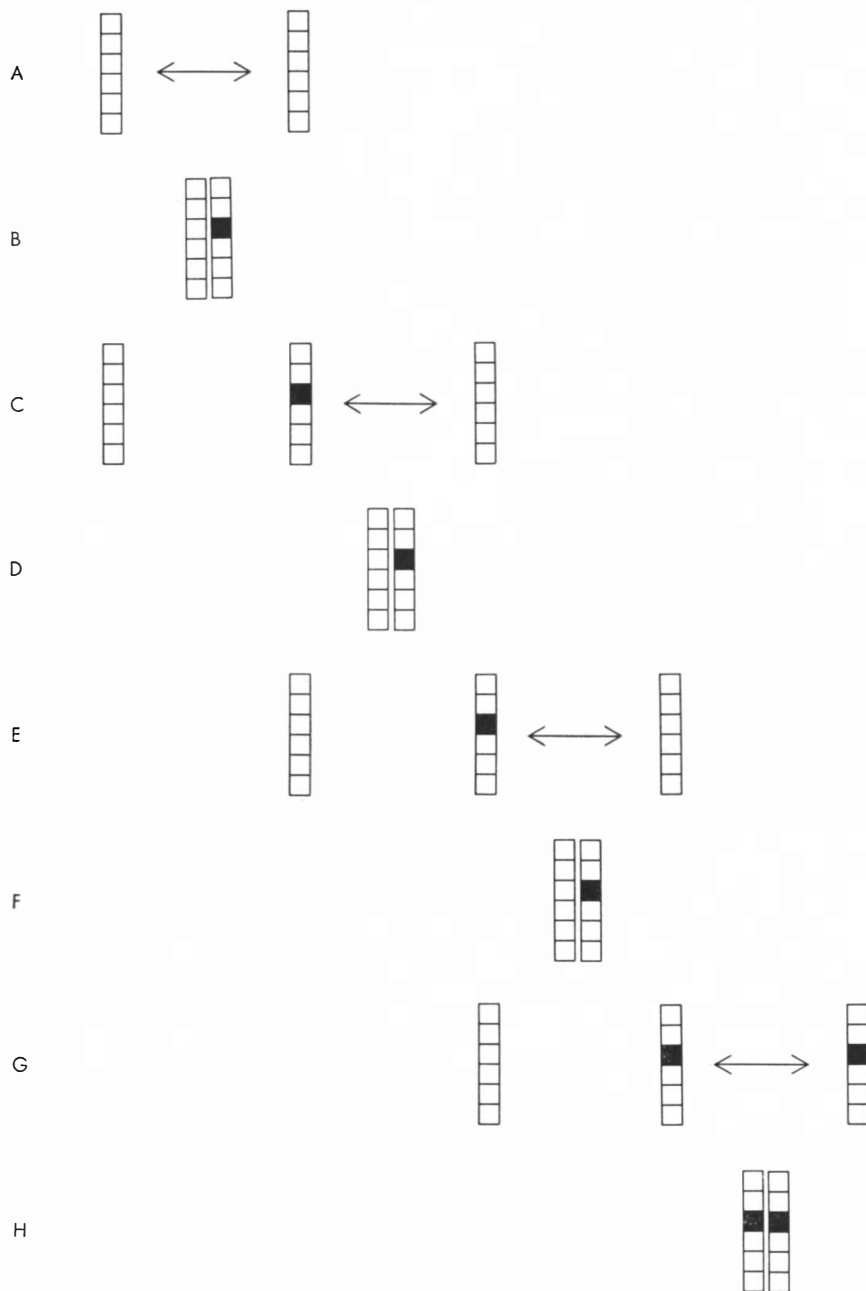


For the design,
engineering and
manufacture of
electro-hydraulic
servo valves
and actuators.

MOOG

VALVE CO., INC.

PRONER AIRPORT
EAST AURORA, N. Y.



HARMFUL RECESSIVE MUTATION may persist for generations before it is fully expressed. This diagram is based on the schematic chromosomes depicted on page 60. In row A the chromosomes of two parents are paired (*arrow*). In row B a gene of their offspring mutates (*black*). In row C the mutant gene has been transmitted to the next generation. If the mutant gene is recessive (*i.e.*, if the corresponding gene of the paired chromosome has a dominant effect), it is masked. Here a new set of genes is introduced (*second arrow*) from another line of descent. In rows D, E and F the mutant gene is passed along. In row G a mutant gene of the same character is introduced from still another line of descent. In offspring of this union (*row H*), the harmful effect of the paired recessive genes is expressed.

tests of the past year approximately doubled the background radiation for the year, in regions of the earth remote from the explosions. In the U. S. they raised the background radiation from about .1 to about .2 of a roentgen for the year. The natural background radiation of about .1 roentgen per year causes, we estimate, about 5 per cent of the spon-

taneous mutations in man. Hence a doubling of it would cause a rise of the same amount in the occurrence of new mutant genes. Although this influence, if continued over a generation, would induce an enormous number of mutations—of the order of 20 million in the world population of some two billion—nevertheless the effect, in relation to the

already accumulated store of detrimental mutations, would be comparatively small. It would raise the per capita content of mutant genes at most by only a few tenths of 1 per cent.

Much more serious genetic consequences would follow from atomic warfare itself, in the regions subject to the fall-outs of the first few days. As for regions remote from the explosions (say the Southern Hemisphere), Rotblat and Ralph Lapp have reckoned that a hydrogen-uranium bomb like those tested in the Pacific would deliver an effective dose of about .04 roentgen throughout the whole period of radioactive disintegration. Thus 1,500 such bombs would deliver about 60 roentgens—an amount which might somewhat more than double the mutation frequency for one generation. Since there would be relatively little residual radioactivity in these remote regions after the passage of a generation, and since it is scarcely conceivable that such bombing would be repeated in many successive generations, it seems probable that most of the world's inhabitants below about the Tropic of Cancer would escape serious genetic damage. However, they would be likely in the course of centuries to become contaminated by extensive interbreeding with the survivors of the heavy irradiations in the North. For although an attempt might be made to establish a genetic quarantine, this would, for psychological reasons, be unlikely to be maintained with sufficient strictness for the hundreds of years required for the success of such a program.

In the regions subject to the more immediate fall-outs, pattern bombing could have resulted in practically all populous areas receiving several thousand roentgens of gamma radiation. Even persons well protected in shelters during the first week might subsequently be subjected to a protracted exposure adding up to some 2,500 roentgens. Moreover, this estimate fails to take into account the soft radiation from inhaled and ingested materials which under some circumstances, as yet insufficiently dealt with in open publications, may become concentrated in the air, water or food and find fairly permanent lodgment in the body. Now although some 400 roentgens is the semilethal dose (that killing half its recipients) if received within a short time, a considerably higher dose can be tolerated if spread out over a long period. Thus it is quite possible that a large proportion of those who survive and reproduce will have received a dose of some 1,000 to 1,500 roentgens or even more. This would

cause a 12-fold to 40-fold rise in the mutation frequency of that generation.

Such an increase, assuming that the population was already loaded with an accumulation of mutant genes amounting to 40 times the annual spontaneous mutation rate, would at one step cause a 30 to 100 per cent increase in the mutant gene content. In fact, the detrimental effect would be considerably greater than that indicated by these figures, because the newly added mutant genes, unlike those being "stored" at an equilibrium level, would not yet have been subjected to any selective elimination in favor of the less detrimental ones. It can be estimated that this circumstance might cause the total detrimental influence to be twice as strong for each new mutant gene, on the average, as for each old one. Therefore the increase in detrimental effect would be between 60 and 200 per cent.

Owing to these circumstances, an effect would be produced similar to that of a doubled accumulation of genes, such as we saw would ensue from a doubled mutation frequency after about a thousand years of repetition. Thus offspring of the fall-out survivors might have genetic ills twice or even three times as onerous as ours.

The worst of the matter is that the effects of this enormous sudden increase in the genetic load would by no means be confined to just one or two generations. Here is where the inertia of mutant-gene content, which in the case of a moderately increased mutation frequency works to spread out and thus to soften its impact, now shows the reverse side of its nature: its extreme prolongation of the effect. That is, the gene content is difficult to raise, but once raised, it is equally resistant to being reduced.

Supposing the average content of markedly detrimental genes per person to be only doubled, from 8 to 16, more than 50 per cent of the population would come to contain a number of these mutant genes (16 or more) that was as great or greater than that now present in the most afflicted 1 per cent, if the distribution followed the Poisson principle. When we consider the extent to which we are already troubled with ills of partly or wholly genetic origin, especially as we grow older, the prospect of so great an increase in them in the future is far from reassuring.

It is fortunate, in the long run, that sterility and death ensue when the accumulated dose has risen beyond about 1,000 to 3,000 roentgens. For the frequency of mutations received by the

descendants of an exposed population is thereby prevented from rising much beyond the amount which we have here considered. This being the case, it is probable that the offspring of the survivors, even though considerably weakened genetically, would nevertheless—some of them—be able to struggle through and reestablish a population which could continue to survive.

Yet, supposing the population were able to re-establish its stability of numbers within, say, a couple of centuries, what would be the toll among the later generations in terms of premature death and failure to reproduce? If 40 roentgens produce .2 new mutant genes per person, then 1,000 roentgens must on the average add five mutant genes to each person's composition. All of these five genes must ultimately lead to genetic extinction. But if, to be conservative, we suppose that two to three genes, on the average, work together in causing extinction, we reach the conclusion that, in a population whose numbers remain stable after the first generation following the exposure, there will ultimately be about two cases of premature death or failure to reproduce for each first-generation offspring of an exposed individual.

If, however, the descendants multiply and re-establish the original population size in a century or two, then the number of extinctions will be multiplied also. Over the long run the number of "genetic deaths" will be approximately twice as large, altogether, as the population total in any one generation. The future extinctions would in this situation be several times as numerous as the deaths that had occurred in the directly exposed generation.

Even though it is probable that mankind would revive ultimately after exposure to radiation, large or small, let us not make the all-too-common mistake of gauging whether or not such an exposure is genetically "permissible" merely by the criterion of whether or not humanity would be completely ruined by it. The instigation of nuclear war, or indeed of any other form of war, can hardly find a valid defense in the proposition, even though true, that it will probably not wipe out the whole of mankind.

Radiation from Other Sources

It is by the standard of whether individuals are harmed, rather than whether the human race will be wiped out, that we should judge the propriety of everyday practices that may affect the human genetic constitution. We have to consider, for one thing, the amount of radi-



NEW advantages in a growing list of commercial applications focus closer attention upon soluble zirconium compounds. TAM is your one source for all.

ZIRCONIUM OXYCHLORIDE

A precipitant for acid and basic dyestuffs in preparation of lakes and toners. Active ingredient in wax emulsion type water repellents for textiles and leather. Source material for other zirconium compounds.

ZIRCONIUM TETRACHLORIDE

Raw material for preparation of zirconium metal, zirconium alloys, and organic-zirconium complexes. Catalyst for Friedel-Crafts and other organic syntheses.

ZIRCONIUM ACETATE SOLUTION

Active ingredient in better wax-emulsion type water repellents for textiles. A catalyst for methyl silanes in silicone repellent treatments of leather and textiles. A precipitant for many proteinic materials in finishing of textiles, leather, etc.

AMMONIUM ZIRCONYL CARBONATE SOLUTION

Used as an active ingredient in basic water repellents. Improves scrub resistance of latex emulsion paints.

HYDROUS ZIRCONIA (Carbonated)

A strong chelating and coordinating reagent. Useful in treatment of poison ivy, as a deodorant in cosmetic creams, and as an absorbent for various ions.

ZIRCONIUM SULPHATE

A source for zirconia for the impregnation of catalysts. As a tanning agent... processing white leather. Raw material for preparation of organic-zirconium compounds.

ZIRCONIUM LACTATES AND GLYCOLATES

Being used more and more in pharmaceuticals and personal deodorant preparations.



TAM* is experienced and equipped to produce any zirconium compound. We will work with you in supplying those which best suit your problem or operation. Address correspondence to our New York City offices.

*TAM is a registered trademark



tion which the population should be allowed to receive as a result of the peacetime uses of atomic energy.

How much effort, inconvenience and money are we willing to expend in the avoidance of one genetic extinction, one frustrated life and other partially frustrated lives, not to be beheld by us? Shall we accept the present official view that the "permissible" dose for industrially exposed personnel may be as high as .3 roentgen per week, that is, 300 roentgens in 20 years—a dose which would cause such a worker to transmit somewhere between .5 and 1.5 mutations per offspring conceived after that time?

Exactly the same questions apply in medical practice. A U. S. Public Health survey conducted three years ago showed that at that time Americans were receiving a skin dose of radiation averaging about two roentgens per year per person from diagnostic examinations alone. Of course only a small part of this could have reached the germ cells, but if the relative frequencies of the different types and amounts of exposure were similar to those enumerated in studies recently carried out in British hospitals, we may calculate that the total germ-cell dose was about a thirtieth of the total skin dose, namely, about .06 roentgen per person per year. This is about 12

times as much as the dose that had previously been estimated to reach the reproductive organs of the general population (not the hospital population) in England. However, the U. S. is notoriously riding "the wave of the future" in regard to the employment of X-rays; it is still expanding their use rapidly, while other countries are following as fast as they can.

Now this dose of .06 roentgen per year, the only estimate for the U. S. that we have, is of the same order of magnitude (perhaps twice as large) as the annual dose received in the U. S. over the past four years from all the nuclear test explosions. It seems rather disproportionate that so much furor should be raised about the genetic effects of the latter and so little about the former.

The writer's personal conviction is that, at the present stage of international relations or at least at the stage of the past several years, the tests have been fully justified as warnings and defensive measures against totalitarianism, despite the future sacrifices that they inexorably bring in their train, although it is to be hoped that this stage is now about to become obsolete. On the other hand, it seems impossible to find justification for the large doses to which the germ cells of patients are exposed in medical practice. It would involve comparatively little care or expense to shield the gonads or take other precautions to reduce the dose being received by the reproductive organs and other parts not being examined. And the deliberate irradiation of the ovaries to induce ovulation, and of the testes to provide an admittedly temporary means of avoiding pregnancies, should be regarded as malpractice.

We must remember that nuclear weapons tests and possibly nuclear warfare may be dangers of our own turbulent times only, whereas physicians will always be with us. It is easier and better to establish salutary policies with regard to any given practice early than late in its development. If we continue neglectful of the genetic damage from medical irradiations, the dose received by the germ cells will tend to creep higher and higher. It will also be joined by a rising dose from industrial uses of radioactivity. For the industrial and administrative powers-that-be will tend to take their cue in such matters from the physicians, not from the biologists, even as they do today. It should be our generation's concern to take note of this situation and to make further efforts to start off the expected age of radiation, if there is to be one, in a rational way as regards protection from this insidious agent, so

as to avoid that permanent, significant raising of the mutation frequency which in the course of ages could do even more genetic damage than a nuclear war.

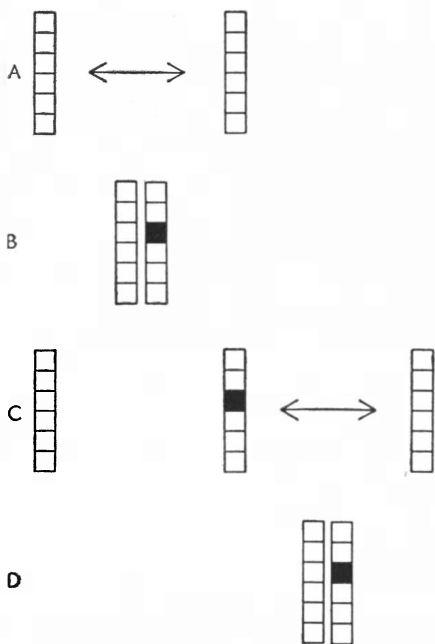
Chemical Agents

Radiation is by no means the only agent that is capable of drastically increasing the frequency of mutation. Diverse organic substances, such as the mustard gas group, some peroxides, epoxides, triazene, carbamates, ethyl sulfate, formaldehyde and so forth, can raise the mutation frequency as much as radiation.

The important practical question is: to what extent may man be unwittingly raising his mutation frequency by the ingestion or inhalation of such substances, or of substances which, after entering the body, may induce or result in the formation of mutagens that penetrate to the genes of the germ cells? As yet far too little is known of the extent to which our genes, under modern conditions of exposure to unusual chemicals, are being subjected to such mutagenic influences.

A surprising recent finding by Aaron Novick and Leo Szilard at the University of Chicago is that in coli bacteria the feeding of ordinary purines normal to the organism more than doubled the spontaneous mutation frequency, while methylated purines, and more especially caffeine (as had been found by other workers), had a much stronger mutagenic effect. Thus far, however, caffeine has not proved mutagenic in fruit flies, although it is possible that it is destroyed in their gut. In Novick and Szilard's work compounds of purines with ribose (*e.g.* adenosine) counteracted the mutagenic effect of the purines. Furthermore, adenosine and guanosine even acted as "antimutagens" when there had been no addition of purines to the nutrient medium, as though a considerable part, about a third, of the spontaneous mutations were being caused by the purines naturally present in the cells. This work, then, indicates both the imminence of the mutagenic risks to which we may be subject and also the fact that means of controlling these risks and, to some extent, even of controlling the processes of spontaneous mutation themselves, are already coming into view.

Other large differences in the frequency of so-called spontaneous mutations were found in my studies in 1946 on the mutation frequencies characterizing different stages in the germ-cell cycle of the fruit fly. Moreover, J. B. S. Haldane, dealing with data of others,



HARMFUL DOMINANT MUTATION, as opposed to a recessive one, is quickly eliminated. Here the mutation (*black*) occurs at the same stage as in the diagram on page 62. It occurs in a germ cell, so its effect is not expressed in that generation. When the chromosome bearing the mutant gene is paired with another, however, the mutation is expressed in the offspring of the union.

adduced some evidence that the germ cells of older men have a much higher frequency of newly arisen mutant genes than those of young men. If this result for man, so different from what we have just noted for fruit flies, should be confirmed, it might prove to be more damaging, genetically, for a human population to have the habit of reproduction at a relatively advanced age than for its members to be exposed regularly to some 50 roentgens of ionizing radiation in each generation.

It is evident from these varied examples that the problem of maintaining the integrity of the genetic constitution is a much wider one than that of avoiding the irradiation of the germ cells, inasmuch as diverse other influences may play a mutagenic role equal to or greater in importance than that of radiation.

The view has been expressed that, since some chemical mutagenesis and even radiation mutagenesis occur naturally, the effects of such normal processes should cause us no great concern. Aside from the fact that not everything that is natural is desirable, we must always be conscious of the hazards added by civilization. Certain civilized practices, such as the use of X-rays and radioactivity (and possibly reproduction at an advanced age or the drinking of coffee and tea), are causing genetic damage to be done at a significantly more rapid rate than in olden times.

Relaxed Selection

It is evident that the rate of elimination of mutant genes is just as important as the mutation frequency in the determination of the human genetic constitution. What we really mean here, of course, is "selective" elimination. The importance of this distinction is seen in the fact that in the ancestors of both men and mice much the same mutations must have occurred, but that the different conditions of their existence—the ever more mousy living of the mouse progenitors and the manlier living of the pre-men—caused a different group of genes to become selected from out of their common store.

A very distinctive feature of our modern industrial civilization is the tremendous saving of human lives which would have been sacrificed under primitive conditions. This is accomplished in part by medicine and sanitation but also by the abundant and diverse artificial aids to living supplied by industry and widely disseminated through the operation of modern social practices. The proportion of those who die prematurely is now so

LOOK HOW

Linde
TRADE-MARK

**silicones
make water behave itself!**



LOOK AT the benefits

Guarding many thousands of cars today against rain, snow, and dirt, are auto polishes made easier-to-apply and longer-lasting by LINDE Silicones.

Silicones give milady a helping hand, too . . . in her hand lotions, for example. They help ward off soapy dish water and detergents. Her sun-tan preparations stay on even after a swim in the deep.

And of growing importance are above-grade masonry water repellents made with LINDE Silicones that hate water. These "invisible rain-coats" are protecting homes, schools, institutions, factories, against damage from water seepage for as much as ten years. They slash both interior and exterior maintenance costs, and preserve original building beauty and quality.

If you want a silicone that will make water "behave," or for some totally different use in your products, call on LINDE. Their wide experience and that of other Divisions of UNION CARBIDE puts a large store of industrial knowledge at your service. Write Dept. R-11.

LOOK TO

Linde

for silicones

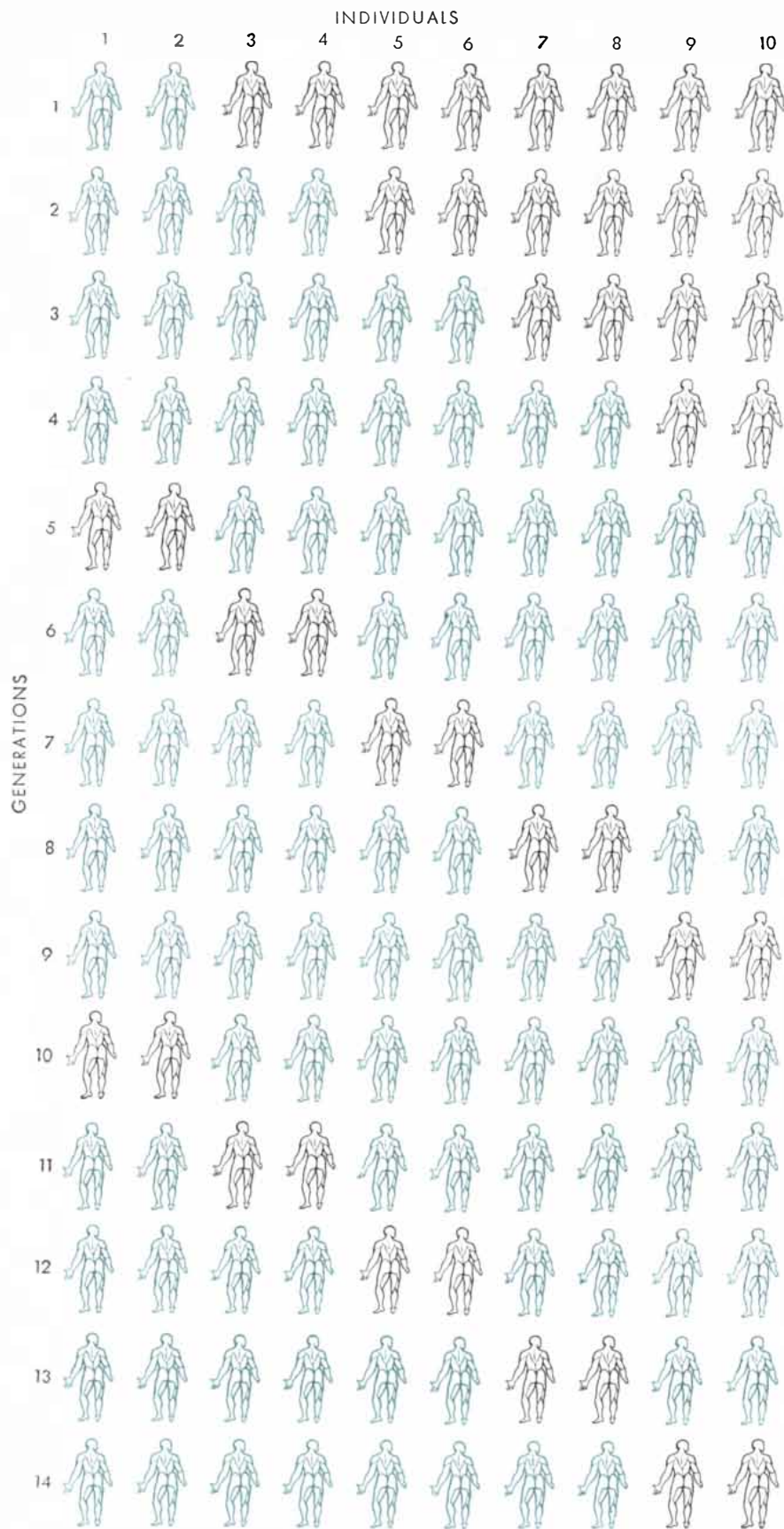
Linde
AIR PRODUCTS
COMPANY

A DIVISION OF
**UNION CARBIDE
AND CARBON CORPORATION**

30 East 42nd Street **UNCC** New York 17, N. Y.

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited

The term "LINDE" is a registered trade-mark of Union Carbide and Carbon Corporation.



EQUILIBRIUM IS ATTAINED by recessive mutant genes under the conditions assumed here. The first assumption is that in each generation (*horizontal rows*) two new mutant genes (*colored figures*) arise among 10 individuals. The second assumption is that each line of descent bearing the mutant gene dies out four generations after the mutation has occurred. In the diagram this extinct line is then replaced by a new one. Thus after three generations the number of individuals bearing a mutant gene is stabilized at eight out of 10.

small that it must be considerably below the proportion who would have to be eliminated in order to extinguish mutant genes as fast as new ones arise. In other words, many of the saved lives must represent persons who under more primitive conditions would have died as a result of genetic disabilities. Moreover, the genetically less capable survivors apparently do not have a much lower rate of multiplication than the more capable; in fact, there are certain oppositely working tendencies.

It is probably a considerable underestimate to say that half of the detrimental genes which under primitive conditions would have met genetic extinction, today survive and are passed on. On the basis of this conservative estimate we can calculate that in some 10 generations, or 250 to 300 years, the accumulated genetic effect would be much like that from exposure of a population to a sudden heavy dose of 200 to 400 roentgens, such as was received by the most heavily exposed survivors of Hiroshima. If the techniques of saving life in our civilization continue to advance, the accumulation of mutant genes will rise to ever higher levels. After 1,000 years the population in all likelihood would be as heavily loaded with mutant genes as though it were descended from the survivors of hydrogen-uranium bomb fall-outs, and the passage of 2,000 years would continue the story until the system fell of its own weight or changed.

The process just depicted is a slow, invisible, secular one, like the damage resulting from many generations of exposure to overdoses of diagnostic X-rays. Therefore it is much less likely to gain credence or even attention than the sensational process of being overdosed by fall-outs from bombs. This situation, then, even more than the danger of fall-outs, calls for basic education of the public and publicists, if they are to reshape their deep-rooted attitudes and practices as required.

It is necessary for mankind to realize that a species rises no higher, genetically, and stays no higher, than the pressure of selection forces it to, and that it responds to any relaxation of that pressure by sinking correspondingly. It will in fact take as much rope in sinking as we pay out to it. The policy of saving all possible genetic defectives for reproduction must, if continued, defeat its own purposes. The reason for this is evident as soon as we consider that when, by artificial devices, a moderately detrimental gene is made less detrimental, its frequency will gradually creep upward toward a new equilibrium level, at which

it is finally being eliminated anyway at the same rate as that at which it had been eliminated originally, namely, at the rate at which it arises by mutation. This rate of elimination, being once more just as high as before medicine began, will at the same time reflect the fact that as much suffering and frustration (except insofar as we may deaden them with opiates) will then be existing, in consequence of that detrimental gene, as existed under primitive conditions. Thus, with all our medicine and other techniques, we will be as badly off as when we started out.

Not all genetic disabilities, however, would simply be made less detrimental. Some of them would be rendered not detrimental at all under the circumstances of a highly artificial civilization, in the sense that they were enabled to persist indefinitely and thus to become established as the new norm of our descendants. The number of these disabilities would increase up to such a level that no more of them could be supported and compensated for by the technical means available and by the resources of the social system. The burden of the individual cases, up to that level, would have become largely shifted from the given individuals themselves to the whole community, through its social services (a form of insurance), yet the total cost would be divided among all individuals and that cost would keep on rising as far as it was allowed to rise.

Ultimately, in that Utopia of Inferiority in the direction of which we are at the moment headed, people would be spending all their leisure time in having their ailments nursed, and as much of their working time as possible in providing the means whereby the ailments of people in general were cared for. Thus we should have reached the acme of the benefits of modern medicine, modern industrialization and modern socialization. But, because of the secular time scale of evolutionary change and the inertia which retards changes in gene frequency, this condition would come upon the world with such insensible slowness that, except for a few long-haired cranks who took genetics seriously, and perhaps some archaeologists, no one would be conscious of the transformation. If it were called to their attention, they would be likely to rationalize it off as progress. It is hard to think of such a system not at length collapsing, as people lost the capabilities and the incentives needed to keep it going. Such a collapse could not be into barbarism, however, since the population would have become unable to survive primitive

"The best laid schemes 'o mice and men

Gang aft a-gley."

BURNS

A year or so ago we advertised our new series AM relays designed for AUTOMATION. The response was overwhelming and for a while we believed that we were really "in business." Yet, because of circumstances beyond our control, the entire project had to be scrapped, at no small loss to both our pride and resources. We feel that we owe our sincere apologies. Perhaps the following explanation is in order.

On October 15th, a fully automated pilot run of 4¾ AM units was completed, the first such production, we believe, ever to be achieved. Full-scale production facilities were immediately set up in an adjoining structure, acquired when the lessee, an abacus manufacturer, sold out last year to an associate of Gen. MacArthur. Production of AM relays in commercial quantities (as advertised) began, directed by digital tape recordings of the last board of director's meeting (with quantitative control, of course, being provided by simple "Start-Stop" switching circuits installed on our Production

Manager's desk).

We are certain this arrangement would have been wholly satisfactory, had not one serious oversight been made. Our (former) production manager failed to adjust the automated timing cycle to coincide with a recent shift from Daylight Saving Time, with the result that AM production became a continuous feedback arrangement of finished relays to initial assembly. Not only did this destroy our costly facilities, but resulted in a finished product which was not a true AM relay, but instead a null-seeking abacus.

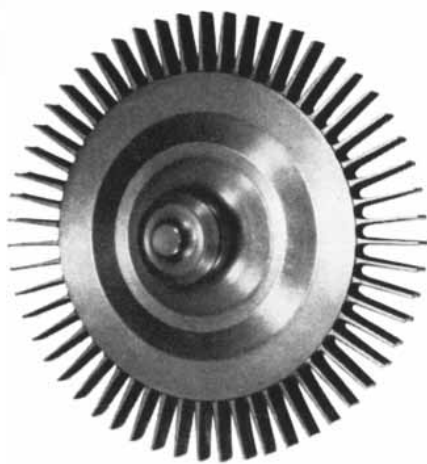
We sincerely regret our inability to make delivery of our Automation Relays at this time (or any time), but trust you will inform us of any future need for conventional Sigma relays (produced under somewhat more normal circumstances). In case you have hopes of obtaining a n.-s.a. from us, forget it. The entire lot has been dispatched, with our Production Manager and advertising counsel, to a point just inside Outer Mongolia.

SIGMA

SIGMA INSTRUMENTS, INC.

40 Pearl Street, So. Braintree, Boston 85, Mass.

25 Ampere Sensitive Contactors	General Purpose Sensitive DC Relays
Missile Relays	High Speed Relays
Sensitive, Low Cost AC Relays	Low Cost Polar Relay
Miniature Sensitive, General Purpose DC Relays	High Speed Electromagnetic Counters
	Null-Seeking Relays



KENTANIUM*

... from powders, a family of high temperature strength, thermal shock resistant, titanium carbide base compositions—for a wide variety of applications at continuous operating temperatures up to

2200°F
—for limited applications up to
4000°F

Many grades of this lightweight, exceptionally pure titanium carbide have been developed for various requirements where conditions of intermittent or continuous high temperatures in oxidizing atmospheres are combined with abrasion and compressive or tensile loads.

These Kentanium grades can be extruded and molded into many forms in the powdered state. More intricate forms are machined from pressed slugs. Precise tolerances are obtained by grinding after forms are sintered.

A few of the more important applications and potential uses include: bearings and parts subject to high temperatures in contact with liquid metals, nozzle vanes, blades and wheels for gas turbines and jet engines, rod mill guide inserts.

Additional information is contained in a new bulletin entitled: "Kentanium." Write for it. Then contact Kennametal engineers for cooperation on the application of Kentanium to your specific problem. Sales offices are located in principal cities.

KENNAMETAL INC., LATROBE, PA.

* Registered Trademark



conditions; thus a collapse at this point would mean annihilation.

Countermeasures

There is an alternative policy, and I am hopeful it will be adopted. The alternative does not by any means abandon modern social techniques or call for a return to the fabulous golden age of noble savages or even of rugged individualism. It makes use of all the science, skills and genuine arts we have, to ameliorate, improve and ennoble human life, and, so far as is consistent with its quality and well-being, to extend its quantity and range. Medicine, especially that of a far-seeing and a promoting kind, seeking actively to foster health, vigor and ability, becomes, on this policy, more developed than ever. Persons who nevertheless had defects would certainly have them treated and compensated for, so as to help them to lead useful, satisfying lives. But—and here is the crux of the matter—those who were relatively heavily loaded with genetic defects would consider it their obligation, even if these defects had been largely counteracted, to refrain from transmitting their genes, except when they also possessed genes of such unusual value that the gain for the descendants was likely to outweigh the loss. Only by the adoption of such an attitude towards genetics and reproduction, an attitude seldom encountered as yet, will it be possible for posterity indefinitely to sustain and extend the benefits of medicine, of technology, of science and of civilization in general.

With advance in realistic education should come a better realization of man's place in the great sweep of evolution, and of the risks and the opportunities, genetic as well as nongenetic, which are increasingly opening up for him.

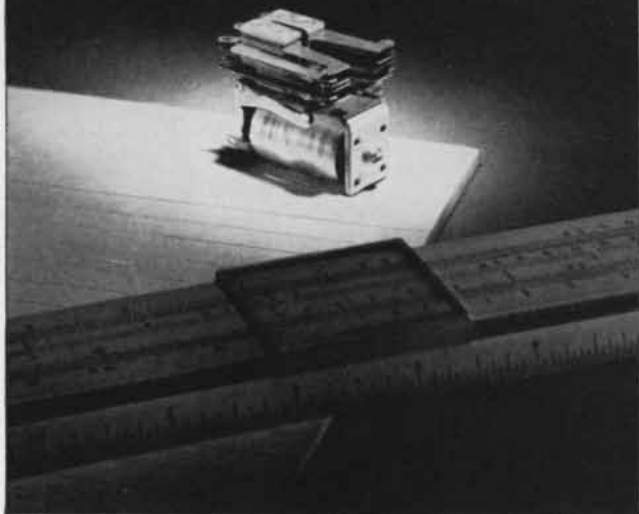
It is evident from these considerations that the same change in viewpoint that leads to the policy of voluntary elimination of detrimental genes would carry with it the recognition that there is no reason to stop short at the arrested norm of today. For all goods, genetic or otherwise, are relative, and, so far as the genetic side of things is concerned, our own highest fulfillment is attained by enabling the next generation to receive the best possible genetic equipment. What the implementation of this viewpoint involves, by way of techniques on the one hand, and of wisdom in regard to values on the other hand, is too large a matter for treatment here. Nevertheless, certain points regarding the genetic objectives to be more immediately sought do deserve our present notice.

For one thing, the trite assertion that one cannot recognize anything better than oneself, or in imagination rise above oneself, is merely a foolish vanity on the part of the self-complacent. Among the important objectives to be sought for mankind are all-around health and vigor, joy of life and longevity. Yet they are far from the supreme aims. For these aims we must search through the most rational and humane thought of those who have gone before us, and integrate with it thinking based on our present vantage point of knowledge and experience. In the light of such a survey it becomes clear that man's present paramount requirements are, on the one hand, a deeper and more integrated understanding and, on the other hand, a more heartfelt, keener sympathy, that is, a deeper fellow-feeling, leading to a stronger impulse to cooperation—more, in a word, of love.

It is wishful thinking on the part of some psychologists to assert that these qualities result purely from conditioning or education. For although conditioning certainly plays a vital role, nevertheless *Homo sapiens* is both an intelligent and a cooperating animal. It is these two complex genetic characteristics, working in combination and serviced by the deftness of his hands, which above all others have brought man to his present estate. Moreover, there still exist great, diverse and numerous genetic differences in the biological bases of these traits within any human population. Although our means of recognition of these genetic differences are today very faulty and tend to confound differences of genetic origin with those derived from the environment, these means can be improved. Thus we can be enabled to recognize our betters. Yet even today our techniques are doubtless more accurate than the trials and errors whereby, after all, nature did manage to evolve us up to this point where we have become effective in counteracting nature. Certainly then it would be possible, if people once became aware of the genetic road that is open, to bring into existence a population most of whose members were as highly developed in regard to the genetic bases of both intelligence and social behavior as are those scattered individuals of today who stand highest in either separate respect.

If the dread of the misuse of nuclear energy awakens mankind not only to the genetic dangers confronting him but also to the genetic opportunities, then this will have been the greatest peacetime benefit that radioactivity could bestow upon us.

From
miniature relays
to
massive
radar systems . . .



Producing small, sensitive electrical "nerves", or constructing great penetrating radar "eyes" . . . each demands advanced technology. And these are but two of the *hundreds* of complex tasks the AMF organization performs every day.

The highly specialized yet widely diversified activities of some 35 engineering and production

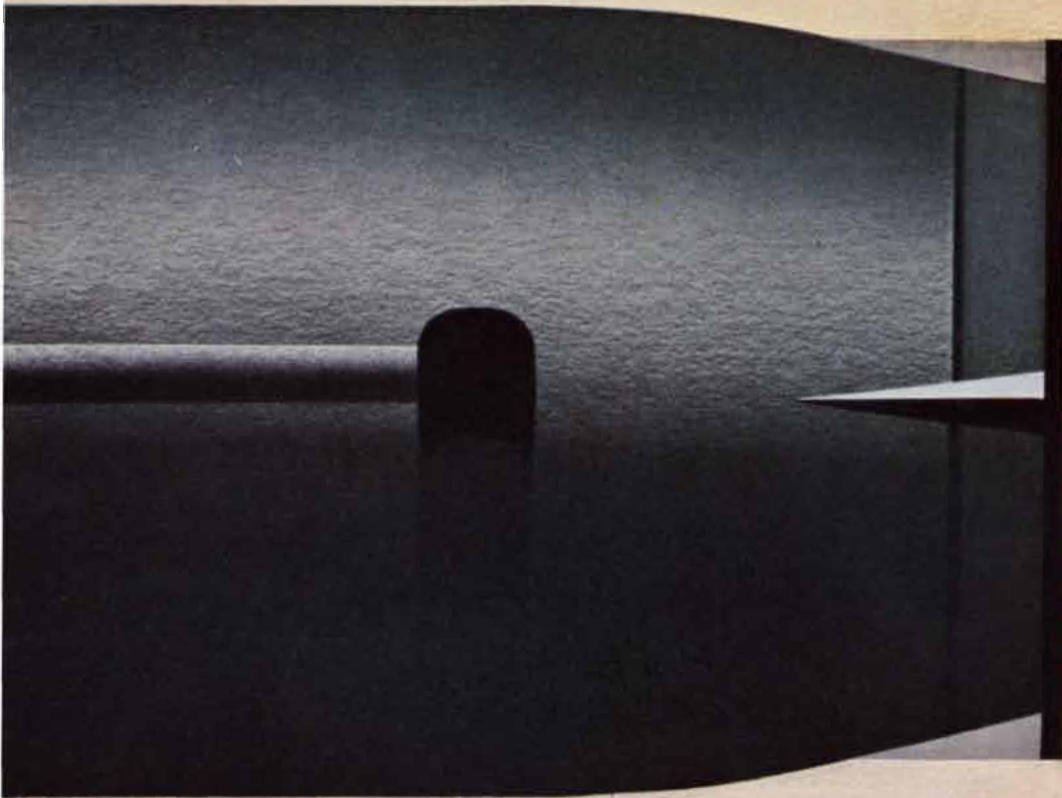
facilities provide AMF with a wealth of experience that covers nearly every field of industry. And it is immediately available to *you*.

Call upon AMF with your problem. See for yourself why this all-around experience in answering the needs of government and industry alike has made AMF the "can do" company.

AMF HAS EXPERIENCE YOU CAN USE!



AMERICAN MACHINE & FOUNDRY COMPANY, Defense Products Group, 1101 N. Royal Street, Alexandria, Virginia
Executive Offices—AMF Building • 261 Madison Avenue, New York 16, N. Y.



Giusti

ENGINEERS WANTED:

For top-flight men, Lycoming offers unusual opportunities to explore new scientific frontiers that lead to outstanding and rewarding careers. Write to Vice President, Industrial Relations, Stratford, Conn.

Lycoming

Lycoming harnesses the hot breath of a new era

Now, in the lungs of Lycoming's advanced gas turbines developed for the Military—the turbine principle finds new usefulness, this time for helicopters. Employing broad knowledge and bold thinking in aerodynamics, thermodynamics, and metallurgy, scientists of Avco's Lycoming Division have achieved in the T 53 turbine important design advantages: dramatic compactness (never before has 800 H. P. been housed in so little space), versatility in installation and operating characteristics, high efficiency, ruggedness, long life, and low production cost. The T 53, developed in close cooperation with the U. S. Air Force and U. S. Army Transportation Corps for helicopter use, also broadens the benefits of turbine power to fixed wing aircraft and many other mobile and stationary applications. Through advanced turbines—as well as improved reciprocating engines, better components, finer precision parts—Lycoming translates research into practical realities for defense, for peace.

*The turbine era is here. A broad variety
of future non-military applications
of gas turbines awaits the ingenuity of industry.
If your plans are in any way linked
to power—turbine or reciprocating—now
is the time to look to Lycoming!
Write on your letterhead to Lycoming,
Stratford, Conn. Ask for T-53 booklet.*

FOR A COPY OF THIS GUSTI ILLUSTRATION, SUITABLE FOR FRAMING,
WRITE TO PUBLIC RELATIONS DEPT., LYCOMING, STRATFORD, CONN.

avco DEFENSE AND INDUSTRIAL PRODUCTS

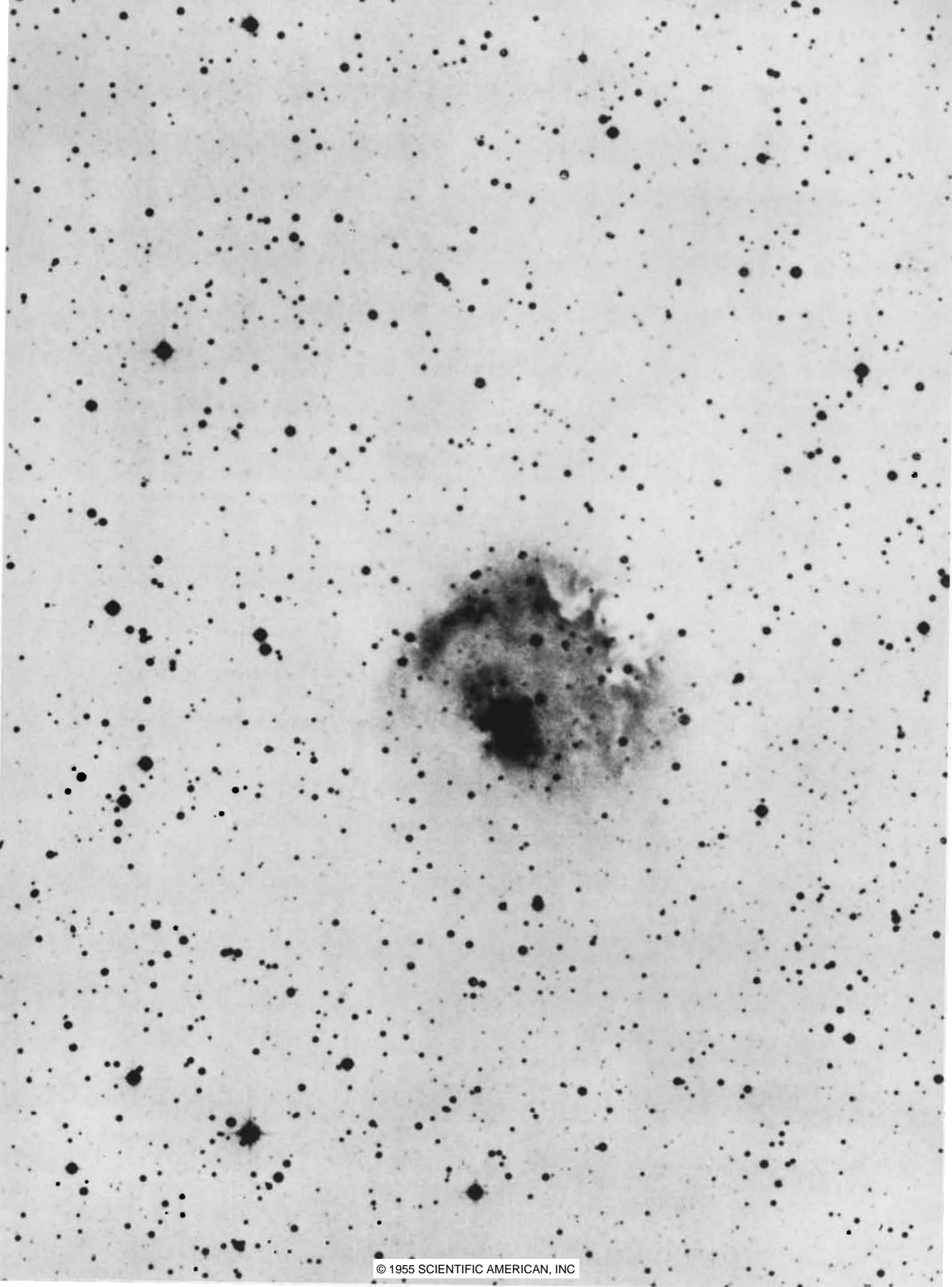
POWER PLANTS
ELECTRONICS
AIR-FRAME COMPONENTS
PRECISION PARTS

Designed, developed, and produced by

Lycoming ▼ **avco** advanced development ▼ **Crosley**

BOSTON, MASS. • CINCINNATI, OHIO • DAYTON, OHIO • EVERETT, MASS. • LOS ANGELES, CALIF. • NASHVILLE, TENN. • STRATFORD, CONN. • WASHINGTON, D. C. • WILLIAMSPORT, PA.

TODAY'S MILITARY SERVICES, WITH THEIR TREMENDOUS TECHNOLOGICAL ADVANCES MADE POSSIBLE THROUGH SCIENCE, OFFER A VITAL REWARDING CAREER



“Empty” Space

The vast reaches between stars contain about one atom per cubic centimeter, perhaps a quarter of the matter in our galaxy. This substance is made visible by the ultraviolet radiation of stars

by H. C. van de Hulst

For those wishing to dream away into the universe the stars are lights on little islands in an infinite sea. They are familiar beacons for a traveler, and the stellar landmarks would still look reassuringly familiar even if he sailed away from the earth into space. The earth and moon and planets would fade away; the sun would become an inconspicuous star; Sirius might grow dimmer and other stars brighter; but for a long time the constellations would keep their well-known outlines. At any random point of the journey the starry sky would look much as it does on a clear night on earth.

Yet while the distant scene might look much the same, how strange would seem the cold, black, silent interstellar space through which the traveler was moving! The dark void of the heavens has always frightened and mystified mankind. And it has not invited investigation. Until this century interstellar space failed to capture the imagination of astronomers, because it did not seem to do anything to their instruments. Apparently its only property was to let the light of the stars pass through.

In the last 25 years the situation has changed drastically. Interstellar space has become an exciting field of research.

LUMINOUS NEBULA was photographed by the 48-inch Schmidt telescope for the National Geographic Society-Palomar Observatory Sky Survey. Located in the constellation of Cygnus, the nebula represents a local concentration of interstellar dust and gas. Due to overexposure its illuminating star is not visible. On this positive print the stars and the luminous gas are dark and the obscuring dust is light. Prints of this kind are used by astronomers partly to increase the contrast between light and dark areas. Copyright National Geographic Society-Palomar Observatory Sky Survey.

Theoretical studies and observations by new techniques, proceeding hand in hand, have disclosed that the so-called “empty space” of the universe is far from empty.

In 1925 the Dutch astronomer Jan H. Oort, then only 25 years old, demonstrated by an indirect method that the space between the stars must contain a considerable amount of matter. He measured the weight of a large volume of space, including the stars and everything else it contained, by determining the gravitational action of this volume upon the motions of stars toward and away from the plane of the Milky Way. Oort found that the gravitational effect of the region in question could not be accounted for by the weight of the stars alone; it must contain other matter. We now know that the additional weight consists mostly of hydrogen gas in the interstellar space. The hydrogen gas amounts to about one atom per cubic centimeter, and there are smaller quantities of other atoms and molecules mixed in as “impurities.” In the neighborhood of the solar system interstellar gas makes up about one quarter of the total weight of a given volume, stars accounting for the rest.

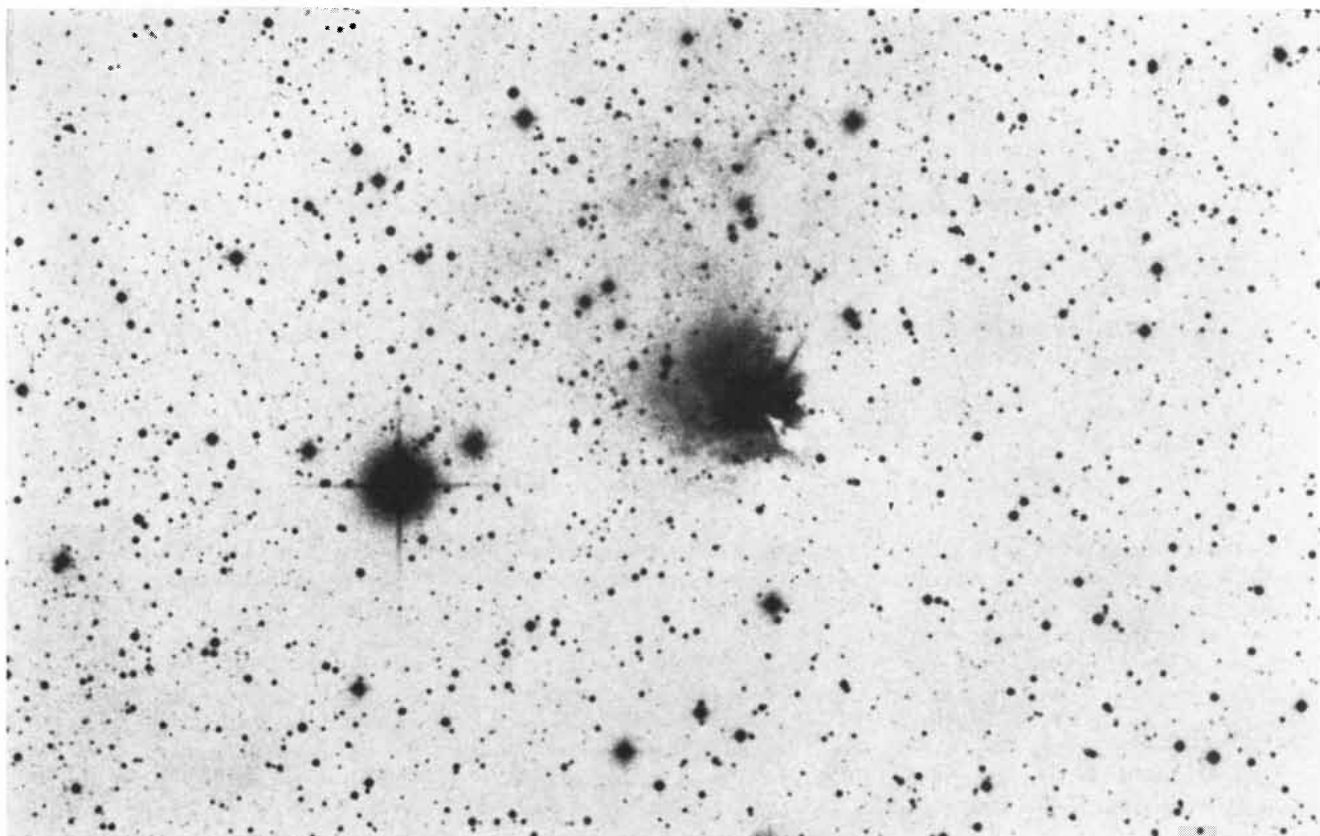
Another proof that interstellar space is not empty came from a quite different angle. About 1930 astronomers discovered with some shock that as the light of the stars passes through certain regions of interstellar space it is dimmed and scattered in various directions. Up to that time astronomers had the attitude toward interstellar absorption of light that some people have toward ghosts: they didn't believe in its existence and yet they were afraid of it. It is obvious what the astronomers were afraid of. If there was indeed an interstellar haze which dimmed the light of distant stars

or made them altogether invisible, then many of their calculations of star distances and their picture of our galaxy were wrong. Further studies proved that the fear was justified. Starlight passing through the crowded regions of our galaxy loses roughly half of its energy by absorption and scattering in every 2,000 light-years of its travel. As a result, even with our most powerful telescopes we cannot see the center of our galaxy, some 25,000 light-years away. Beyond about 6,000 light-years from our observing station most of our studies of the galaxy are literally lost in the fog.

What is the agent that absorbs and scatters sunlight? It cannot be hydrogen or any other gas. This can be proved by a little computation. The column of air over each square centimeter of the earth weighs about one kilogram. We know from everyday experience that this density of air is almost perfectly transparent to sunlight and starlight. Now the hydrogen gas in interstellar space is so thin (one atom per cubic centimeter) that a centimeter-square column weighing one kilogram would be roughly 5,000 times longer than the diameter of our whole galaxy! Obviously the hydrogen gas within the galaxy must be completely transparent.

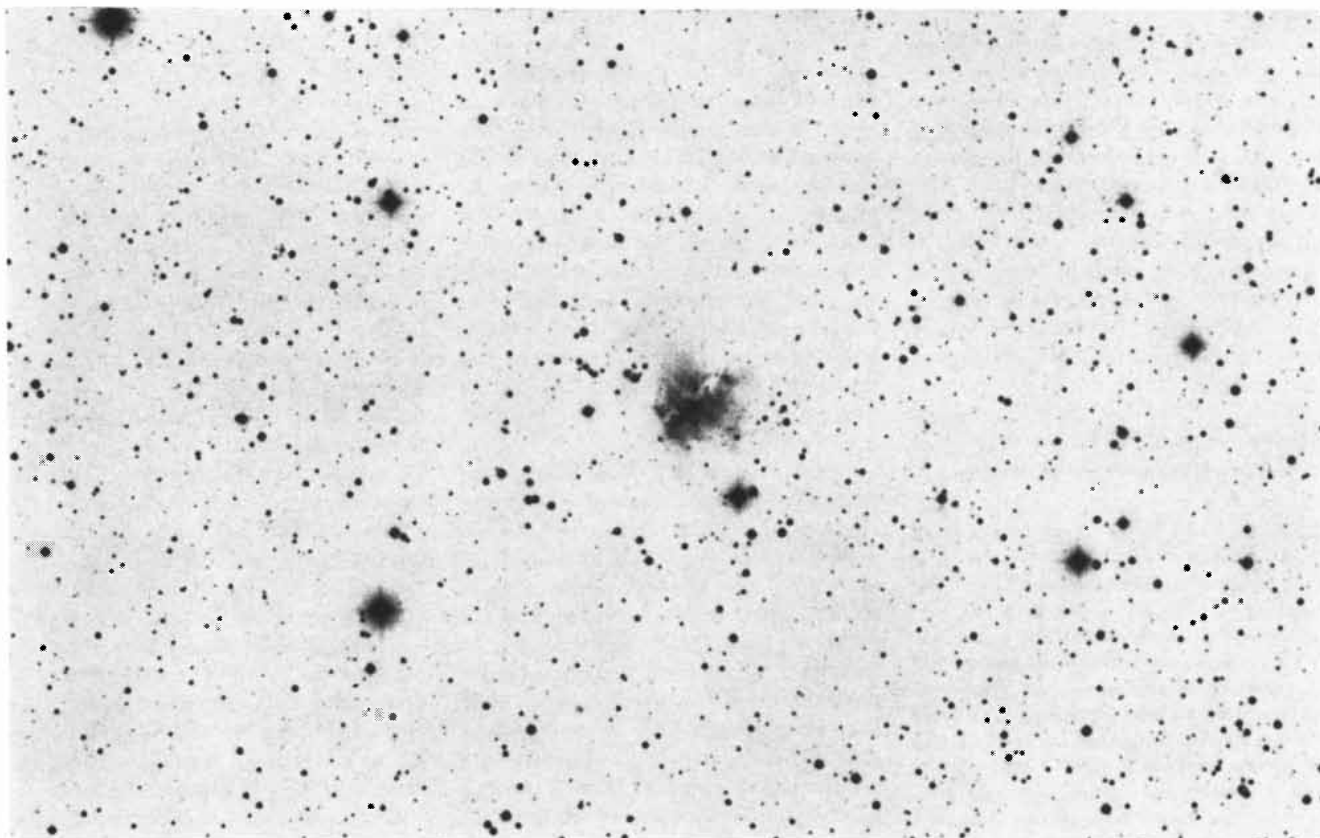
We can find clues to what the obscuring agent really is in certain other facts of our everyday experience. Water molecules in vapor form are transparent to light. But when the same water molecules in the air condense and collect in drops, which in turn form clouds, they block light. On the other hand, if they fall as rain and fill a shallow basin, the water becomes transparent again.

So we see that the effectiveness with which matter blocks light depends upon the size of the particles. Of all particle



NEBULA IN AURIGA was also photographed by the 48-inch Schmidt. The small triangular area (*bright in this positive print*)

at the edge of the nebula is a dark cloud of very high opacity. Copyright National Geographic Society-Palomar Observatory Sky Survey.



ANOTHER NEBULA IN AURIGA is photographed by the 48-inch Schmidt. The four faint points around many of the star images are

due to diffraction around the supports of the plate holder. Copyright National Geographic Society-Palomar Observatory Sky Survey.

sizes, those in a cloud of smoke or dust scatter light most efficiently in proportion to weight. A wisp of cigarette smoke weighing only a tiny fraction of a gram can form an opaque screen. Thus we have to infer that the agent which scatters starlight in space is smoke or dust. Either the color of the scattered light or the color of the light that penetrates a cloud may identify the particle size. From accurate measurements of the color of starlight passing through obscuring clouds in space it is possible to estimate the size of the particles and the weight of the clouds. It appears that on the average the dust in the clouds of interstellar space accounts for only 1 or 2 per cent of their total weight. The rest is gas.

These results, obtained from a fairly straightforward explanation of astronomical observations, set the stage for an eventful story. Space between the stars is not empty. It is occupied by at least two different things: gas, mostly hydrogen, and smoke or dust, consisting of small solid grains. Do these live a peaceful coexistence, or is one devoured by the other; that is, does gas gradually condense into solid grains or do grains evaporate into gas? Do the stars, sailing slowly through space, shed matter or collect it from interstellar clouds by gravitation?

This is a set of characters for an exciting plot. And the plot has to be written by theoretical astrophysicists rather than by observing astronomers, for there is so little to go by that the hope of a direct interpretation of observational data is awfully slim.

Let us pose one simple question first: How cold is interstellar space? This question, simple as it seems, cannot be answered, for it makes no sense. It all depends on what thermometer one uses. The interstellar gas and the dust grains, which are thermometers of a kind, reach quite different temperatures. This state of affairs is due to the extremely diluted state of interstellar matter.

In the familiar case of a gas on the earth the temperature of the gas is a measure of the general degree of commotion among the molecules: molecules in a hot gas move faster on the average than molecules in a cold gas. (Molecules in a solid body move, too, but most of them are bound to positions and move like leaves on a tree.) The motion of an individual molecule cannot be predicted, but the average speed of the molecules is accurately fixed by the temperature. It is logical to choose the temperature scale so that zero temperature means no

NEW!

**Fastest,
easiest way
to analyze
METAL
SPECIMENS**



**All-new comfort-
first design . . .
exclusive performance
advantages . . . make all
other metals microscopes
obsolete!**

BAUSCH & LOMB

Dynoptic

**METALLURGICAL
MICROSCOPES**

NEW EASE! Your hand rests on table for effortless precision focusing and mechanical stage control. Binocular eyepieces inclined at comfortable viewing angle. You remain relaxed, fatigue-free throughout prolonged examinations.

NEW SPEED! Ball bearings and rollers quickly float the microscope into critical focus, without drift or binding.

NEW ACCURACY! Pressure-loaded ball bearings assure lifelong centration of Roto-sphere nosepiece, for identical repeat settings. Balcote anti-reflection coated objectives provide vivid, detailed images for dependable analyses.

NEW VERSATILITY! Monocular tube, for photomicrography and measuring, readily interchangeable with binocular body. Choice of vertical or transmitted illumination. Optional mechanical stage.

FREE ON-THE-JOB DEMONSTRATION

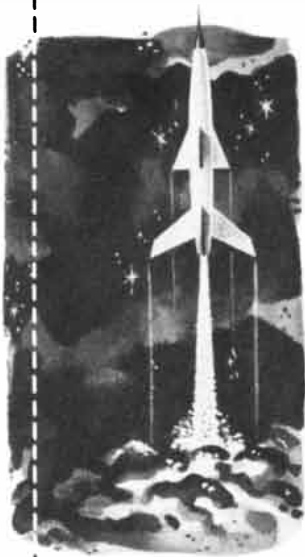
See the difference! Feel the difference! Prove for yourself how exclusive B&L advantages help you do your best work faster, more easily.

WRITE, WIRE or PHONE today for demonstration and Catalog D-1053, Bausch & Lomb Optical Co., 75847 St. Paul St., Rochester 2, New York. (Phone: LOCUST 3000)



AMERICA'S ONLY COMPLETE OPTICAL SOURCE
. . . FROM GLASS TO FINISHED PRODUCT

MR. ENGINEER:



the way is UP...

WHEN YOU JOIN THE
BENDIX RADIO
ENGINEERING TEAM!

Electronic Eng.
Mechanical Eng.
Physicists

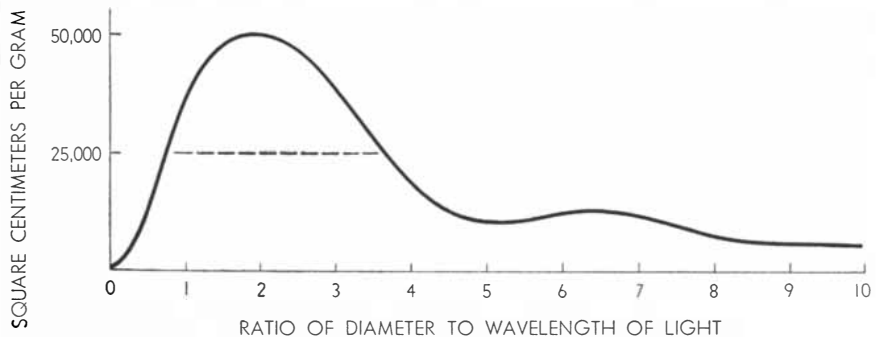
Many missile systems are guided by Bendix Radio equipment. Our history of success in producing the world's finest electronic equipment is resulting in a phenomenal growth of both our government and commercial business. Currently we are planning a great new engineering building—the most modern that expert planning can produce. We are continuing to pioneer great new strides in advanced electronics! Top salaries . . . moving expenses negotiated . . . placement at highest level of your capabilities . . . all employee benefits. Ideal working conditions.

Bendix Radio is GROWING fast...NOW is the time to move up with us to higher levels of accomplishment!

Write, wire or phone:
MR. L. H. NOGGLE
Dept. S

**Bendix
Radio**

DIVISION OF BENDIX AVIATION CORP.
TOWSON 4, MARYLAND
Phone: VAlley 3-2200



SIZE OF COSMIC DUST GRAINS can be computed as shown above. Solid curve indicates the screening efficiency (in square centimeters of obscuring area per gram of suspended material) for dust particles of various sizes. Broken line shows the observed screening efficiency of interstellar dust. Thus the particles must have diameters between about one and four wavelengths of light, or between about one half and two thousandths of a millimeter.

motion at all. This fixes the scale of absolute temperatures. Zero degrees Kelvin is the absolute zero; 273 degrees K. corresponds to the temperature of freezing water, and 373 degrees K. to that of boiling water.

The concept of temperature presupposes a lot of energy exchange which distributes the energy fairly evenly among all the molecules. To measure the temperature of a room we do not have to be very careful about where or how we position the thermometer; in any case there will be energy exchange by manifold molecular collisions which will let the thermometer take part in the general commotion.

Interstellar space is set to a slower pace. Any atom has to travel millions of miles before it hits another. This takes weeks or months. The number of collisions in the gas is still sufficient to insure an even temperature in large portions of it. The concept of temperature can also be applied to a single solid particle, because its molecules are packed close together. However, the temperature of the solid particles need not be the same as the gas temperature; in fact, it would be surprising if it were, because the particles and gas atoms exchange energy very infrequently and react to radiation from the stars in quite different ways. Furthermore, no real thermal equilibrium can exist in interstellar space, as it does in the more or less enclosed places on the earth. In space matter is exposed at one side to the hot but distant stars providing the heat and on the other side to the dark depths of space into which the heat is lost. The situation in interstellar space is not altogether unlike that in a house with a hot furnace in a freezing winter climate. All we can say offhand is that the room temperature will be somewhere between the temperature in the furnace and the temperature out-

doors. We can make it hot by constructing a system of effective energy transport from the furnace to the room and by insulating the room against heat losses to the outer air. Or we may make it cool by closing the radiators and opening the windows.

Computing the temperature of interstellar matter therefore is a problem of estimating the gains and losses, being quite careful that we do not forget any leaks! A. S. Eddington estimated in 1916 that the gas should be blazing hot and the dust deadly cold. Although we now have to qualify his statement, it is still basically correct. A gas atom moving with high speed through interstellar space has no way of radiating its kinetic energy and stands little chance of being slowed down by collisions. The same holds for electrons and ions. So the gas temperature is maintained at a high level—probably about 10,000 degrees K.—in the neighborhood of hot stars where hydrogen is ionized. The gas gets rid of some of the energy absorbed (radiating it away when ions are raised to a higher energy state by collision with electrons), but in general it is well insulated against heat losses.

The dust, however, is as poorly insulated as a person sitting at a great distance from an open fire. The particles shed heat into cold space more readily than they absorb it from the stars. Nevertheless, their radiation is limited by the fact that the dust grains are much smaller than the infrared heat waves (perhaps one ought to say cold waves) they have to emit to get rid of their energy, so that their temperature does not fall below about 10 or 20 degrees K. This is still low enough to freeze anything but helium and hydrogen.

The real problem child of space astrophysicists is the behavior of the gas in the vast reaches of space far distant

from stars. In about 90 per cent of space the hydrogen atoms are too far from stars to be ionized. These clouds of neutral hydrogen have a much smaller energy budget; that is, their income and expenditure of energy are at a lower level. Theoretical calculations based on this budget led Lyman Spitzer of Princeton University to predict that the neutral clouds should be at least 100 times cooler than the hot (10,000-degree) gas in the ionized regions; their probable temperature should be about 50 degrees K.

In 1951 it became possible to study the cold regions of interstellar gas directly by means of radio astronomy, through the discovery of the 21-centimeter wavelength emission of hydrogen atoms in space. These studies indicated that the temperature of the cool hydrogen clouds is about 125 or 150 degrees K. Astronomers at first were highly enthusiastic about this result, for it confirmed the theoretical prediction that vast regions of the interstellar gas were very cold. But the discrepancy between the predicted figure of 50 degrees and the 125 degrees actually observed could not be ignored. Astronomers therefore had to consider what source of heat might raise the temperature of the hydrogen clouds. Some suggested that the source might be radiation from dark giant stars. But Franz Kahn of Manchester has proposed a more plausible idea. He suggests that about once in seven million years one hydrogen cloud collides with another and the collision heats both to several thousand degrees. The clouds thereafter behave like someone who has received a large legacy. They spend most of the new energy in a short time but then taper off and spend the rest slowly over a long period. Thus Kahn estimates that a collision-heated cloud may cool rapidly from 3,000 degrees to 500 and then very gradually from 500 to 50 degrees. The 125-degree temperature observed by radio astronomy may be an average; further studies with the big new radio telescopes which are now under construction may show large temperature variations from cloud to cloud.

Where does the dust in space come from? In the last years of World War II several Dutch astronomers and physicists in occupied Holland tackled this question theoretically. The most plausible explanation seems to be that the dust particles are basically grains of ice, for oxygen combines easily with hydrogen and it is the next most abundant element in the universe after hydrogen



How you can insure a product's future . . .

For a currently successful product line—or a new design still on the drafting board—how can you protect market position, insure future customer satisfaction and avoid product obsolescence? Or how can you launch a new product profitably?

A proven answer is DFI ENGINEERING AUDITS.

The DFI Engineering Audit is a service developed and proved through more than 20 years of successful planned product development for industry. It is an unbiased analysis of your products and of the factors affecting design, production and markets, both current and future.

We apply a critical and experienced “outside engineering viewpoint” to each of these four areas:

1. **Product Analysis**—to uncover possibilities for cost savings and improvements.
2. **Field Investigations**—suppliers, distributors, users, buyers and competitors . . . to establish specifications for optimum value and profit —for today, and tomorrow!
3. **Design Engineering**—to finalize functional design and provide flexibility for future changes.
4. **Production Engineering**—to translate designs into practical form, and establish most up-to-date manufacturing techniques and methods.

DFI Engineering Audits are available on a single product or a complete product line . . . on an annual basis or an individual product-budget basis. For further information, write for descriptive information on this service. Or, if you have a specific problem, we'll be glad to have a representative call, without obligation.

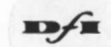
Designers for Industry
Incorporated 1935

2915 Detroit Avenue • CLEVELAND 13, OHIO

Technical Surveys • Design Engineering

Research and Development • Production Engineering

ENGINEERING



AUDITS

ENGINEERING
AUDITS

LEDEX ROTARY SOLENOIDS

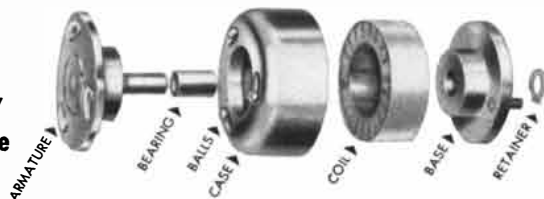
GIVE POSITIVE, POWERFUL SNAP-ACTION!



Here's how a LEDEX ROTARY SOLENOID operates . . .

The magnetic pull moves the armature along the Solenoid axis. This action is efficiently converted into a rotary motion by means of ball bearings on inclined races. The inclined ball races are made to compensate for the magnetic pull increase as the Solenoid air gap closes, thereby providing substantially equal starting and ending torque during the rotary stroke. The rotary snap-action power of the Ledex can be efficiently harnessed with a minimum of linkages, through the use of one or more standard features available on all models.

Here's why LEDEX ROTARY SOLENOIDS are dependable!



As can be seen from the exploded view, Ledex Rotary Solenoids are simply constructed with few moving parts. All parts are manufactured to exacting tolerances and are carefully inspected and assembled. The copper wire coil, the heart of the Solenoid, was developed especially for this product. It is wound by a precision winding process that puts a maximum amount of magnet wire into available space . . . giving tremendous power to compact Ledex Rotary Solenoids.

Basic sizes of LEDEX ROTARY SOLENOIDS to choose from!



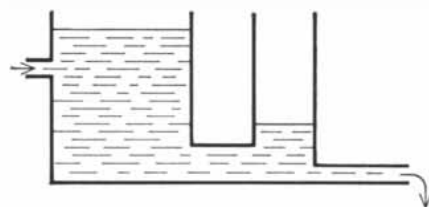
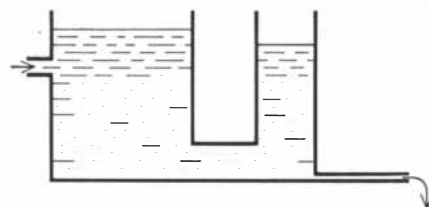
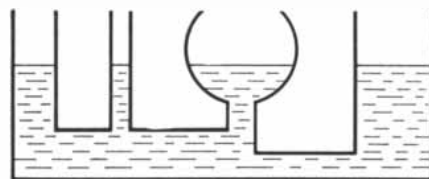
Model No.	2	3	4	5	6	7	8
Diameter inches	1 1/8	1 5/16	1 1/2	1 7/8	2 1/4	2 3/4	3 3/8
Torque lbs.-inches	.4	1.0	1.7	4.0	7.5	25.0	54.0

Torque values for normal intermittent duty and 45° stroke.

Engineering data is available upon request.
WRITE FOR DESCRIPTIVE LITERATURE TODAY!

I N C .

TREET, DAYTON 2, OHIO
KITCHENER, ONTARIO



HEAT BUDGET of interstellar matter is illustrated by hydraulic analogy. For equilibrium (top) all parts of the system stay at the same height (temperature) regardless of the size of the channels connecting them. Where interstellar dust (right-hand vessel in two lower pictures) loses heat, it will stand lower (cooler) than the reservoir if the channel is wide (bottom) than if narrow (middle).

and helium. It is not hard to picture how such grains might grow in space. Each particle is so cold that any gas atom or molecule colliding with it will freeze and stick to its surface. The particle will continue to grow even though most of the hydrogen and helium atoms attaching themselves to it soon evaporate. But as we know, the particles do not grow beyond a certain small size. This must mean that they are destroyed from time to time; considering their observed size, their average lifetime cannot be more than about 10 million years. Very likely they evaporate when clouds collide.

An interesting problem arose when it was discovered in 1949 that dust clouds in space polarize light. The discovery indicated that the dust grains are not neat spheres but must be egg-shaped, disk-shaped or perhaps even needle-shaped, and aligned to some extent in the same direction. There remain also some uncertainties about the composition of the particles; one theory is that many of them may be flakes of graphite. But the nature of the dust in space is considered now to be at least partly solved.

In 1949 a group of 50 experts in as-

Quicker way to separate chemical Sheep from Goats



Major chemical developments frequently bring secondary results of far-reaching importance. A typical example is acid-washed aluminum oxide of high purity, which offers numerous industries a faster, lower-cost way to separate chemical "sheep" from "goats."

Merck Research May Have The Answer To Your Chemical Problem

If the problem you face involves chemistry, an excellent starting point is to consult Merck. The results of the Merck research program have proved so valuable to manufacturers in numerous fields that you, too, may find them helpful. A letter places you under no obligation. *Please write to: Director, Scientific Administration, Merck & Co., Inc. Dept. S-11.*

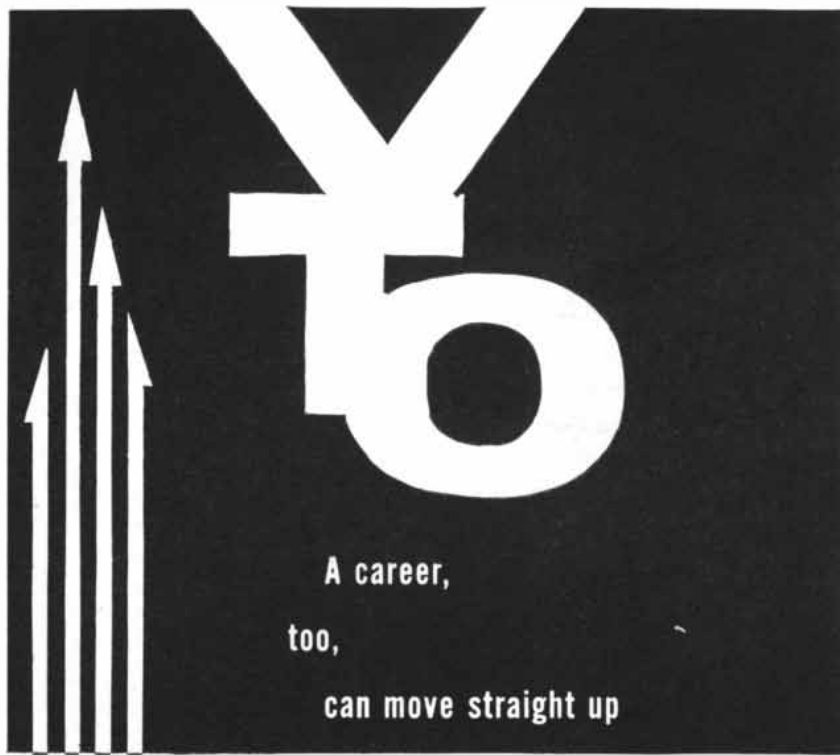
This compound was first used in the Merck Research Laboratories during the original research on cortisone and hydrocortisone. Merck promptly made acid-washed aluminum oxide generally available to scientists and industry, and it has become one of the greatest timesavers in chromatographic operations. Because it does not destroy some of the substances under process, as does non-acid-washed aluminum oxide, it is ideally suited for separating numerous complex organic compounds—notably steroids, alkaloids, and antibiotics.

Chromatographic chemicals are only a few of many Merck developments that may give manufacturers in numerous fields the key to establishing more efficient procedures or developing profitable new products.

*Research and Production
for the Nation's Progress*



MERCK & CO., INC.
Manufacturing Chemists
RAHWAY, NEW JERSEY



A career,
too,
can move straight up

Specialists in VTO: Take a look at Fairchild's progress in this exciting field of modern aviation!

Here is real opportunity to make your mark in this important work, offered by the fast-growing, progressive organization that gave the world the famous C-119 *Flying Boxcar* and C-123 *Provider*. For now at Fairchild extensive research and development programs are in progress to create new VTO craft, as well as transports, fighters and missiles.

If you have experience in this field, and can make genuine contributions to its advancement, then you have an important place at Fairchild, and the chance to move straight up in your profession.

Consider, too, the added advantages of living and working close to Baltimore and Washington, in the attractive Cumberland Valley, where housing, schools and recreational facilities are among the nation's finest. And, Fairchild's salary plan, paid pensions, health, hospitalization and life insurance benefits give you extra security in which to build your future.

Send a detailed resume of your experience to Walter Tydon, Chief Engineer. All correspondence will be kept in strictest confidence, of course.

*"where the future is
measured in light-years"*

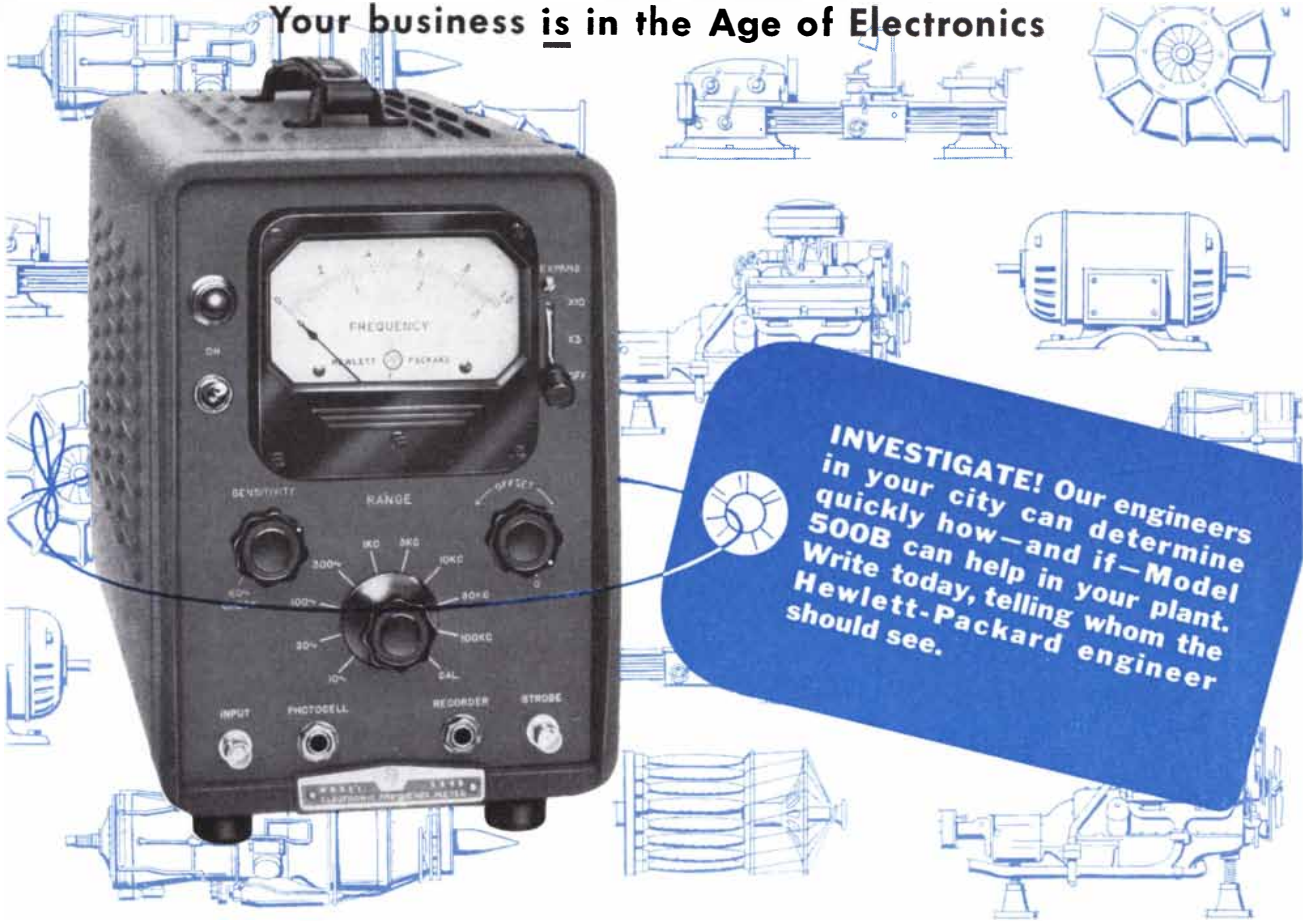


tronomy and gas dynamics met in Paris for a week to discuss the unsolved problems concerning the gas in interstellar space. Why does the gas collect in clouds? What is the driving force that moves these clouds through space? How can one account for the fact that the clouds seem to have an intricate structure and rapid internal motions? The experts could do little more than define the problems. Four years later they met again in Cambridge, England. The problems were not yet by any means completely solved, but they were more clearly defined and some reasonable answers could be given. Here is how the present ideas run.

The interstellar gas is the dominant matter in space. Its dynamics molds the shape of the clouds and probably of whole spiral arms in our galaxy. Compared to it the dust is unimportant. For astronomers the obscuring dust is usually just a nuisance, except for the one helpful circumstance that it shows where the invisible gas is concentrated, as the smoke from a chimney may show the direction of the invisible wind. Concerning the driving energy that moves the clouds, the experts now doubt that the rotational motion of the galaxy is sufficient to account for their motion in the face of energy losses by friction, collisions and the formation of cosmic rays. A more powerful driving mechanism is needed, and the answer may be the temperature differences between the ionized and nonionized regions of the interstellar gas. If one part of a mass of gas is 100 times hotter than another part, the enormous pressure difference set up would start a kind of explosion which would shoot out portions of the mass as clouds traveling at high speeds. Thus the energy of the clouds' motion may derive from the radiation of the hot stars that heat the gas, and the energy of the stars in turn derives from nuclear reactions in their interiors. In short, nuclear power appears to be the driving power even of the motions of interstellar clouds.

The hot stars that produce such heating of the gas can have only a short lifetime—one to 10 million years. Stars of this kind must be formed continually from the same complexes of interstellar matter that they finally manage to blow apart as a chick breaks its eggshell. Thus the formation of stars and the formation of interstellar clouds are parts of one and the same problem for astronomers. So far the astronomers are occupied with too many other questions to worry much about the question as to which came first: the chicken or the egg?

Your business is in the Age of Electronics



INVESTIGATE! Our engineers in your city can determine quickly how—and if—Model 500B can help in your plant. Write today, telling whom the Hewlett-Packard engineer should see.

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.



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

What Makes Leaves Fall?

Plants shed their leaves not only in the fall, but continuously. New experiments indicate that they do so when old leaves flag in their production of the hormone auxin and young leaves make more

by William P. Jacobs

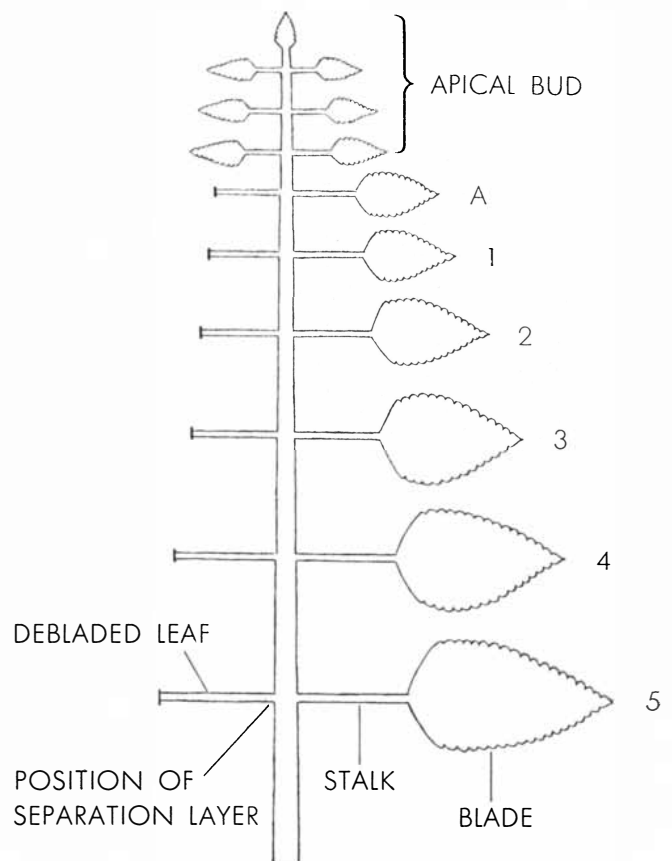
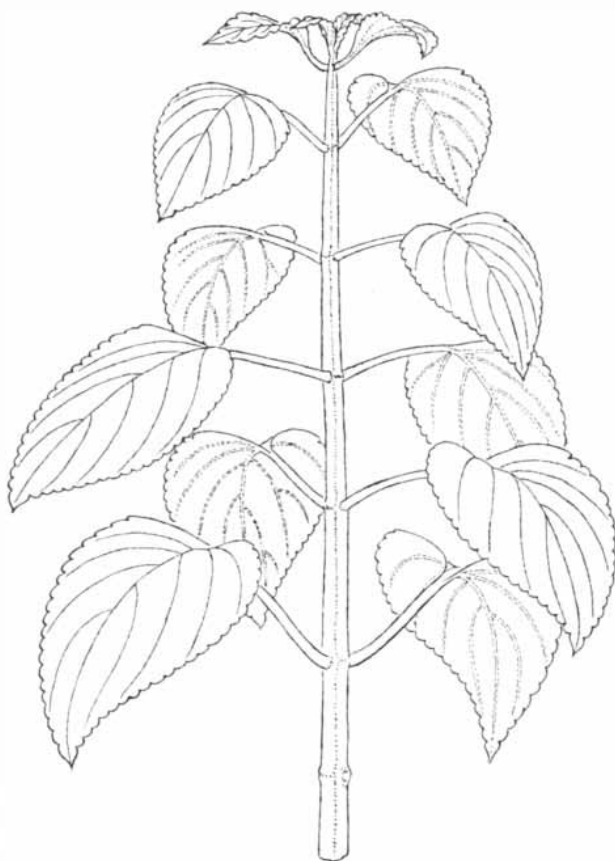
The falling of the sere and yellow leaf symbolizes autumn, but leaf fall is not limited to that season. All summer long in temperate zones and all the year round in the tropics there is a steady, though inconspicuous, rain of leaves from trees. Plants continually shed tissues (not only leaves but also fruits, flowers and other organs) as the organs grow old. This gives them certain en- vial advantages denied to most of the

animal kingdom. If man, for example, could shed his aging extremities and grow new ones to take their place, Renoir would not have had to strap his brush to his old and trembling hand in order to paint what his still "young" mind could conceive.

Botanists have been trying for nearly a century to discover the process by which plants shed their leaves. One of the first clues that attracted their atten-

tion was the fact that some plants develop a distinct layer of cells at the base of the leaf stalk and the leaves then break off at that point. But the so-called "separation layer" proved to be a false clue. Many plants have no such layer, and many others have one but their leaves do not separate at that place.

The leaf-shedding process, whatever its physiology, is speeded in the autumn by the shortening of the day; this was



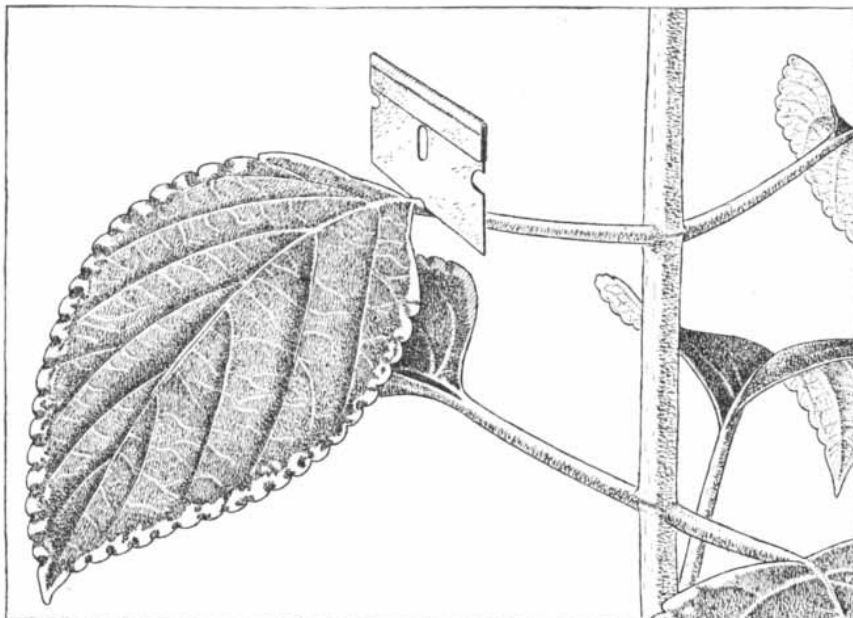
EXPERIMENTAL PLANT was Coleus, called the "beefsteak plant" because of its deep red leaves. It has a bud at the top and six pairs

of mature leaves. In the schematic drawing at the right the apical bud has been opened out to show the immature leaves within it.

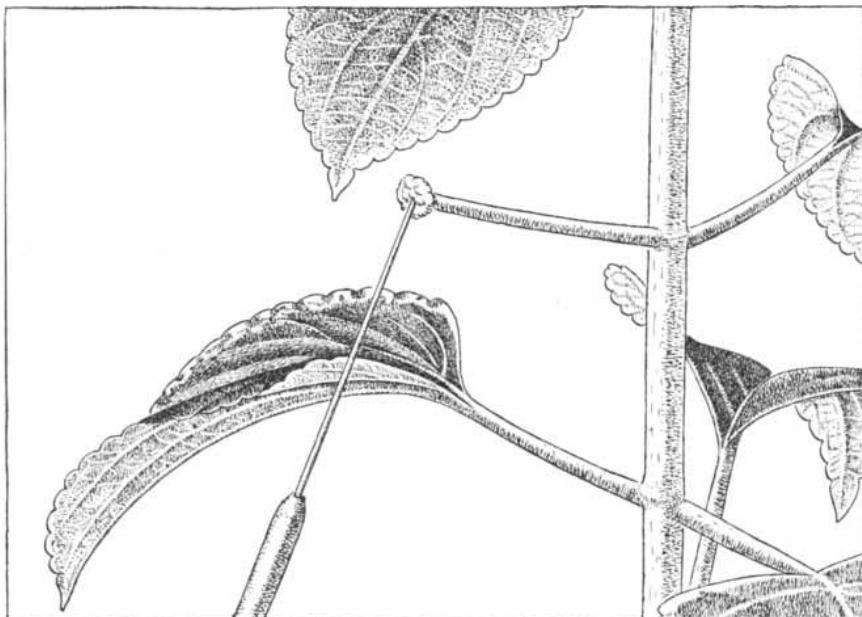
confirmed long ago by experiments which demonstrated that when the day was lengthened by artificial light, trees held their leaves later than usual. But various other factors also were found to influence the process. And among these the one that has been the greatest help in unraveling the mystery is the observation, made almost 100 years ago, that when the blade of a leaf is cut off or severely damaged, the leaf stalk falls off the plant very soon afterward.

This lead has been pursued with much zest and profit in recent years by laboratory experiments. For precise and extensive experimentation trees are remarkably inconvenient. Most of us do not have a musculature which would make us look forward to manipulating oaks and maples. And trees take so long to do almost anything! So for the same reasons that animal biologists are much better acquainted with the physiology of mice than of elephants, plant physiologists like to work with greenhouse plants. The favorite plant for studying leaf fall is the familiar house plant *Coleus*, also called the "beefsteak plant" because of its deep red leaves. When grown in the greenhouse under the cultural conditions which we have used for our experiments, *Coleus* keeps a fairly constant number of leaves on its main stem. Every seven to ten days the oldest pair of leaves falls off at the bottom of the stem and a new pair forms at the apex. *Coleus* has the further great advantage that it is easy to grow from cuttings, so that a large collection of genetically identical plants can be developed from a single original parent. In our experiments we have used some 3,000 plants, all derived from one original plant: in effect our subjects have been "identical twins" multiplied 1,500 times! With this uniformity of heredity, it is possible to measure reliably very small treatment effects even with small sample sizes.

The two major parts of a leaf are the flat blade and the stalk by which the blade is attached to the plant stem. When the blade of a leaf is cut off, the remaining leaf stalk soon separates and drops from the stem. For instance, a young, fast-growing *Coleus* leaf, which normally takes 35 to 40 days to reach the age of natural fall, will fall in only five or six days if it is debladed. The first substantial hint as to the internal mechanism controlling fall came when it was found that if even only a tiny piece of the leaf blade was left on the stalk, the leaf would stay on the stem just as long as if it had a complete blade. This in-



LEAF WAS DEBLADED by making the cut indicated in this drawing. Technically the leaf consists not only of the blade but also of the stalk that connects it to the stem of the plant.



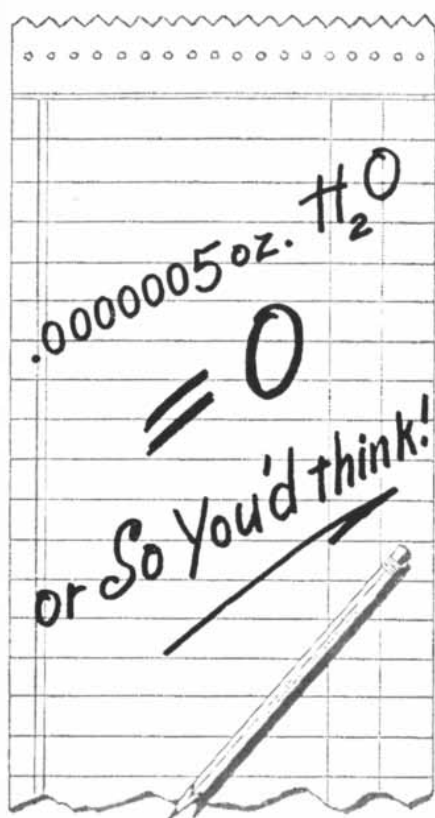
AUXIN WAS APPLIED in a dab of paste placed on the end of the cut stalk. In this way it was investigated whether auxin made by the leaf blade affected other parts of the plant.

dicated that the substance in the blade that prevented the fall of the leaf must be active in very minute amounts. It could not be a general nutrient such as sugar; most likely it was a hormone.

The hormone was soon identified. It is the plant growth substance known as auxin [see "Plant Hormones," by Victor Schocken; *SCIENTIFIC AMERICAN*, May, 1949]. An alert German investigator applied the hormone to debladed *Coleus* leaves and found that the substance not only kept the leaves growing but "in-

creased their longevity," that is, delayed their fall.

It was later established that the leaf blades of *Coleus* produce substantial amounts of auxin, and a clear and direct relation between auxin production and leaf fall was worked out. The more auxin a leaf produces, the longer it takes to fall [see chart on page 86]. The fastest-growing leaves produce most auxin; the maximum production occurs when the young leaf is 60 to 100 millimeters long (between two and a half and four inches).



But the principle behind the Alnor Dewpointer is so exacting that if that one half of one millionth of an ounce of transient water vapor were not sealed out—it would make an error of 10° at -60° F. In many fields today where the Dewpointer is used, such an error in dew point determination would be worse than no answer at all.

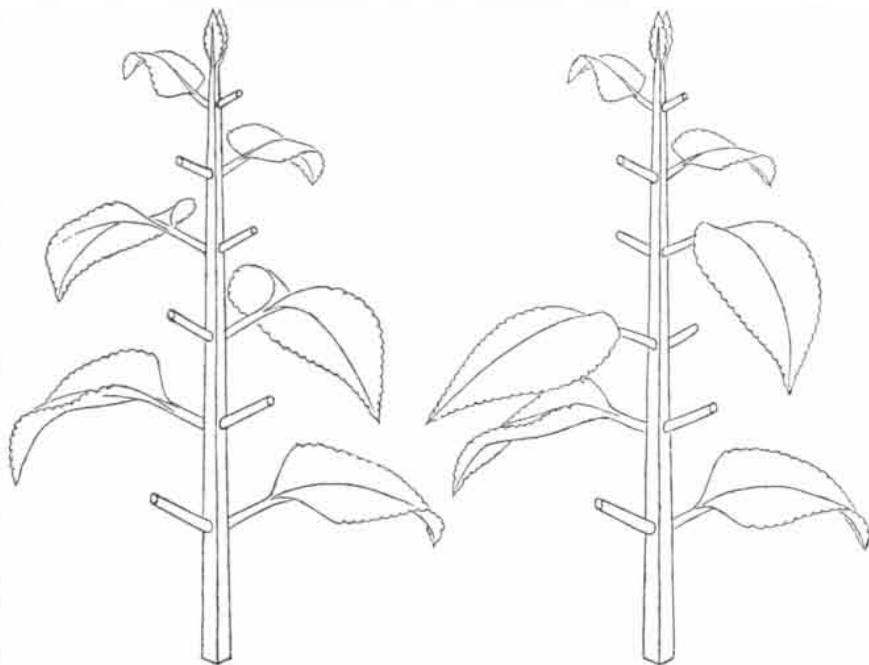
That is the policy at Alnor. Take the most exact laboratory method of determining dew point, velocity, temperature—and design an instrument that will provide laboratory results under all conditions.

Precision. Portability. Simple operation. These are the goals of Alnor's manufacturing and research divisions . . . looking at old problems . . . finding new and better answers for industry. Each Alnor product is a result of this modern thinking . . . designed to meet industry's production line methods.

Modern principle behind the Dewpointer is explained in our Bulletin number 2051. Write for your copy.



ILLINOIS TESTING LABORATORIES, INC.
Room 548, 420 N. LaSalle Street
Chicago 10, Ill.



DIFFERENT PATTERNS of leaf-blade removal were tried to ascertain the effect of the rest of the plant on leaf fall. At left is a "two-sided" pattern; at right, a "spiral" pattern.

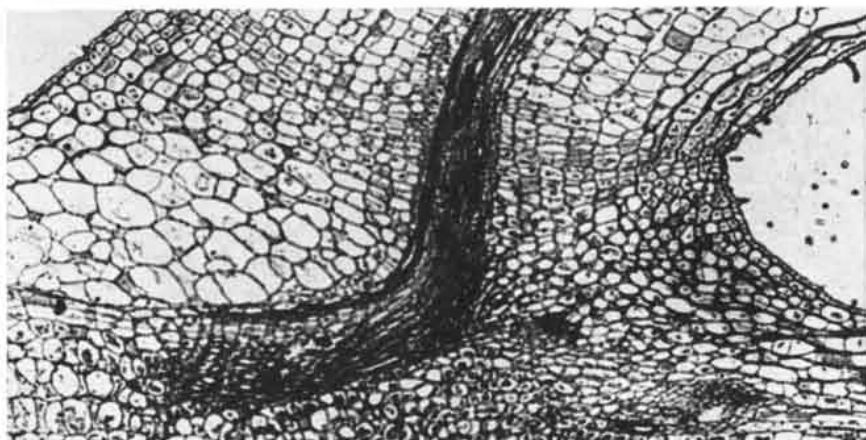
The oldest leaves produce little or no auxin.

Quantitative experiments, in which synthetic auxin was applied to debladed leaves in the amounts that would normally be manufactured by the blade, showed that it had exactly the same effect in inhibiting leaf fall. The general conclusion was that auxin produced in the leaf blade moves down into the leaf stalk, and there inhibits leaf fall in direct relation to how much auxin there is. This conclusion was confirmed in a qualitative way for the leaves of other plants and for a number of kinds of fruits. In fact, spraying apple trees with auxin has become a fairly routine method of preventing premature dropping of the fruit.

The control of leaf fall by auxin seemed to be completely clear. It was,

in fact, *too* clear. As often happens when our interpretations of nature seem marvelously simple, the simplicity turns out to reside in us, not in nature.

While thinking over this theory of leaf fall, I was struck by the odd circumstance that each leaf seemed to be acting as an independent entity. The theory implied that the fall of a leaf depended only on how much auxin was coming into its stalk from its own blade. Now in most cases that we know of, the behavior or development of one part of a plant is subject to inhibitions and stimulations from other parts of the plant. One therefore had to suspect the completeness of the hypothesis that leaf fall was totally independent of influence from the rest of the plant. Furthermore, while the hypothesis seemed to explain what pre-



SEPARATION LAYER in the leaf stalk was an early, but misleading, clue to the process of leaf fall. It is the band of smaller cells running across the top of this photomicrograph.

vented leaves from falling, it left unclear what causes them to fall when they do.

With these thoughts in mind, we planned some experiments to try to detect influences from the rest of the plant. These involved trials of various patterns in deblading the leaves of a plant. Coleus leaves grow in pairs, the two members of each pair coming from opposite sides of the stem [see drawing on page 82]. The usual practice had been to deblade one of each pair, leaving the "sister" leaf intact as a control. Now if the fall of each leaf was controlled independently within itself, it should be immaterial in what pattern the leaves up the stem were debladed, or how many of them were. But experiments showed that the pattern of deblading did make a consistent, though small, difference in the time of leaf fall, and that when *all* the leaves (except those in the bud at the apex of the stem) were debladed, the fall was strikingly slowed down!

The most obvious conclusion was that the presence of intact leaves in some way speeded the fall of debladed leaves. Indeed, their presence accelerated the fall even of old leaves that were not debladed, for when the blades were removed from all the younger leaves, the old ones remained on longer than they would have otherwise.

It seemed, then, that leaf blades produce not only a substance (auxin) which inhibits falling but also a substance which speeds falling. What might this substance be? The most likely candidate was ethylene. This ingredient of illuminating gas has long been known to cause trees' leaves to fall, and recently it has been learned that some ethylene is naturally present in plant tissues; it is emitted by ripening fruit and by leaves. However, we were unable in an extensive series of experiments to find any evidence that ethylene from leaves speeded leaf fall.

Although we scoured the research literature, we could find no other leads that proved fruitful. We therefore decided to look more closely at the experimental plants. It was then we noticed something we should have seen before. In every experiment we had left untouched the tiny leaves in the apical bud at the top of the stem. And every treatment that speeded the fall of leaves lower on the stem had at the same time accelerated the growth of the apical leaves. We now noticed a clear correlation between this growth and the time of the debladed leaves' fall. They fell just when the bottom leaves of the apical bud above them reached a length of 70



ART IN SCIENCE

Still available—a limited number of copies of ART IN SCIENCE, a portfolio of paintings, drawings and photographs first published in SCIENTIFIC AMERICAN during the past six years.

The collection is representative of this magazine's use of the graphic arts in the communication of science.

Bernarda Bryson, Antonio Frasconi, Rudolph Preund, John Langley Howard, Joseph Low, David Stone Martin, Stanley Meltzoff, Eric Mose, Walter Murch and Ben Shahn are among the distinguished artists whose work is presented.

Included in the 32 plates are 22 SCIENTIFIC AMERICAN covers in full color.

Handsomely boxed, printed on heavy coated stock 11 by 13 inches, the plates are suitable for framing.

An essay by Gyorgy Kepes, Professor of Visual Design at Massachusetts Institute of Technology, introduces the collection.

If you have not yet ordered a copy for yourself or would like to have one sent as a gift, this may be your last opportunity.

Please fill out the coupon below.

ORDER YOUR COPY TODAY

SCIENTIFIC AMERICAN
Dept. S, 2 West 45th Street
New York 36, N. Y.

Please send me the portfolio, ART IN SCIENCE, published by Simon and Schuster.

I am enclosing \$6.00 for each copy.

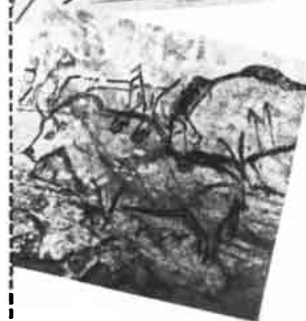
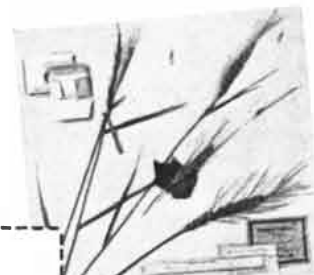
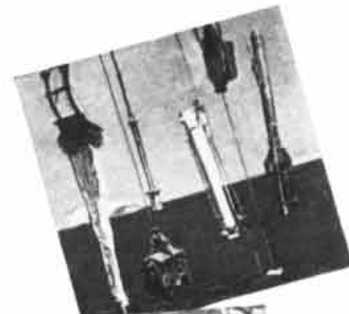
Name _____

Address _____

City _____ Zone _____ State _____

(New York City residents please add 3% Sales Tax)

A PORTFOLIO
OF 32
PAINTINGS,
DRAWINGS
AND
PHOTOGRAPHS
FROM
SCIENTIFIC
AMERICAN



BALLS

• All Materials

Tungsten Carbides	Magnesium
Chromium Carbides	Pyrex Glass
Synthetic Sapphire	Silver
Stainless Steels	Teflon
High Speed Steels	Carbon
Titanium	Nylon
Zirconium	Ceramics
Aluminum	Cast Iron

...and any other workable material

• All Sizes— Standard and Special

from 1/32" to 6" or larger.

• Any Quantity

from 10 balls to millions.

• High Precision—

to .000010" on size and sphericity.

• Engineering Service

On request, our Engineering Department will assist in selecting the material and other characteristics required for best service on specific applications.

WRITE FOR quotation and descriptive bulletin.



NUCLEAR AIRCRAFT
POWERPLANT CONTROLS

ENGINEER

This is an unusual opportunity for a Project Engineer who can assume full responsibility for developing controls for a nuclear-powered aircraft engine.

To qualify, you must have 10 to 15 years of pertinent experience. This must include 5 to 7 years' development or analytical work on aircraft powerplant control systems.

At least a B.S. degree is required from an accredited college. Degree must be in Mechanical, Electrical or Aeronautical Engineering.

The man selected will have unequalled facilities at his disposal, for this opening is in the engineering department of Pratt & Whitney Aircraft—world's largest designer and builder of aircraft engines.

Attractive salary and employee benefits. Good schools and excellent living conditions in pleasant upper Connecticut.

Please send complete resume covering education, experience and accomplishments to Employment Supervisor.

**PRATT & WHITNEY
AIRCRAFT**

DIVISION OF UNITED AIRCRAFT CORP.

EAST HARTFORD 8, CONNECTICUT

to 80 millimeters. Fast leaf fall seemed to be closely tied up with the presence just above of leaves 70 to 80 millimeters long.

Why should this particular length of the apical leaves be so important? The answer is that when a leaf reaches this size it attains its maximum production of auxin. It was beginning to look as if the primary cause of speeded leaf fall was auxin production by the apical bud leaves above the debladed leaves. Further analysis indicated that the presence of intact leaves lower on the stem speeds leaf fall indirectly by speeding the growth of these apical leaves.

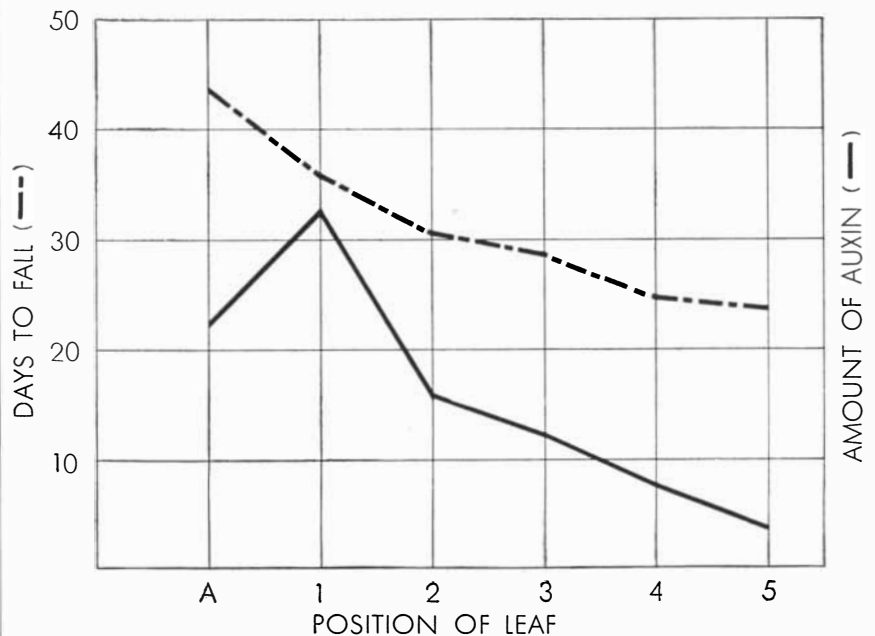
This view was confirmed by the following experiment. Many plants were prepared in which the young leaves were debladed and the older leaf pairs left intact. As in earlier experiments, the presence of the older leaves low on the stem speeded the fall of the debladed leaves above them, so long as the apical bud was left intact. But when the apical bud was cut off, the debladed leaves in that set of plants fell much more slowly. If, however, synthetic auxin was applied in place of the cut-off bud, the debladed leaves fell as fast as if the bud were on. Thus the experiments confirmed our surmise that auxin from the apical bud speeds the fall of debladed leaves.

These experiments, along with others which there is not space to describe, show that the fall of leaves is controlled by an "auxin-auxin balance." Auxin both

slows and speeds leaf fall. So long as a leaf's own blade produces enough auxin to overcome the effect of auxin coming from younger leaves above, the leaf will stay on the plant. But as soon as its production of auxin drops to less than the critical rate—because of old age, too much shade, insect attack or deblading—the auxin from the younger, more vigorous leaves above causes the leaf to fall. Such a system has obvious adaptive value. The old and infirm are shed by the action of a hormone from the young and vigorous.

It is a great surprise that the same hormone should act as both the stimulator and the inhibitor of leaf fall. Apparently its contrary effects depend simply on the direction from which it comes. We can only marvel at the frugality of nature, which has endowed plants with a single hormone that can do so many different things.

So much for Coleus. How much of this applies to trees? Since detailed experiments of the sort described here have never been done with trees, we do not know. In fact, it seems unlikely that such experiments ever will be done on trees: to perform tree experiments equivalent to those with our 3,000 genetically identical Coleus plants one would need some 10,000 trees grown from seed. However, there is reason to believe that an auxin-auxin balance is at work in trees as in Coleus. Artificial lengthening of the daylight has been found to increase the



AMOUNT OF AUXIN produced by each leaf (right) is related to the number of days it takes the leaf to fall (left). The position of the leaf on the stem of the plant (bottom) is indicated by the symbols used in the drawing at the right in the illustration on page 82.



PROGRESS THROUGH ANACONDA METALS

Alloys that help make boating more fun, less care



Typical boat fittings and fastenings of Everdur

THE PROBLEM: If you've steel-wooled rust from a pair of pliers—if you've heard a squall scream through rigging—you know the problem. Fastenings and fittings on sailboats—cleats, hardware, and the nails or screws that fasten planking *on all boats*—must be tough, dependable, and corrosion-resistant if boating is to remain a carefree pleasure.

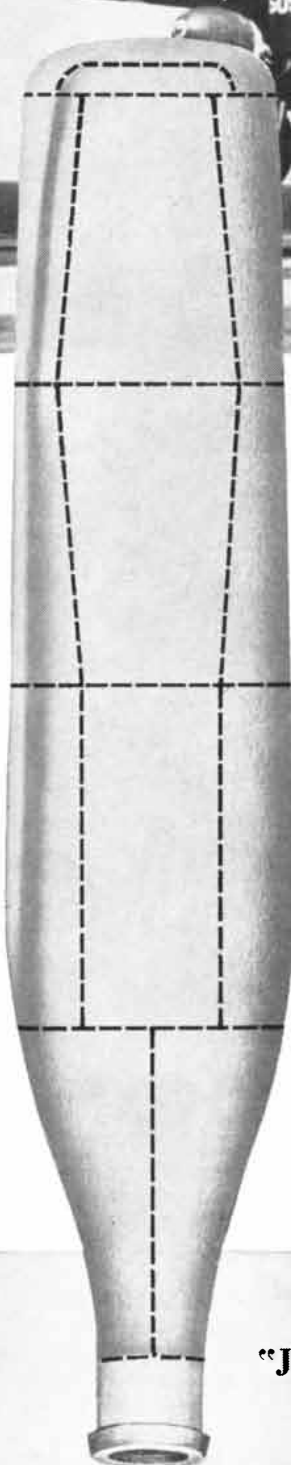
THE SOLUTION: When Anaconda developed Everdur®, its famous family of copper-silicon alloys, marine architects and boatbuilders had for the first time a single type of metal to meet a wide variety of marine applications. It resists corrosion. It has the high strength and toughness required; parts can be made smaller, consequently lighter. It is available in cast parts and forms that can be fabricated easily into forgings, screws, bolts and hardware. Everdur has become standard for all types of boat—from large racers to \$49 do-it-yourself kit boats.

THE FUTURE: If you are buying a boat, look for Everdur, Anaconda's exclusive alloys—the sign of quality for more than 25 years. Everdur has many uses on land, too—for tanks, welding, outdoor electrical connectors. In the field of nonferrous metals, Anaconda offers the world's most complete line of alloys and metal products, as well as a full line of electrical wire and cable. Take advantage of Anaconda's experience—talk to the *Man from Anaconda* about your special problems. *Anaconda, 25 Broadway, New York 4, N. Y.*

55232

THE ANACONDA COMPANY

How we work steel to make steel work for you



"WHRRR'RING!"

Unique A. O. Smith process offers industry four benefits

Perhaps you can capitalize on A. O. Smith's experience in mass production of military aircraft propeller blades.

For this critical job, we developed a unique manufacturing method. To make each hollow steel blade, *seventeen pieces of steel were precision-forged and contour rolled . . . then automatically welded together.* Result: a 4-way pay-off — (1) LIGHTER, (2) STRONGER blades . . . produced in (3) LESS TIME and at (4) LOWER COST.

The techniques employed here may

provide the answer to your production problems. It's possible, too, that you can make good use of other A. O. Smith successes in the field of aviation. Our experience includes volume production of aircraft landing gear, structural airframe components and other products in a variety of metals.

Write for comprehensive brochure that describes the special skills of A. O. Smith's Aeronautical Division . . . also tells of the many other ways *we work steel to make steel work for you.*



"Jigsaw" puzzle
... perfectly solved

Dotted lines on hollow steel propeller blade show where welding joined the seventeen precision-forged, contour-rolled steel pieces.

Through research  ... a better way

A.O. Smith

C O R P O R A T I O N

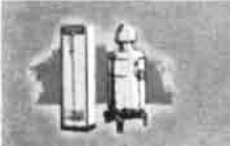
MILWAUKEE 1, WISCONSIN

11 plants in New York, New Jersey, Pennsylvania, Ohio, Wisconsin, Illinois, Texas and California.


International Division: Milwaukee 1, Wisconsin

A.O. Smith
CORPORATION
MILWAUKEE 1, WISCONSIN


... where creative work
with steel makes products
like these for home,
farm and industry




Permaglas
and Burkay water heaters




Permaglas
home heating and
cooling systems




Glass-lined and
stainless tanks




Glascoite
processing equipment



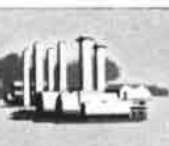
Vertical
turbine pumps



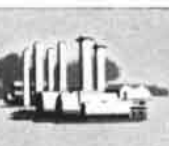
Line pipe,
oil well casing



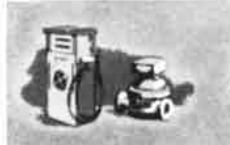
Harvestores
for the farm




Permaglas Storage Units
for industry




Pressure vessels,
heat exchangers,
glass-lined smoke stacks




Gasoline dispensers,
liquid meters



Welding machines,
electrodes, accessories



Electric motors

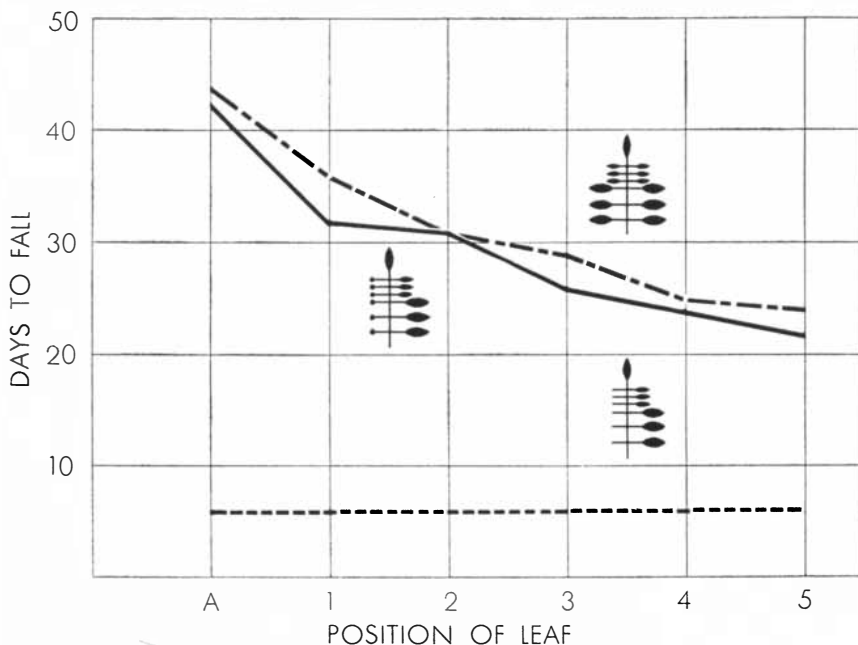


Automobile
frames

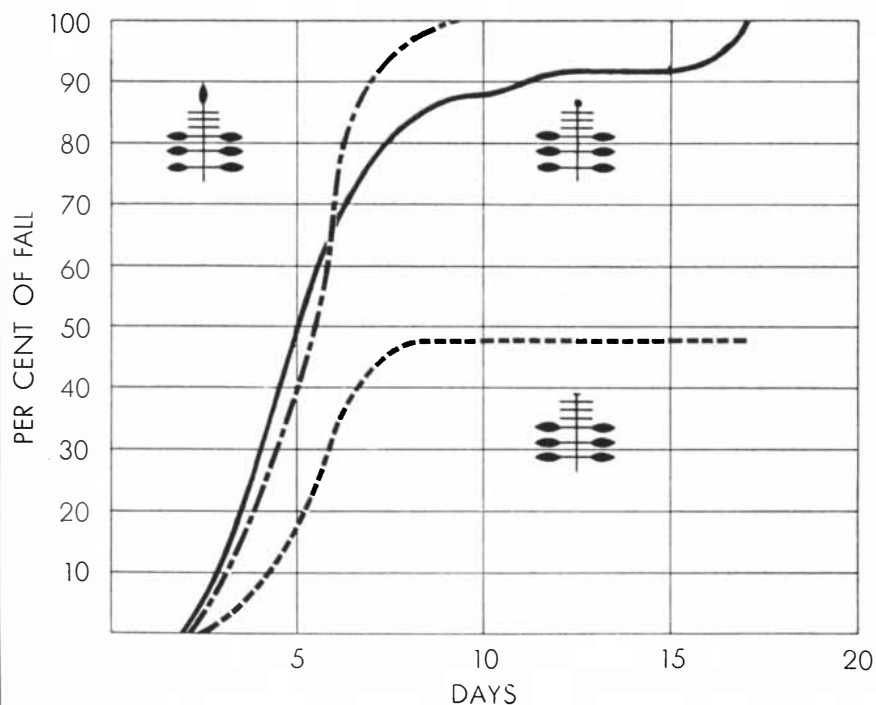
amount of auxin produced by the blades of tree leaves. The fast growth of a new branch in spring is accompanied by the production of a big gush of auxin by the new branch, which presumably speeds the fall of the older leaves.

There is as yet no evidence as to the role of auxin in the shedding of leaves by trees in the autumn. But until more

specific evidence is available, we will adopt the biologist's usual attitude in such cases: "Organisms are presumed the same until proved different." According to such a view the leaves of a tree, like the leaves of *Coleus*, remain on the tree until their own production of auxin becomes so small that auxin produced by other leaves can force them to fall.



REMOVAL OF LEAF BLADES in a spiral pattern caused their stalks to fall sooner (*bottom curve*). When the blades were removed, but auxin applied to the cut stalks (*middle curve*), the stalks fell at about the same time as the intact leaves of a normal plant (*top curve*).



REMOVAL OF APICAL BUD cut the fall of debladed leaves (*short dashes*), compared to plants with the leaves off but the bud on (*long and short dashes*). When the bud was replaced with auxin, the rate of fall (*solid curve*) was much the same as in the plant with the bud.

ETRUSCAN METALLURGY

Ancient Etruria, which extended roughly from Rome to Florence, was the birthplace of metallurgical industry. Today metallurgists seek the formula of its remarkable bronze and mine its slag heaps

by Aldo Neppi Modona

The Etruscan civilization bloomed in central Italy from the seventh to the first century B.C. It is one of those ancient cultures whose birth and death are surrounded with a certain degree of mystery. Like an exotic flower, the brilliant Etruscan civilization sprang up as if from nowhere and disappeared

in the same way. Historians are not entirely certain about who the Etruscan people were, though the evidence now seems fairly clear that they came from Asia Minor and the islands of the Aegean Sea, settled on the west coast of Italy on the shores of the Tyrrhenian Sea and gradually spread over the middle of the

Italian peninsula. By the fifth century B.C., at the height of their power, the Etruscans were the masters of all central Italy from the Po River on the north to the provinces around Rome on the south. But when, some four centuries later, the Romans marched forth to conquer an empire, the Etruscan civilization was



ETRUSCAN PITTSBURGH was Populonia, now the site of a mere hamlet. Here ore from Elba and the Metallurgic Mountains was

smelted, and metals shipped all over the Mediterranean. Medieval castle stands on the foundations of the ancient city's citadel.

completely swallowed up. Its writings and language disappeared; its cities withered away, and its arts and industries were eventually buried under the soil blanket of time.

It was the archaeologists who rediscovered the Etruscan culture. In the 18th century they began to dig into the long-buried Etruscan sites, and they turned up astonishing treasures. Paintings, sculptures, jewelry and beautiful metal work came from the diggings in a rich stream. Etruscan objects of art now adorn museums all over Europe and in America. Etruscan architecture attracts visitors from every land to the exhumed towns of ancient Etruria. But to modern eyes perhaps the greatest marvel is the Etruscans' metallurgy. It was carried out with such skill and on such a scale that Etruria can justly be called the birthplace of civilized man's metallurgical industry.

The rediscovery of the magnitude and character of the Etruscans' metallurgy began only a few decades ago. In the early years of the 20th century the rebuilders of Italy drained and reclaimed a deserted stretch of the Tyrrhenian coast which for centuries had been a malaria-ridden marshland. Practically the only surviving settlement along this stretch of coast was a hamlet called Populonia—a small cluster of houses within the crumbling stone walls of an ancient castle. After the land had been reclaimed, geologists visiting the area were greatly interested by a curious range of rounded hillocks that dotted the flat coastal plain near Populonia. When they dug through the surface earth, they found it to be underlain by what appeared to be a dark, spongy soil. This material did not at first receive much attention, for further digging soon unearthed a large cemetery of ancient Etruria.

One after another, three distinct layers of tombs emerged in Populonia's necropolis—city of the dead. At the top were Roman tombs of the first and second centuries B.C. Beneath these were Etruscan tombs going back several centuries earlier. And at the lowest level were simple circular graves of the Iron Age, dating from about the eighth and ninth centuries B.C. All the tombs contained ornaments, tools and other objects, since the Etruscans, like other peoples of antiquity, buried the deceased's favorite personal possessions with him, believing that they would be of use in the nether world. Thus archaeologists have been able to trace at Popu-



BRONZE HAND MIRROR has fine detail incised in its decorative back. Although the metal is impure, the Etruscans had an unknown process for molding it with a perfect finish.

Brown Converters



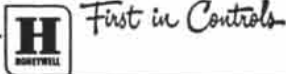
—for low noise,
highly stable
servo circuit service

60 cycle type

Ideal for converting low-level d-c to a-c, these precision-made components are designed for exceptionally low noise level and freedom from stray pick-up. Synchronous "make before break" contact action eliminates inductive transients. Rugged design assures long service life. Operate in any position. Nominal frequencies are 25, 40, 60 and 400 cycles. Write for Data Sheets No. 10.20-5 and 10.20-1.

MINNEAPOLIS-HONEYWELL REGULATOR Co., Industrial Division, 4580 Wayne Ave., Philadelphia 44, Pa. —in Canada, Toronto 17, Ontario.

Honeywell
BROWN INSTRUMENTS



Here's why **RULON** solves bearing problems

RULON is a unique new oil-free bearing material for light loads. Developed through original basic research on friction, Rulon never requires lubrication because very low friction coefficient is *inherent*. Excellent abrasion resistance. Chemically inert, extremely resistant to chemical corrosion. Zero water absorption. Operates without distortion submerged in water and most acid or alkali solutions. Exceptional anti-hesiveness, cannot accumulate dust, dirt, air-borne sediment. Readily sterilized, resists temperature extremes — 100°F to over 400°F. Special electrical properties adapt it to electro-mechanical applications. Supplied in any form, completely finished or for machining in your own plant. Already used in widely varied applications, but potential largely untapped — Rulon may solve *your* problem. 20 Data Sheets available giving special properties, case histories, all details. Request without obligation.

DIXON CORPORATION
Bristol, Rhode Island

Advertisement

lonia the evolution of the Etruscans' customs, crafts, architecture and industries through the centuries of their flourishing civilization.

The architecture of the tombs shows the Etruscans' progressive development of the vault: the earliest tombs were pits in the shape of a well, capped with a pseudo cupola built cone-fashion with successively narrower blocks of stone set on one another; the later tombs were

square chambers surmounted with a true vault and a round cupola. This later style, beginning in the eighth century B.C., shows traces of oriental influence—support for the theory that its builders came from the Near East.

The Populonia graves yielded finds of great historical and documentary interest: in the earliest tombs there were glass necklaces, bronze rings and bracelets, fine specimens of bronze oil lamps and



BRONZE HELMET AND LAMP are typical of the well-made metal artifacts that have been found in Etruscan tombs. Oil lamps of this design still light some homes in rural Italy.

many other significant objects; the later graves contained coins, mirrors, ivories, helmets, beautifully decorated vases, gold and silver ornaments laced with the finest filigree, large bronze ritual fans, parts of chariots and an exquisitely wrought statuette of Ajax in the act of killing himself.

But among all the excavations at Populonia none was more exciting than the uncovering of its principal industry—metallurgy. The hillocks at the site of the ancient city, now covered with grass, wheat and olive groves, proved to be huge heaps of slag from the Etruscans' forges and furnaces. Three striking evidences of the importance of this industry have been uncovered at Populonia: first, a furnace area which spreads over nearly 45 acres and contains masses of slag totaling upward of two million tons; second, great heaps of ore at the Populonia harbor, where they were unloaded from ships; and third, a smelting and refining area beneath the castle, or citadel, of the ancient city.

Populonia was clearly the industrial center and most important commercial town of the Etruscans. Indeed, the city was renowned in antiquity; it is mentioned in the writings of both Greek and Roman historians. The heavily fortified town (its citadel walls were built of enormous stones) guarded a rich region of minerals, which were the source of the Etruscans' prosperity. Six miles offshore from the city lies the island of Elba, with a fabulous wealth of iron ore. Behind the town is a hinterland of mountains with a profusion of minerals which have been known and mined since prehistoric times. It abounds in iron, copper, tin, lead and silver ores—colorful minerals bearing romantic names such as cinnabar, ocher, ironstone, galena, blende, ilviate, tourmaline and cassiterite.

The Etruscan prospectors appear to have been endowed with exceptional, not to say supernatural, gifts for discovering minerals. Without any of the technical aids now at our disposal, they managed to stake out most of the principal riches in the undersoil of central Italy. They mined copper and iron on Elba, and tin, copper, lead, iron and silver in other parts of Etruria. By digging small test pits they traced the bounds of the underground veins and then excavated shafts to take the ore. These underground caves also served a religious purpose, affording a means for a devout approach to the Etruscans' underground deities.

The mines were worked by gangs of slaves, convicts and prisoners of war,

for Christmas and all of 1956



For Christmas and all of 1956, you couldn't choose a more perfect gift for your science-minded friends and associates than a subscription to SCIENTIFIC AMERICAN. Whether they are professionals in science, students, or informed laymen, they will be enjoying their issues and thanking you for them long after most people have forgotten other gifts.

Take advantage of the low gift rates by sending your gift list today. Each of your friends will receive an attractive Christmas Card to inform him of your thoughtful gift.

P. S. If you are not now a subscriber, this is a timely opportunity for you to take advantage of this Christmas subscription offer.

Special Christmas Gift Rates:

Your own subscription or first gift	\$5.00
Second subscription	4.00
Additional subscriptions	3.50

Please **ENTER** the following Gift Subscriptions to

SCIENTIFIC AMERICAN

To _____

NAME

STREET ADDRESS, CITY, ZONE, STATE

From _____

TITLE, BUSINESS CONNECTION

GIFT CARD TO READ

To _____

NAME

STREET ADDRESS, CITY, ZONE, STATE

From _____

TITLE, BUSINESS CONNECTION

GIFT CARD TO READ

YOUR NAME _____

YOUR ADDRESS _____

STREET ADDRESS, CITY, ZONE, STATE

11-5

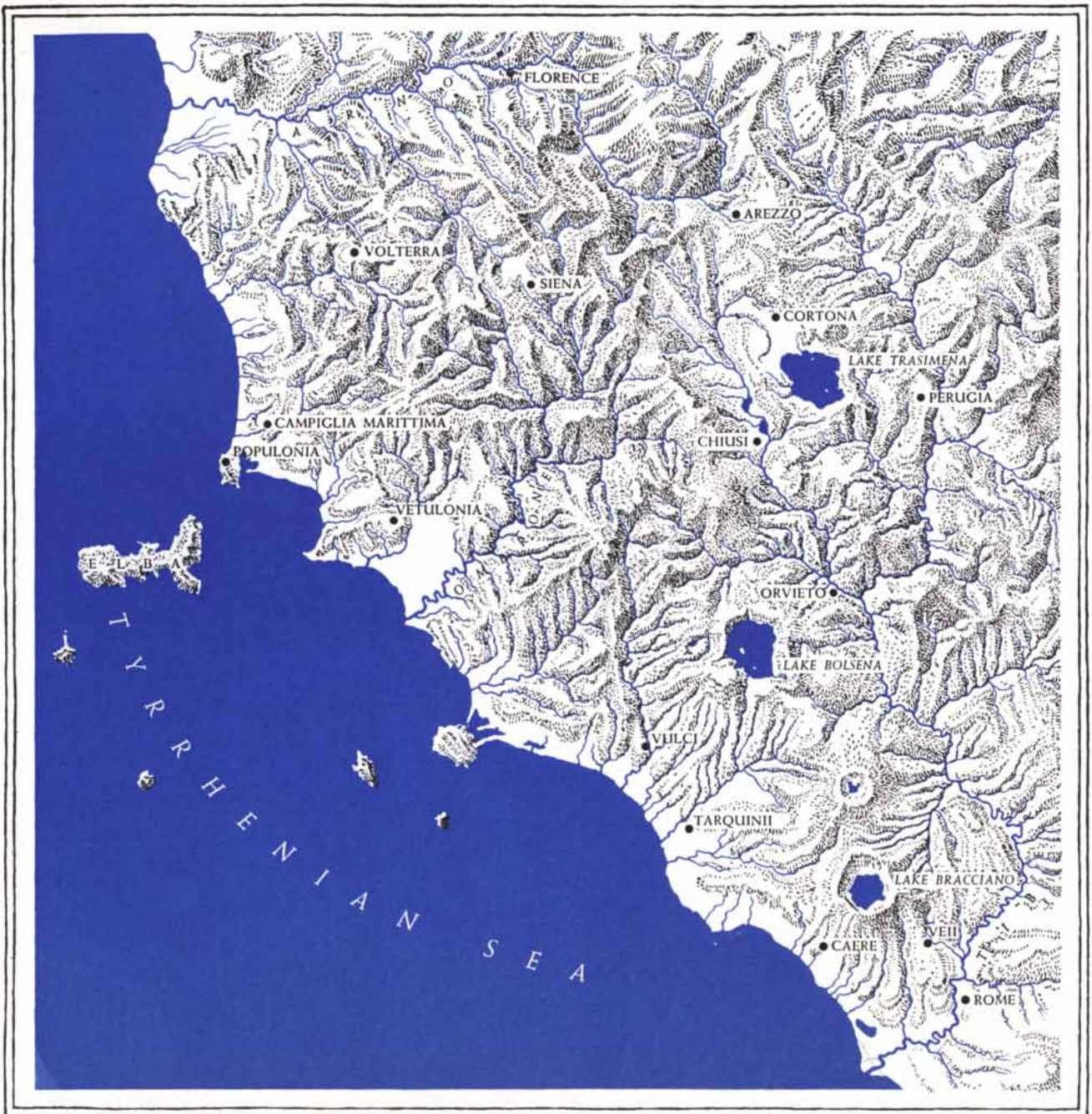
Also enter or extend my own subscription for a year as part of this order.

Enclosed is \$ _____ for _____ subscriptions.

Bill me later.

ABOVE RATES FOR UNITED STATES ONLY. CANADA AND LATIN AMERICA: ADD \$1.00 TO DOMESTIC RATES FOR EACH SUBSCRIPTION. FOREIGN: ADD \$3.00 TO DOMESTIC RATES FOR EACH SUBSCRIPTION.

2 WEST 45TH STREET **SCIENTIFIC AMERICAN** NEW YORK 36, N. Y.



ANCIENT ETRURIA was based on the area between the Tiber and the Arno. Towns no longer inhabited are labeled with their historic

names. At the height of their power the Etruscans colonized the Po Valley and the Adriatic shore and dominated the Tyrrhenian Sea.

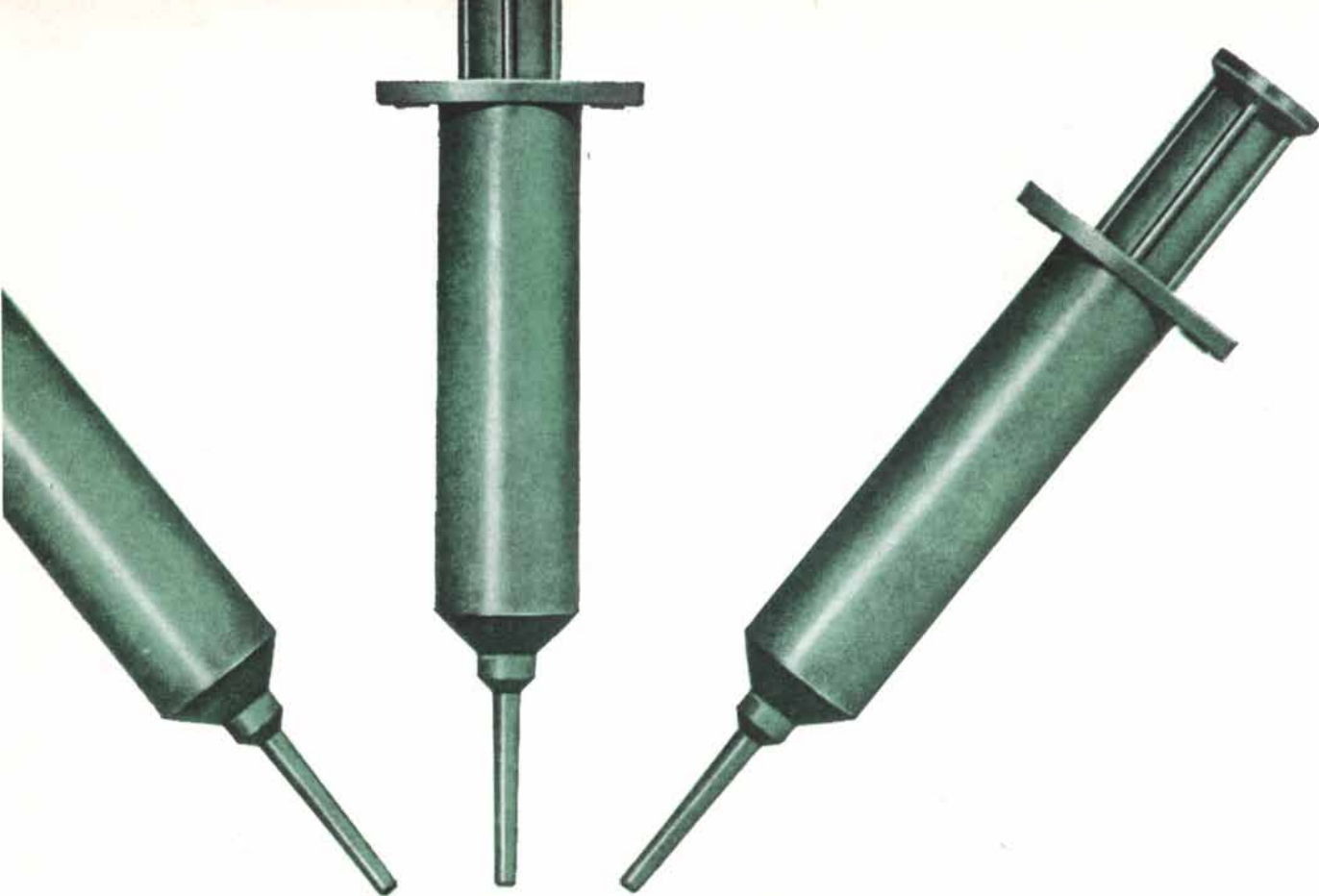
who quarried the ore with crude tools and carried it out in leather or wicker panniers on their backs. The earliest miners used tools of wood and flint, and the mines were shallow, open pits. After iron implements were developed, the Etruscans dug the pits much deeper and reinforced them with stone props and pillars. The still later mines of Roman times had air shafts and a network of intercommunicating galleries.

The furnaces for treatment of the ores were built as near as possible to the mines themselves. A few of the ancient

furnaces have been found in fairly good condition in the Val Fucinaia (Valley of the Forges), not far from Populonia. Completely covered with earth except for a front opening, the furnaces were built of sandstone, with a clay plaster over the interior and in all joints. They were conically shaped, about six feet across at the base and five and two thirds feet at the top. A horizontal partition made of small blocks of quartz porphyry divided the furnace into two chambers, with holes cut in the partition. The upper chamber was filled with ore, and the

fuel—usually charcoal—was burned in the lower one.

The Val Fucinaia furnaces were evidently used for roasting copper ore; the slag piles near them contain a good deal of copper mineral. Roasting separated the copper from sulfur and from iron and other metals that were mixed in the minerals. Elsewhere in Etruria iron was extracted in much the same way. The iron ore was first roasted in the upper chamber to free it of sulfur and water; then the treated ore was laid in alternate layers with charcoal and smelted to pro-



Syringes made of **TENITE POLYETHYLENE** are non-reactive, non-toxic and inexpensive enough to throw away after one use

These veterinary syringes made of Tenite Polyethylene are a new idea. They are both container and dispenser for drugs.

Pharmaceutical firms load them with the right dosage of a specific drug and sell them as single-treatment packages.

Veterinarians or farmers buy these pre-loaded syringes, administer the drugs to the animals and then throw the syringes away. There's no re-use of the syringe, there's no chance to infect other animals. Since Tenite Polyethylene is reported chemically inert to these sensitive drugs this means complete protection with no danger of contamination or chemical reaction.

Ideas like this are expanding the use of versatile Polyethylene. Today, applications include packaging film, molded products, wire and cable in-

sulation, pipe and tubing, paper coatings and unbreakable containers of all types.

Does Tenite Polyethylene give you ideas? Perhaps you have a product that could be given more sales appeal, better performance or longer life if made of Polyethylene. If so, make it of *Tenite Polyethylene*.

There are many advantages to specifying Tenite Polyethylene. This Eastman plastic comes in the form of spherical pellets that flow freely through molding and extrusion machine hoppers. Their smooth surfaces resist dirt and, because there are fewer "fines," molders can clean hoppers quickly when changing colors. In addition, you get outstanding color quality, homogeneous color dispersion and a finish that approaches the smooth, lus-

trous surfaces obtained with plastics of much greater inherent hardness.

For advice and more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
POLYETHYLENE
an Eastman plastic



SAVINGS in STEEL

NOW POSSIBLE WITH THE NEW

Alumicoat

Molten Aluminum Coating Process

In many cases, expensive high alloy strategic steels may be replaced with low alloy steels which have received the ALUMICOAT Molten Aluminum Coating Process. Under high temperature conditions, these low alloy steels would ordinarily oxidize and scale, but after the application of the ALUMICOAT Process, they have proven superior to strategic alloy steels.

TABLE SHOWING ALUMICOAT PROTECTION				
Steel Samples	Temp. F.	Time hrs.	Change in Weight*	
WITHOUT ALUMICOAT				
18-8 Chromium Nickel	1,350	24	- 17.0%	
25-20 Chromium Nickel	1,350	4	- 8.3%	
27% Chromium Steel	1,350	24	- 8.4%	
WITH ALUMICOAT				
Plain Steel	1,350	192	- 0.1%	
18-8 Chromium Nickel	1,350	192	- 0.1%	
Plain Steel	1,700	48	- 0.3%	
18-8 Chromium Nickel	1,700	48	0.0%	

*After corrosion scale was tapped off.

The above table showing ALUMICOAT protection, is a factual report of the protective capacities inherent in the application of this process to different metals at different conditions.

The Alumicoat Process has been successfully applied to Jet Aircraft Components, Petroleum Refinery Equipment, Exhaust Manifolds, Diesel Engine Components, etc. Full details of the Alumicoat Process will be furnished upon request.

ARTHUR TICKLE ENGINEERING WORKS, INC.
21-A Delevan Street Brooklyn 31, N. Y.



Licked by a Dragon?

Don't let the problems of miniaturization tie you up!

Send today for our new free

24-page catalog, describing 450 types and sizes of MPB's* such as these

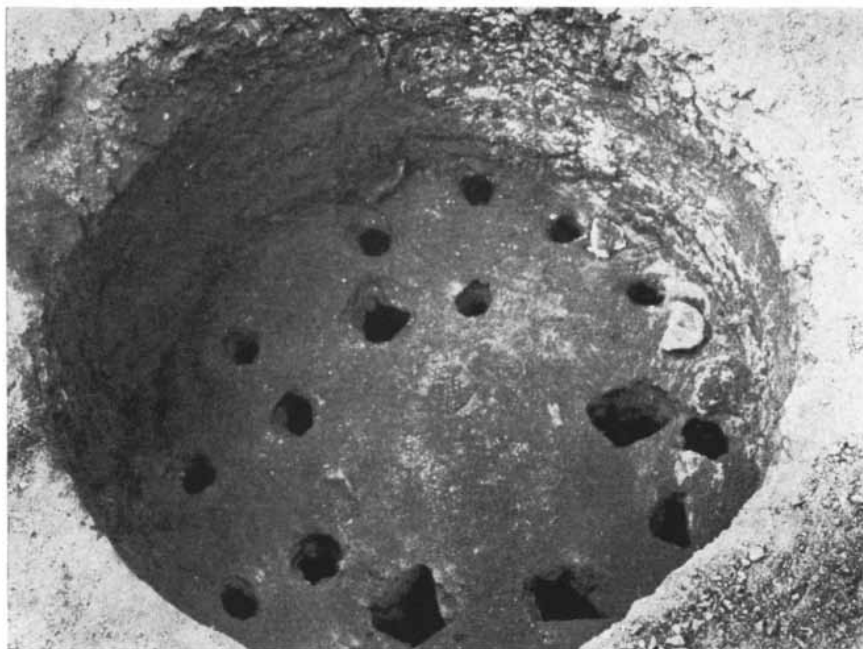


BALL BEARINGS ACTUAL SIZE

*MINIATURE PRECISION BEARINGS, INC.
19 Precision Park, Keene, N. H.

Please send MPB's new Catalog to

Name.....Title.....
Company.....
Street.....
City.....Zone.....State.....



CONICAL FURNACE unearthed in the Valley of Forges is almost six feet in diameter. The perforated partition supported the ore, which was roasted by charcoal in a lower chamber.

duce a spongy iron. The sponge iron was either forged into tools and implements or molded into pig iron for export.

The Etruscans exported iron to all the countries of the ancient Mediterranean world, and particularly to Greece, whose terrain has always been poor in metals. This trade accounts for the outstanding importance of Populonia in the Etruscans' industry. The city not only had an excellent natural port but was also surrounded with supplies of minerals and of stone and clay for its furnaces. Moreover, thick forests nearby furnished an abundance of fuel. Thus Populonia was ideally placed to be a great center of industry and commerce in the ancient world. From this capital the Etruscans made treaties with other Mediterranean countries, established maritime laws and spread abroad to other lands their culture, art and mastery of metalcraft.

The Etruscans' skill in working metals was unsurpassed in the ancient world, and in some respects it is unequalled even today. They made marvelous ornaments of precious metals, with the finest embossing and filigree. But even more remarkable was their production of bronze, the secret of which has never been rediscovered. The Etruscan bronze was so beautiful and so perfectly fused that a research center has been established in Florence to investigate what can be learned from the Etruscans' metallurgy. Their bronze was created not by science but by artistic genius.

Bronze today is manufactured according to precise formulas. The Etruscans made theirs by some empirical method. Their metals were highly impure, but they evidently knew how to turn these very impurities to advantage. By a series of smeltings, in which they solved the problems at each stage in intuitive fashion, they produced an alloy of matchless beauty and resistance. Their method of fusing bronze enabled them to run the molten metal into molds in extremely thin layers, so that the minutest details have a perfect finish. Even after iron came into general use, the Etruscans continued to employ bronze, sometimes using both metals together: some of their objects had a decorative design in iron inlaid in bronze.

When the Romans conquered Etruria and absorbed the Etruscan civilization, its mining and metal industries swiftly declined. The Roman conquerors found more attractive mineral riches in Gaul, Britain, Spain and Sardinia. And after the fall of the Roman Empire, Etruria like the rest of Italy was overrun by barbaric tribes who obliterated the last traces of its industry.

Today, after centuries of oblivion, the ancient metallurgical industry of central Italy has been revived. The archaeologists' discovery opened an unexpected bonanza for economic exploitation. The slag heaps of the Etruscans contain a great deal of rich and usable mineral. Since their wood fuel could not heat the ore above about 800 degrees centigrade,

BUSINESS IN MOTION

To our Colleagues in American Business ...

Last year a famous manufacturer of domestic refrigerators decided that an automatic juice dispenser would be a desirable feature for special models of its 1955 line. It was known that in many homes two kinds of concentrate are regularly stocked in the refrigerator. One is orange, the other may be lemon, lime, or some other juice. Two containers for concentrate were therefore required, size one pint each, plus a two-quart water tank, with appropriate connections with the household water system, and a metering mixing valve. Thus it would be possible for the housewife, or her children, to push a button or otherwise operate the valve, and obtain juice properly mixed with the correct amount of chilled water.

As is always the case with any good new idea, reducing it to practicality required a lot of hard work. The mixing valve was readily obtainable from a valve specialist. Unexpectedly, difficulties arose in connection with the water tank. This is made of red brass, 85/15. Two almost identical one-quart cups are drawn from soft strip, the seam brazed, the necessary water connections brazed in, and the outside tinned.

This would seem to be a simple operation, but Revere was told that there was too much breaking and tearing of the brass in drawing. Although at that time we were not supplying the brass, we were glad to work with the firm which had the tank contract. The Revere Research Department reported that the

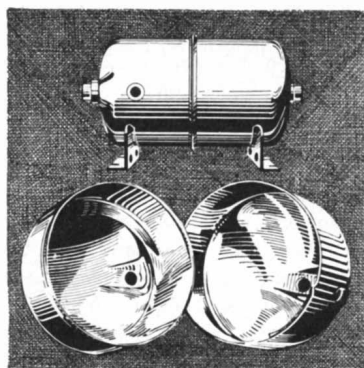
grain size of the unsatisfactory metal varied between .035 and .050 mm., and that holding the size closely to .050 mm. would cure the difficulty. In addition, suggestions were made as to die design, and die lubricants. Revere also was asked the reason for defects in brazing. This became another project for Revere Research, which sent a man to the plant to study the methods used. After some special work in the laboratory at Rome, N. Y., it was found possible to make a successful adjustment of conventional brazing

methods to the ones the fabricator wished to use. Still further, Revere's Methods Department recommended changes in the beading operation, ending breaking there. A Call Report written at the end of all this work states that the customer "is very enthusiastic in his praise."

Refrigerators with this new and enticing feature entered the market on schedule last spring. No premium was charged by Revere for the metal required,

nor was there a fee for our collaboration, which we render as a part of our service to American industry.

Manufacturers in a great many lines develop new ideas and new products constantly, as a part of the competitive process. If you encounter problems when you try to put something new into production, why not call in your suppliers? They know their materials, whether they be metals or plastics, glass, wood or whatever. Their knowledge added to yours can be worth a lot, yet it is free.



REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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

FREE BULLETIN

on

SURFACE ROUGHNESS

tells..

- What surface roughness consists of.
- How to establish roughness specifications for parts that are in production—and for parts of new design.
- How to show roughness specifications on drawings and shop prints.
- Practical advantages of numerical roughness specification.

ALSO gives tips on MEASURING surface roughness in the shop—and briefly tells why most plants use the PROFLOMETER® for doing this.



Write Today!

Ask for Bulletin LT72.

Profilometer is a registered trade mark.



**MICROMETRICAL
MANUFACTURING COMPANY**

337 S. MAIN ST. ANN ARBOR, MICH.

NEW USES FOR STRAITS TIN



NEW TIN-NICKEL PLATING ALLOY

A modern method of electroplating bright tin-nickel now provides a practical alternate to chromium on nickel-copper. Tin-nickel is both more corrosion resistant and more attractive in color than chrome. For more information on new ways you can use Straits Tin, write:



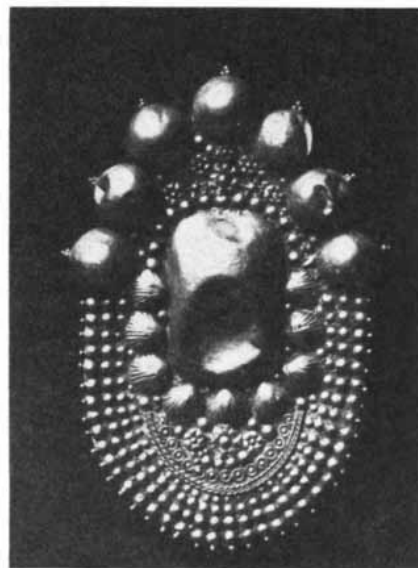
**The Malayan
Tin Bureau**

Dept. 15L, 1028 Connecticut Ave.,
Washington 6, D.C.

and since their furnaces were short-lived, the Etruscans were able to extract only a small fraction of the metals in their ores. The iron slag (easily separated from the soil deposits by electromagnetic means) contains up to 60 per cent iron, and the copper refuse is similarly rich in copper carbonate. Modern industry has found it worth while to salvage the ancient mounds of slag and establish metal foundries at the very sites where the Etruscans developed man's first great metallurgical industry 2,500 years ago.

An amusing sidelight on this revival was an ownership dispute fought through the law courts. The landowners around Populonia maintained that the slag was part of the real estate. The concerns who wished to use the slag contended that it was a buried treasure, and as such movable property. The courts upheld the second contention, but they also ruled that according to Italian law all "mineral underground treasure" belongs to the state. Thus the mineral wealth of Populonia is now owned by the Italian government, which leases it to private concerns for exploitation.

The chimney stacks of modern blast furnaces now rise at the same site where the ancient Etruscans wrought their craft, and modern machines drill for iron ore in the very same mines on Elba where the Etruscans once sank their pits. The long-desolate land is once again a center of industry. And side by side with the steam shovels digging into the ancient piles of slag, archaeologists also are excavating for more knowledge of the brilliant Etruscan civilization.



PERSONAL ORNAMENT is an example of detail executed in metal by the Etruscans.

To the ENGINEER of high ability

AiResearch is looking for your kind of engineer. Through the efforts of engineers like yourself our company has become a leader in many outstanding aircraft accessory fields. Among them are: air-conditioning and pressurization, heat transfer, pneumatic valves and controls, electric and electronic controls, and the rapidly expanding field of small turbomachinery. AiResearch is also applying this engineering skill to the vitally important missile accessory field.

Our engineers work on the very frontiers of present day scientific knowledge. We need your creative talents and offer you the opportunity to progress by making full use of your scientific ability.

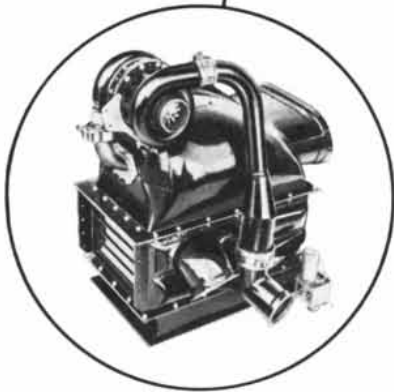
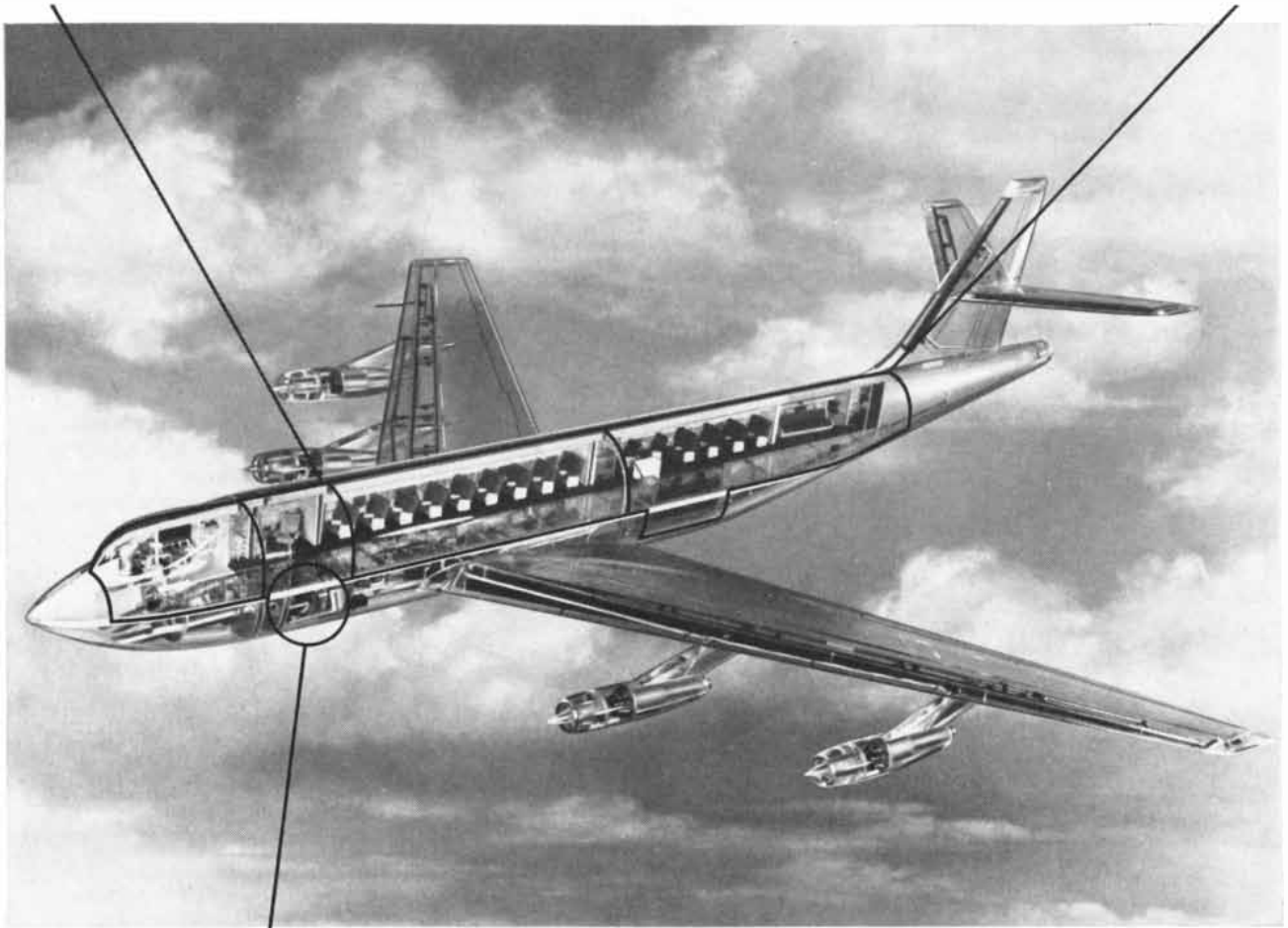
Positions are now open for aerodynamicists...mechanical engineers...physicists...specialists in engineering mechanics...electrical engineers...electronics engineers.

For further information write today to Mr. Wayne Clifford, THE GARRETT CORPORATION 9851 S. Sepulveda Blvd., Los Angeles 45, California. Indicate your preference as to location between Los Angeles and Phoenix.

THE GARRETT CORPORATION

AiResearch
Manufacturing
Divisions

Cabin air conditioning



REFRIGERATION PACKAGE, HEART OF THE AIR CONDITIONING SYSTEM

Components of the complete system include refrigeration turbines, heat exchangers, water separators, a humidifier system, cabin temperature controls, air flow regulators and pneumatic air shut-off valves.

in one system

Components of the AiResearch cabin air conditioning system work in complete compatibility with one another. Such functional inter-relation can best be achieved when all such units have been developed and manufactured by one company. AiResearch air conditioning systems have been proved by millions of hours of operating time. Air conditioning is one of many aircraft systems completely engineered and manufactured by AiResearch. In the field of integrated aircraft systems and specialized components, AiResearch has more experience than any other company.

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



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

HOW YOU BENEFIT WHEN YOU USE SUN RUBBER PROCESS AIDS

IF YOU PROCESS	USE	BECAUSE
<p>OIL EXTENDED POLYMERS</p> <p>GR-S TYPES 1703 1707 1708 1801</p>	<p>CIRCOSOL-2XH</p>	<p>Now Available at New Low Cost. Has relatively low staining properties for use on white goods. Improves the rebound characteristics of GR-S vulcanizates. Assures constant uniformity with minimum downgrading.</p>
<p>OIL EXTENDED POLYMERS</p> <p>GR-S TYPES 1705 1709 1710</p>	<p>SUNDEX-53</p>	<p>Versatile. Gives quicker, more thorough plasticization. Highly compatible with natural rubber and reclaims as well as with GR-S rubber types.</p>
<p>NEOPRENE WHV</p>	<p>SUNDEX-53</p>	<p>Highly Extended, Neoprene WHV compounds can be made for prices comparable with those of low-cost elastomers.</p>
<p>REGULAR NEOPRENES and NATURAL RUBBER</p>	<p>CIRCO LIGHT RUBBER PROCESS-AID</p>	<p>Gives True Softening by physical changes in rubber structure rather than chemical. Large quantities can be absorbed without blooming.</p>

To learn more about using Sun Rubber Process Aids to get better physicals, lower costs, and easier processing, see your Sun representative. Or write for your copy of Sun's latest Technical Bulletin describing any of the above products. Address SUN OIL COMPANY, Philadelphia 3, Pa., Dept. SA-11.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY, LTD., TORONTO AND MONTREAL



TOO MANY DEER

A biologist demonstrates that the number of deer is regulated not by predators, including man, but by their food supply. The moral: More hunting would result in healthier deer and less damage to crops

by A. Starker Leopold

The shy deer, drifting through forest shadows and bounding over brushy hills, is blissfully ignorant of the fact that for decades it has been a subject of fierce polemics. The point of contention has been: Should the deer population be curbed or be helped to multiply? Nature lovers want more deer to look at and hunters want more of them to shoot. On the other hand, gardeners,

ranchers and foresters would like to see fewer of them because they eat up too much vegetation. Government conservationists have had a difficult time trying to find a formula which would satisfy these conflicting interests.

After much research in the field, biologists are coming to the regretful conclusion that in many parts of the U. S. we have too many deer. The

charming animals have a tendency to outgrow their food supply and sink into a gaunt, enfeebled existence. The ecological evidence strongly suggests that it would be best for all concerned, including the deer population itself, if many more deer were shot.

Studies of the population dynamics of deer disclose some paradoxes. Most people probably associate deer with the



THREE WHITE-TAILED DEER lie dead of starvation in Pennsylvania's McKean County. That malnutrition, rather than disease,

is the cause of death in deer is often determined by examining the condition of the marrow in the femur, the upper bone of the leg.

New Dover Releases

World's best values in SCIENCE books

1. **HYDRODYNAMICS: A STUDY IN LOGIC, FACT, AND SIMILITUDE** by Garrett Birkhoff. Stimulating; pure math. to applied problem. 200 pp. Paperbound. \$1.75
2. **TRIGONOMETRICAL SERIES** by Antoni Zygmund. Modern, advanced; trigonometrical, Fourier series; indispensable, advanced students. 331 pp. Paperbound. \$1.75
3. **PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS** by A. G. Webster. 97 fig. 447 pp. Formerly \$10.00. Classic. Paperbound. \$1.98
4. **NON-EUCLIDEAN GEOMETRY: A CRITICAL AND HISTORICAL STUDY OF ITS DEVELOPMENT** by Roberto Bonola. Carlsaw trans. Includes two new appendices: Lobachevski's Theory of Parallels, Bolyai's Science of Absolute Space. 428 pp. Paperbound. \$1.90
5. **MATHEMATICAL ANALYSIS OF ELECTRICAL AND OPTICAL WAVE-MOTION ON THE BASIS OF MAXWELL'S EQUATIONS** by H. Bateman. 168 pp. Formerly \$15 up, o.p. Paperbound. Special, \$1.60
6. **THE PRINCIPLE OF RELATIVITY** by Einstein, Lorentz, Minkowski. Weyl. Eng. trans. of 11 important original papers on special and general theories. Sommerfeld notes. 224 pp. Paperbound. \$1.60
7. **INTRODUCTION TO SYMBOLIC LOGIC** by Susanne Langer. No mathematical background necessary. You start with the simplest symbols, end up with a good grasp of Russell-Whitehead, Boole-Schroeder systems. Truth-value tables. 2nd ed. 368 pp. Paperbound. \$1.70
8. **HIGHER MATHEMATICS FOR STUDENTS OF CHEMISTRY AND PHYSICS** by J. W. Mellor. 4th ed. Most useful aid. 670 pp. Paperbound. \$2.00
9. **THE ANALYTICAL THEORY OF HEAT** by Joseph Fourier. Freeman trans. Classic on heat, Fourier integral, etc. Formerly \$5. 489 pp. Paperbound. \$1.95
10. **NATURE OF PHYSICAL THEORY** by P. W. Bridgman. Nobel prizewinner. Brilliant critique of many aspects of modern mathematical physics. 149 pp. Paperbound. \$1.25
11. **COMMON SENSE OF THE EXACT SCIENCES** by W. K. Clifford. Ed. by Karl Pearson. Newly ed. by J. R. Newman. Preface by Bertrand Russell. 315 pp. Formerly \$4.50. \$1.60
12. **MATTER AND LIGHT: THE NEW PHYSICS** by Louis De Broglie, Nobel Prizewinner. 304 pp. \$1.60

Dover Publications, Inc. Dept. 49
920 Broadway, N.Y. 10, N.Y.

Please send books circled: 1 2 3 4
5 6 7 8 9 10 11 12

Name..... Please print

Address.....

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

I enclose \$..... in full payment. Add 10c per book postage, handling. SATISFACTION GUARANTEED. All books returnable in 10 days for full cash refund. Write for free science catalogue.

3 POSITIONS WITH ADVANCED GUIDED MISSILES PROGRAM AT GENERAL ELECTRIC

Analytical, Mathematical, Statistical or Systems Background

For man with analytical systems experience or background, an opportunity to assume responsibility for establishing over-all feasibility and composition of atomic weapons fusing and arming systems. Systems must meet basic requirements established by Military Characteristics.

For man with analytical mathematical background or experience, work involving statistical and analytical studies to establish feasibility, accuracies, dud and premature probabilities applicable to fusing and arming systems and components thereof for missile weapons.

A man capable of applying a broad viewpoint to the problems of weapons systems and of using a creative approach to synthesize systems meeting military requirements. At least 10 to 15 years experience is desirable and should include a background in servo systems, radar systems, guidance systems, etc. An engineer with 3 to 7 years experience will also be considered for work in carrying out the more detailed portions of the systems synthesis function.

Exceptional working conditions, full facilities, extensive program of benefits including technical courses.

Please send resume to:

MR. JAMES HEVELIN
SPECIAL DEFENSE PROJECTS DEPT.

GENERAL ELECTRIC

2900 Campbell Avenue
Schenectady, New York



MULE DEER DOE was photographed in Yosemite National Park as it reached upward for twigs of chokecherry. The sprouts on the lower branches of the tree had already been eaten.

forest primeval, but actually they do best in lands that have been cleared and settled by man. Unlike other wild ungulates such as the bison, the caribou and the mountain goat, which tend to disappear as man disturbs their natural ranges, deer thrive on new or secondary vegetation. Their favorite foods are shrubs and young trees. In the western mountains, for example, the ranges that support the most deer are cut or burned timberlands which have grown up to

wild lilac shrubs and mountain mahogany, scrub oak, willow and aspen trees. Similarly in the eastern U. S. deer favor the second-growth lands where palatable young trees grow in place of the original forest. This kind of vegetation is called "subclimax." A climax (mature) forest generally supports few deer.

It follows that a given range changes in deer-carrying capacity. After a forest has been logged or burned, the new young growth may support a large deer



YEARLING MULE DEER DOE, also photographed in Yosemite, had survived winter in poor shape. It nibbles manzanita, a food which is eaten only when better forage is gone.

population for a time. But as the canopy of trees closes over again, reducing the supply of shrubs and other young vegetation, the deer dwindle in numbers. By periodic logging or burning, we can produce the conditions that will maintain a high deer population. However, the deer themselves may create a Malthusian scarcity. Protected populations of deer often consume the food supply of their range long before it would have disappeared naturally.

Food is the all-important regulator of their numbers. Curiously, the presence of wild animals that prey on deer seems to have comparatively little effect on the size of their population. In parts of Mexico where lions and wolves are still numerous, the size of deer herds still seems to be a function of the deer's food supply. Poor ranges support few deer; good ranges support many deer, predators notwithstanding.

In recent years biologists have studied in considerable detail how food regulates deer numbers. They have learned a great deal about the ways in which nutrition influences the deer's birth and death rates.

A female deer in perfect health is capable of producing one offspring in her first breeding season and a litter of two each year thereafter. But because of seasonal shortages of the most nutritious foods, few herds in the wild approach this potential rate of increase. Studies in New York State of the white-tailed deer, which may ovulate and breed during the first year after birth, showed that only 20 to 40 per cent of the female fawns on the best wild ranges actually became pregnant. On poor ranges practically no fawns bred. Similar studies of the western mule deer, which can bear its first offspring when it is two years old, showed that on poor ranges or under crowded conditions most females do not bear young until they are at least three years old.

Thus poor diet clearly delays the age at which deer reach sexual maturity. It also reduces the number of young a doe may bear after she starts breeding. On a good range twins are common, and the average pregnancy rate may be 160 to 175 fetuses per 100 does. In contrast, on poor ranges the females rarely bear more than a single offspring. The pregnancy rate may be as low as 80 fetuses per 100 adult females. Moreover, many of these apparently are lost at birth or shortly afterward, for it is frequently observed that the number of fawns following their mothers in early summer is considerably below the number of pregnancies count-

NEW PAN CINOR ZOOMING LENS GIVES

through-the-lens viewing • superb optical quality • variable focal distance •

New Pan Cinor-70 and Pan Cinor-100 by Som Berthiot provide unique flexibility with zooming ability plus optical sharpness at all apertures. The Pan Cinor-70 zooms from 17.5 mm to 70 mm — from wide angle to telephoto. The Pan Cinor-100 zooms from 25 mm to 100 mm—standard to extreme telephoto. Zooming may be used for dolly effects.

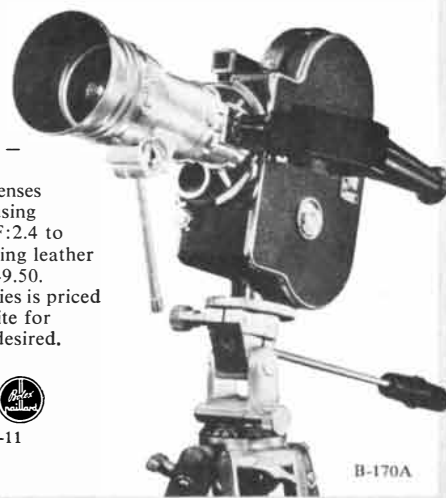
Ideal lenses for wildlife, sports, scientific or medical filming; useful for sequences, tilting, stop-action or animation such as in charts, diagrams; many other uses.

Now any 16 mm motion picture camera — in or out of the laboratory — becomes a through-the-lens viewing device. Both lenses focus from 7' to infinity and from 32" using close-up attachments. Apertures from F:2.4 to F:22. Price of the Pan Cinor-70, including leather case, sunshade, and filter adapter is \$449.50. The Pan Cinor-100 with above accessories is priced at \$750*. See your Bolex dealer, or write for further information specifying details desired.

*NOT AVAILABLE FOR IMMEDIATE DELIVERY

BOLEX 

PAILLARD PRODUCTS, INC. Dept. SA-11
100 Sixth Avenue, New York 13, N. Y.
Fine Swiss Mechanisms since 1814



NEW ENGLAND . . .

The region of the finest educational, cultural and recreational activities in America, can be *your* home.

There are positions with unlimited opportunity NOW OPEN at ADL for men with university training and appropriate experience.

If you want professional diversity and the opportunity for growing responsibility in client relationships, you can find both at ADL. You will also find stimulation from your professional associations in a friendly atmosphere, and from a wide variety of interesting problems in different industries.

Your inquiry or resume will receive prompt, individual attention.

WRITE TO

PERSONNEL DIRECTOR-PROFESSIONAL STAFF

Dept. 16

Chemistry and Physics—
Pure and Applied
Process Engineering
Mechanical Analysis,
Design and Development
Metallurgy
Electronics Research

Petro-Chemical Technology
Food and Flavor Research
Biology
Operations Research
Industrial Economics and
Management Services
Regional Development

Arthur D. Little, Inc.
Established 1886
30 Memorial Drive
Cambridge 42, Mass.

**AN
INVITATION TO JOIN THE
Aircraft Nuclear
Propulsion Field**

The next step in the application of nuclear power—aircraft propulsion—offers both professional challenge and opportunities for personal achievement at General Electric.

DESIGN ENGINEER

Engineering degree and several years diversified experience in analysis and design of power plant components, including design of nuclear reactors. For preliminary analysis and scale design of aircraft nuclear power plants.

SENIOR METALLURGICAL ENGINEER

Degree in physical metallurgy or metallurgical engineering and 8 to 10 years experience with high temperature or corrosion resistant metals and alloys. Will be responsible for materials research and radiation studies to provide improved metals and alloys for use in aircraft nuclear power plants.

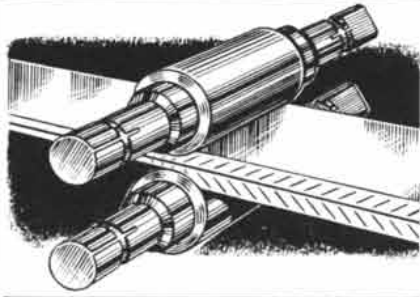
**PUBLICATION OF RESEARCH RESULTS
IN THE APPROPRIATE CLASSIFIED OR
OPEN LITERATURE IS ENCOURAGED**

*Send resume,
in confidence, to:*
TECHNICAL PERSONNEL
Aircraft Nuclear Propulsion Dept.

GENERAL  ELECTRIC

P.O. Box 132, Cincinnati, Ohio

**Why TWO metals
instead of ONE?**



Because many clad metals do jobs that no single metal can do!

For example—silver-clad phosphor bronze combines high electrical conductivity and spring properties for use in current carrying springs—or nickel clad steel replaces scarce, costly solid nickel in radio cathode parts.

ASC composites include combinations of—

- Ferrous to non-ferrous
- Precious to non-ferrous
- Precious to ferrous
- Thicknesses down to .003"
- Overlays as thin as .00005"
- Tolerances as close as $\pm .0001$ "

Clad metals can now offer new, more compact designs AND production savings! Tell us what you'd like to accomplish; we'll be glad to make our recommendations.



**Industrial Metals Division
AMERICAN SILVER COMPANY, Inc.**

36-12 Prince Street, Flushing 54, N. Y.

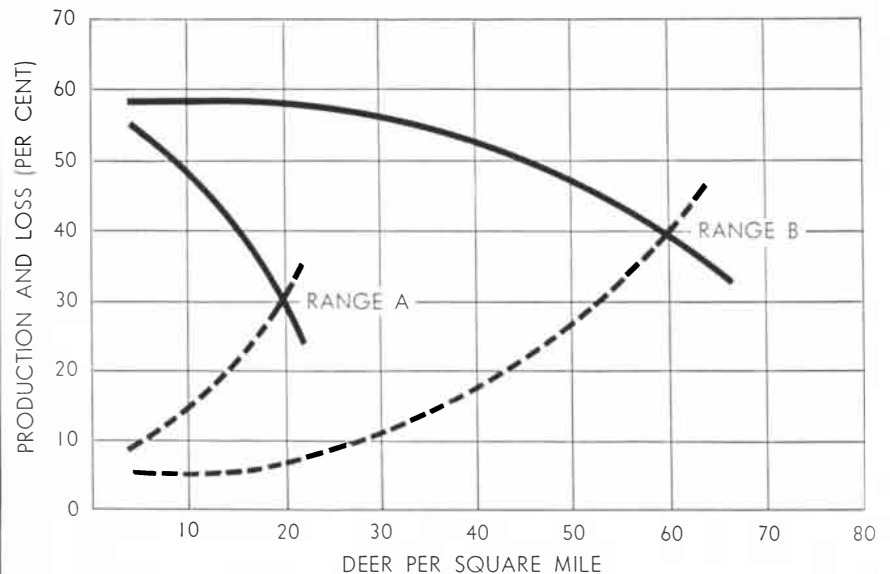


GOOD DEER FORAGE often grows in forest areas that have been burned over. Here wild cherry and white thorn grow on the site of the Wright's Creek burn of 1952 in California.

ed in the same herd a few months earlier. Presumably poor nutrition of the breeding females, resulting in failure of the pregnancy or the birth of weak fawns, is responsible for these losses.

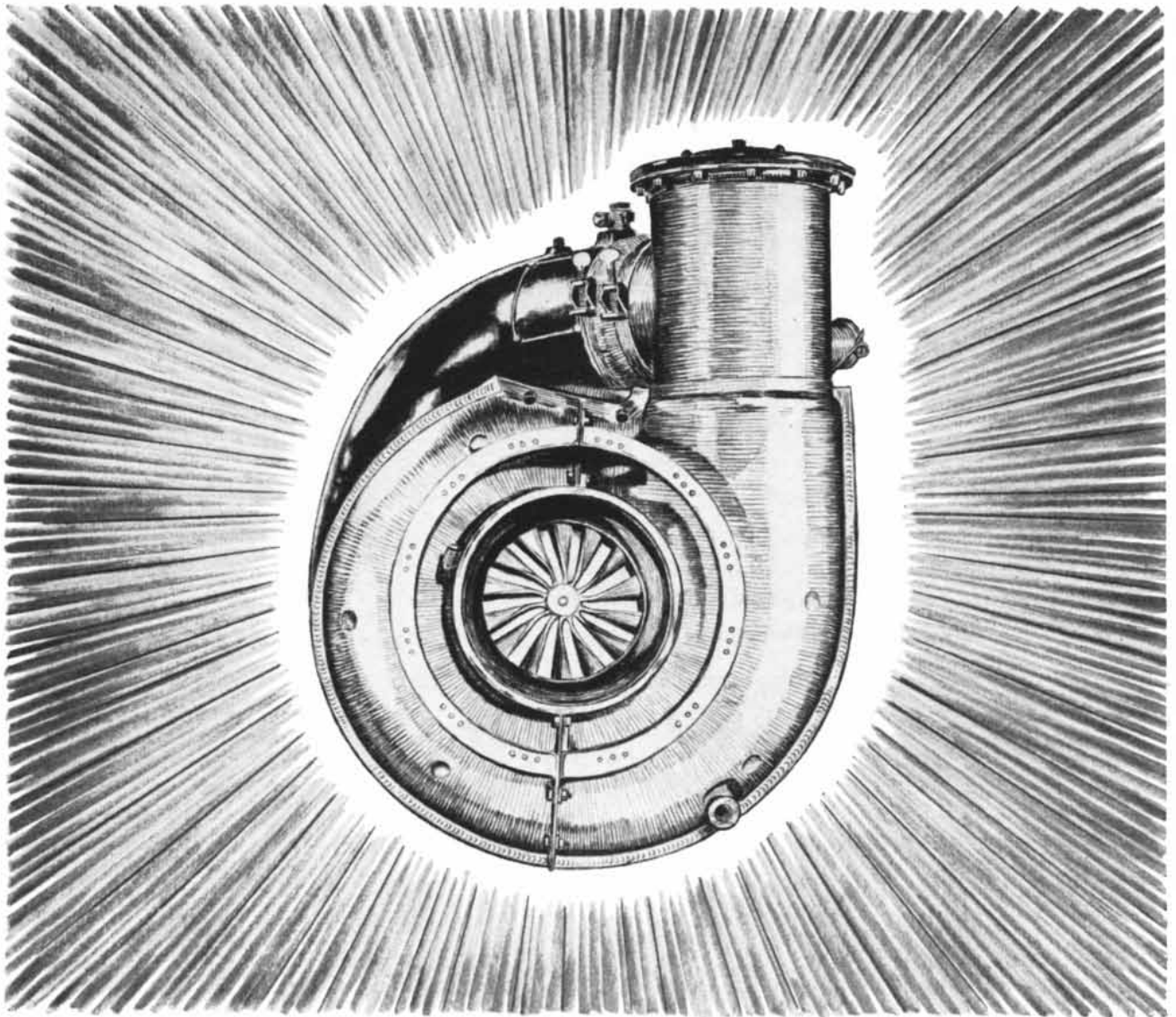
In short, shortages of nutritious food strike hard at the ability of deer to reproduce. In some cases this can be related directly to the amount of competition among the deer for the available food. For example, when a large part of a herd is killed off by hunters or by winter conditions, the productivity of the remaining females increases considerably, sometimes twofold, the following season.

As diet is the basic regulator of the deer's rate of reproduction, so also it controls their chances of survival. In cold climates winter is the critical season. A well-fed herd can easily endure cold and snow. But if food becomes scarce or poor in quality, the deer's vulnerability rises sharply. In the colder areas of North America hundreds of thousands of deer die during an average winter, and probably millions during a severe one. The herd usually eats up all the nutritious forage early in the winter and then has to subsist on second-choice foods of low digestibility. Most of those



TWO HYPOTHETICAL DEER RANGES yield these curves of production (solid lines) and mortality (broken lines). On the poor range (A) a dynamic balance is reached at a level of 20 deer per square mile, with an annual turnover of 30 per cent (30 deer per 100). On the good range (B) the density is 60 deer per square mile and the turnover 40 per cent.

POWER PLANT OF THE FUTURE



The Solar "Mars"® Gas Turbine Engine

THE SIMPLEST PRACTICAL fuel-burning engine yet constructed is shown above. It is the Solar Mars 50 hp gas turbine. It weighs less than 100 lb and fits in a two-foot cube. It operates on a variety of fuels. Its construction is simple. And the ruggedness of the Mars engine has been proven by many thousands of hours of trouble-free service.

The Mars is a constant speed engine for emergency or stand-by duty where fuel consumption is not of primary importance. Your forward planning should include the Mars gas turbine. For detailed information about this power plant of the future, write today to Solar Aircraft Company, Dept. B-78, San Diego 12, Calif.

SOLAR
AIRCRAFT COMPANY



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

INDUSTRIAL OPERATIONS RESEARCH OPENING

Extraordinary Career Challenge to your versatility and ingenuity now offered with integrated company active in many energy fields. Opportunity to apply optimization techniques at the staff level to all phases of operations.

Qualifications: Extensive analytical background in the physical sciences, engineering, or applied mathematics and statistics. Experience in Operations Research not necessary. Creative analysts with interest in entering Operations Research invited to submit résumé.

Good Location: Modern, medium sized Southwestern community. Pleasant surroundings with excellent family recreation, religious and educational facilities.

Reply by letter giving age, experience and other qualifications. All applications carefully considered and kept confidential. Write:



Employee Relations Manager
Research and Development Department
PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma



TWO MULE DEER FAWNS were photographed with a doe in Yosemite National

SPERRY ENGINEERS :

... nearly half a century of engineering history ...
now pointing to a new era of engineering opportunities

From the memorable day in 1911 when the first gyro-compass went aboard the USS Delaware to modern electronic "miracles", Sperry Engineers have pioneered the way. Their achievements have made Sperry an institution possessing a broad base of engineering "know how" for ventures into new and diverse fields.

ENGINEERS ARE INVITED to investigate openings on Sperry's large Engineering Staff, offering unusual opportunities for professional development, expression and recognition.

Please submit resume to **J. W. DWYER**
Engineering Employment Supervisor
or Phone **Fieldstone 7-3600 Ext. 2605 or 8238**
for interview appointment
(Interviews arranged for Sat. or Wed. Eve.)



SPERRY GYROSCOPE COMPANY
Division of Sperry Rand Corp.
Great Neck, Long Island, New York

that perish die directly of starvation. But the weakened deer also become prey to other causes of death. Even in a warm climate undernourished deer die on an epidemic scale—from parasites and diseases if not from starvation.

One way or another, the herd is balanced to its food supply. For example, in a certain range of natural chaparral growth on the coast of California, the deer population averages about 20 animals per square mile. It has been found that a range in the same region where the year-round food supply has been improved by controlled burning and seeding of grasses can support three times as large a population—an average of about 60 deer per square mile. However, the better range, paradoxically, has a higher death rate. This fact is not so mysterious if we remember that in a stable population deaths must balance births. The better range is stabilized at a higher density, but since more deer are born, more must die to keep the herd at the limit imposed by the supply of food. Thus on the poorer range the annual turnover rate (the number of deaths replaced by births) is about 30 per 100, while on the better range it is 40 per cent or more.

If we convert these statistics into a life-expectancy table, it becomes clear that the better the range and the higher the population, the shorter will be the



Park. Poorly fed deer tend to produce one fawn per gestation; well-fed deer, twins.

average life span of the individual deer. This paradox has implications which go beyond the competition for food. Apparently density *per se* has adverse effects upon a population. And indeed close studies not only of deer but also of elk and of laboratory rats have indicated that high population density produces considerable bickering which may cause nervous strain and physical weakening.

A good deal of study has been given to the dietary requirements of deer. It has been demonstrated that they need foods rich in protein and probably also in easily digestible carbohydrates. Like other ruminants, deer can convert woody material to food by breaking down cellulose to digestible compounds with the help of bacteria in their stomachs. But they seem to need sugar in their food to catalyze this bacterial action, and they require minerals and vitamins as well. The intensive chemical and physiological studies of deer diet should soon enable biologists to tell precisely what kind of browse is best for the animals.

Yet it is obvious that the amount of good forage any range can produce is limited, and therefore the number of deer it will support cannot be increased beyond a certain maximum no matter how solicitously they are protected. Indeed, too much protection may allow them to overrun their food supply and

F L P
SERVICE MARK

Design NEWS

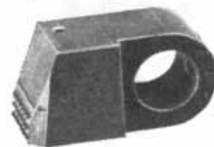
News of Another Design Problem Solved With Flame-Plated Tungsten Carbide Coatings.



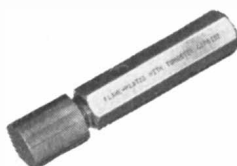
Aluminum Forging



Shaft Seal



Gripping Dog



Plug Gage



Bushing



Turbine Rotor

Here are a few highly successful Flame-Plating applications. Perhaps Flame-Plating can help you solve design problems on similar parts.

Flame-Plating proves

"Two metals are better than one"

Many times two metals are better than one especially when you can combine the wear-resistance of tungsten carbide with the metallurgical advantages of most any other metal. For example, by Flame-Plating a thin coating of tungsten carbide on aluminum, magnesium, or titanium, you can combine wear-resistance with light weight and low moment of inertia. Undoubtedly, you can think of many other combinations that would help you solve your design problems.

Flame-Plating is LINDE's service, performed in LINDE's plants, for depositing a thin coating of tungsten carbide on metal parts. Finished or semi-finished parts can be Flame-Plated without distortion for the temperature of the part being plated seldom reaches 400 deg. Fahrenheit. The coating may be used in as-coated condition (similar to fine emery paper) or finished to fine tolerances for precision applications.

For the full Flame-Plating story, call your nearest LINDE Office or write for your free copy of the Flame-Plating booklet.



design with Flame-Plating in mind

LINDE AIR PRODUCTS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y. **UCC** Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

Linde
Trade-Mark

"Linde" is a trade-mark and "F L P" is a service mark of UCC.

adding NEW uses daily!

Advantageous new uses are being found for felt daily! It's truly the most versatile of all fabrics for no one has ever been able to tabulate all the functions it so ably performs! There's a Continental Felt for every purpose . . . everywhere in daily life . . . and an even bigger place for felt in your future!

FELT for fashion
for industry

by

Continental



Write for Catalog

"Introduction to Continental's Magic Carpet" showing how you can use Continental Felt to advantage in your business.

CONTINENTAL FELT COMPANY, INC. 1965
22-26 WEST 15th STREET NEW YORK 11, N. Y.

Santa Says . . . Please clip this advertisement and leave it in an appropriate place in your home!

Dear
(Insert name of person most likely to give you gift.)

ALL I WANT FOR CHRISTMAS
is a New Universal
DESK-TOPPER
Personal Size Drafting Ensemble
For a LIFETIME of Drafting Ease!

Signed
P.S. You can get it at most every drafting materials dealer . . . or write to . . .

UNIVERSAL DRAFTING MACHINE CORP.
7960 LORAIN AVENUE • CLEVELAND 2, OHIO

thus actually reduce their numbers in the end. The best thing we can do for the deer is to permit a great deal more hunting. It would eliminate the excess of population each year and leave the remaining deer in a healthier and more thriving condition.

One serious present obstacle to such control is the "buck law," which prohibits the shooting of any deer but full-grown bucks. This measure, though not popular when first adopted, has come to be accepted as part of the sportsman's code. The buck-hunting tradition practically limits the maximum hunters' kill of any herd to about 4 to 9 per cent of the population. Yet a dense deer population could withstand a kill of at least 40 per cent per year, for this is no more than its natural turnover rate. It might be desirable to shoot an even higher proportion, in order to reduce the population density. Such a principle of limitation is applied by every livestock rancher who is managing his stock for the maximum yield of healthy animals.

To take 40 per cent of a deer herd each year would require shooting does and fawns as well as bucks. Consequently game biologists have been trying to convince state game commissions, legislatures and the interested public that the hunting of does and young deer would be in the interests of the deer as well as of the hunters. Considerable progress in this direction has been made: most deer states are now relaxing their rigid protective laws.

A second step in better management of the deer population should be to maintain their ranges in a condition of maximum productivity, consistent with other uses of the land. Forage conditions for the deer can be improved with only slight modifications in forestry practices and in cattle grazing. One of the effective measures is controlled burning of areas in some types of otherwise unproductive forests. The paramount need is to provide the deer with better food. A dollar spent on improving their food supply will often yield far more returns than the same dollar invested in some other form of protection.

As a result of biological research, deer management is evolving rapidly from a legal and quasi-political undertaking to an applied science, comparable to modern forestry or livestock management. A few decades hence the deer kill by hunters should be several times greater than it is today. The controlled and well-fed deer herds will then do much less damage to ranges and crops, and there will still be plenty of deer for the nonhunting public to see.

Engineers!

Join this winning team!

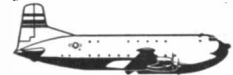
At DOUGLAS you'll be associated with top engineers who have designed the key airplanes and missiles on the American scene today. For example:



DC-7 "SEVEN SEAS" America's finest, fastest airliner



F4D "SKYRAY" Only carrier plane to hold world's speed record



C-124 "GLOBEMASTER" World's largest production transport



NIKE Supersonic missile selected to protect our cities



"SKYROCKET" First airplane to fly twice the speed of sound



A3D "SKYWARRIOR" Largest carrier-based bomber



A4D "SKYHAWK" Smallest, lightest atom bomb carrier



B-66 Speedy, versatile jet bomber

With its airplanes bracketing the field from the largest personnel and cargo transports to the smallest combat types, and a broad variety of missiles, Douglas offers the engineer and scientist unequalled job security, and the greatest opportunity for advancement.

For further information relative to employment opportunities at the Santa Monica, El Segundo and Long Beach, California, divisions and the Tulsa, Oklahoma, division, write today to:

DOUGLAS AIRCRAFT COMPANY, Inc.

C. C. LaVene, Employment Mgr.
Engineering General Office
3000 Ocean Park Blvd.
Santa Monica, California



TACTICAL PROBLEM: *To raise a protective "umbrella" against jet attacks at sea—in nothing flat*

PRACTICAL REPLY: *The fastest carrier-based fighter plane in naval history*



— the DOUGLAS F4D Skyray

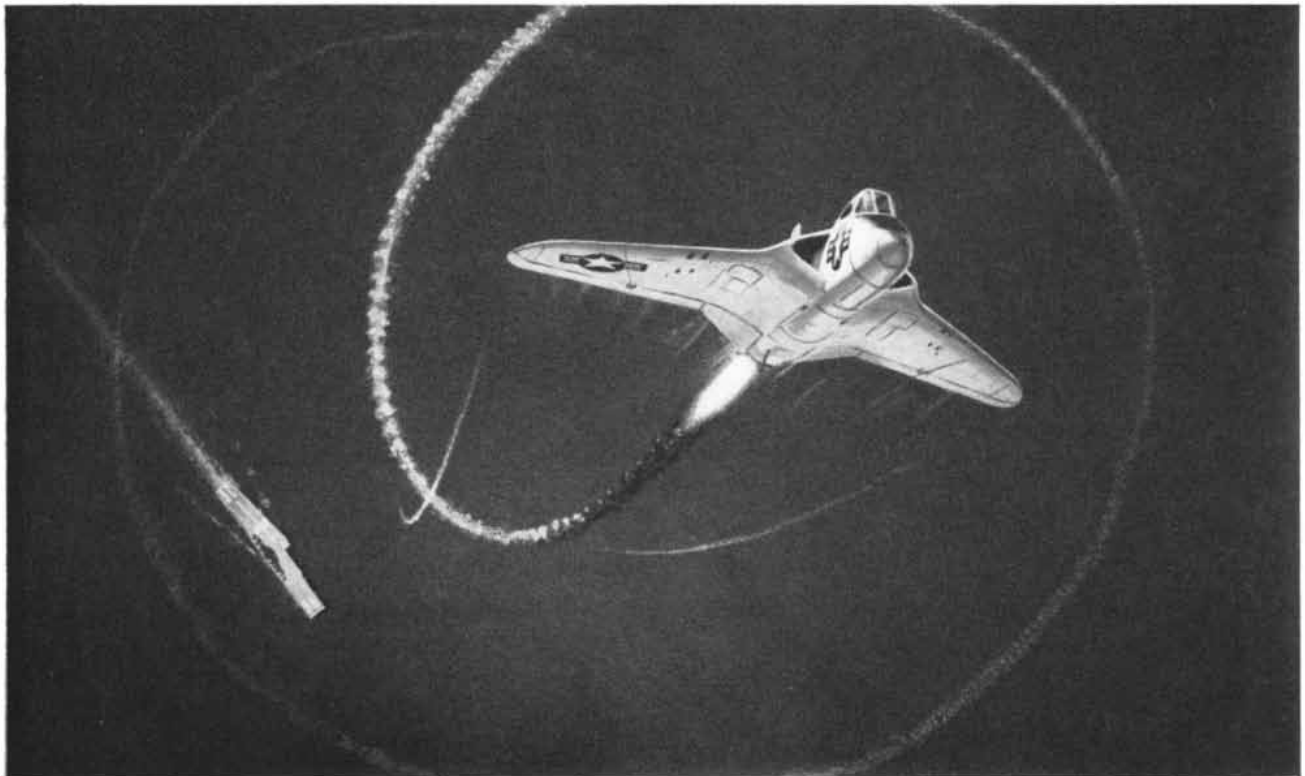
Cut loose the power of a Douglas F4D Skyray, and this fast Navy jet climbs from its carrier to operational altitudes in "nothing flat."

Its extremely high rate of climb makes Skyray—holder of the official F.A.I. sea-level speed record—well adapted for assign-

ments of positive interception. Designed for the U. S. Navy, it is powered by a Pratt & Whitney J-57 engine with afterburner and carries an armament of cannons and rockets. Agile as well as fast, Skyray's low landing speeds permit normal operation from any aircraft carrier

now in service . . . for unlimited fleet duty.

Skill in design which produced top-performing Skyray is a big reason for Douglas leadership in aviation. And it is the force behind the major trend to simplify aircraft, build more plane per pound, or per defense dollar.



Be a Naval Flier—write to Nav Cad, Washington 25, D. C.

Depend on **DOUGLAS**



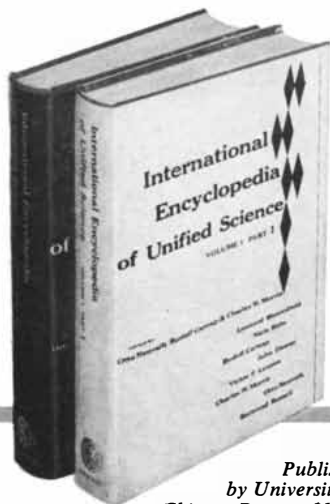
First in Aviation

The Library of Science

Invites You to Receive as a Membership GIFT

the Monumental New Two-Volume

INTERNATIONAL ENCYCLOPEDIA OF UNIFIED SCIENCE



Just
Published
by University of
Chicago Press at \$11.00

Now available for the first time in book form, the *Encyclopedia* demonstrates the logical structure common to all the sciences, and integrates the knowledge and methodology of every major scientific discipline within a single philosophical framework. Among the noted contributors are Niels Bohr, Bertrand Russell, Rudolf Carnap, Ernest Nagel, Philipp Frank, Egon Brunswik and Felix Mainx.

Free to You on Joining the
LIBRARY OF SCIENCE

In these volumes, thirteen of the most distinguished scientific figures of our time provide what The New York Times has called "the foundation on which may be built the bridges that are to connect the sciences."

Because these volumes may be so important to the work and thinking of readers of *Scientific American*, the LIBRARY OF SCIENCE has arranged to send you the *Encyclopedia* entirely without charge to demonstrate the benefits of membership. For the LIBRARY OF SCIENCE brings its members, at substantial savings, the books destined to play an important role in their thinking—authoritative works from the individual disciplines, books pointing up the unity of science, special translations and importations.

Since the LIBRARY OF SCIENCE serves scientists and professionals on a professional level, members have no obligation to buy any fixed number of Selections and may discontinue membership at any time. Reduced member prices and free books of your choice with every fourth Selection taken effect savings up to 40%.

You are invited to enroll in the LIBRARY OF SCIENCE and choose your first Selection below. With it you will receive the two volumes of the *International Encyclopedia of Unified Science* entirely free, as much as \$16.00 worth of books for as little as \$3.95. You are not obligated to take any additional books. If you wish, you may substitute any of the Selections described below as your free membership Gift.

Choose Your First Membership Selection from These Outstanding Volumes in the LIBRARY OF SCIENCE

PHYSICS & MICROPHYSICS

by Louis De Broglie

Just translated. "A unique book. . . . The presentation of molecular physics of the last decades should broaden and deepen the scope of every reader."

—Albert Einstein

List price \$4.50, Member's price \$3.95

ALBERT EINSTEIN: Philosopher-Scientist

Edited by Paul A. Schilpp

The work, thought and influence of Albert Einstein, authoritatively appraised by 25 colleagues, including 6 Nobel Prize winners. Einstein replies and also contributes the only autobiography he ever published.

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

MATHEMATICS & PLAUSIBLE REASONING

(2 vols.)* by George Polya

Analyzes the methods of mathematical problem-solving, to demonstrate their usefulness in all scientific investigation. "The material is

fresh and highly original . . . stimulating, informal and occasionally humorous."

—Scientific American

List price \$9.00, Member's price \$6.50

*(Two volumes count as one Selection.)

A HISTORY OF SCIENCE

Through the Golden Age of Greece

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."

—The 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, astro-

physics, genetics, sensation and perception, virology, zoology, geology, animal behavior.

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

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) an account of the directions in which thought is leading on the frontiers of astronomy."

—The London Times

List price \$5.00, Member's price \$3.95

ANTHROPOLOGY TODAY

Edited by A. L. Kroeber

966 pages, 52 contributors. "Scientists in neighboring disciplines . . . can for the first time find within the covers of one book a trustworthy survey of the present position of anthropological studies."

—Clyde Kluckhohn, Ph.D.

List price \$9.00, Member's price \$6.95

LIBRARY OF SCIENCE

371

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 am under no obligation to order additional books and may discontinue membership at any time.

FREE BOOK

FIRST SELECTION

NAME _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

You Are Invited to Use the Enrollment Form Attached



LIBRARY OF SCIENCE, 59 Fourth Avenue, New York 3, N. Y.



BOOKS

A physicist's speculations about the evolution of technology during the next hundred years

by James R. Newman

THE FORESEEABLE FUTURE, by Sir George Thomson. Cambridge University Press (\$2.50).

How foreseeable is the future? Sir Charles Galton Darwin once took a long look ahead: in a book reviewed here in 1952 he leaped over no less than a million years. Now another eminent British physicist, Sir George Thomson, making a shorter jump, peers into the middle of the next century. On Sir Charles' scale this is a modest prophecy, but it is not necessarily easier to make. In 10,000 centuries averages assert themselves and entropy does its dreary work. Darwin could count on the fact that even the best machines run down. A million years from now the earth, because of the voracious habits of its occupants, will be poorer and shabbier. Its resources will be depleted. Men may be wiser but not happier; plankton is no diet for joy. Maybe they will have to quit this planet for another.

Sir George's picture of 2050 is less doleful. He is chiefly concerned with the future of technology; in this direction, he says, predictions are possible. The scientific revolution has been churning for more than three centuries, during which enormous advances have been made in man's control over his environment. The rate of progress still seems to be accelerating. It is natural to ask how long this pace can continue. To be sure, a catastrophe may intervene—a man-made holocaust which would leave the future to rats or insects. We shall assume, however, that this will not happen: that either there will be no more big wars or the zeal for self-extermination will flag, once a war is on, before we are all dead. On this assumption we can look forward to continued material improvement. We cannot say exactly where science and technology will carry us in a hundred years, but something of the future of machines is discernible in outline. The

trend of social circumstance is more shadowy. "Sociology," says Thomson, "has still to find its Newton, let alone its Planck, and prediction is guesswork." Still, it is hard to resist the temptation to speculate on people's responses to technical progress, and this book has something to say about the society of the 21st century as well as the machines.

Science limits technology at the same time it feeds it. This fact is not widely understood. We expect too much of mechanical ingenuity. Technology has been so successful that men are apt to suppose that everything can be solved, answered, cured, that there are no limits. We have a light in the refrigerator, therefore we will fly to the moon; our theaters are air conditioned, therefore we can change the world's climate. Let us grant that inventors are fertile and may make us immortal. But there are things they cannot do, things prohibited by the nature of nature as we understand it.

Sir Edmund Whittaker, I believe, coined the phrase "principles of impotence" to describe the scientific rules of what cannot be done. Since these are Thomson's guidelines, they are worth listing. Perhaps the most familiar is Einstein's principle "that no material object and no signal can go faster than the velocity of light." This should not unduly distress either aeronauts or astronauts; nevertheless it sets bounds. The conservation of mass-energy is another limiting principle. Of course the fact that this principle is a combination of two others, conservation of mass and conservation of energy, which 50 years ago were thought to be distinct and immutable, is disquieting and suggests that there are no permanent principles of impotence. But we shall have to do with the science we have, at least until another Einstein appears. Sir George covers his tracks by saying that while it would be rash to suppose the principles will remain for all time, it would be "still more rash to suppose that they can be modified in any particular way."

That one cannot make an electric charge or a magnetic pole "without making an equal one of opposite sign some-

where else," that a particle of atomic size cannot be pinned down exactly both as to velocity and position, that no two electrons can be close to each other both in position and in velocity (Pauli's "exclusion principle")—these represent four more principles to be added to the list. Finally there is the second law of thermodynamics, which says that "order always tends to disappear till complete chaos is reached."

The foreseeable future of science and of its offspring technology is thus bounded by the principles of impotence. Moreover it is reasonable to suppose that other such principles may be discovered, valid not only in physics and chemistry but in biology also. As Sir George points out: "Animals and plants have to be able to reproduce and grow as individuals from a relatively very small seed or egg, which yet contains the pattern of the whole. There must be limitations introduced here. Not every arrangement of bones and nerves and muscles, even though it might make a viable animal, could, one would suppose, grow from an egg—still less be developed by evolution. Perhaps this is why nature never has produced a workable wheel or even a 'caterpillar' track."

Besides principles of impotence, there are other fundamentals which must be taken into account. These define the scope of technology as a whole just as an individual craftsman's materials and tools define what he can do. There is not an infinite number of different materials in nature, nor of forms, nor of building blocks. The marvelous profusion of the world is achieved with comparatively simple means. The universe is formed from less than 100 different kinds of atoms (which themselves are made of only a few basic constituents). A peach tree differs from a grain of sand which in turn differs from a star; yet at bottom the three are alike and differ only as do mosaics. The fixed properties of the fundamental atomic particles impose limitations not only upon the particles themselves but upon the larger bodies built of them. Man, for example, cannot grow beyond a certain size without altering

REFLECTIONS of a PHYSICIST

by P. W. BRIDGMAN

NEW ENLARGED EDITION

This collection comprises the bulk of the non-technical writings of Dr. Bridgman, including ten papers here added to the first edition of 1950. The topics range over a considerable field, but there is a certain unity in the treatment in that the "operational" approach is used throughout. It is this approach which has made possible the success of modern physics in meeting revolutionary new physical situations. The present collection may be regarded as an extension of the operational approach to problems in other fields than physics.

CONTENTS

I—General Points of View

Operational Analysis—Some General Principles of Operational Analysis—Science: Public or Private?—Freedom and the Individual—On Scientific Method—Some Implications of Recent Points of View in Physics—The Operational Aspect of Meaning—Science and Common Sense—The Present State of Operationalism.

II—Applications to Scientific Situations

The New Vision of Science—Permanent Elements in the Flux of Present-Day Physics—The Recent Change of Attitude toward the Law of Cause and Effect—Statistical Mechanics and the Second Law of Thermodynamics—The Time Scale—On the Nature and Limitations of Cosmical Inquiries—Einstein's Theories and the Operational Point of View—Impertinent Reflections of History of Science.

III—Primarily Social

The Struggle for Intellectual Integrity—Society and the Intelligent Physicist—Science, and its Changing Social Environment—Scientists and Social Responsibility—Science and Freedom—Reflections of a Physicist—The Strategy of the Social Sciences—Science, Materialism and the Human Spirit—The Discovery of Science—The Task before Us.

IV—Specific Situations

"Manifesto" by a Physicist—A Challenge to Physicists—Scientific Freedom and National Planning—Sentimental Democracy and the Forgotten Physicist.

V—Prophetic

The Prospect for Intelligence—New Vistas for Intelligence.

Mail to your Bookseller or to

PHILOSOPHICAL LIBRARY, Publishers
15 East 40th Street, Desk 96, New York 16, N. Y.

Please send mecopies of "REFLECTIONS OF A PHYSICIST" @ \$6.00 each. I enclose remittance to expedite shipment and save mailing cost.

Name.....
Address.....
City.....Zone.....State.....

shape. Beyond a critical point his bones will not support him; if he were as big as the moon he would have to be spherical, because "no material could make a neck capable of supporting such a head without being crushed." One thing is in man's favor in seeking to control nature. While it is true that he is "despicably weak" compared with elemental forces, the disposition of energy frequently enables him to take advantage of what are called "trigger" actions, "where a small cause produces a disproportionate effect." A boulder perched on a ledge may be pushed off easily and produce an avalanche. A handful of silver iodide may produce rainfall over a big area. There is a large class of such "metastable" systems, organic and inorganic, requiring only a small key to unlock their energy. The right key is, of course, not always easy to find, nor are the consequences always easy to reckon. "A very high degree of understanding," Thomson warns, "is needed by those who would interfere with nature in this way."

Having set forth briefly some of the limitations on technology and having told us what will not happen in the next century, Sir George undertakes to predict what can be expected. He discusses the future of energy and power, of materials, of transport and communications, of meteorology, of food, of applied biology, of social studies, of mechanical devices for solving problems far more complex than any we are able to tackle at present. What he offers is a brilliantly succinct review of the main questions of contemporary science and technology, together with clues and conjectures as to how they will be answered.

Many books and articles have appeared in recent years on future needs and sources of power. Until nuclear energy was discovered, the outlook was bleak. Even now there are experts who are skeptical about atomic power. Sir George puts matters into perspective and resolves many doubts. He makes several things clear: first, that supplies of fossil fuels, coal in particular, are still very large; second, that we are so wasteful and incompetent in generating power that some of our processes might properly be regarded as no better than "burning the house down to roast the pig"; third, that the potentialities of solar energy and of combustible materials raised in agriculture (such as peat) require much more serious consideration than has been given them; fourth, and most important, that electricity derived from nuclear reactions, both fission and fusion, will be available in almost any quantities that we want for a very long

time. This is not to say nuclear power will necessarily be cheap. Technical improvements will bring costs down, but large-scale projects will still be expensive in terms of capital investment, depreciation and the like. Efficiency will therefore be at a premium.

Shipping will "go nuclear" about the time that natural oil gives out. The internal combustion engine is already an anachronism and only waits upon the invention of a satisfactory electrical accumulator to become wholly obsolete. The heat pump, says Sir George, is a device of much promise, especially for the heating of homes. It is "really a refrigerator in which instead of creating cold inside the refrigerator by taking the heat away and then discarding the heat, you have the refrigerator out of doors and introduce the heat into the house." With cheap electricity as the power source it is "the obvious way" of keeping houses warm.

In sum, whatever shortages may arise during the next century, power will not be among them. This is less obviously true of materials. Our civilization would be quite different if it were deprived of the new materials introduced in the last 50 years: light metals, plastics, steel alloys. Thus far we have been fortunate in finding great concentrations of valuable metals, but even the richest lodes are not inexhaustible, and it will soon be necessary to search for and exploit the leaner deposits. This demands improved methods of prospecting, of mining at great depths where it is very hot and of handling "enormous masses of material in order to extract very little." Sir George suggests the possibility of deep mining by techniques like those in oil drilling. Under the crust of the earth lies molten magma, a pasty primordial mixture of minerals or organic matter. No one knows the extent of such veins of liquid, but if they could be located it is conceivable they could be tapped and brought to the surface.

A more promising source of minerals, perhaps, is the "fluid ore" composing the ocean. Concentrations are very low, but quantities are immense and the fluid ore is easily handled. Certain sea animals extract from the water metals forming an essential constituent of their blood. There are fish that are able to concentrate copper and vanadium, which occur in sea water only to the extent of about two parts in 10,000 million. It may be possible, Sir George believes, to breed plants or other organisms which will perform for us the first stage of extraction; then we can take over with our clumsier methods.

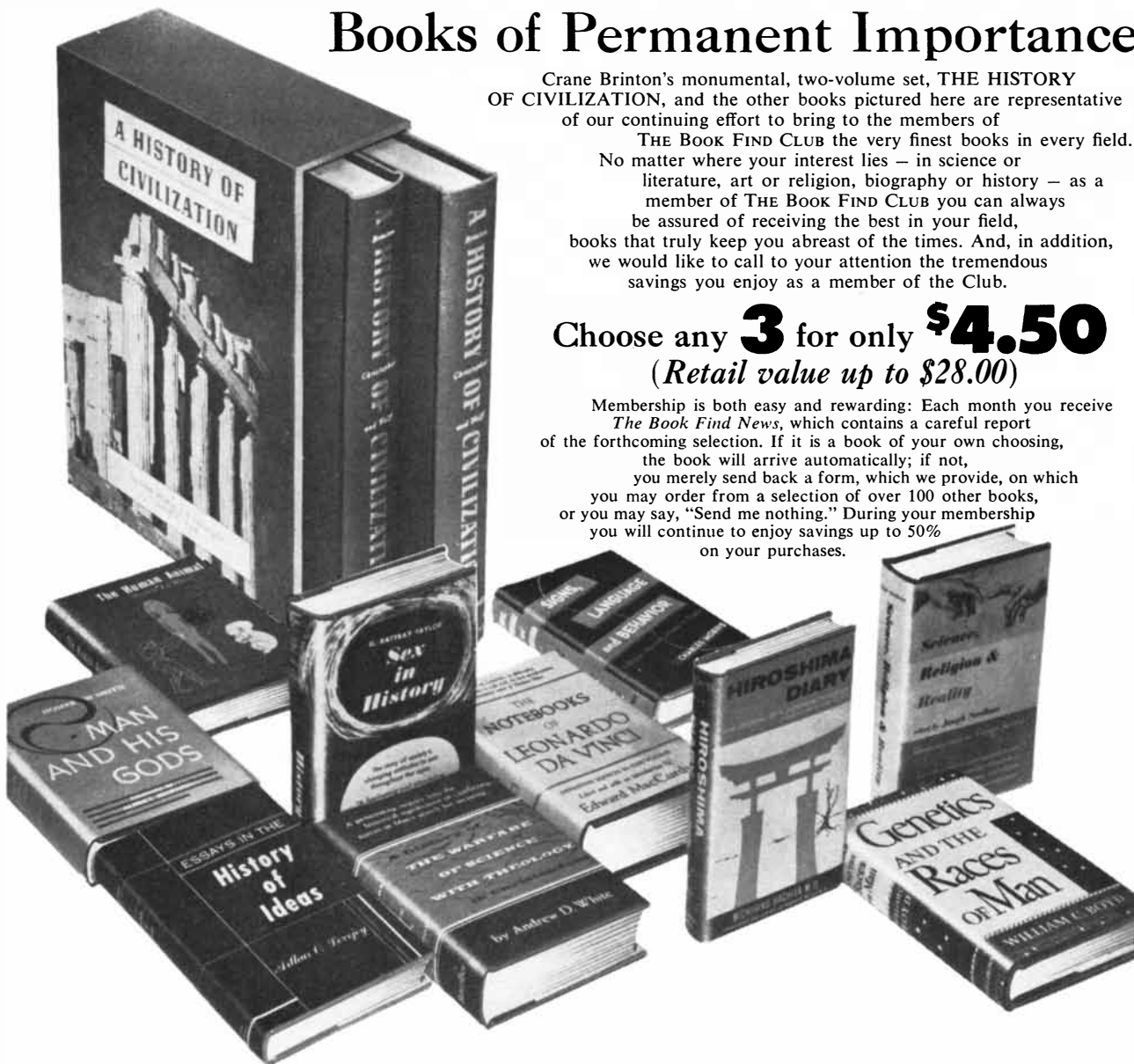
Books of Permanent Importance

Crane Brinton's monumental, two-volume set, **THE HISTORY OF CIVILIZATION**, and the other books pictured here are representative of our continuing effort to bring to the members of

THE BOOK FIND CLUB the very finest books in every field. No matter where your interest lies — in science or literature, art or religion, biography or history — as a member of **THE BOOK FIND CLUB** you can always be assured of receiving the best in your field, books that truly keep you abreast of the times. And, in addition, we would like to call to your attention the tremendous savings you enjoy as a member of the Club.

Choose any **3** for only **\$4.50**
(Retail value up to \$28.00)

Membership is both easy and rewarding: Each month you receive *The Book Find News*, which contains a careful report of the forthcoming selection. If it is a book of your own choosing, the book will arrive automatically; if not, you merely send back a form, which we provide, on which you may order from a selection of over 100 other books, or you may say, "Send me nothing." During your membership you will continue to enjoy savings up to 50% on your purchases.



1 — A HISTORY OF CIVILIZATION. By Crane Brinton, John B. Christopher & Robert Lee Wolff. 2 vols., boxed, more than 1400 pages, 8" x 10". Hundreds of illustrations, more than 50 maps, endpapers. A brilliant survey of man's experience from pre-history to mid-twentieth century. List price \$16.00. Members' price \$9.95.

2 — SCIENCE, RELIGION AND REALITY. Edited by Joseph Needham. Introductory Essay by George Sarton. A brilliant discussion of the relations of science and religion by Malinowski, Singer, Eddington and others. Pub. ed. \$3.95. Members' price \$2.45.

3 — SEX IN HISTORY. By G. Rattray Taylor. The history of human attitudes towards sex and its role in society, art and religion. Pub. ed. \$5.00. Members' price \$2.50.

4 — THE HISTORY OF THE WARFARE OF SCIENCE WITH THEOLOGY IN CHRISTENDOM. Andrew D. White's comprehensive study of the continuing struggle for dominion over the minds of men. One-vol. ed. Members' price \$5.00.

5 — THE HUMAN ANIMAL. By Weston La Barre. A basic work in the biological interpretation of human nature and conduct. Pub. ed. \$6.00. Members' price \$2.50.

6 — GENETICS AND THE RACES OF MAN. By William C. Boyd. Physical anthropology in the light of contemporary science. Pub. ed. \$6.00. Members' price \$2.65.

7 — HIROSHIMA DIARY. By Michihiko Hachiya, M.D. A major documentary of our times — a tribute to the courage and hopefulness of man. Pub. ed. \$3.50. Members' price \$2.25.

8 — SIGNS, LANGUAGE AND BEHAVIOR. By Charles Morris. An inquiry into the origins and function of language in social behavior. Published at \$5.00. Now available as a re-issue. Members' price \$3.75.

9 — MAN AND HIS GODS. By Homer W. Smith. An examination of man's religious beliefs through the ages, by one of today's outstanding scientists. Pub. ed. \$5.00. Members' price \$2.45.

10 — THE NOTEBOOKS OF LEONARDO DA VINCI. A magnificent record of Leonardo's thought, illustrated with his drawings. Originally published in two volumes at \$15.00. One vol. ed. Members' price \$5.00.

11 — ESSAYS IN THE HISTORY OF IDEAS. By Arthur O. Lovejoy. The historical development and influence of ideas—from the communism of St. Ambrose and the oriental origins of Romanticism to the role of Kant, Schiller and Rousseau. Originally published at \$5.50. Now available as a re-issue. Members' price \$3.75.

CLIP COUPON BELOW AND MAIL TODAY

THE BOOK FIND CLUB • 215 Fourth Avenue • New York 3, N. Y.

Please enroll me as a member and send me, for only \$4.50 plus 24¢ postage and handling, the three books I have indicated by encircling the appropriate numbers at right. I am to receive free the monthly Book Find News. I agree to buy as few as 4 additional books during my first year of membership; and I may resign without obligation at any time thereafter.

1 2 3 4 5 6 7 8 9 10 11

Name _____ (please print)

Street _____

City _____ Zone _____ State _____

(In Canada: 105 Bond St., Toronto 2, Ont.) SA-45-9

THE BOOK FIND CLUB

California

BOOKS IN SCIENCE

● Theoretical Genetics

By **Richard B. Goldschmidt**

A distinguished zoölogist and pioneer in modern genetics synthesizes many related fields, including cytogenetics, pure and unorthodox genetics, biochemical genetics, developmental and physiological genetics, genetics of lower organisms, cytology and biochemistry, and experimental morphology to give his answer to the basic problems of genetics.

574 pages

\$8.50

● Electronic Motion Pictures

By **Albert Abramson**

A history of the television camera which discusses the past, present, and possible future development of this new process. Deals with precursors of the electronic motion picture; the use of film camera and sound recording in early television; experimental processes of television, development of commercial and large-screen television.

240 pages

79 illus.

\$5.00

● California Grizzly

By **Tracy I. Storer and
Lloyd P. Tevis, Jr.**

Natural history, history, and legends of the now-extinct ferocious California grizzly are included in this copiously illustrated volume which will interest naturalists and historians as well as the general reader.

342 pages

44 illus.

\$7.50

● Birds and Mammals of the Sierra Nevada

By **Lowell Sumner and
Joseph S. Dixon**

A handbook on Sierra wildlife and its continental distribution. Invaluable for naturalists, nature lovers, and professional scientists.

502 pages

46 illus., maps

\$7.50

UNIVERSITY OF CALIFORNIA PRESS

Address: Berkeley 4, California

Much can be done to increase the strength of materials. Metals, for example, fail by slippage of one layer over another due to "dislocations"—faults within the crystal structure [see "Dislocations in Metals," by Frank B. Cuff, Jr., and L. McD. Schetky; *SCIENTIFIC AMERICAN*, July]. There is no reason to believe, Thomson says, that these elements of weakness cannot ultimately be eliminated.

Once materials can be manufactured with much higher breaking stresses, a drastic change in structures will result. Buildings, airplanes and suspension bridges will be transformed. The buildings of the 21st century "may be a little like the masts and rigging of a sailing ship, with the spaces between the structural members enclosed with a light 'cladding' of which a considerable fraction will be transparent." Sir George predicts that "the world of the future may be expected to look more aetherial, more like fairyland, than the world of the present or of the past."

Communication has come a long way in the last 50 years, and further improvements are foreseeable. The walkie-talkie will undoubtedly proliferate as transistors are improved. Television will be much extended. We can anticipate face-to-face "meetings" of groups of people while each person remains in his own home or office. Business, political and even scientific gatherings could be arranged in this way. Yet one dares to hope that the need and desire for actual human contacts will not have vanished in a century, and it is reassuring to know that for various technical reasons there are limitations upon remote communication and upon the possibilities for invasion of privacy. Perhaps we should recall Thoreau's famous question on learning that Maine and Texas were to be joined by telegraph: "Who knows whether Maine and Texas have anything to communicate?"

How fast will our descendants travel? Faster than now but not so fast as some undoubtedly would like. The famous drag factor bedevils every effort to increase air speed; resistance due to the waves at the bow and the turbulence in the wake cuts into a ship's speed. Crossing of the Atlantic in an hour and a half is foreseeable, and routine train speeds of 100 to 150 miles per hour. While these by no means represent upper limits, it must be recognized that much higher speeds, especially for short distances, are simply not worth while. Increased speed means increased cost; the question is whether it is worth assuming the larger cost when there are end delays (at the

start and finish of the journey) which are apt to account for half or more of the total elapsed time. Sir George does not foresee everyone hopping around in helicopters. At best they will not be as easy to operate as automobiles, and air space is not unlimited.

An interesting point arises in connection with ocean travel. A fast-moving ship produces waves which offer high resistance. This resistance increases rapidly and can be overcome only by lengthening the ship or by redesigning it so that it lifts itself out of the water and is partly an airplane. A better alternative is "to copy the fishes." They create practically no waves. With nuclear power available, and with the elimination of surface "excrescences" that produce "skin friction," it should be possible to drive submarines at 70 or 80 knots "with considerably less horsepower per ton than an Atlantic liner of the present day."

Sir George is pleasantly calm in discussing the prospects of space travel. In due time we shall get to the moon. The problems of getting there, landing and returning are difficult but can be overcome. A very pretty idea is the possibility of making a rocket propelled by particles emitted in nuclear fission. Fast electrons escaping from radioactive fission products, while themselves too light to form the material for an efficient rocket jet, might be used to generate an electric field; this, in turn, could be used "to accelerate heavier charged bodies, either atoms or clusters of atoms, which provide the actual material of the jet." The peacefully inclined will be interested to read that Thomson characterizes as "absurd" the idea of the satellite station as an instrument of war. "I cannot see the least prospect of establishing a station that would not be destroyed almost at once by guided missiles from below, which would be far easier to construct than the station itself," says Sir George.

Travel into interstellar space "is not imminent but we may well be nearer to it in time than we are to Peking man." The nearest star, Proxima Centauri, is 4.3 light-years away. If velocities could be attained equal to half that of light, the journey would become feasible. Because of the relativistic contraction of time, the trip would be shorter from the point of view of the travelers than as measured on the earth. Roughly 2.6 years might be saved. This shrinking of time for the participants, observes Sir George, "seems a small prize for all the discomfort and risk" of the voyage.

There is promise at last of doing something about the weather. In fact we may

Given to you... IF YOU JOIN THE CLUB NOW AND AGREE TO BUY SIX BOOKS DURING THE NEXT YEAR

ANY ONE of these Valuable Library Sets



Carl Sandburg's
Pulitzer Prize-Winning Biography
ABRAHAM LINCOLN
THE WAR YEARS
In Four Volumes • Retail Price \$36

Winston Churchill's
THE SECOND WORLD WAR
IN SIX VOLUMES
Retail Price
(If Bought Separately) \$36

GREAT SHORT NOVELS
IN FOUR VOLUMES • BOXED
Retail Price \$21
Partial List of Authors

Balzac	Gogol	Katherine Anne Porter
Chekhov	Aldous Huxley	Stephen Crane
Conrad	Henry James	Tolstoy
Stephen Crane	Samuel Johnson	Turgenev
Dostoevsky	Maitreux	Edith Wharton
George Eliot	Melville	Virginia Woolf
Flaubert	Stendhal	Zola

THIS INTRODUCTORY OFFER is a demonstration of three marked advantages of membership in the Book-of-the-Month Club.* First, as a member, you are kept from missing the important new books. Secondly, you get Club choices at a considerable saving: an average of about 20% less than the retail price, over the past two years. On top of this, you share in about \$12,000,000 worth of free books (retail value) distributed during the year among members as Book-Dividends. Because of its large membership the Club prints enormous editions of its selections at a great saving in manufacturing costs. The money thus saved is invested in editions of other desirable volumes, each of which is a Book-Dividend* given without charge to members. The Library Set you choose to receive, free, represents "advanced" Book-Dividends, earned by the purchase of the six books you engage to buy during the year.

*** YOU AGREE TO BUY ONLY SIX BOOKS** within your first year of membership, from among the Club Selections and Alternates. During the year at least 100

good books will be made available to you, from which you may choose. You receive a careful advance description of each Selection and if you think it is a book you would *not* enjoy, you send back a form (always provided) specifying some other book you may want. Or you may say: "Send me nothing next month."

*** YOU WILL RECEIVE AT ONCE THE LIBRARY SET YOU CHOOSE.** It will be sent with the first book you order from the Club. For a list of good books from which you can make your first selection, please see coupon.

*** AFTER BUYING SIX BOOKS**—and as long as you remain a member—you will receive a Book-Dividend with every second book you buy from among the Club Selections and Alternates.

*** YOU MAY CANCEL YOUR MEMBERSHIP** any time after buying six books. Membership in the Club is for no fixed period, continuing until notice of cancellation is received from the member.

BEGIN YOUR MEMBERSHIP WITH ANY OF THESE

- | | | |
|--|---|--|
| <input type="checkbox"/> INSIDE AFRICA
by John Gunther
Price (to members only) \$1.25 | } Double Selection | <input type="checkbox"/> NO TIME FOR SERGEANTS
by Mac Hyman and GOOD MORNING, MISS DOVE
Combined price (to members only) \$3.95 |
| <input type="checkbox"/> MARJORIE MORNINGSTAR
by Herman Wouk
Price (to members only) \$3.95 | | <input type="checkbox"/> GREAT RIVER (2 vols. boxed)
by Paul Horgan
Price (to members only) \$5.95 |
| <input type="checkbox"/> SOMETHING OF VALUE
by Robert Ruark
Price (to members only) \$3.95 | <input type="checkbox"/> ONIONS IN THE STEW
by Betty MacDonald \$3.50 | <input type="checkbox"/> TIGER OF THE SNOWS:
The Autobiography of Tezting of Everest
Price (to members only) \$3.95 |
| <input type="checkbox"/> GRANDFATHER STORIES
by Samuel Hopkins Adams \$3.50 | <input type="checkbox"/> A STILLNESS AT APOMATTOX
by Bruce Catton
Price (to members only) \$3.95 | |
| <input type="checkbox"/> THE GOOD SHEPHERD
by C. S. Forester
Price (to members only) \$3.75 | | |
| <input type="checkbox"/> THE FLOWER GIRLS
by Clemence Dane
Price (to members only) \$3.95 | | |

BOOK-OF-THE-MONTH CLUB, Inc. A7011
345 Hudson Street, New York 14, N. Y.

Please enroll me as a member and send, free, the work I have checked below with the purchase of my first selection, indicated above. I agree to purchase at least five additional monthly Selections—or Alternates—during the first year I am a member. I have the right to cancel my membership any time after buying six selections from the Club. (A small charge is added for each book bought to cover postage and mailing expenses.)

(Indicate which of these three works you wish to receive free)

- The Second World War Abraham Lincoln
 Great Short Novels

Mr. }
Mrs. }
Miss }
(Please Print Plainly)

Address.....

City..... Postal Zone No.State.....
(if any)

Book prices are slightly higher in Canada, but the Club ships to Canadian members without any extra charge for duty, through Book-of-the-Month Club (Canada), Ltd.

*Trademark Reg. U. S. Pat. Off. and in Canada



SCIENCE IN PROGRESS:

Ninth Series

edited by George A. Baitsell

Eminent scientists report on important developments in their respective fields, in this new addition to an outstanding biennial series. Contributors are: Laurence H. Snyder, Curt Stern, E. J. Kraus, Kenneth V. Thimann, George Wald, Lee E. Farr, Felix Bloch, William Shockley, D. B. Steinman, Wallace R. Brode. **\$6.50**

SCIENCE AND THE COURSE OF HISTORY

by PASCUAL JORDAN

A leading European physicist presents in simple, non-technical language a remarkable account of man's place in the universe in the light of our present scientific knowledge.

\$2.50

YALE university press
new haven, conn.

THE NATURE OF THE UNIVERSE
was only a warmup

for

FRED HOYLE'S FRONTIERS OF ASTRONOMY

The audacious young "Cambridge cosmographer" brings to bear on the cosmic mysteries the findings of atomic physics, recent discoveries made with the 200-inch Palomar telescope, and his own remarkable insights.

• "A fascinating book, full of the high, wild thinking which proves that a science is alive."

—*N. Y. Times Book Review*

48 pages of photos—many made with the 200-inch telescope—and 67 drawings.

\$5.00 at all bookstores

HARPER & BROTHERS

49 East 33rd St., New York 16

be able to change it before we can predict it. As one illustration of the horrendous difficulties of forecasting, Sir George estimates that an electronic computer must perform 30 million individual operations to digest the data needed to calculate an hour stage of upper winds over a small section of the Atlantic. Meteorology is not only complex but filled with paradoxes. For example, it appears that an increase in heat radiation from the sun would not make the earth warmer but instead would lead to an ice age. The argument is that the earth's atmosphere is driven by solar radiation, that an increase of the latter would speed up the winds and so lead to more precipitation which, at the poles, would appear as snow.

Weather is "like a pencil balanced on its point." A slight tremor may make it fall; the problem is to get it to fall in the direction you want. One can approach the problem with brute force or delicately. With large amounts of nuclear energy one might attempt to break up the Arctic ice or Greenland barrier and so change the climate over large areas. On the other hand, an atom-thick layer of material laid on the earth would absorb enough solar radiation to affect the weather, perhaps profoundly. To spread such a thin blanket over the whole earth might not be impossible (about a million tons of material would be required). It is far from certain, however, that the results would be desirable. The attempts to produce artificial rainfall by seeding are impressive, but it is still too early, according to Sir George, to be confident of the usefulness of this method. The growing of plants in desert areas, thereby altering the absorption of radiation by the ground, has a high chance of modifying climate for the better. It is important to realize, however, that changes in the vegetation of one area may adversely affect the climate of an adjoining area, so that the method has political implications, international as well as domestic. In the world of today, and even more of tomorrow, nobody's backyard, it appears, is really his own.

There will be enough food to go around for quite a while, says Sir George. Chlorella has possibilities, so have yeasts. He also has much to say on other absorbing topics, such as artificial mutations, domestication of animals (it is suggested that we train monkeys to pick our crops), control of population, and the prevention of old age. (Immortality, in his opinion, is not impossible.)

On the social consequences of another century of technological progress, Thomson's comments are much less interesting

than the rest of his book. His views on "the future of the stupid" (he seems to favor a return to "domestic service" for those who cannot master the ways of the bright new world), on education and on the uses of leisure are at worst not very creditable and at best unoriginal. He does, however, make a few shrewd observations that can bear repeating, among them that there is "far less real evidence on the best method [of teaching reading] than there is on the best sort of potato to grow."

The last chapter of the book, in which Sir George speculates on various aspects of the theory of communication, is fascinating. Very little is known about the working of the brain, but in time we shall know more. The big computers will help us, as will developments in electrophysiology, information theory and so on. Already enough is known to make one realize that the small, intricate, fleshy lump in our skulls, "with its ten thousand million working parts and its countless possible interconnections, vastly exceeds anything we are ever likely to be able to make and is [utterly] unlike the unorganized masses we physicists study, which show at best the rather banal wallpaper patterns that crystals display."

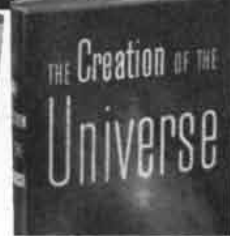
Suppose we attain a much deeper understanding of brain processes than at present; suppose we glimpse what is involved in the formation of ideas, habits, prejudices, desires and the like. Philosophers and even plain men have long esteemed self-knowledge as one of the greatest goods. Will they continue to esteem it if it should reveal the origins of altruism, tolerance, kindness and other human virtues in terms of electrical circuits? Many things that men value may not survive such analysis. It is dangerous enough to understand the secrets of the atom, but suppose we understood, as we understand the operation of an electric washing machine, why we laugh or are patriotic or admire Matisse or embrace religion. How long could these values be maintained once their genesis and nature were expressed as a circuit diagram? Sir George suggests that the possibility of reducing human responses to electromagnetic patterns need not necessarily impoverish life. We may learn new scales of values, learn to appreciate the intrinsic profundity of what seemed to us trivial at the same time we perceive the trivial in what seemed to us profound. "Consider the relation of Jove's thunderbolt to the fluttering of chaff round a piece of rubbed amber; consider how relatively easy we now find the movement of the planets, and

Any 3 for only \$3⁹⁵

VALUES UP TO \$17⁹⁰

to demonstrate the superb quality of the books you can obtain at savings up to 40% by now joining the

science book club



ROCKETS, MISSILES AND SPACE TRAVEL
by WILLY LEY

Not fiction, but thrilling facts... including a preview of already planned flights to the moon and planets. Illustrated.
Retail price \$5.95

GREAT ADVENTURES IN MEDICINE

Edited by SAMUEL RAPPORT and HELEN WRIGHT

The most interesting, exciting and important developments in the field of medicine from earliest times to the present.
Retail price \$5.00

A TREASURY OF SCIENCE

Edited by HARLOW SHAPLEY

A massive anthology of man's entire universe of knowledge, with selected writings of all the greatest scientists from Galileo to Einstein. New 3rd Edition.
Retail price \$5.95

THE CHALLENGE OF MAN'S FUTURE

by HARRISON BROWN

One of our top geo-chemists presents a sobering analysis of the hazards that face mankind in the future. "This objective work has high value."—Albert Einstein
Retail price \$3.75

ANIMALS, MEN AND MYTHS

by RICHARD LEWINSOHN

Written by one of the most brilliant scientists of our time, this is a unique account of man's knowledge of the animal world down through the ages.
Retail price \$5.00

LEONARDO DA VINCI

by ANTONINA VALLENTINI

A truly definitive and absorbing biography of the immortal genius who, 500 years ago, laid the foundations for half a dozen sciences.
Retail price \$5.00

THE WORLD OF NATURAL HISTORY

by JOHN R. SAUNDERS

A personally conducted tour of that fabulous treasure house, the American Museum of Natural History.
Retail price \$5.00

IDEAS AND OPINIONS OF ALBERT EINSTEIN

Assembled under the supervision of Einstein himself, this is the most complete collection of his popular writings ever published.
Retail price \$4.00

THE CREATION OF THE UNIVERSE

by GEORGE GAMOW

Giving the origins of galaxies, stars and planets in the light of known nuclear reactions, the author traces the expansion of the universe through three billion years.
Retail price \$3.75

AMERICAN SOCIAL INSECTS

by CHARLES D. MICHENER and MARY H. MICHENER

The whole amazing story of the bees and ants, wasps, hornets and termites, living in highly organized societies. 109 illustrations, 30 in color.
Retail price \$6.00

EXPLORATIONS IN SCIENCE

by WALDEMAR KAEMPFERT

The dramatic stories behind the scientific wonders that have made headlines in recent years. The author is a former Editor of *Scientific American* and is now Science and Engineering Editor of the *N. Y. Times*.
Retail price \$3.75

MEMBERSHIP BENEFITS

This Club is for people who want to keep abreast of scientific discoveries, inventions and developments of all kinds the world over.

Each month the Club's editors select an outstanding book. This and other significant works in the same field are described in *The Science Report* which you receive free.

By joining NOW, you receive any THREE of the books shown here (values up to \$17.90!) for only \$3.95, plus a nominal charge for mailing. TWO of these books will be yours FREE, as a membership GIFT. The third will be considered your first selection. For every four additional selections you take after joining, you receive a valuable Bonus Book FREE.

You do not have to accept every selection. You accept only the books you want, and pay only the special reduced price for members, plus a small fixed mailing charge, after receiving them.

It costs nothing to join and you may cancel your membership at any time after accepting as few as four selections. You need send no money now. But mail the coupon TODAY.

This FREE GIFT Coupon Makes You a Member

SCIENCE BOOK CLUB, Inc., Dept. 2136
11 East 36th Street, New York 16, N. Y.

Check THREE:

- TREASURY of SCIENCE
- THE CHALLENGE of MAN'S FUTURE
- ROCKETS, MISSILES and SPACE TRAVEL
- THE WORLD of NATURAL HISTORY
- GREAT ADVENTURES in MEDICINE
- THE CREATION of the UNIVERSE
- ANIMALS, MEN and MYTHS
- AMERICAN SOCIAL INSECTS
- LEONARDO DA VINCI
- EXPLORATIONS in SCIENCE
- IDEAS and OPINIONS of ALBERT EINSTEIN

Name.....

Address.....

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

Please enroll me as a member and send me the THREE books checked below. Two of these are to be FREE, as my membership gift, and I will be billed only \$3.95, plus a nominal charge for postage and packing for the third which is to be my first selection. For each four additional selections I accept, I am to receive a valuable Bonus Book FREE. I am also to receive the Club's Science Report FREE each month. My only obligation is to accept as few as four selections the first year I am a member, paying only the special member's reduced price plus 25c for postage after receiving them.



physics

chemistry

electronics

mathematics

engineering

metallurgy

these
6 fields
of scientific
research
are a
challenge...

... and the scientific and engineering personnel of the Los Alamos Scientific Laboratory working with some of the Western World's finest equipment and facilities—are meeting the challenge with independent and original research, application and development work.

Excellent opportunities now exist at Los Alamos for qualified men wishing to further their scientific careers.

The nation's most important institution for the development of atomic weapons, offers unlimited opportunity for individual growth and development. In addition to its continuing and ever expanding achievement in nuclear weapons research, the Laboratory is now pioneering in the fascinating fields of nuclear power and nuclear propulsion.

Los Alamos itself, beautifully located among pines on the lower eastern slope of the towering Jemez mountains, is a delightful small city—an ideal community and climate in which to live and raise a family.

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

DIRECT YOUR
INQUIRY AND
BACKGROUND
RESUME TO
DEPARTMENT
OF
SCIENTIFIC PERSONNEL
Division 112

how hard it still is to understand the workings of a worm."

It cannot be said that we are remotely within sight of the relation between brain and what we call mind. That there is a simple one-to-one correlation between states of the brain and of consciousness has been assumed but never proved. Now doubt has been cast on this assumption by research on extrasensory perception, yielding evidence which Sir George regards as uncomfortably impressive. It may be necessary, if the evidence accumulates and stands up, drastically to revise our general scheme of thought. "The importance of the subject," says Sir George, "is enormous and much too little work is being done on it." Clearly the frontiers of the mind lie much beyond us; not only is it possible that we use unsuspected modes of communication but there are plain indications that "we are far from using our full mental potentialities." There is no permanent reason why only a few men should be bright and the rest mediocre, or worse. Why should the calculating wizard or the musical prodigy so often be an idiot in other respects? Is there no way to train special mental powers so that many will be able to do what can now be done only by a few? It is difficult to prophesy how men's brains will be improved, whether by drugs, by "feeding in electrical impulses of the right kind," by new methods of education, by psychiatric stratagems employed in earliest youth, by selected mutations. But it will be done, Sir George believes, and since we have come a long way from being mollusks, in the head as well as in the body, we have proof that it can be done. That the brain which can foresee has a future that is not foreseeable is the greatest of the promises that lie ahead.

Short Reviews

THE LIFE AND WORK OF SIGMUND FREUD: VOL. II, by Ernest Jones. Basic Books, Inc. (\$6.75). In this second volume of his definitive biography of Freud (the first volume was reviewed in the November, 1953, *SCIENTIFIC AMERICAN*), Dr. Jones covers Freud's "years of maturity," from 1901 to 1919. In 1901 Sigmund Freud was in his 45th year, and his greatest creative labor, *The Interpretation of Dreams*, in which he built the foundations of psychoanalysis, lay behind him. The rest of his life he was to devote to elaborating and extending the theories put forward in that work and to applying his concepts of the role of the unconscious and infantile sexuality to the understanding not only of mental

disorders but also of other aspects of human life, such as myths, legends, folklore and custom. Freud's exertions on behalf of his science took many forms and required an all but incredible expenditure of energy. During 10 months of the year Freud toiled from 15 to 16 hours a day. He saw his first patient at eight in the morning, his last at eight in the evening. He took time out for meals and for brisk walks, but by 10:30 or 11 he was back at his desk for another two-to-three-hour stint answering correspondence, reading, correcting proofs, working on one of his books or papers. Yet somehow time had to be found for still other essential activities. For years Freud had lived in "splendid isolation," as he described it. But with the turn of the century, as his reputation spread, as he gained adherents and enemies, new tasks and responsibilities were thrust upon him. He had to participate in the affairs of psychoanalytical groups and societies that were being formed. He had to write for and even to keep alive journals and yearbooks he had started. He had to encourage and make peace among his disciples—a brilliant, wayward, ill-assorted and neurotic collection of mavericks. He had to fend off critics for whom his "obsession with sex" was as outrageous, as much a basis for moral loathing, as a belief in communism is in the U. S. today. He had to struggle to propagate his theories, and to gain wider acceptance for them in the face of the defections and outright repudiations by persuasive and influential disciples such as Jung and Adler. All that needed to be done he did. His professional duties were never neglected; his writings poured forth in prodigious quantity; he kept the key societies and publications going; he soothed and scolded and polemicized as occasion demanded; he met the opposition with courage, pertinacity and superb self-confidence. There were, of course, moments of doubt and periods of despair. He was deeply grieved when followers deserted him. His health was basically sound but he suffered from a chronic intestinal disorder. That he won out in the end, as Jones convincingly shows, was as much a tribute to his simplicity and faith, to his sheer will, as to the validity and profundity of many of his insights. From the average reader's standpoint, this second volume of Jones's cannot be said to come up to the interest of the first volume. Inevitably a good deal more space has to be devoted to the dissensions, to the character of the disciples, to somewhat technical analyses of Freud's voluminous writings. Yet there is much in these pages that will stir and

MISSILE SYSTEMS

PHYSICISTS AND ENGINEERS

Research and development in the technology of guided missiles is not confined to any one field of physics. Broad interests and exceptional abilities are required by the participants. Typical areas at Lockheed Missile Systems Division include:

- Applied mathematics such as the numerical solution of physical problems on complex computers
- Analytical systems analysis of guidance and control problems
- Ballistics and the integration of ballistic type missiles with vertical guidance
- RF propagation, microwave and antenna research and development
- Integration of ground and flight test data to evaluate dynamic performance
- Stress and structures
- Instrumentation and telemetering
- Advanced electronics and radar systems

Continuing developments are creating new positions for those capable of significant contributions to the technology of guided missiles.

Lockheed

**MISSILE
SYSTEMS
DIVISION**

research and engineering staff

LOCKHEED AIRCRAFT CORPORATION

VAN NUYS • CALIFORNIA

Prepare Now for Leadership in the Second Industrial Revolution

computers—automation—robots—etc.
Knowledge is power in this rapidly expanding new field. Get that knowledge at your own pace through our courses by mail.

"20" Courses (New Series): All in one part—Including all books and materials—Returnable in seven days for full refund—Also partially returnable (if you have some of the books, etc.)—With question-answering, guidance, and help for 8 months:

Course S 20: THE ALGEBRA OF CLASSES AND OF STATES AND EVENTS, AND HOW TO DESIGN CIRCUITS WITH IT. The algebra of AND, OR, NOT, . . . classes, statements, etc.; Boolean algebra. Applications to on-off circuits using relays, electronic tubes, diodes, etc. The algebra of WHEN, BEFORE, AFTER, HAPPEN, . . . states, events, changes, etc.; Boolean algebra modified to include time. Applications to delay lines, flip flops, sequential circuits, etc. Circuits for control, programming, computing, etc. Course Fee, including four publications totaling 127 pages, course directions, set of questions and assignments, personal instruction and guidance. . . \$18.

Course C 21: AUTOMATIC COMPUTING MACHINERY. The Second Industrial Revolution. Automatic machinery for handling information; computers and other data processing machines. Properties, advantages, disadvantages. Applications in business, engineering, government. The course includes a 260-page book, a 160-page directory of manufacturers, products, services, etc., a glossary of over 400 terms, a magazine subscription, course directions, set of questions, assignments, personal instruction and guidance. Course Fee including everything. . . \$28.

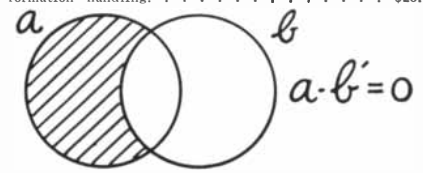
Course M 21: INTRODUCTION TO THE THEORY OF GAMES. The theory of games of strategy. Payoffs, strategies, saddle points, dominance, and other powerful concepts. Computing the odds; arriving at a strategy. This course includes a 230-page book, materials for strategic games for analysis (and fun to play), course directions, set of questions and assignments, personal instruction and guidance. Course Fee including everything. . . \$19.

M 20: INTRODUCTION TO MATHEMATICAL STATISTICS. . . . \$29. (including everything).

C 20: GENIACS—SMALL ELECTRIC BRAIN MACHINES—AND HOW TO CONSTRUCT THEM. . . . \$28. (including kit and everything).

Regular Courses (Original Series): In three or more parts, first installment \$11.—Payable in 3 monthly installments—1/2 years' study time with personal instruction and guidance—Individuals or study groups—Cost in study groups as low as \$9. per member—Scholarships, incentives, etc.—References not included.

S1: SYMBOLIC LOGIC: Nonnumerical exact reasoning using efficient symbols for calculation. Applications to information handling. . . \$28.



OPR 1: OPERATIONS RESEARCH: Methods of scientific research applied to the evaluation of equipment and of tactical and strategic operations. Mathematical methods, techniques for getting information, etc. Applications to military, business, and industrial problems. . . \$32.

C4: CYBERNETICS: "Control and communication in the animal and the machine." Servomechanisms and automatic controllers. Analog and digital computers, control and capacity. Comparative psychology of animals. The human brain and its functioning. . . \$22.

L1: LANGUAGE: Scientific study of language. Nature, development and origin. Relation to symbolic techniques permitting calculation such as mathematics, symbolic logic. Words, meanings, contexts. Language in relation to organization of thinking and society. Applications. . . \$28.

EXP 1: TECHNIQUE OF EXPLANATION: The problem of explaining. The nature of understanding. Examples of good and poor explanation. Vocabulary, readability, people's attitudes, and other factors. . . \$28.

M15: MATHEMATICS FOR PEOPLE WHO DIDN'T LIKE IT: A new kind of mathematics course. The psychology of dislike, fear, and avoidance. The maturing of personality. What mathematics essentially is. Languages of mathematics, what they refer to, how to understand them. . . \$30.

G1: GENERAL KNOWLEDGE 1: MAN IN PERSPECTIVE: Earth, Moon, Mars, and Venus. The biography of the Earth. Life and its environments. Other societies, cultures, languages, economic systems, technologies, etc., contrasted with ours. The long broad view of man. An attempt to escape from the provincialism of one time and one place. . . \$22.

M11: Elementary Algebra . . . \$28. **M2: Higher Algebra** . . . \$28. **M3: Geometry** . . . \$28.

M4: Trigonometry . . . \$28. **M5: Analytic Geometry** . . . \$28. **M6: Calculus** . . . \$32. **M1: Topics in Modern Mathematics** . . . \$32. **M8: Probability** . . . \$28. **M12: Calculus of Finite Differences** . . . \$32. **M13: Differential Equations** . . . \$35. **S2: Advanced Symbolic Logic** . . . \$35.

L2: Readable Writing . . . \$35. **C5: Construction of Small Robots** . . . \$32.

We have students in 48 states and territories, 20 foreign countries; we offer 25 other publications (including reprint of *Symbolic Logic* by Lewis Carroll, publ. P 32, \$2.50).

MAIL THIS COUPON—
EDMUND C. BERKELEY and Associates
815 Washington St., R 129, Newtonville 60, Mass.
1. Please send me items circled:
I enclose \$ _____ equal to full payment for:
S20 C21 M21 M20 C20 P32
And \$11.00 first installment for:
S1 OPR C4 L1 EXP 1 M15 G1 M11 M2 M3
M4 M5 M6 M1 M8 M12 M13 S2 L2 C5
Returnable in 7 days for full refund if not satisfactory
(or if prerequisites not met).
2. Please send free announcement of publications and
 courses, both series.
My name and address are attached.

fascinate almost everyone: brilliant vignettes of personalities, intimate glimpses of Freud at work and at leisure, lucid explanations of difficult psychoanalytical concepts, descriptions of major and trivial sequences in Freud's life. One emerges from this massive and meticulous book with a sense of grasping the dimensions and lineaments of its subject, with renewed admiration for the biographer's skill, and with a feeling of gratitude and relief that the work itself is not yet finished, that more good things are still to come.

THE INTERPRETATION OF DREAMS, by Sigmund Freud. Basic Books, Inc. (\$7.50). *Die Traumdeutung* made its first appearance in 1899. Thereafter seven other German editions were published during its author's life, as well as three editions of English translations, the first two by A. A. Brill. This new volume is an entirely new translation by the distinguished British student James Strachey, who has labored for many years to render into English other of Freud's writings. Freud himself tinkered repeatedly with his masterpiece, adding material, modifying various passages, reorganizing entire sections. In this way he tried to keep the book more or less up to date. But it was not a systematic effort and the result was something of a hodgepodge, the despair of the faithful. Strachey has now produced what will probably be accepted as the definitive English version of *The Interpretation of Dreams*. All the material Freud added is here: "An effort has been made to indicate, with dates, every alteration of substance introduced into the book since its first issue." There is a formidable critical apparatus of references and explanatory notes. The translation itself is exemplary; where it is hard going, the difficulties are imposed by the material, not by any shortcomings of the translator. For any student who is interested in Freud's thought processes this admirable edition, executed with so much devotion and skill, is indispensable.

MAN ABOVE HUMANITY, by Walter Bromberg. J. B. Lippincott Company (\$5.75). This book is a history of psychotherapy by a psychiatrist of broad experience and a capable student of his subject. Dr. Bromberg offers a detailed account of man's striving to control mental disease, at first by exorcising spirits, by treating the sick as if they were unclear or evil and by cruel restraint and sheer brutality, later by pseudo science and faith healing, finally, in our own time, by kindness, understanding, hy-



Executives and Engineers deserving higher salary

now can completely, confidentially make arrangements for better positions through our unique Job Improvement Service.

As publishers of Engineers' Job Directory we have close contact with leading manufacturing and research firms in all sections of the country.

Here's what you do. Send us your name, title, company and home address. We will forward to your home brief forms which you fill out and return. We compare your experience and desires with our file of specific job openings. You make the decision. No obligation to you, no cost whatsoever. Our clients pay us to find you. Find out what you're really worth—today. Write, phone or wire.

DECISION INC.
Management and
Recruitment Consultants
Oliver P. Bardes, President
430 First National Bank Building
Cincinnati 2, Ohio

THE ONLY PHOTOCOPIER BUILT FOR TRAVEL



With a Contoura* and Constat*, error-proof copies of anything written, drawn or printed can be made wherever there is an electric lighting outlet. Scientists, professors, lawyers, sales engineers, historians, musicians, hobbyists, can copy book pages, scores, charts, graphs, maps, tabulations, scientific articles, letters, diaries. The quickest and easiest research method. 40 seconds per copy.

Portable. Maneuverable. Simple. Low Cost. Guaranteed. Write for full details.



F. G. LUDWIG, Inc. 784 Coulter St.
Old Saybrook, Conn.

*T.M. Reg.
U.S. Pat. Off.

giene and rational therapy. It is a fascinating drama of many acts, persons, devices and theories: incubi and succubi, Lydia Pinkham and Sigmund Freud, Benjamin Rush and his "tranquilizing chair," Mesmer and his magnet, "Dr. Diet and Dr. Quiet," Phineas Quimby, Harry Stack Sullivan, sodium pentothal, Paracelsus, libido, the malleus maleficarum, malicious animal magnetism, Mary Baker Eddy, mescaline and bedlam. Despite a weakness for jargon, and an inclination to pile up quotations and footnotes which make it difficult at times for the plain reader to see where the main road is heading, Bromberg succeeds pretty well in conveying the richness and variety of a momentous struggle for light.

ANXIETY AND STRESS, by Harold Basowitz, Harold Persky, Sheldon J. Korchin and Roy R. Grinker. McGraw-Hill Book Company, Inc. (\$8.00). An understanding of anxiety is of central importance to all psychiatric theory. These authors studied several groups of soldiers undergoing paratroop training, reasoning that the intense social pressure to succeed, as well as the constant physical dangers to which the airborne trainees were exposed, would make them ideal subjects for an investigation of anxiety states. As their training progressed, the soldiers were repeatedly subjected to biochemical and psychological tests. The chief merit of the work lies in demonstrating clearly the many problems involved in this sort of investigation. Despite a worthy effort, the research yield was poor. This is due in part to the inherent methodological difficulties of multidisciplinary studies. There was also the disconcerting finding that paratroop training does not create the expected amounts of free anxiety in trainees. The thought of jumping from an airplane may make research workers more anxious than it does the soldier volunteers.

THE OCEAN FLOOR, by Hans Pettersson. Yale University Press (\$3.00). Oceanographers have their own special methods for reconstructing the past. They study ocean currents and probe great marine trenches and deeps; by analyzing cores from the sedimentary carpet on the ocean floor they are able to make remarkable conjectures as to the history of the earth. This book by a distinguished Swedish oceanographer is based on the Silliman Lectures given at Yale University in 1952. It reports fully on findings of recent years, especially those made by the Swedish Deep-Sea

"Follow the Leader" is a kid's game-



but it's better to JOIN a leader when you begin your career in ENGINEERING

Allison—in Indianapolis—is a leader in the design, development and production of turbo-jet and turbo-prop engines.

The Allison Turbo-Prop engine is backed by more than 6 million hours of turbine engine flight time which makes Allison a world leader in experience with gas turbine engines. Future opportunity for engineers in this field is unlimited. And, we are faced with immediate expansion of our engineering staff.

Too, our long-range expansion program in engineering provides for newest engineering test and research facilities. This program—a \$75 million project—creates an immediate need for a 40% increase in engineers and well-qualified, technically-trained personnel. If you've had experience, or training, in any of the following fields, we want to talk to you about your future at Allison:

***Stress Analysis • Design of High Speed Rotating Machinery
Theory and Design Servo-Mechanisms
Engine and Aircraft Performance Analysis
Experimental Test of Gas Turbine Engines and Components
Design of Axial Flow Compressors and Turbines
Design of Blading for Axial Flow Compressors and Turbines***

**Write to Salaried Personnel, telling us about yourself,
your qualifications, your academic and work experience.**

ALLISON DIVISION *General Motors Corporation*
Indianapolis 6, Indiana
Dept. SA

GIVE "THE GIFT OF LANGUAGE"
 TO FRIENDS, FAMILY and YOURSELF

IT'S FUN TO LEARN
 by **LINGUAPHONE**
 World's-Standard Conversational Method
 The Quick, Natural EASY Way



Another language gives you an invaluable asset for business, school, armed forces, social life and travel. Treat your family, friends and yourself to the "Gift of Language"—a Linguaphone Conversational Set in:

**FRENCH • SPANISH
 RUSSIAN • GERMAN
 ITALIAN • JAPANESE
 MODERN GREEK**

34 languages available on
10 DAY FREE TRIAL

With the amazing, up-to-date Linguaphone recordings, you learn another language AT HOME in just 20 minutes a day. It's the same easy, natural way you learned your mother tongue before you went to school.

You listen, you hear 8 to 12 of the world's best native language teachers, both men and women, speak about every day matters in their native language—YOU understand. You speak correctly as they do. It's like living in another country.

That's why Linguaphone is used 'round the world by scientists, educators, governments and business firms for personnel training. More than a million home-study students of all ages.

10 DAY FREE TRIAL
 Send today for Free booklet that tells about Linguaphone and how you may obtain a COMPLETE Course-unit in the language you choose on 10 day FREE TRIAL

Linguaphone Institute, T-3115
 Radio City, New York 20.

SEND FOR FREE BOOK

"PASSPORT TO A NEW WORLD OF OPPORTUNITY"



LINGUAPHONE INSTITUTE
 T-3115 Radio City, New York 20, N.Y.

Please send me your FREE Book about Linguaphone plus details of 10 DAY FREE TRIAL. No obligation, of course.

Language interest

Name

Address

City Zone State.....

Leaders for Over Half a Century in Up-To-Date Modern Language Courses

Expedition of 1947-1948, in which Pettersson participated ["Exploring the Ocean Floor," by Hans Pettersson; SCIENTIFIC AMERICAN, August, 1950]. The evolution of the oceans is described, and the author considers the remote, but not impossible, prospect of our planet ultimately becoming desiccated. Pettersson's well-written book enables the reader to gain a vivid appreciation of scientific method and reasoning.

AIRBORNE CONTAGION AND AIR HYGIENE, by William Firth Wells. Harvard University Press (\$6.00). Support for the airborne theory of disease has fluctuated over the centuries. Among the ancients the source of epidemics was thought to be the "winds." The plagues of the Middle Ages shifted attention to the dangers of actual contact with the sick. In the 19th century, with the rise of chemistry and the newer knowledge of gases, medicine turned again to "miasmatic concepts." For a time it was believed that "expiratory droplets" carrying infectious microbes did not travel more than arm's length from the sick person before falling to the ground. Then in 1933 research, mainly by the author of this book, disclosed that most droplets "atomized into air evaporate almost immediately, leaving disease germs drifting like cigarette smoke in droplet nuclei." Thus for the first time there is scientific evidence for the belief that contagion is truly airborne; indeed droplet infections are now held to be "the most prevalent and the most damaging of the infections to which flesh is heir." Wells's book is so constructed that both laymen and specialists will find it useful.

THE ANCIENT NEAR EAST IN PICTURES RELATING TO THE OLD TESTAMENT, by James B. Pritchard. Princeton University Press (\$20.00). Few books are more cogent proof than Pritchard's of the truth of the cliché that a single picture is better than a thousand words. The author has collected some 700 photographs constituting a superb pictorial record of the history, daily life and religion of Palestine and adjacent and related cultures during the span of biblical times. The peoples and their dress are shown, the jewelry, cosmetic aids, agricultural implements, methods of husbandry, boating, shipping, fishing, buildings and fortifications, arts and crafts, hunting, warfare, games and dances, writing practices and tools, historical records and monuments, habits of kings and commoners, the Gods and their emblems, religious practices. Each photograph is accompanied by a full descrip-

ELECTRONIC ENGINEERS

\$10,000 to \$18,000
NO FEES

Outstanding company in the East, a leader in the electronic industry has several key openings at the project level or above.

They are working on guided missiles, air-borne radar, analogue computers, etc.

You owe it to yourself to investigate these opportunities on a confidential basis at no obligation to you.

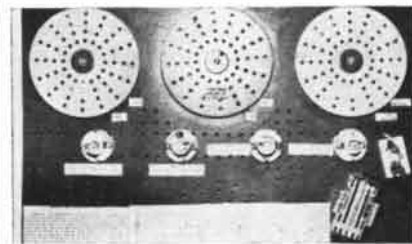
Send three copies of your resume to:

Harry L. Brisk (Member I.R.E.)
 Department C

ACCREDITED PERSONNEL SERVICE

12 South 12th Street,
 Philadelphia 7, Pa.

Can you think faster than this Machine?



Control Panel of GENIAC set up to do a problem in check valve research.

Be careful before you answer. GENIAC the first electrical brain construction kit is equipped to play tic-tac-toe, cipher and encipher codes, convert from binary to decimal, reason (in syllogisms) as well as add, subtract, multiply and divide. Specific problems in a variety of fields—actuarial, policy claim settlement, physics, etc.—can be set up and solved with the components. Connections are solderless and are completely explained with templates in the manual. This covers 33 circuits and shows how new ones can be designed.

You will find building and using GENIAC a wonderful experience; one kit user wrote us: "this kit has opened up a new world of thinking to me." You actually see how computing, problem solving, and game play (Tic-tac-toe, nim, etc.) can be analyzed with Boolean Algebra and the algebraic solutions transformed directly into circuit diagrams. You create from over 400 specially designed and manufactured components a machine that solves problems faster than you can express them.

Schools and colleges, teachers of science or math, engineering, philosophy or psychology will find these excellent demonstrators of circuitry, solutions in symbolic logic, theory of numbers, cybernetics, and automation.

Note: Teachers take advantage of our 10% discount to educational institutions and for group purchases.

SEND for your GENIAC kit now. Only \$19.95 with over four hundred components and parts, fully illustrated manual and wiring diagrams. We guarantee that if you do not want to keep GENIAC after two weeks you can return it for full refund plus shipping costs.

MAIL THIS COUPON

SCIENCE KITS, Department SA 140
 Oliver Garfield Company
 546 Summit Avenue
 Jersey City, N.J.

Please send me:

1 GENIAC Electric Brain Construction Kit and Manual.

\$19.95 (East of Mississippi) _____

\$20.95 (Elsewhere in United States) _____

\$21.95 (Outside the United States) _____

Returnable in seven days for full refund if not satisfied. I enclose \$..... in full payment.

My name and address are attached.

tive note and by other details. In Pritchard's book ancient cultures are revived in all their richness, and ancient peoples again live and breathe.

ONE MILLION DELINQUENTS, by Benjamin Fine. The World Publishing Company (\$4.00). Among our pressing social problems juvenile delinquency has been pre-eminent in its capacity to evoke lopsided statements about its causes, dramatic and titillating caricatures of its subjects, and apathy or credulity concerning its management. Benjamin Fine, education editor of the New York Times, stimulated by Attorney General Brownell's observation that one million children would be in some kind of trouble with the police during 1954, spent that year surveying the problem. His book is a mature and balanced report of current thinking and practice in the field. Delinquency, as any sensible person would suspect, is a complex social phenomenon whose roots are nourished much more by poverty and neglect than by comic books, poolrooms and pornography. The serious delinquent emerges as a child who is trapped in life by overwhelming circumstances. As to treatment, Fine points out how tragically little we use of the limited understanding we have. The author's writing is pedestrian, but fortunately he often allows the children to speak for themselves.

FOUNDATIONS OF QUANTUM THEORY, by Alfred Landé. Yale University Press (\$4.00). Despite its brilliant success in mathematical physics, quantum mechanics continues to stick in the craw. Not a few scientists are dissatisfied with the picture of nature which it implies: a world of discontinuous jumps between discrete states. It is not a comfortable nor an intuitive notion: many an investigator accepts it for the time being because it is useful, but hopes something cozier and more deterministic will turn up to take its place before long. It may be that Dr. Landé has come to the rescue. This uncommonly interesting essay attempts to save the method while reinstating continuity. The argument points out that the principles of classical thermodynamics themselves lead to a discontinuity of entropy known as the Gibbs paradox. If now a postulate is introduced which removes this discontinuity from the classical scheme, one can straightway deduce the general structure of the quantum theory. Landé's work is not a book for beginners. But they can at least catch a glimpse of the challenging ideas of a most inventive theoretical physicist.

Billy

Eagle Wing's

Last Stand—



Billy is one of America's forgotten children. He is a Navajo Indian, an innocent victim of neglect and denial of opportunity. As a youth of 9, he already faces problems other boys and girls do not know about. His clothes are tattered and patched—he has no warm coat, no sturdy shoes. His health is fair now, but bitter cold weather finds him vulnerable to disease.

His father, a hard-working sheepherder, ekes out a meager living on the reservation for the family of four, which includes mother and daughter. Father and mother have high hopes for Billy's future for a life with opportunity and usefulness. But they can do nothing for Billy to give him a chance.

This is *Billy's last stand*, against the poverty and misery that surround him and darken his future. As a native American and inheritor of a glorious tradition, he deserves a chance to live and become a useful citizen.

HOW YOU CAN HELP

You can help Billy or another needy Navajo child through the Federation's CHILD SPONSORSHIP plan. For just \$8 a month, \$96 a year, you will provide "your" child with warm clothing, sturdy shoes and other needed items.

You will receive a case history, like the story of Billy Eagle Wing, and if possible, a photograph. You can write "your" child or the parents, and be their friend. You will know how much your generosity means to them.

A contribution in any amount will help

SCF NATIONAL SPONSORS (a partial list)

Miss Faith Baldwin, Mrs. Mark W. Clark, Mrs. Dwight D. Eisenhower, James A. Farley, Lynn Fontanne, Norman Rockwell, Dr. Ralph W. Sockman, Gladys Swarthout, Mrs. Wendell L. Willkie



SAVE THE CHILDREN FEDERATION Established 1932

Carnegie Endowment International Center,
United Nations Plaza, New York 17, N. Y.

- I would like to sponsor a Navajo child for one year. I will pay \$96.00 for one year (or \$8.00 a month). Enclosed is payment for the full year first month . Please send me the child's name, story and picture.
- I cannot sponsor a child, but I want to help by giving \$.....

Name

Address

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

Contributions to Save The Children Federation are deductible from income tax

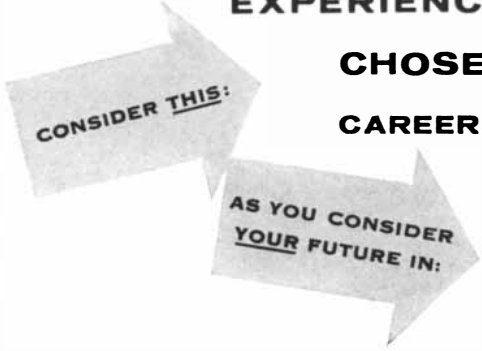
SA-9

OVER 600

EXPERIENCED ENGINEERS AND SCIENTISTS*

CHOOSE RCA SYSTEMS, DESIGN OR DEVELOPMENT CAREERS IN THE LAST YEAR!

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



SYSTEMS ENGINEERING
COMPUTERS
GUIDED MISSILE ELECTRONICS
AVIATION ELECTRONICS
ELECTRON TUBES

FIELDS OF ENGINEERING ACTIVITY	TYPE OF DEGREE AND YEARS OF EXPERIENCE PREFERRED											
	Electrical Engineers			Mechanical Engineers			Physical Science			Chemistry Ceramics Glass Technology Metallurgy		
	1-2	2-3	4+	1-2	2-3	4+	1-2	2-3	4+	1-2	2-3	4+
SYSTEMS <i>(Integration of theory, equipments and environment to create and optimize major electronic concepts.)</i>												
AIRBORNE FIRE CONTROL			W M			M				W M		
DIGITAL DATA HANDLING DEVICES			C			C				C		
MISSILE AND RADAR			M X			M				M		
INERTIAL NAVIGATION			M			M				M		
COMMUNICATIONS			C I							C I		
DESIGN • DEVELOPMENT												
KINESCOPIES (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			
MICROWAVE TUBES —Tube Development and Manufacture (Traveling Wave—Backward Wave)		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 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			
COMPUTERS —Systems—Advanced Development—Circuitry—Assembly Design—Mechanisms—Programming	C	C X	M C X	C	C X	M C X	C	C X	C	C		
RADAR —Circuitry—Antenna Design—Servo Systems—Gear Trains—Intricate Mechanisms—Fire Control	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	I		I	I			
MISSILE GUIDANCE —Systems Planning and Design—Radar—Fire Control—Shock Problems—Servo Mechanisms	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			

Location Code: C—Camden, N.J. H—Harrison, N.J. I—International Div. L—Lancaster, Pa. M—Mourestown, 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-1L, Radio Corporation of America
30 Rockefeller Plaza, New York 20, N. Y.



RADIO CORPORATION of AMERICA

Copyright 1955 Radio Corporation of America



THE AMATEUR SCIENTIST

*On the making of recording instruments
and a moving model of the solar system*

Henry Marrows, an instrument designer of New York City, quarrels with the cliché that the primary tools for scientific research ultimately boil down to just a pencil and a sheet of paper. "A brain limited to this method of recording data," he writes, "would certainly arrive at a narrow concept of the universe!" Over most of the spectrum of natural phenomena it is impossible to record observations without the assistance of more rapid, more sensitive, more tireless or more accurate re-

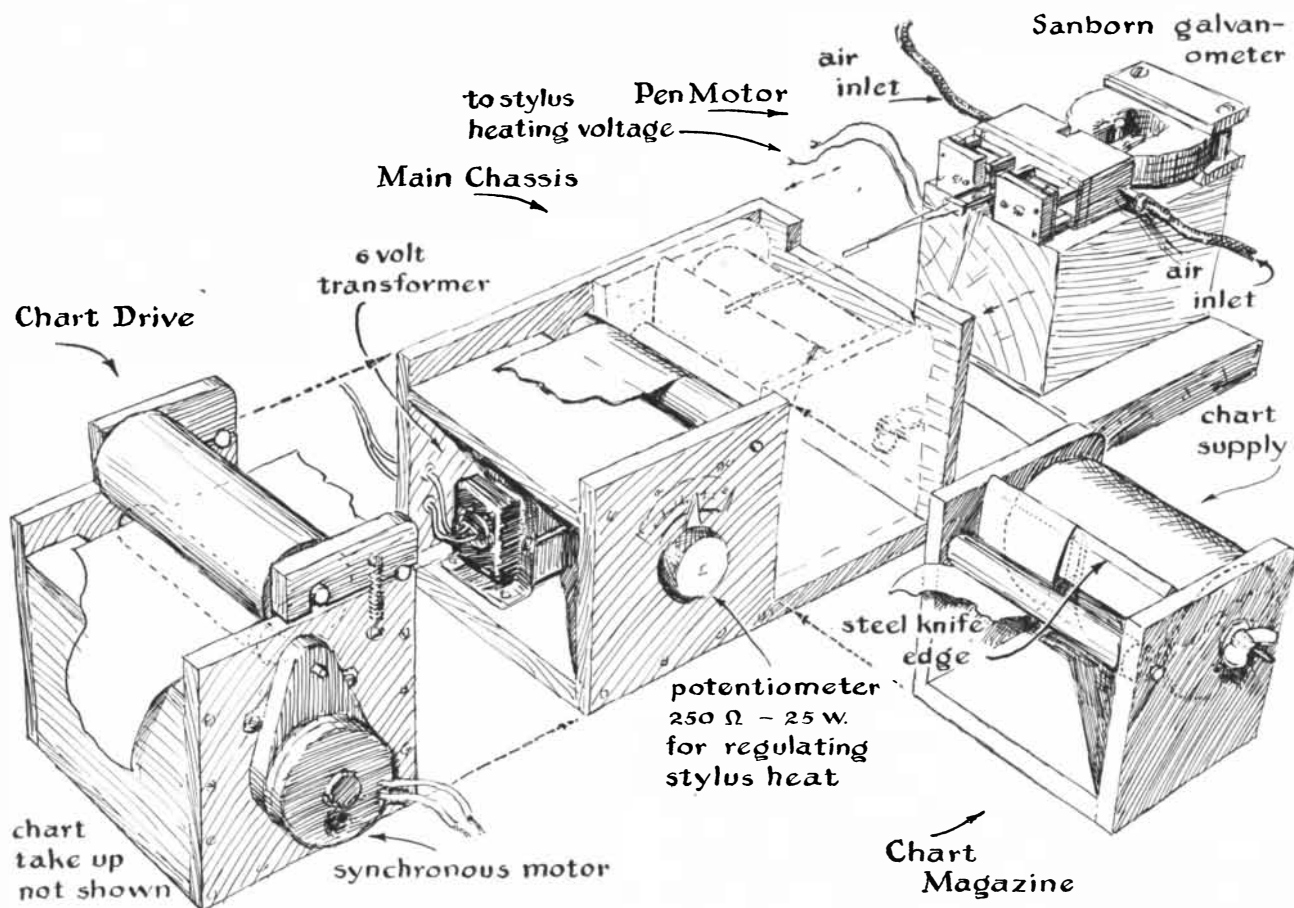
ording instruments. Marrows explains:

"A pencil propelled by human muscle can keep up with only about five events per second, and a human being cannot stay awake long enough to make a continuous record of events lasting more than about 24 hours. In the parlance of instrument designers, the muscle-driven pencil has a sharply limited frequency response. The frequencies of nature stretch across a spectrum paced at one extreme to the slow evolution of galaxies, covering billions of years, and at the other extreme to the spin of an electron, taking place within a millionth of a microsecond.

"At the low-frequency end, nature

provides some ready-made recorders. The age of galaxies is recorded in their slowly changing form. The eras of the earth's evolution have been registered as strata in the rocks. The cycles of climate and other annual events can be read in tree rings and varves (lake-bottom mud deposits). And for recorders of more rapid events we have the deposits left by flash floods, the craters left by meteorites and the fused substances marking points where lightning has struck.

"There are certain important gaps in the spectrum where nature fails to furnish a record. Most of the interesting ones lie in the frequency band between a few hours and an infinitesimal fraction



A pneumatic recorder which may be built by an amateur

LENSES 500,000 OF THEM
 Send 3 cent stamp for "BARGAIN" list
AVAILABLE NOW!
 Let's Go!

MOUNTED AIR SPACED OBJECTIVES

We offer the lowest priced air spaced hand-corrected precision American made astronomical objectives Mounted in Black Anodized Aluminum Cells.

"THOSE IN THE KNOW" BUY FROM US BECAUSE:

These lenses will meet and surpass all competition. They are corrected for the C & F Lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. Each lens is thoroughly tested by us. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problem. Buy this lens under our money-back guarantee.

DIA.	F.L.	Not Coated.....	PRICE
3 1/4"	48"	.....	\$28.00
3 1/4"	48"	Coated.....	32.00
4 1/8"	62"	Not Coated.....	60.00
4 1/8"	62"	Coated.....	69.00

We can supply ALUMINUM TUBING for the above lenses.

"BIG" LENSES

Our selection of diameters and focal lengths is the largest in the United States available for immediate delivery. Perfect magnesium fluoride coated and cemented achromatic telescope objectives. Made of finest Crown and Flint optical glass, fully corrected, can be readily used with 1/4" F.L. eyepieces. Build astronomical Telescopes, Spotting Scopes, Collimators, etc. Original Gov't cost approx. \$100.00 or more.

Diameter	Focal Length	Each
54m/m (2 1/8")	254m/m (10")	\$12.50
54m/m (2 1/8")	300m/m (11.811")	\$12.50
54m/m (2 1/8")	330m/m (13")	\$12.50
54m/m (2 1/8")	390m/m (15.356")	\$ 9.75
54m/m (2 1/8")	508m/m (20")	\$12.50
54m/m (2 1/8")	622m/m (24 1/2")	\$12.50
54m/m (2 1/8")	762m/m (30")	\$12.50
54m/m (2 1/8")	1016m/m (40")	\$12.50
78m/m (3 1/8")	381m/m (15")	\$21.00
80m/m (3 1/8")	495m/m (19 1/2")	\$28.00
81m/m (3 1/8")	622m/m (24 1/2")	\$22.50
83m/m (3 3/8")	660m/m (26")	\$28.00
83m/m (3 3/8")	711m/m (28")	\$28.00
83m/m (3 3/8")	762m/m (30")	\$28.00
83m/m (3 3/8")	914m/m (36")	\$28.00
83m/m (3 3/8")	876m/m (34 1/2")	\$28.00
83m/m (3 3/8")	1016m/m (40")	\$30.00
110m/m (4 3/8")	1069m/m (42 1/8")	\$60.00
110m/m (4 3/8")	1069m/m (42 1/8")	\$67.00
128m/m (5 1/16")	628m/m (24 3/4")	\$75.00
128m/m (5 1/16")	628m/m (24 3/4")	\$85.00

*Not Coated
 We can supply ALUMINUM TUBING for the above lenses.

"MOUNTED" EYEPIECES

The buy of a lifetime at terrific savings to you. Perfect War Surplus lenses mounted in black anodized standard aluminum 1/4" mounts.

F.L.	TYPE	PRICE
12.5m/m (1/2")	Symmetrical	\$ 6.00
16 m/m (5/8")	Erfel (Wide Angle)	\$12.50
16 m/m (5/8")	Triplet	\$12.50
18 m/m (3/4")	Symmetrical	\$ 6.00
22 m/m (27/32")	Kellner	\$ 6.00
32 m/m (1 1/4")	Orthoscopic	\$12.50
35 m/m (1 3/8")	Symmetrical	\$ 8.00
55 m/m (2 1/8")	Kellner	\$ 6.00

The above eyepieces can be supplied COATED at \$.75 each extra.

BINOCULARS. beautiful, imported, coated binoculars, precision made, at a low low price within the reach of every man's pocketbook. Complete with carrying case and straps. *Price plus 10% excise tax.

Power	Individual Focus	Center Focus
6 x 15	\$12.75	\$21.00
6 x 30	\$18.00	\$22.35
7 x 35	\$20.75	\$26.75
7 x 35 B&L Type	.....	\$27.75
7 x 35 B&L Type 10°	.....	\$44.75
Wide Angle	.....	\$29.75
7 x 50	\$23.75	\$32.50
8 x 30	\$19.00	\$32.50
10 x 50	\$30.25	\$39.75
16 x 50	.....	\$54.25
20 x 50	\$49.75	.....

- 7x50 MONOCULAR Brand New, coated, genuine leather case, straps.....\$17.50
- 3X ELBOW TELESCOPE makes a nice finder, achro objective Amici Prism, 1 1/2" F.L. achromatic eyepiece, Plain Optics.....\$9.75-Coated Optics.....\$12.50
- GIANT WIDE ANGLE FOCUSING EYEPIECES 2 1/2" dia., contains 3 coated achromats, E.F.L. 1 1/2".....\$12.50
- GIANT WIDE ANGLE FOCUSING EYEPIECES 3" dia., contains 3 achromats, E.F.L. 1 1/2".....\$18.50
- 6X BATTERY-COMMANDER PERISCOPE Length 28" brass 3 1/2 lbs., focusing eyepiece.....\$15.00

Free Catalogue "MILLIONS" of Lenses, etc.

We pay the POSTAGE—C.O.D.'s you pay postage—Satisfaction guaranteed or money refunded if returned within 10 days.

A. JAEGER'S 691A Merrick Road LYNBROOK, N.Y.

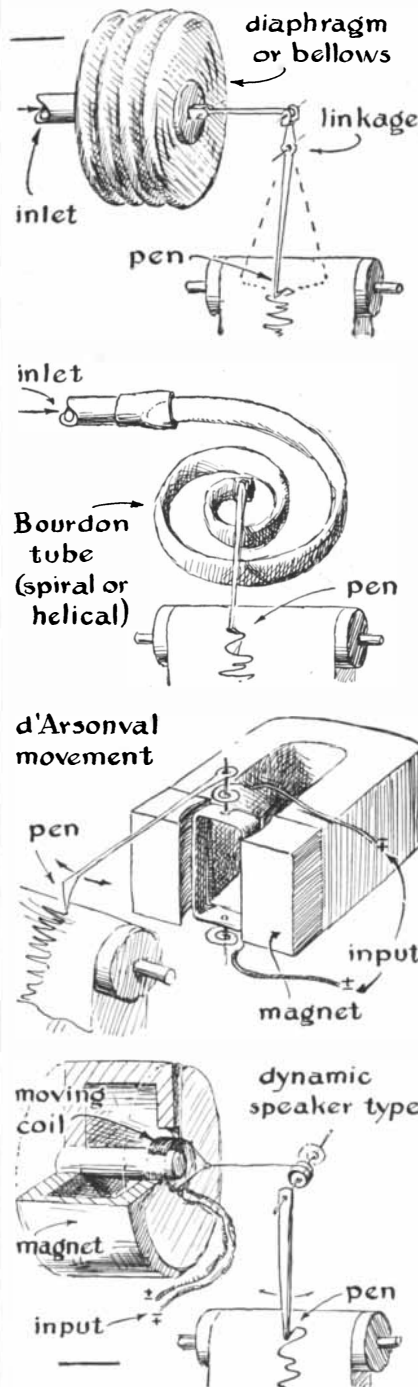
of a second. To bridge these gaps modern instrument makers have devised various types of recorders. All of them consist essentially of a pen which automatically traces a record of the observed event on a chart of some kind. The pen may be linked to any kind of detecting or observing instrument—a barometer, a thermometer, a seismometer, a telescope or whatever. The sensing instrument translates what it observes into a signal—mechanical or electrical—which drives the recording pen. A recording instrument

has two paramount advantages over a pencil-using human recorder: it can operate tirelessly around the clock and it is capable of responding to much higher frequencies.

"The chart on which the instrument's pen writes may be a fixed sheet, a moving ribbon, a cylinder or a disk. The pen may be powered directly by the energy of the event itself (as in an old-fashioned seismograph) or may be driven by a motor actuated by an amplified signal from the event (as in a starlight photometer).

"The varieties of events to which a recorder may be applied are legion. Albert G. Ingalls, formerly editor of this department, spent his first summer in retirement recording the tidelike seiches (vibrations) of Seneca Lake in New York by means of a mechanically-actuated pen recorder which he constructed during the winter months. Studying his graph, 90 feet long, he found that the 35-mile lake had a long-period vibration of 56 minutes. He is now analyzing higher-frequency modes which appear as tiny peaks on the graph. The study promises to disclose interesting information about the shape of the lake bottom as well as clues to the forces responsible for the seiches. Another amateur, John Ruiz of Dannemora, N. Y., recently constructed a seismograph of the velocity type and is recording movements of the earth's crust through the range of 30 seconds per vibration to half a second. His home-built recorder employs electronic amplification. John Wilke of Chicago has fitted his eight-inch reflecting telescope with a photoelectric cell photometer and an electronic recorder which enable him to plot the decay of starlight during occultations in increments of two hundredths of a second. Radio hams and high-fidelity addicts study vibrations in the range from about 20 per second to billions per second. You find these amateurs investigating everything from the characteristics of transistors and homemade loudspeakers to the electromagnetic resonance of chemical compounds.

"Amateurs frequently ask for advice about the best kind of recorder to buy or build. Usually they have in mind a universal recorder—one that will accept signals from many types of sensing instruments. The criterion of selection is frequency response. The pen of the ideal recorder should be capable of full-scale deflection for frequencies 10 times higher than those anticipated in the variable under measurement. Thus if it takes a tenth of a second for the moon to occult a star, the photometric recorder should have a minimum response time of a hun-



Four basic pen motors

Attention!

NON-CITIZEN ENGINEERS & DESIGNERS...

... now you can work at Republic Aviation Corporation through a liberal new arrangement made available to all engineers and designers experienced in the Aircraft and Guided Missiles fields.

If you have had 5 or more years experience in AERONAUTICAL ENGINEERING and DESIGN—emphasizing one or more of the following areas, Republic may have an important position for you in:

AERODYNAMICS	WEIGHTS
DYNAMICS	AIRCRAFT & MISSILE DESIGN
FLIGHT TEST	PRELIMINARY DESIGN
THERMODYNAMICS	ELECTRONICS
FLUTTER & VIBRATIONS	CONTROLS
STRESS	SYSTEMS

Today Republic's famous Thunderjets and Thunderstreaks are in service throughout the free world. These planes, as well as the new RF-84F Thunderflash, form part of the striking arm of the air forces of the U. S. and other NATO countries. Soon to appear are the F-103 and F-105, while planes embodying advanced aerodynamic

concepts are already in the mock-up and prototype stage. Still others are on Republic's drafting tables.

AND TO WORK FOR REPUBLIC IS TO LIVE ON LONG ISLAND! You'll enjoy living in the playground of the East Coast, with its fine suburban communities, modern highways, miles of beaches and many state parks.

RELOCATION EXPENSES PAID...LIBERAL BENEFITS. Republic relieves you and your family of all financial worries connected with moving to a new position on Long Island. The company also pays life, health and accident insurance—up to \$20,000—for you, plus hospital-surgical benefits for the whole family, and $\frac{2}{3}$ the cost of your collegiate and graduate studies.

If you wish to join the select group of Republic engineers, no matter where you are located now, write promptly, describing your experience and training in detail.

A convenient interview can be arranged *in your vicinity*.



Address:

Mr. R. L. Bortner
Assistant Chief Engineer

REPUBLIC AVIATION

FARMINGDALE, LONG ISLAND, NEW YORK

**Get this FREE Buyer's Kit
on UNITRON
Astronomical Telescopes!**

Learn how to choose the telescope best for you, before you buy.

The quality of your observations is no better than the telescope you use. You want your telescope to be worthy of your investment and of the time you will devote to using it. UNITRON'S Free "Buyer's Kit" and catalog is required reading for prospective telescope owners. It is yours for the asking.



The 1.6", 2.4", 3" and 4" UNITRON Refractors

The UNITRON line of refractors is the most complete ever offered. Accessories include the UNIHEX Rotary Eyepiece Selector, the DUETRON Double Eyepiece, sunscreens, clock drives, viewfinders, astro-cameras and every convenience for critical observing. No wonder, then, that UNITRON is the choice of leading universities, government agencies and amateurs all over the world. There is no need to deprive yourself of a UNITRON, since any model may be purchased under our Easy Payment Plan.

Here is a typical UNITRON value—



UNITRON 2.4" Altazimuth Refractor

Complete with eyepieces for 129X, 100X, 72X, 50X; UNIHEX Rotary Eyepiece selector; altazimuth mounting with slow motion controls; tripod; viewfinder; sunglasses; and cabinets.
Express collect

only \$125.

OTHER UNITRON REFRACTORS INCLUDE:

1.6" ALTAZIMUTH.....	\$ 75
2.4" EQUATORIAL.....	225
3" ALTAZIMUTH.....	265
3" EQUATORIAL.....	435
4" ALTAZIMUTH.....	465
4" EQUATORIAL.....	785

All instruments fully guaranteed. Send check or M.O. or 25% deposit with balance C.O.D. or use our Time Payment Plan.

This valuable catalog is yours for the asking!

LEARN ABOUT—

- equatorial and altazimuth mountings
- objective lenses
- refractors and reflectors
- magnification and eyepieces
- the latest accessories

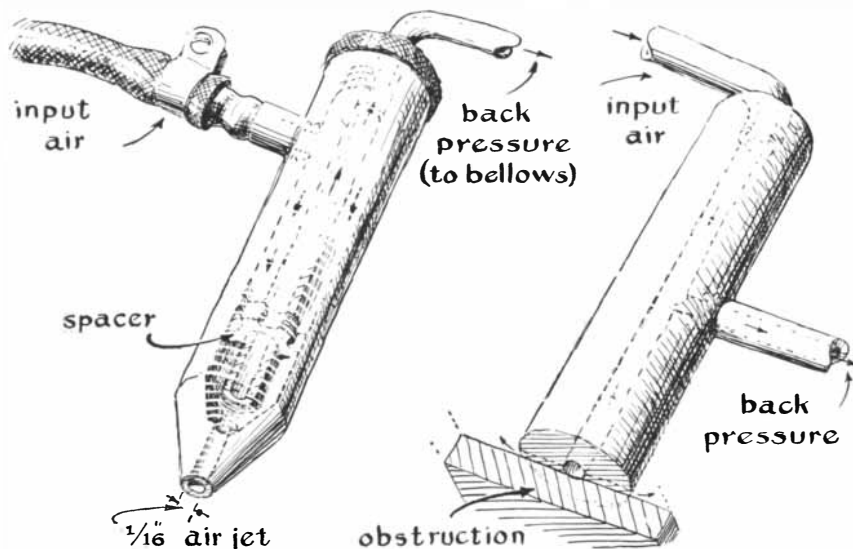
Send for your FREE copy now!



United Scientific Co.

204-6 MILK STREET • BOSTON 9, MASS.

Please rush to me, free of charge, your "Buyer's Kit" and catalog on UNITRON Astronomical Telescopes. My name and address are attached.



Details of the pneumatic pen motor

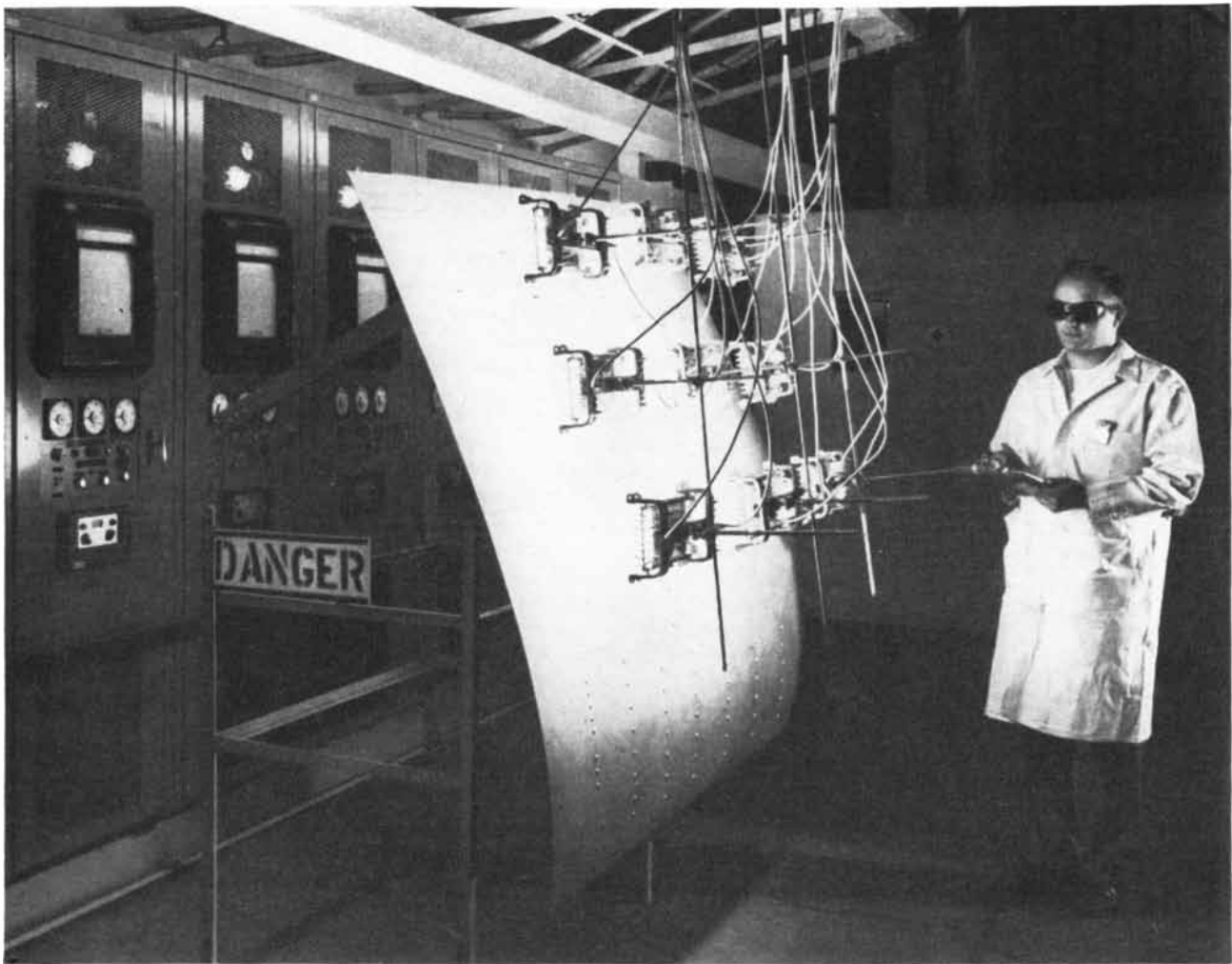
dredth of a second. Such a recorder will give a 'flat' response: that is, at every frequency the signal will deflect the pen by the same amount, thus tracing a straight line. Instruments of poor response, in contrast, will not respond uniformly to all frequencies, and therefore the graph will be a curve.

"A flat response is not necessary for all purposes. Sometimes a less than ideal instrument will do. One amateur biologist now investigating the circulatory system of the frog wanted to make recordings of the electrical impulses liberated by the beat of the animal's heart. He was interested in frequencies up to 200 cycles per second. He built an instrument around a war-surplus oscillograph but found that the pen covered only 7 per cent of its full-scale swing at 200 cycles and 50 per cent at 60 cycles. By taking this limited response into account, however, he could interpret the records as faithful measurements of the frog's heart action.

"The high cost of direct-writing recorders has discouraged many amateurs from taking up such hobbies as variable-star observing, seismology, micrometeorology and other avocations in which precise records are essential. A good chart drive and pen motor sells for about \$300. A companion amplifier and power supply adds another \$500. Equipment for dividing or multiplying the incoming frequencies and thus extending the range of the basic combination, plus equalizing amplifiers to compensate for distortion, can shoot the investment into the stratosphere. But if you have access to a drill press and a small lathe, you can make a good wide-range recorder at a cost of less than \$250.

"You start with the pen motor, the heart of any recorder. A number of basic types are shown in the drawings on page 126. Most commercial instruments utilize the d'Arsonval movement in one form or another. Its construction, however, is strictly a job for the experienced instrument maker. In contrast, the pneumatic pen drive is relatively easy and inexpensive to make. It consists of a simple bellows linked to a pivoted lever which carries the pen on its outer end. The pneumatic motor may appear crude, particularly to devotees of electronic technology. Yet when coupled to a nozzle of the type shown above, the pneumatic motor is capable of astonishing sensitivity.

"The nozzle consists of a pair of coaxial tubes. Its outer tube ends as a small orifice from which a minute jet of air escapes. As an example of how it works, suppose we use it with a seismometer. To the pendulum of the seismometer is linked a vane, which is placed close to the orifice and moves toward it and away from it with motions of the pendulum. When the vane comes within a few thousandths of an inch of the jet, back pressure builds up inside. As the vane moves toward or away from the orifice the back pressure varies in direct proportion. The pressure is communicated through the small central tube to a bellows, which in turn moves the pen. The pen therefore swings in direct proportion to the movement of the pendulum. With air under a pressure of 30 pounds per square inch flowing from a sixteenth-inch orifice, the device is sensitive to a change of two millionths of an inch in the distance between the orifice and the vane. It gives a directly proportional response for dis-



How Boeing engineers are penetrating the "thermal thicket"

When this bank of lights is turned up to its full 288 KW, skin temperature of the aluminum panel reaches 700° F in a few seconds. Data from this and many other research projects help Boeing engineers create systems and components able to withstand the sudden increases in temperature of tomorrow's fast accelerating airplanes and missiles.

More than 6,000 engineers are meeting the challenges of aviation's future at Boeing. They include mechanical, electrical, civil and aeronautical engineers and mathematicians and physicists with advanced degrees. And more engineers of every kind are needed for Boeing research, design and production projects, ranging from nuclear power to titanium forgings and from guided missiles to gas turbines.

Boeing engineers are investigating problems never faced before. Often they design their own test equipment, like the "quick heat" facility shown here. Other Boeing-designed equipment includes electronic computers of the latest type, a new supersonic wind tunnel capable of velocities up to Mach 4, test chambers to produce extremely low temperatures and atmospheric pressures and the superbly-appointed, multi-million-dollar Flight Test Center.

A great and ever-growing team of engineers operates these test facilities and is now creating from resulting data the very high-speed planes and missiles of a few years hence. Because of Boeing's solid growth, there are more than twice as many engineers with the company now than at the peak of World War II. A

quarter of them have been with Boeing more than 10 years and some for more than 30.

This indicates the security and growth potential of a job with Boeing. If you want to be a member of aviation's top creative team, it will pay you to investigate the advantages of a Boeing career.

• **JOHN C. SANDERS, Staff Engineer—Personnel**
• **Boeing Airplane Co., Dept. B-45, Seattle 14, Wash.**

• Please send further information for my analysis.
• I am interested in the advantages of a career with Boeing.

• Name _____
• College(s) _____ Degree(s) _____ Year(s) _____
• Address _____
• City _____ Zone _____ State _____
• Phone number _____

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS

OPTICAL BARGAINS

SPITZ JR. PLANETARIUM

Latest Model . . . Fascinating!

Amazing! Projects on ceiling of darkened room nearly 400 stars, more than 70 constellations in proper relation. No batteries; uses home current. Rheostat control for brightness. About 14" high on a 7"x7" base. Projection sphere 7" diameter. Included FREE: Illuminated POINTER . . . also 32 page information book.

Stock No. 70,040-S

\$14.95 Pstpd.



50-150-300-power MICROSCOPE

Low Price Yet Suitable for Classroom Use! only \$14.95

3. Achromatic Objective Lenses on Revolving Turret!

A terrific value because it's imported! The polychromatized, cemented achromatic lenses in the objectives give you far superior results to the single lenses found in the microscope selling for \$9.95! Results are worth the difference!

The greater range of powers make it easier to find the object—give the instrument greater versatility, since much of the beginner's work is done at 100 power.

Fine rack and pinion focusing. Definition is surprisingly clear and good . . . in fact, amazing! — at this price! Revolving diaphragm, adjustable mirror. Square stage (2 1/2" x 2 1/2") with slide clamps. Packed in sturdy, finished hardwood case. Accessory eyepieces and objective available.

This is the greatest microscope bargain on the market! Try it for 10 days . . . if you're not completely satisfied, we'll return your money in full!

Stock No. 70,008-S . . . \$14.95 postpaid
Clip this ad for 127-page book "Hunting With the Microscope" only 75c. Order stock #9207-S

NEW! ASTRONOMICAL TELESCOPE KIT Build instrument worth up to \$500.00. Grind your own mirror. Contains: mirror blank, eye-piece lenses, diagonal, abrasives, etc. Stock #70,004-S . . . Size 6" . . . \$11.40 Pstpd

See the Stars, Moon, Planets Close Up!
BUILD A BIG 100 POWER, 3" REFLECTING TELESCOPE . . . with This Complete "Do-It-Yourself" Kit

Everything you need! No machining! Easily assembled! We furnish complete, simple instructions. Kit includes: 3" f/10 Aluminized and over-coated Spherical Mirror, 60X Eyepiece and 100X Barlow Lens, Crossline Finder, Sturdy 40" Tripod, Fork type Equatorial Mount with locks on both axes, Ventilated 3" Mirror Mount, heavy wall, black Telescope Tube. All nuts and bolts supplied. Nothing extra to buy. Our 3" spherical mirror (30" f.l.) is guaranteed to resolve detail right up to the theoretical limit. Your finished scope can also be used terrestrially in 15" Newton back guarantee. Shipping weight—10 lbs. Stock No. 85,025-S . . . \$29.50 f.o.b. Barrington, N. J.



Order by Stock No. Send check or M.O. (Open acct. to rated firms.) Money back guaranteed.

We have Literally Millions of WAR SURPLUS LENSES AND PRISMS AT BARGAIN PRICES Write for Catalog "S"—SENT FREE!

EDMUND SCIENTIFIC CORP.
BARRINGTON, NEW JERSEY

We accept with enthusiasm the challenge to solve the unusual or especially difficult problems in the production of **high precision optics** . . . whether the factor be one of cost, time, precision, or a combination of all three.

Ferson Optical Company, Inc.,
Ocean Springs,
Mississippi.

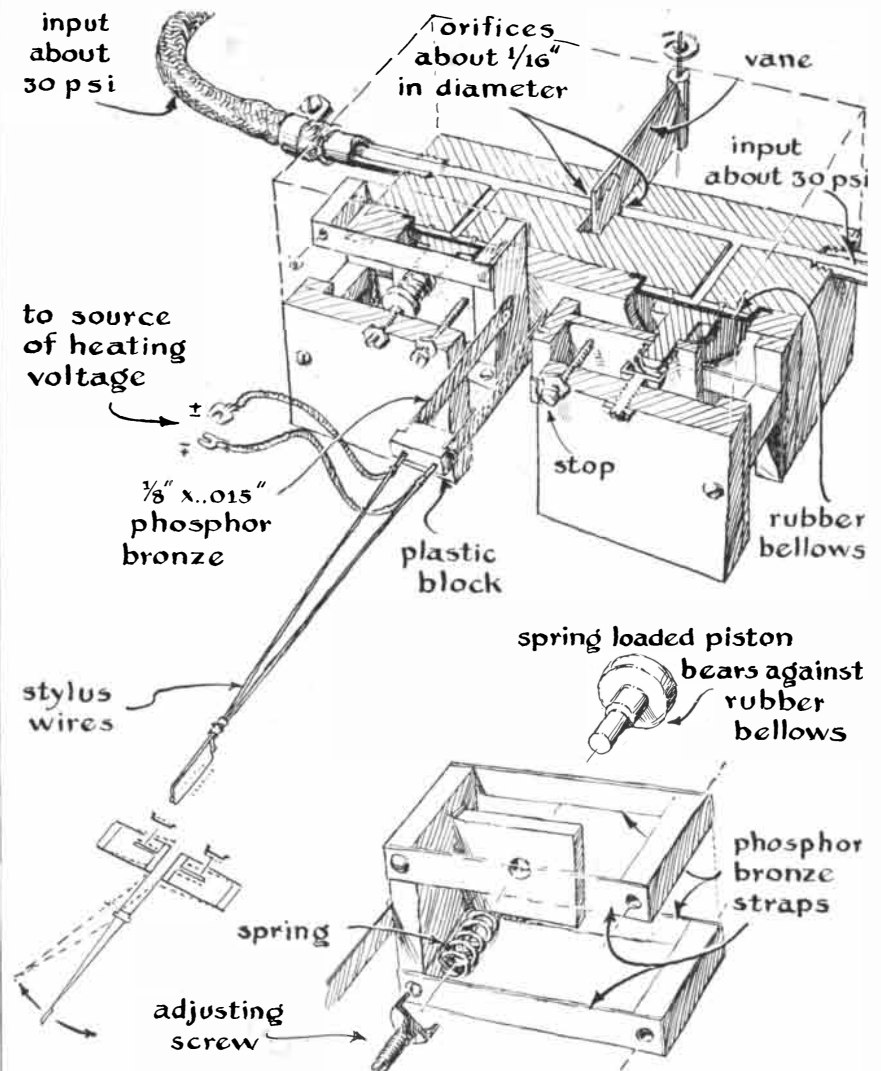
tances up to 15 thousandths of an inch. The obstruction need not be a vane, of course. The pen will indicate changes in distance between the orifice and any smooth object.

"A single tube with a 'T' near the center works as well as the coaxial jet over distances up to four thousandths of an inch. One end of the tube is connected to the air supply and the other becomes the jet. Back pressure is taken from the 'T' connection.

"It is interesting to arrange a pair of 'T' jets and companion bellows mechanisms for operation as a push-pull pen motor [see drawing on this page]. The obstruction can be a vane of light metal supported between the jets by a pivoted arm. Mechanical signals from the observing instrument are coupled to the vane through a conventional linkage. A regulated supply of compressed air enters the sensing nozzles at 30 pounds per square inch and impinges on opposite

sides of the vane. The spacing between the surface of the centered vane and each orifice should not be more than two thousandths of an inch. As the vane is moved back and forth by incoming signals, back pressure is communicated to the bellows alternately, causing the spring-loaded pistons to swing the pen. The pen is centered by adjusting the spring tension. The vane floats free between the opposing jets, hence little energy is required to move it. The result is a combination pen motor and pneumatic amplifier capable of power gains of 10,000 to one and higher.

"Electrical signals also can be fed into the device, but they must first be converted into mechanical movement by a device such as the d'Arsonval motor. (This unit is sold by the Sanborn Company, the Brush Electronics Company, the Edin Company Inc., and others.) Alternating-current signals of five hundredths of a volt fed into the d'Arsonval



Details of a push-pull pneumatic pen motor

Lockheed diversification in action...

Below: engineers and scientists work on some of the 46 major projects in progress at Lockheed



Operations Research discussion on continental defense

Operations Research openings

Electronics Specialists
Fire Control and Guidance Specialists
Aerodynamics Engineers
Physicists



Fatigue test on Super Constellation skin

Structural Engineering openings

Research Specialists
Structures Engineers
Stress Analysts
Weight Engineers



Hot-air cyclic de-icing test on radar search plane

Thermodynamics openings

Research Specialists
Thermodynamics Engineers
Thermodynamicists



Design study on hydraulic requirements of new transport

Design openings

Design positions are open at all levels in controls, electrical, hydraulics, mechanical, power plant and structures fields.



IBM 701 applied to jet transport flutter problem

Math. Analysis openings

Math. Engineers
Math. Specialists
Math. Analysts



Antenna pattern study on radar search planes

Electronics openings

Electronics Research Engineers
Airborne Antenna Designers
Research Specialists



In-flight test on air speed performance

Flight Test Engineering openings

Flight Test Engineers
Flight Test Analysts
Instrumentation Engineers
Electrical Research Engineers



Aerodynamic meeting on high-speed fighter

Aerodynamics openings

Aerodynamics Engineers
Aerodynamicists
Dynamics Engineers
Wind Tunnel Test Engineers

Why Lockheed offers Engineers better careers

There are three main reasons:

- 1. More opportunity for promotion**
because there are more supervisory positions to be filled with 46 major projects underway, including 13 models of aircraft on assembly lines.
- 2. More career security**
because Lockheed activities cover virtually the entire spectrum of aeronautical endeavor.
- 3. Life in Southern California**
Scenic beauty, unmatched climate, wide recreational opportunities enhance life in the San Fernando Valley.

To Engineers who lack aircraft experience

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering — at full pay.

Coupon below is for your convenience

in requesting application form and more information on how Lockheed's expanding program can advance your career.

E. W. Des Lauriers, Dept. C-12-11

Lockheed AIRCRAFT CORPORATION
CALIFORNIA DIVISION • BURBANK
California

Please send me a brochure describing life and work at Lockheed and an application form.

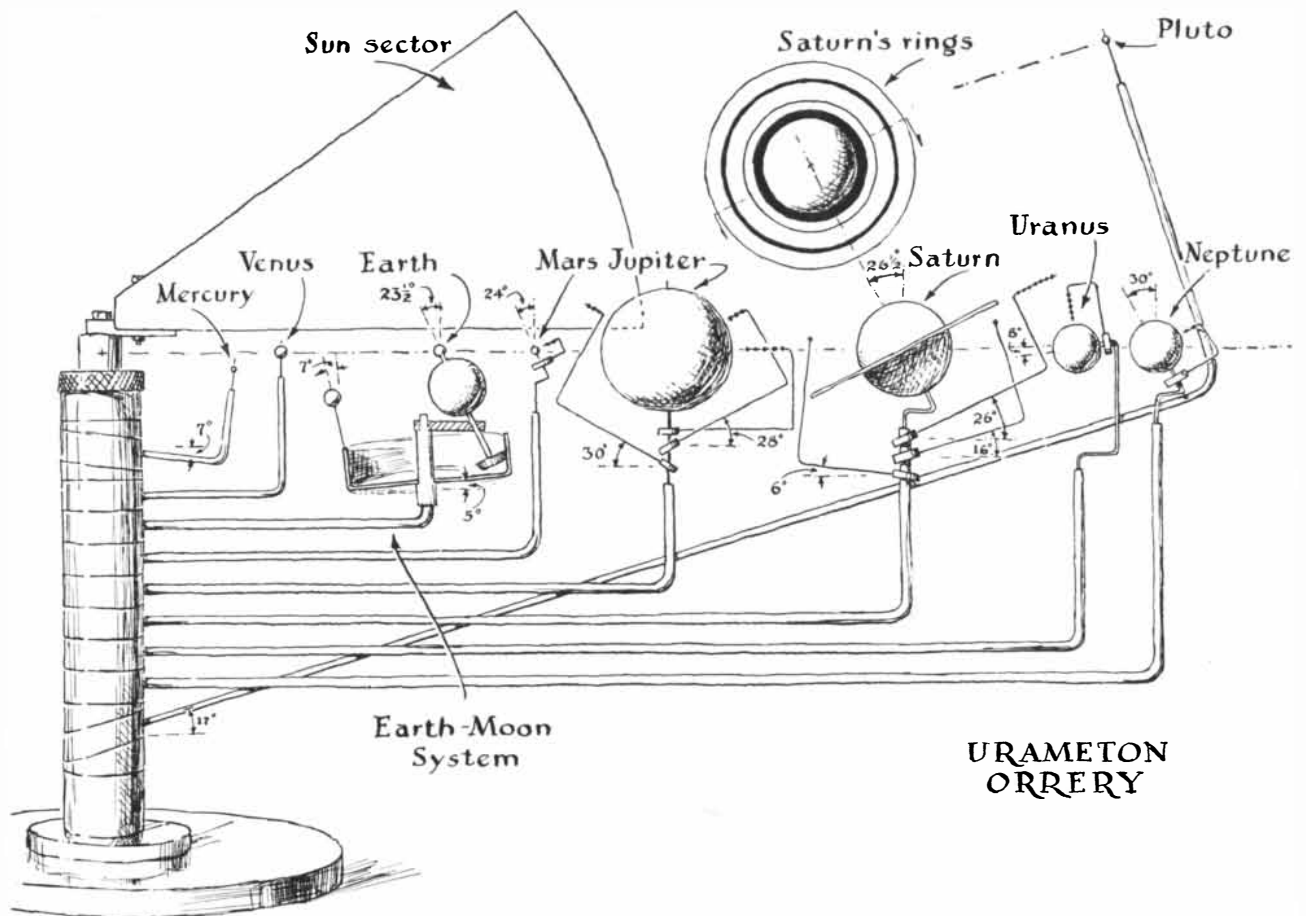
Name

Field of Engineering

Street Address

Phone

City and State



An orrery, or model of the solar system, built by a British amateur

unit will deflect the pneumatic pen to the limit of its travel. Moreover, the response is uniform for all frequencies from one to 60 cycles per second.

“What is perhaps more appealing than the sensitivity of the unit is its remarkable stability and reproducibility. It requires no controls for keeping the pen centered on the chart or for adjusting its sensitivity to various frequencies. In many applications extremely small mechanical signals can be fed directly into the vane. Because of the push-pull arrangement, small variations in the pressure of input air do not perceptibly affect either accuracy or stability. A small compressor of the type used for a paint sprayer will supply all the pressure needed, and the only electrical power required is 110-volt alternating current for working the compressor, heating the stylus and driving the chart motor.

“For the chart a direct-writing recorder may employ writing paper, wax paper or paper that changes color when an electrical current is passed through it. Each has characteristic advantages and limitations. The pneumatic pen motor develops enough power to drive any conventional writing tip, even pencil lead.

Unless the chart movement is slow (a few inches per hour) pencils are inconvenient because they require frequent sharpening. An inking pen, preferably in the form of a glass tube pulled to a point and rounded against a fine carborundum stone, is convenient in low-frequency applications at any chart speed. But a pen is messy, clogs easily and at high frequencies tends to throw ink. On some tracings it may be accelerated at the rate of 16,000 feet per second.

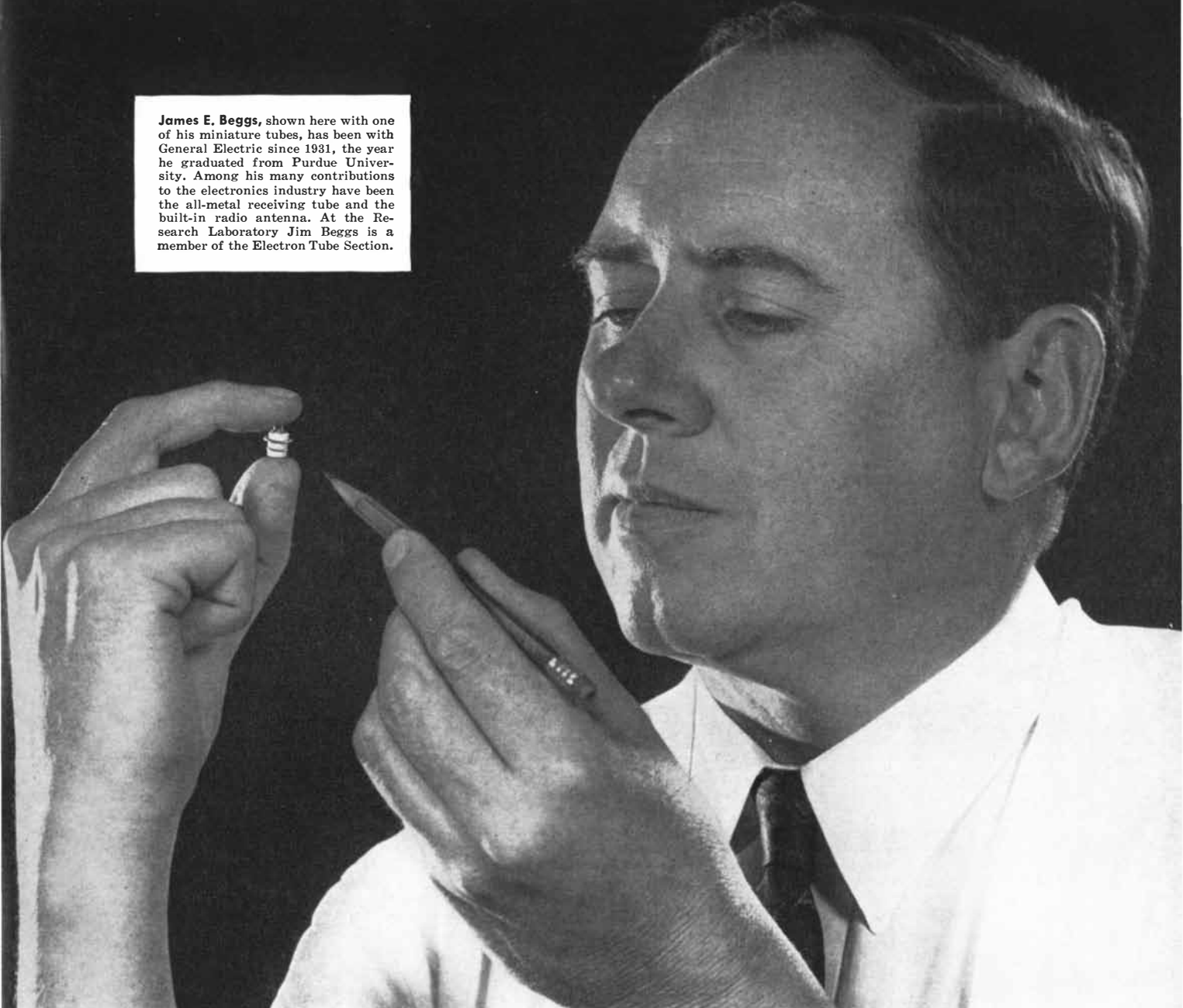
“Waxed paper (inscribed by a heated stylus) behaves nicely at high acceleration, but it costs more than untreated paper and the thickness of the trace varies somewhat with frequency.

“The heated stylus is more difficult to construct than an inking pen. It also requires a transformer for stylus voltage and a rheostat for controlling the heat. However, the heated stylus has the important advantage of making a trace that moves across the chart in substantially a straight line, instead of in an arc as conventional recording pens do. The impression is made at the point where the stylus crosses a knife edge that supports the chart. During lateral excursions the radius of the stylus arm is increased.

“An electrical stylus writing on paper sensitive to current also works well at high frequencies, but it is plagued by its own set of disadvantages. Its resolution is not as good; it requires special transformers, voltage-regulating devices and sensitized paper, and it is subject to arcing and pitting.

“For propelling the chart the available mechanisms range from weight-driven cylinders such as are employed in the old Wiechert seismograph to perforated tapes moved by high-speed sprockets geared to synchronous motors. Seismograms have even been made on the smoked surface of a paint bucket turned by the hour shaft of an alarm clock. The problem of the drive has been simplified by the recent development of inexpensive synchronous motors of the fractional horsepower type.

“It is now common practice to record events at frequencies between 200 and 100,000 cycles per second on magnetic tape. Several basic tape-pulling mechanisms, together with recording, reproducing and erasing heads, are now available for less than \$100. They must be appropriately housed and modified for the frequency range in which they are



James E. Beggs, shown here with one of his miniature tubes, has been with General Electric since 1931, the year he graduated from Purdue University. Among his many contributions to the electronics industry have been the all-metal receiving tube and the built-in radio antenna. At the Research Laboratory Jim Beggs is a member of the Electron Tube Section.

Revolutionary vacuum tubes

James E. Beggs of the G-E Research Laboratory combines new knowledge with new materials and new processes

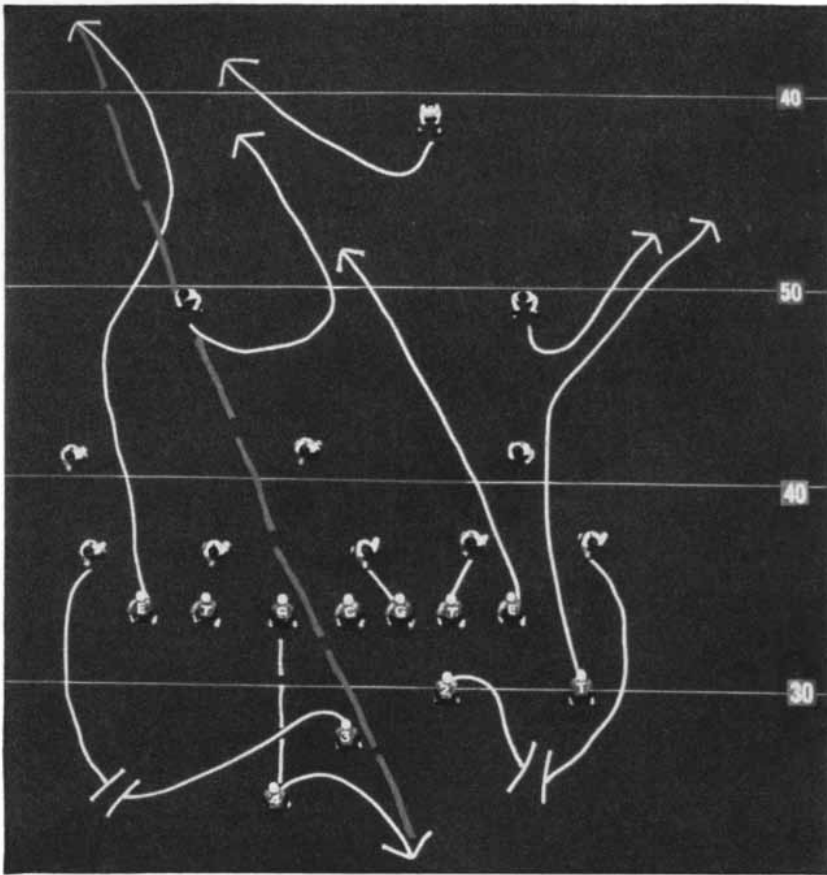
Jim Beggs has a unique talent for employing research results from many scientific fields to produce ingenious new vacuum-tube concepts and designs. Most recently, the man who 23 years ago demonstrated the first practical all-metal tube has pioneered what will certainly become a long line of microminiature ceramic vacuum tubes. The G-E Tube Department's first production version is the 6BY4 triode, which promises to bring UHF television within the range of many heretofore "televisionless" homes.

Beggs' tubes are no bigger than a shirt stud, but they will be invaluable to both industry and defense because of their low-noise and high-gain characteris-

tics, usefulness at microwave frequencies, ability to operate while red hot, and unusual ruggedness. To achieve this revolution in the vacuum-tube art, Beggs coupled his own ingenuity in designing tubes with the work of other G-E scientists — new fundamental knowledge about titanium, new insulating ceramic materials with special expansion characteristics, and new processes for sealing metals to ceramics.

Progress Is Our Most Important Product

GENERAL  ELECTRIC



aerial attack

Q: What has *this* to do with the aircraft industry—and you?

A: It may have plenty to do with both. Here's how:

Football teams are judged by scoring ability in top competition—teamwork, form, ability, strategy, class. So, too, are aircraft companies.

Martin has created one of the finest engineering teams in the whole world of aviation. And under the new Martin concept of design and development by team operation, every engineering problem—from today's experimental contract to the frontier problems of the future—is the target for a coordinated "aerial attack" by a top-flight team of specialists.

Result: Martin's team operation technique has opened up important opportunities for young creative engineers.

Contact J. M. Hollyday, Dept. S-11, The Martin Company, Baltimore 3, Maryland.

MARTIN
BALTIMORE

to work. With this type of recorder high-frequency events can be replayed in 'slow motion.' The low-frequency signal of the reproduction is fed into the electropneumatic pen motor and transcribed as a chart. Frequencies up to 100 cycles per second are recorded by means of frequency modulation, and those above this band by the conventional amplitude techniques. When driven at 60 inches per second, magnetic tape registers signals from 200 to 80,000 cycles uniformly with an error of not more than about three decibels. At high frequencies speed regulation of the tape-propulsion mechanism becomes critical. The speed is sometimes regulated by generating a 60-cycle signal from a tuning fork and amplifying it for power to drive the motor of the tape puller. The frequency stability of commercial electric power is generally adequate for recordings up to 10,000 cycles.

"Construction details of an experimental pneumatic recorder equipped with a heated stylus and a Sanborn transducer are shown on page 125. The specifications are not rigid: an ingenious experimenter doubtless will find ways to modify this plan. Aluminum stock is specified for the chassis because it is easy to cut with hand tools. For sufficient strength the aluminum should be a quarter of an inch thick. Amateurs with limited shop facilities may adapt war-surplus apparatus for some of the parts.

"One such item available as a starting point is a McElroy telegraph tape puller. It is equipped with a 110-volt motor drive and sells for about \$20. Its aluminum casting will serve for constructing the chassis of a two-inch chart. Another basic unit is a magnetic wire-recorder magazine which sells for about \$18. Another piece of surplus gear, designed as an element of a photographic processing machine, looks promising as a part for a recorder equipped with a pair of two-inch charts and companion pen motors—a so-called two-channel recorder. It consists of a magnesium casting with a side compartment housing gears on detachable shafts. These could be moved around to form almost any type of gearing arrangement. It is fitted with rollers which could be modified for the chart drive. This unit is priced by my instrument maker at \$8.

"The most difficult part of the pneumatic recorder to make is the pen motor. If the recorder's frequency response is not critical, a pressure transmitter made by the General Electric Company can be used when modified. It will work on a back pressure in the neighborhood of 10 pounds per square inch. My instru-

Automation Motor Control Panels

*...built from
standard components*

The first requirement of a motor control panel for modern automation service is that it be trouble free. The failure of only one component may result in costly production shutdowns.

That's why so many equipment manufacturers have standardized on Allen-Bradley motor controls. The Allen-Bradley reputation for quality—supplemented by the simplicity of design of its control apparatus—is your assurance of trouble free operations. Also, the Allen-Bradley trademark on your machines will be a real sales asset.

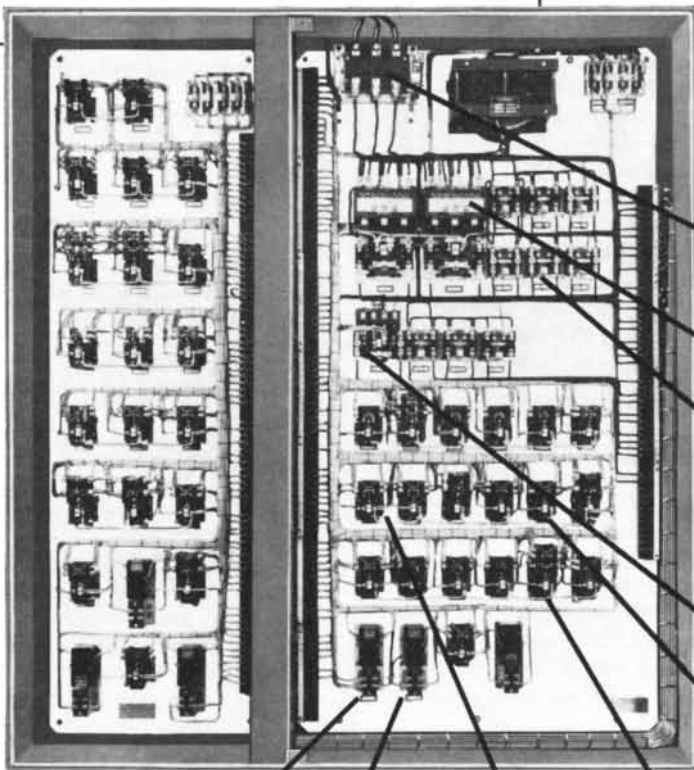
Allen-Bradley offers a complete line of manual and automatic motor control components for your special control panels. Send for the latest edition of the 120-page Allen-Bradley Handy Catalog.

Allen-Bradley Co.
134 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada—
Allen-Bradley Canada Limited, Galt, Ont.

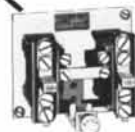
ALLEN-BRADLEY
QUALITY MOTOR CONTROL



THE SIGN OF
QUALITY
MOTOR CONTROL



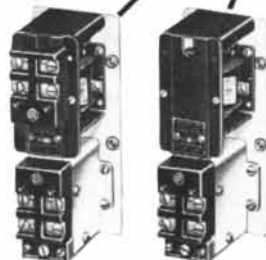
Manual Disconnect
Visible blades



Overload Relays
Reliable, Accurate



Solenoid Starters
In all ratings



Pneumatic Timers
A wide variety



Solenoid Relays
A complete line



TASTY CREAM CANDIES

... with longer shelf life

Candy makers have a problem when cream fillings develop disagreeable taste and odor after a few weeks on store shelves. They've looked long and hard for a way to eliminate this spoilage which is caused by the formation of free fatty acids. Researchers have tried to stop or slow down the reaction by adding chemical retardants. But taste and texture could not be sacrificed.

Tests have shown that in some cases addition of 1-2% Glycerine almost doubles shelf life, promising a more trouble-free future for the candy industry.

The unique balance of properties that won such wide acceptance for Glycerine in the candy industry in the past continues to open new doors to progress. In paints, foods, pharmaceuticals, packaging . . . for tomorrow's surge of new specialties . . . in formulations and reactions yet unknown, nothing takes the place of Glycerine.

For your free copy of a 16-page booklet on Glycerine properties and applications, write to - GLYCERINE PRODUCERS' ASSOCIATION • 295 Madison Avenue., New York 17, New York.

This balanced group of properties

HYGROSCOPICITY • STABILITY • NONVOLATILITY •
 SOLVENT POWER • VISCOSITY • MW/HYDROXYL RATIO •
 NONTOXICITY • TASTE

keeps **Glycerine's** usefulness growing

HUMECTANT • CARRIER • EMOLLIENT •
 SOLVENT • ANTI-FREEZE •
 LUBRICANT • ALKYD BASE •
 SOFTENER

ment maker has a limited number of these in stock priced at \$10."

This department will forward the address of Marrows' instrument maker to any reader who sends a stamped, self-addressed envelope.

The imminent attempt to launch the first man-made satellite into space undoubtedly will heighten interest in the planets and satellites of the solar system and their motions. One of the most interesting refresher courses you can take on these matters is to construct an orrery. This classic model of the solar system, long a fixture of physics classrooms and planetaria, was named by its inventor, George Graham, after his patron, Charles Boyle, Fourth Earl of Orrery. An English engineer, Frank W. Cousins, submits the design for a simple orrery pictured here [see page 132].

"The orrery," writes Cousins, "shows all known planets—except the minor ones—from Mercury to Pluto, with their satellites. You will find an imitation pearl necklace with beads of various sizes a splendid source of spheres to represent the planets. The scale of sizes here is based on a bead one eighth of an inch in diameter for the earth. The satellites are too small to be scaled to this standard and therefore are represented by small beads of uniform size.

"A circular scale mounted on the base gives the zodiac, the months and the right ascension from zero to 24 hours. The sun sector, attached to the tip of the central spindle, is made to scale and gives some idea of the great size of the sun when compared with that of the planets.

"The planets are mounted on arms with devices for showing their inclination to the plane of the ecliptic. In the cases of Mercury and Pluto, this is managed by means of tilted washers on the central spindle. For the earth, Mars, Saturn, Uranus and Neptune we use Z-shaped axis rods turning in deep sockets at the ends of the orbit arms.

"The central spindle and washers are of brass and the orbit arms are of silvered steel.

"As you doubtless know, we English have a custom of naming the things we make. I call this instrument the 'Urameton Orrery.' I have had a lifelong interest in the physics of astronomy, and when uranium 235 came into prominence I chanced to remember the Metonic cycle (235 lunations equals 19 years). My address is 235 Bilton Road, Greenford. I was so impressed by the coincidence that I immediately christened my observatory *Urameton!*"

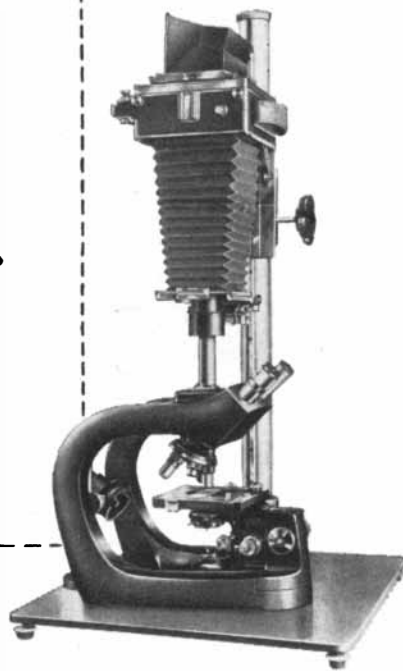
ACCREDITED PERSONNEL SERVICE.....	122
Agency: Gunn-Mears Advertising Agency Corp.	
ALL AMERICAN ENGINEERING COMPANY....	50
Agency: Gaynor & Company, Inc.	
ALLEN-BRADLEY CO.....	135
Agency: The Fensholt Advertising Agency, Inc.	
ALTO SCIENTIFIC COMPANY, INCORPORATED ..	10
Agency: L. C. Cole Company	
AMERICAN CYANAMID COMPANY.....	8, 9
Agency: Hazard Advertising Company	
AMERICAN MACHINE & FOUNDRY COMPANY, DEFENSE PRODUCTS GROUP ..	69
Agency: Fletcher D. Richards, Inc.	
AMERICAN SILVER COMPANY, INC., INDUSTRIAL METALS DIVISION.....	104
Agency: Walter Wiley Advertising Inc.	
ANACONDA COPPER MINING CO.	87
Agency: Kenyon & Eckhardt, Inc.	
ARMSTRONG CORK COMPANY, INDUSTRIAL DIVISION	16, 17, 30
Agency: Batten, Barton, Durstine & Osborn, Inc.	
AVCO DEFENSE AND INDUSTRIAL PRODUCTS, LYCOMING DIVISION	70, 71
Agency: Benton & Bowles, Inc.	
BAUSCH & LOMB OPTICAL CO.....	12, 51, 75
Agency: Ed Wolf & Associates	
BELL TELEPHONE LABORATORIES.....	11
Agency: N. W. Ayer & Son, Incorporated	
BENDIX AVIATION CORPORATION, BENDIX RADIO DIVISION.....	76
Agency: Ogden Advertising	
BERKELEY, EDMUND C., AND ASSOCIATES....	120
Agency: Battistone, Bruce and Doniger, Inc.	
BOEING AIRPLANE COMPANY.....	129
Agency: N. W. Ayer & Son, Incorporated	
BOOK FIND CLUB, THE.....	113
Agency: Roeding & Arnold, Incorporated	
BOOK-OF-THE-MONTH CLUB, INC.....	115
Agency: Schwab and Beatty, Inc.	
BROWN COMPANY.....	18
Agency: J. M. Mathes, Incorporated	
CALIDYNE COMPANY, THE	26
Agency: Meissner & Culver, Inc.	
CARBOLLOY DEPARTMENT OF GENERAL ELECTRIC COMPANY.....	57
Agency: Brooke, Smith, French & Dorrance, Inc.	
CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION.....	55
Agency: Ellington & Company, Inc.	
CLEVELAND PNEUMATIC TOOL COMPANY....	14
Agency: Meldrum & Fewsmith, Inc.	
CONSOLIDATED ENGINEERING CORPORATION	22
Agency: Hixson & Jorgensen, Inc.	
CONSOLIDATED VACUUM CORPORATION, A SUBSIDIARY OF CONSOLIDATED ENGINEERING CORPORATION.....	4
Agency: Charles L. Rumrill & Co., Inc.	
CONTINENTAL FELT COMPANY, INC.....	108
Agency: Ritter, Sanford & Price, Inc.	
DECISION INC.....	120
Agency: Farson, Huff & Northlich	
DESIGNERS FOR INDUSTRY INCORPORATED..	77
Agency: Fuller & Smith & Ross Inc.	
DIXON CORPORATION.....	92
Agency: George T. Metcalf Co.	

INDEX OF ADVERTISERS

NOVEMBER, 1955

DOUGLAS AIRCRAFT COMPANY, INC.....108, 109 Agency: J. Walter Thompson Company	HUGHES RESEARCH AND DEVELOPMENT LABORATORIES 15 Agency: Foote, Cone & Belding	OLIN MATHIESON CHEMICAL CORPORATION 23 Agency: Doyle, Kitchen & McCormick, Inc.
DOVER PUBLICATIONS, INC..... 102 Agency: Equity Advertising Agency	ILLINOIS TESTING LABORATORIES, INC..... 84 Agency: The Buchen Company	PAILLARD PRODUCTS, INC..... 103 Agency: Fuller & Smith & Ross Inc.
DOW CORNING CORPORATION..... 49 Agency: Church and Guiswite Advertising, Inc.	INDUSTRIAL TECTONICS, INC..... 86 Agency: Carl Connable Advertising	PHILLIPS PETROLEUM COMPANY..... 106
DUREZ PLASTICS DIVISION, HOOKER ELECTROCHEMICAL COMPANY..... 48 Agency: Comstock & Company	INTERNATIONAL BUSINESS MACHINES CORPORATION 19 Agency: Benton & Bowles, Inc.	PHILOSOPHICAL LIBRARY, PUBLISHERS 112 Agency: Lester Loeb Advertising
EASTMAN CHEMICAL PRODUCTS, INC., SUBSIDIARY OF EASTMAN KODAK COMPANY 95 Agency: Fred Wittner Advertising	JAEGERS, A..... 126 Agency: Carol Advertising Agency	PRATT & WHITNEY AIRCRAFT, DIVISION OF UNITED AIRCRAFT CORPORATION..... 54, 86 Agency: G. F. Sweet & Co., Inc.
EASTMAN KODAK COMPANY..... 47 Agency: Charles L. Rumrill & Co., Inc.	KENNAMETAL INCORPORATED 68 Agency: Ketchum, MacLeod & Grove, Inc.	RADIO CORPORATION OF AMERICA, EMPLOYMENT DIVISION 124 Agency: Al Paul Lefton Company, Inc.
EDMUND SCIENTIFIC CORP..... 130 Agency: Walter S. Chittick Company	KLING PHOTO CORP..... 138 Agency: Jack Gilbert Associates	RADIO CORPORATION OF AMERICA, ENGINEERING PRODUCTS DEPARTMENT..... 56 Agency: Al Paul Lefton Company, Inc.
FAIRBANKS, MORSE & CO..... 3 Agency: The Buchen Company	LEITZ, E., INC..... 7 Agency: L. W. Frohlich & Company, Inc.	RAMO-WOOLDRIDGE CORPORATION, THE.. 52 Agency: The McCarty Co.
FAIRCHILD ENGINE AND AIRPLANE CORPORATION, AIRCRAFT DIVISION 80 Agency: Gaynor & Company, Inc.	LELAND, G. H., INC..... 78 Agency: Weber, Geiger & Kalat, Inc.	REACTION MOTORS, INC..... 23 Agency: Doyle, Kitchen & McCormick, Inc.
FARNSWORTH ELECTRONICS COMPANY, A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION 5 Agency: Chamberlin-Junk Advertising, Inc.	LIBRARY OF SCIENCE..... 110 Agency: B. L. Mazel, Inc.	REMINGTON RAND, DIVISION OF SPERRY RAND CORPORATION 28 Agency: Leeferd Advertising Agency, Inc.
FERSON OPTICAL COMPANY, INC..... 130 Agency: Dixie Advertisers	LINDE AIR PRODUCTS COMPANY, A DIVISION OF UNION CARBIDE AND CARBON CORPORATION..... 65, 107 Agency: J. M. Mathes, Incorporated	REPUBLIC AVIATION CORPORATION..... 127 Agency: Deutsch & Shea, Inc.
FORD INSTRUMENT COMPANY, DIVISION OF SPERRY RAND CORPORATION..... 20 Agency: G. M. Basford Company	LINGUAPHONE INSTITUTE 122 Agency: The Kaplan Agency	REVERE COPPER AND BRASS INCORPORATED 97 Agency: St. Georges & Keyes, Inc.
FORMICA CO., THE..... 13 Agency: Perry-Brown, Inc.	LITTLE, ARTHUR D., INC..... 103 Agency: Hilton & Riggio	SAVE THE CHILDREN FEDERATION.. 123 Agency: Vanguard Advertising
FRIDEN CALCULATING MACHINE CO., INC. 6 Agency: J. Walter Thompson Company	LOCKHEED AIRCRAFT CORPORATION, CALIFORNIA DIVISION 131 Agency: Hal Stebbins, Inc.	SCIENCE BOOK CLUB, INC..... 117 Agency: Waterston & Fried, Inc.
GARRETT CORPORATION, THE, AIRESEARCH MANUFACTURING DIVISIONS.....98, 99 Agency: J. Walter Thompson Company	LOCKHEED AIRCRAFT CORPORATION, MISSILE SYSTEMS DIVISION..... 119 Agency: Hal Stebbins, Inc.	SCIENCE KITS, OLIVER GARFIELD COMPANY 122 Agency: Dundon Associates, Inc.
GENERAL AMERICAN TRANSPORTATION CORPORATION, KANIGEN DIVISION... 21 Agency: Weiss and Geller, Inc.	LOS ALAMOS SCIENTIFIC LABORATORY OF THE UNIVERSITY OF CALIFORNIA..... 118 Agency: Ward Hicks Advertising	SIGMA INSTRUMENTS, INC..... 67 Agency: Meissner & Culver, Inc.
GENERAL DRY BATTERIES, INC..... 2 Agency: Meldrum & Fewsmith, Inc.	LUDWIG, F. G., INC..... 120 Agency: The Charles Brunelle Company	SMITH, A. O., CORPORATION.....88, 89 Agency: Klau-Van Pietersom-Dunlap, Inc.
GENERAL DYNAMICS CORPORATION Inside Back Cover Agency: Gotham-Vladimir Advertising, Inc.	MALAYAN TIN BUREAU, THE..... 98 Agency: Gray & Rogers	SOLAR AIRCRAFT COMPANY..... 105 Agency: The Phillips-Ramsey Company
GENERAL ELECTRIC COMPANY.....133 Agency: Batten, Barton, Durstine & Osborn, Inc.	MARQUARDT AIRCRAFT COMPANY..... 23 Agency: Doyle, Kitchen & McCormick, Inc.	SPERRY GYROSCOPE COMPANY, DIVISION OF SPERRY RAND CORP.....106 Agency: Equity Advertising Agency
GENERAL ELECTRIC CO., AIRCRAFT NUCLEAR PROPULSION DEPARTMENT..... 104 Agency: Deutsch & Shea, Inc.	MARTIN COMPANY, THE..... 134 Agency: VanSant, Dugdale & Company, Inc.	SUN OIL COMPANY, INDUSTRIAL PRODUCTS DEPARTMENT 100 Agency: Ruthrauff & Ryan, Inc.
GENERAL ELECTRIC COMPANY, SPECIAL DEFENSE PROJECTS DEPARTMENT..... 102 Agency: Deutsch & Shea, Inc.	MELETRON CORPORATION 1 Agency: Welsh, Hollander & Coleman	TICKLE, ARTHUR, ENGINEERING WORKS, INC..... 96 Agency: Ritter, Sanford & Price, Inc.
GENERAL MOTORS CORPORATION, ALLISON DIVISION..... 121 Agency: H. L. Ross, Advertising	MELPAR, INC., SUBSIDIARY OF WESTINGHOUSE AIR BRAKE COMPANY..... 140 Agency: Equity Advertising Agency	TITANIUM ALLOY MFG. DIVISION, NATIONAL LEAD COMPANY..... 63 Agency: Comstock & Company
GENERAL MOTORS CORPORATION, NEW DEPARTURE DIVISION.....Back Cover Agency: D. P. Brother & Company	MERCK & CO., INC..... 79 Agency: Charles W. Hoyt Company, Inc.	UNION CARBIDE AND CARBON CORPORATION.....Inside Front Cover Agency: J. M. Mathes, Incorporated
GENERAL MOTORS CORPORATION, SAGINAW STEERING GEAR DIVISION... 53 Agency: D. P. Brother & Company	MICROMETRICAL MANUFACTURING COMPANY 98 Agency: Carl Connable Advertising	UNITED SCIENTIFIC CO..... 128 Agency: Robert Hartwell Gabine, Advertising
GENERAL PRECISION EQUIPMENT CORPORATION 24, 25 Agency: Geer, Dubois & Company, Inc.	MINIATURE PRECISION BEARING, INCORPORATED 96 Agency: Henry A. Loudon, Advertising, Inc.	UNITED STATES STEEL CORPORATION... 139 Agency: Batten, Barton, Durstine & Osborn, Inc.
GLYCERINE PRODUCERS' ASSOCIATION. 136 Agency: G. M. Basford Company	MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIVISION... 92 Agency: The Aitkin-Kynett Co.	UNIVERSAL DRAFTING MACHINE CORPORATION 108 Agency: Robert Goulder Advertising
HARPER & BROTHERS..... 116 Agency: Denhard & Stewart, Incorporated	MONSANTO CHEMICAL COMPANY, PLASTICS DIVISION 27 Agency: Needham, Louis and Brorby, Inc.	UNIVERSITY OF CALIFORNIA PRESS... 114 Agency: Sussman & Sugar, Inc.
HEWLETT-PACKARD COMPANY 81 Agency: L. C. Cole Company	MOOG VALVE CO., INC..... 61 Agency: Warman, Robins & Gorham, Inc.	WOLLENSAK OPTICAL COMPANY..... 140 Agency: Ed Wolf & Associates

*What Makes
One Camera
More Suitable
Than Any Other
for SCIENTIFIC
and INDUSTRIAL
PHOTOGRAPHY?*



The photographic needs of the laboratory and the production line are as varied as they are exacting. One moment may call for a micro-photo analysis of a lapped surface — another, for a progress study of a new machine installation — or the picture of an executive for publicity. There is no predicting what may be next. But, whatever it is, the camera must be able to cope with it efficiently.

This imposes at least two important requirements upon the camera to be selected:

- 1. Versatility** — the features and facilities to handle all photographic problems with ease — without awkward adaptations or makeshift arrangements.
- 2. Precision** — the ability to perform its operations with definite exactness and reliable accuracy, thus assuring perfect results every time.

The LINHOF Super Technika is unmatched in these respects. It is a precision optical instrument, qualified by its own inherent design for the most exacting photographic work. It has

been called by many 'the most versatile camera in the world'.

Here are some of its features:

Triple track sections provide greater bellows extension than is possible with any other camera of its type — for extreme magnifications.

Lens standard rises, falls, shifts and tilts. The bed drops. The back revolves 360°, and swings and tilts in any plane for complete control of depth-of-field and perspective distortion.

Prism rangefinder combines micrometer accuracy with high light transmission for ease of operation under adverse light conditions. It can be coupled to as many lenses as desired.

Lenses are quickly interchangeable permitting use of wide-angle, telephoto and other special lenses. Accessory backs are available for projection printing and Polaroid photography.

There are many more features which commend the LINHOF Super Technika as being more suitable than any other camera for scientific and industrial photography. For complete information, use the coupon below.



Linhof SUPER TECHNICA CAMERAS

KLING PHOTO CORP. Dept. S-11, 235 Fourth Ave., New York 3, N.Y.

Please send complete information on LINHOF Super Technika Cameras and other Linhof Precision Products. 2¼x3¼ 4x5 5x7
 Furnish the name of the Linhof Dealer nearest us.

NAME.....
FIRM.....
ADDRESS.....
CITY.....ZONE.....STATE.....

BIBLIOGRAPHY

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

OPINIONS AND SOCIAL PRESSURE

- EFFECTS OF GROUP PRESSURE UPON THE MODIFICATION AND DISTORTION OF JUDGMENTS. S. E. Asch in *Groups, Leadership and Men*, edited by Harold Guetzkow. Carnegie Press, 1951.
- SOCIAL LEARNING AND IMITATION. N. E. Miller and J. Dollard. Yale University Press, 1941.
- SOCIAL PSYCHOLOGY. Solomon E. Asch. Prentice-Hall, Inc., 1952.

THE TRENCHES OF THE PACIFIC

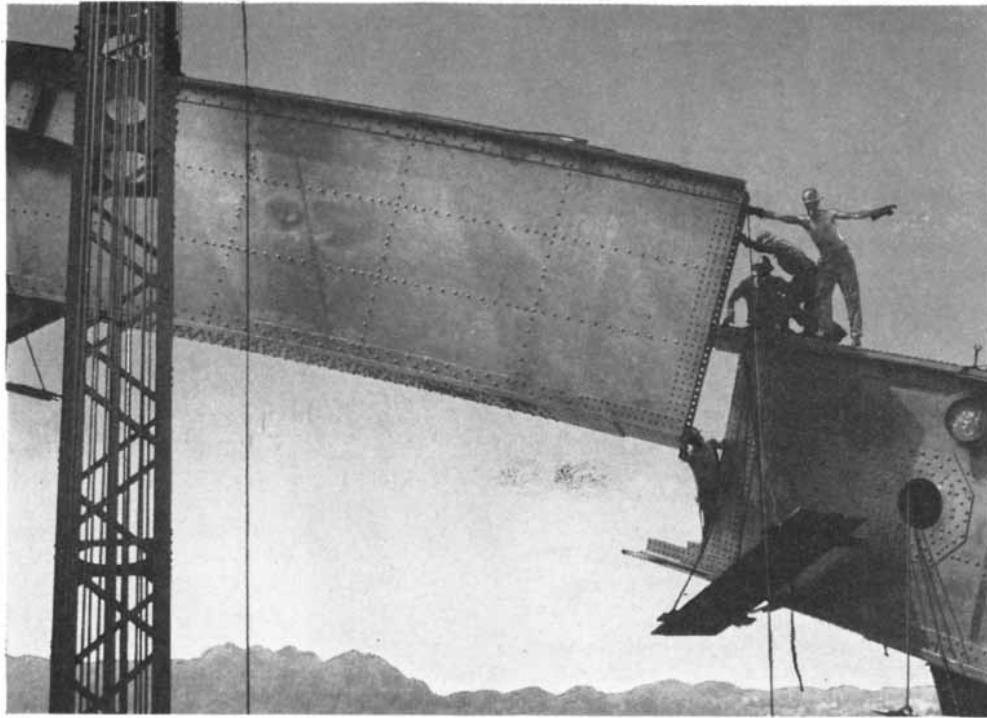
- FURTHER NOTES ON THE GREATEST OCEANIC SOUNDING AND THE TOPOGRAPHY OF THE MARIANAS TRENCH. T. F. Gaskell, J. C. Swallow and G. S. Ritchie in *Deep-Sea Research*, Vol. 1, No. 1, pages 60-63; October, 1953.
- GRAVITY ANOMALIES AND THE STRUCTURE OF THE WEST INDIES, PART I. Maurice Ewing and J. Lamar Worzel in *Bulletin of the Geological Society of America*, Vol. 65, No. 2, pages 165-173; February, 1954.
- THE PHILIPPINE TRENCH AND ITS BOTTOM FAUNA. Anton Fr. Bruun in *Nature*, Vol. 168, No. 4277, pages 692-693; October 20, 1951.
- SEISMICITY OF THE EARTH AND ASSOCIATED PHENOMENA. B. Gutenberg and C. F. Richter. Princeton University Press, 1954.

SYNTHETIC DIAMONDS

- AN EXPERIMENTAL CONTRIBUTION TO THE PROBLEM OF DIAMOND SYNTHESIS. P. W. Bridgman in *Journal of Chemical Physics*, Vol. 15, No. 2, pages 92-98; February, 1947.
- THE PROBLEM OF ARTIFICIAL PRODUCTION OF DIAMONDS. C. H. D[esch] in *Nature*, Vol. 121, No. 3055, pages 799-800; May 19, 1928.

RADIATION AND HUMAN MUTATION

- NATIONAL SURVEY OF CONGENITAL MALFORMATIONS RESULTING FROM EXPOSURE TO ROENTGEN RADIATION. Stanley H. Macht and Phillip S. Lawrence in *American Journal of Roent-*



A better steel for better bridges

● We are in an era of bridge building. You don't have to drive very far through the countryside to be made well aware of this fact. On almost any trip you take, one or more detours marked "Bridge under Construction" have become an accepted part of today's motoring.

That's because an estimated 170,000 highway bridges, considered inadequate for modern traffic, are gradually being replaced, or strengthened or widened to meet present-day needs. In 1954 this country spent almost \$500 million for highway bridges. And that's only the beginning; to date the backlog of proposed bridge construction amounts to more than \$2 billion.

Steel is playing an important role in this tremendous program. For whether it is a small bridge on an obscure rural route or one of the large bridges forming part of a super highway system, steel almost without exception is a basic part of the structure.

To reduce the dead weight of bridges, designers and engineers needed a *high strength* steel. For many years, for long spans in riveted bridges, where weight saving was an

important consideration, they have used structural silicon steel (ASTM A-94) which has a minimum yield point of 45,000 pounds per square inch.

About two years ago, United States Steel metallurgists set to work to develop a new steel for this purpose, that would be even better than structural silicon steel.

Now, in USS MAN-TEN (A-242) Steel, bridge engineers have available a steel that, in thicknesses up to and including 1½ inches, has a higher yield point than structural silicon steel—that has twice the resistance to atmospheric corrosion—that punches, drills and gas cuts as well, and, because of its greater ductility, forms more easily. All this at lower cost.

USS MAN-TEN (A-242) Steel is available in plates, wide flange beams, standard structural shapes, in bars and bar shapes. It is intended primarily for use in members of riveted and bolted structures requiring high strength, good fatigue re-

sistance and atmospheric corrosion resistance equal to that of copper steel.

A number of bridges, both large and small, have already been built, or are under construction, with this superior steel. Among them are the West Virginia State Highway bridge at Wheeling, W. Va., in which 2,500 tons of USS MAN-TEN (A-242) were used; the Maumee River bridge near Toledo, Ohio, (1,913 tons); the Red River bridge at Shreveport, La., (2,000 tons); the Delaware River Turnpike bridge connecting the Pennsylvania and New Jersey Turnpikes, (11,070 tons) and others.

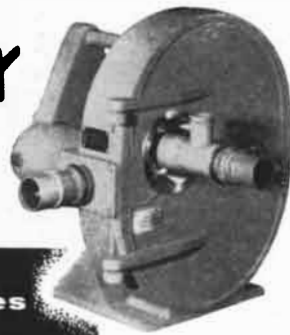
We tell this story because it so well illustrates how United States Steel is constantly working to give America ever finer and more efficient steels—steels of infinite variety that can be confidently counted on to meet every demand that Industry can make on this most versatile of metals. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.



UNITED STATES STEEL

NEW Wollensak **FASTAX**

High-Speed Cine- Oscillographic Cameras



**8 mm-16 mm Cameras with
400 ft. capacity... speed ranges
from 500 to 18,000 pictures
per second.**

With the new combination cine and oscillographic camera there is a simultaneous recording of visual and electrical phenomena. The oscilloscopic image is superimposed over the motion picture image on the emulsion side of the film. Thus a permanent record is available for study and measurement.

NEW FEATURES:

- Lenses in focusing mount with bayonet attachment.
- Through-the-lens viewing and focusing finder for both "oscillo" and motion picture.
- Improved rotating prism for sharper images.
- Can be used either as a high-speed motion picture, streak or combination camera.

WRITE for more detailed information and prices.



WOLLENSAK
OPTICAL COMPANY
850 Hudson Ave., Rochester 21, N. Y.



ENGINEERS Electronic • Mechanical DESIGNERS • DRAFTSMEN

How do you Measure success?

Some measure success only by money; others by the enjoyment they get out of their work. But the true measure of success is a combination of both *plus* the knowledge that your efforts are recognized and appreciated.

Melpar engineers find diversity and opportunity for professional growth; they enjoy being part of a highly creative staff without losing their individuality; and they benefit from Melpar's completely integrated facilities for system responsibility from design concept through production.

To learn how Melpar measures up to your own standards send complete resume to

Technical Personnel Representative



melpar, inc.

Subsidiary of Westinghouse Air Brake Co.
3000 Arlington Blvd., Dept. SA-23 Falls Church, Va.
11 Galen Street, Watertown, Mass. • 99 First St. Cambridge, Mass.

- Network Theory
- Systems Evaluation
- Automation
- Microwave Technique
- UHF, VHF or SHF Receivers
- Analog Computers
- Digital Computers
- Magnetic Tape Handling Equipment
- Radar and Countermeasures
- Packaging Electronic Equipment
- Pulse Circuitry
- Microwave Filters
- Flight Simulators
- Servomechanisms
- Subminiaturization
- Electro-Mechanical Design
- Quality Control & Test Engineers

genology and Radiation Therapy, Vol. 73, No. 3, pages 442-446; March, 1955.

OUR LOAD OF MUTATIONS. H. J. Muller in *American Journal of Human Genetics*, Vol. 2, No. 2, pages 111-176; June, 1950.

X-RAY-INDUCED MUTATIONS IN MICE. W. L. Russell in *Cold Spring Harbor Symposia on Quantitative Biology*, Vol. 16, pages 327-336; 1951.

"EMPTY" SPACE

GAS DYNAMICS OF COSMIC CLOUDS. Edited by Johannes Martinus Burgers and H. C. van de Hulst. Interscience Publishers, Inc., 1955.

WHAT MAKES LEAVES FALL?

AUXINS AND PLANT GROWTH. A. C. Leopold. University of California Press, 1955.

STUDIES ON ABSCISSION. R. H. Wetmore, William P. Jacobs and F. N. Rossetter in *American Journal of Botany*, Vol. 40, No. 4, pages 272-280; April, 1953. Vol. 42, No. 7, pages 594-604; July, 1955.

ETRUSCAN METALLURGY

ETRURIA PAST AND PRESENT. Mary Anderson Johnstone. Methuen and Company, Ltd., 1930.

THE ETRUSCANS. Massimo Pallottino. Penguin Books, 1955.

TOO MANY DEER

THE JAWBONE DEER HERD. A. Starker Leopold, Thane Riney, Randal McCain and Lloyd Tevis, Jr. State of California, 1951.

PENNSYLVANIA'S DEER PROBLEM. Roger M. Latham. Pennsylvania Game Commission, 1950.

A SURVEY OF CALIFORNIA DEER HERDS: THEIR RANGES AND MANAGEMENT PROBLEMS. William M. Longhurst, A. Starker Leopold and Raymond F. Dasmann. State of California, 1952.

THE AMATEUR SCIENTIST

DIRECT-INDICATING RECORDING INSTRUMENTS. S. R. Gilord in *Electrical Manufacturing*, Vol. 52, No. 5, pages 114-121; November, 1953. Vol. 52, No. 6, pages 120-128; December, 1953.

MECHANICAL MEASUREMENTS BY ELECTRICAL METHODS. Howard C. Roberts. The Instruments Publishing Company, 1951.



First in the "Atoms for Peace" series of posters displayed throughout Switzerland during the historic International Conference and Exposition on the Peaceful Uses of Atomic Energy in Geneva.



GENERAL DYNAMICS CORPORATION • 445 PARK AVENUE, NEW YORK 22, N. Y.

NEW

DEPARTURES OF TOMORROW



TOMORROW: Some day soon you may swing aboard an atom-powered jet aircraft and land at a Metro-Port right in the heart of your city.



TODAY: From supersonic military jets to fast-developing executive jet aircraft, New Departure ball bearings play a vital role in keeping moving parts functioning smoothly.

Maybe you'll commute from the suburbs to work on the Jetdome . . . in 1973! Then be whisked from the city's Metro-Port right to your office door. It's an idea that makes sense for tomorrow.

If a "new departure" in timesaving travel like this does take place, you can be sure that New Departure ball bearings will be on the job. Already New Departure's Aircraft Research Program is developing ball bearings for operation at speeds of over 100,000 rpm and temperatures of 500° F. or higher. New Departure ball bearings are specified today on all forms of transportation because they hold friction to an absolute minimum, support loads from any direction, keep parts in perfect alignment, require little or no upkeep. If your present-day product calls for future improvements, call on New Departure. You'll benefit from nearly 50 years of ball bearing experience.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

